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EFFECTS OF INCENTIVE REGULATION ON THE EXCERCISE OF MARKET POWER IN THE U.S. LOCAL TELEPHONE INDUSTRY

By

Hyun-Oh Yoo

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ABSTRACT

EFFECTS OF INCENTIVE REGULATION ON THE EXCERCISE OF MARKET POWER IN THE U.S. LOCAL TELEPHONE INDUSTRY

By

Hyun-Oh Yoo

The purpose of this dissertation is to empirically address the question of how incentive regulation affects pricing behavior of regulated firms. Specifically, this study examined whether price changes (or differences) after the adoption of incentive regulation were due to an increased or decreased exercise of market power while controlling for changes in cost, service quality, and the elasticity of demand in the U.S. local telephone industry.

A structural model derived from the "new empirical industrial organization (NIEO)" paradigm is developed to detect pricing behavior. The model is expected to be able to estimate and identify the degree of market power (pricing behavior) by using a system of behavioral equations based on oligopoly theory and comparative statics. To handle endogeneity in the behavioral equation model, the three-stage least squares estimator was used. To control for unobservable state-specific variables, a fixed effects model was employed using a panel data set. . The state LEC-level data are collected from diverse sources including the FCC's ARMIS (Automated Reporting Management Information System) database on the FCC's web site on the Internet.

The results show firms under price cap and earnings sharing regulation tend to set prices higher above marginal cost than under rate-of-return regulation. The results also

show the existence of economies of scale in residential local telephone service. The higher markup for low-elasticity local service could thus result in better allocative efficiency since the FDC-based (Fully Distributed Cost) price under ROR regulation tends to be lower than the second-best Ramsey price. Since residential local rates have generally been decreasing, the efficiency gain from incentive regulation seems to outweigh the loss in equity.

This dissertation is dedicated to my late father, Sung-Mok Yoo.

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INTRODUCTION

As the legal and institutional environment has changed, the U.S. local telephone industry has experienced a transition from traditional rate-of-return (ROR) regulation to various forms of incentive regulation.[1] Incentive regulation is widely seen as a regulatory method devised to cope with market power in the emerging competitive industry framework. The most popular methods adopted by regulators are earnings sharing and price caps. Incentive regulation allegedly has better efficiency incentives than traditional ROR regulation. In particular, price-cap regulation has been praised as the best alternative and has been widely adopted.

One of the main economic purposes of price regulation in the telecommunication industry is the constraint of market power of naturally monopolistic firms.[2] Initially, ROR regulation was adopted as a tool to protect consumers from monopolistic exploitation while allowing regulated firms to maintain economic viability. Although the economic rationale for regulation of the telecommunication industry due to the existence of natural monopoly has been eroded and weakened, the high market share of incumbent local exchange carriers raises concern about their market power. Price regulation is still in place to protect consumers from monopolistic exploitation. The study of whether alternative price regulatory regimes effectively constrain market power is thus of great

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[1] The term "incentive regulation" may be inappropriate for denoting newly adopted types of non-ROR price regulation. As Lyon (1994) pointed out, all regulation, strictly speaking, is "incentive" regulation in a sense that it generates certain incentives that affect regulated firms' economic behavior. Nevertheless, the term is used here because it has been so popular in both academic and practical fields and has been well understood.

[2] Bauer (1997) addresses the issue of market power in broader contexts. Based on Schumpeterian and neo-evolutionary perspectives, the author proposes the prospect and ultimate possession of market power is a driving force guiding the decisions of economic actors under condition of uncertainty, as a precondition to stimulate innovative activities by firms. Therefore, his argument goes on, regulation should not discourage firms' quest for temporary market power. Although my study is much narrower in its scope, focusing on empirically detecting and measuring market power, the new perspectives based on a dynamic process can enrich the debate over market power.

conceptual and practical importance. There have been, however, few empirical studies of how incentive regulation affects market power in the telecommunication industry.

The purpose of this study is to examine the effects of incentive regulation on the exercise of market power in the US local telephone industry. More precisely, this study will examine whether price changes (or differences) after the adoption of new incentive price regulation were due to an increased or decreased exercise of market power while controlling for changes in cost, quality, and the elasticity of demand. Since the main purpose of price regulation is to constrain market power, studying the effects of (alternative) price regulation on the exercise of market power is of the utmost importance.

Most empirical studies of the effects of (incentive) regulation have been influenced by the structure-conduct-performance (SCP) paradigm of industrial organization (IO). The empirical studies, therefore, are not free from the criticisms applied to the studies guided by the SCP paradigm of industrial organization: flaws in accounting data, endogeneity problems, and problems interpreting high profitability (market power or efficiency).

In response to the criticisms of the SCP studies, industrial organization economists have turned to a new kind of empirical research. This approach is called "new empirical industrial organization (NEIO)." Basically, this new approach uses oligopoly theories and comparative statics to detect and measure market power. By developing a structural model of competition derived from NEIO studies, my dissertation will contribute to the literature as follows.

First of all, this is the first empirical study examining the effects of incentive regulation that aims at detecting and measuring pricing behavior. The difference between pricing behavior and price is not trivial because the degree of market power can be correctly estimated by employing behavioral equations explaining how firms set price and quantity.

Second, this study intends to bridge the gap between theoretical and empirical studies. The theoretical literature has examined the allocative efficiency of alternative forms of incentive regulation. Empirical studies, however, have often been conducted with disregard for the theoretical findings. This is partly due to the limitation of estimation techniques adopted by the empirical studies. For example, pricing behavior, such as marginal cost pricing or monopoly pricing, cannot be identified with one reduced form equation. By adopting a structural model of competition, which encompasses a demand function, a supply relation, and a conduct function, this study will make an unbiased estimation of the degree of allocative efficiency of alternative forms of incentive regulation.

Finally, this study examines another key issue: whether incentive regulation negatively affects service quality. The issue of service quality is closely related to the pricing issue because a decrease in quality will be equivalent to an increase in price holding the quality level constant. By incorporating service quality in the simultaneous equations system, this study intends to detect the unbiased effects of incentive regulation on service quality.

This dissertation is organized as follows. Following this introductory section, section 2 briefly reviews prior theoretical and empirical research related to incentive regulation and market power in the local telephone industry. The theoretical review focuses on the advantages and disadvantages that alternative price regulatory regimes have for managerial and allocative efficiency. Section 3 describes the econometric modeling procedure, data and measures, and the empirical models used to estimate the effect of incentive regulation on the exercise of market power. Section 4 summarizes the results of the three-stage least squares estimation combined with the fixed effect model. Section 5 draws conclusions.

CHAPTER 1

REVIEW OF THEORETICAL AND EMPIRICAL STUDIES

1.1 Price Regulation

1.1.1 The Rationale for Regulation

The central economic rationale for the economic regulation of public utilities such as telecommunications has been the existence of "natural monopoly" in the industry, a fundamental case of market failure. An industry is a natural monopoly if, over the entire relevant range of outputs, the cost function is subadditive.[3] Consider the case in which there are *m* different products and *n* different firms. Each firm may produce any or all of the *m* products. Suppose that **q** is a production vector or plan: $\mathbf{q} = (q_1, \ldots, q_m)$ for the *m* outputs. Let $\mathbf{q}^1, \ldots, \mathbf{q}^n$ denote *n* such vectors. The cost function C is strictly subadditive if

$$\sum_{i=1}^{n} C(\mathbf{q}^i) > C(\sum_{i=1}^{n} \mathbf{q}^i)$$

for all **q** such that $\Sigma_i \mathbf{q}^i \neq 0$.[4]

This definition applies to the single-product cost function if we assume that *m* goods are homogeneous. In this case, a specific good or service could be produced at lowest cost only if supplied by a single firm. Therefore only one firm is viable in the market in a strong natural monopoly, or entry would be socially inefficient in a weak natural monopoly.

[3] A subadditive cost structure need not exhibit economies of scale over the entire relevant range of outputs.
[4] Baumol, Panzar, and Willig (1982).

Then, why should a natural monopoly be regulated? Figure 1 shows why an unregulated natural monopoly is inefficient.

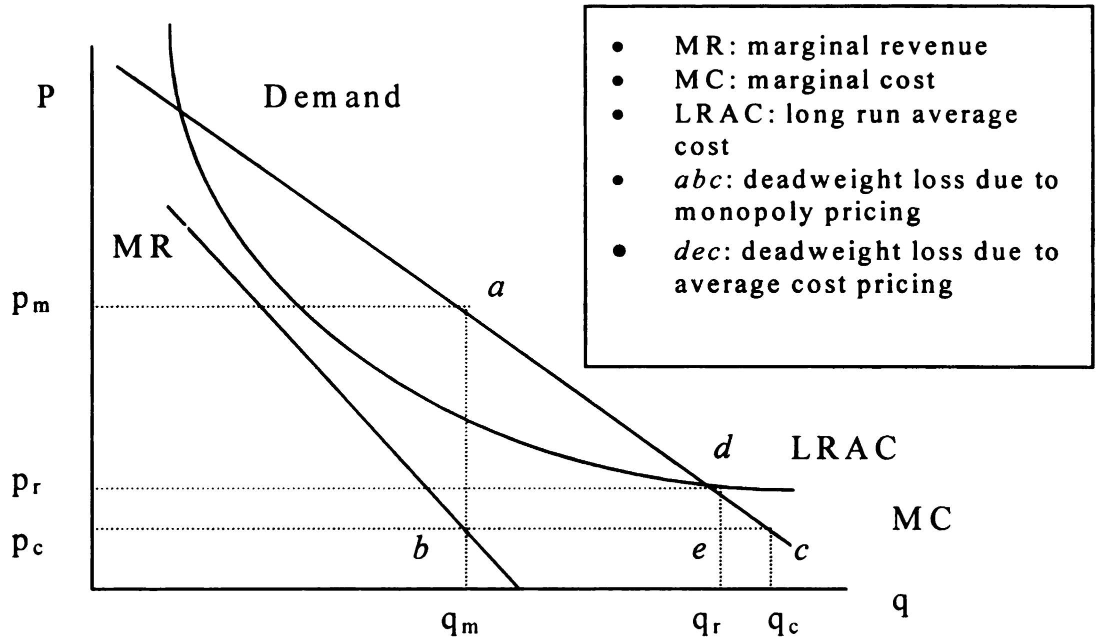

Figure 1. Natural Monopoly

In an unregulated industry, a profit-maximizing firm would produce the output q_m with the monopoly price p_m (p_m = MR), and earn excess economic profits. Entry would be virtually impossible because the natural monopolist could quickly expand output to q_r if threatened with entry. The welfare loss associated with the monopoly pricing is the area *abc*. Such an efficiency loss is called a "deadweight loss."

On the other hand, the socially optimal pricing (p_c)[5] would yield an economic loss because p_c is lower than long run average cost (LRAC). In order for the firm to remain economically viable, a price needs to be equal to or higher than LRAC. Thus, the breakeven-constrained optimum (second-best) occurs at the price $p = p_r$. The welfare loss

[5] In other worlds, first-best pricing or marginal cost pricing.

(deadweight loss) resulting from the second-best (or average cost) pricing is the area *dec*, which is less than the area *abc*. Therefore, "entry and price" regulation was proposed to capture the efficiency advantages of natural monopoly while eliminating some of the potential for monopolistic exploitation.

However, this "natural monopoly" rationale for "entry and price" regulation of the telecommunications industry has been challenged theoretically and empirically. The theory of "contestability," proposed by Baumol, Panzar and Willig (1982), has significantly eroded the theoretical underpinnings of the natural monopoly rationale for regulation. The theory of contestability focuses on competition *for* the market rather than *within* the market.[6] Baumol et al. (1982) argue that having one or a limited number of firms does not necessarily mean there is no competition and that potential competition (the threat of entry) may serve to discipline established firms. Even if competition within the market is not possible due to the existence of natural monopoly, competition for the market, Baumol et al. suggest, can lead to second-best pricing without regulation as long as there are no "sunk" costs.[7] If no costs are sunk, a price above an average cost is not sustainable because an entrant can undercut this price and still make a positive profit. The theory of contestability has presented a strong tool for criticizing the mere existence of natural monopoly as the rationale for "entry and price" regulation.

Another criticism came from empirical studies examining whether the telephone industry is a natural monopoly. Several studies rejected the existence of natural

[6] The concept of "competition for the market" was introduced by Demsetz (1968).
[7] According to the rationale of natural monopoly, fixed costs play a role as a barrier to entry. Fixed costs are defined as costs that are independent of the scale of production and are locked in for some short length of time. On the other hand, sunk costs are those investment costs that produce a stream of benefits over a long time but never can be recouped.

monopoly in the industry although empirical studies addressing the natural monopoly question are not conclusive. Evans and Heckman (1983) rejected that AT&T's cost function was subadditive. Shin and Ying (1992) also found that the cost function of local exchange carriers was not subadditive. On the other hand, studies conducted by Christensen, Cummings, and Schoech (1983), Charnes, Coopers, and Sueyoshi (1988), and Röller (1990) supported the natural monopoly hypothesis in the telephone industry.

The economic rationale for regulation of the telecommunications industry due to the existence of natural monopoly has been eroded and weakened. Nevertheless, the high market share of incumbent local exchange carriers raises concern about their market power. As a consequence, legal restrictions on entry have been substantially eliminated in the telecommunications industry, but price regulation is still in place to protect customers from monopolistic exploitation. Rate of return regulation has been traditionally adopted as a means to achieve this goal.

1.1.2 Rate-of-Return (ROR) Regulation

ROR regulation was widely adopted by state regulatory authorities. It was believed that ROR regulation protected customers from exploitation by private profit-maximizing monopolists.[8] ROR regulation was also believed to help ensure an adequate supply of products and services in the regulated industry by ensuring the financial integrity of the regulated firm.[9]

Rate-of-return (ROR) regulation is a form of "cost-plus", or "cost-of-service-price" regulation. This method estimates the firm's operating costs on a forward-looking

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[8] Kahn (1988).
[9] Sappington and Weisman (1996).

basis. Prices for the services of the regulated firm are then set to generate revenues that cover these costs and provide a “fair” and “reasonable” return on invested capital. The prices are typically set at fully distributed costs (FDC), which attempt to assign joint and common costs fairly across the firm’s different services.[10]

ROR is still in use in many states (14 out of 51 states as of 1997) because it is believed to have several advantages. First, ROR gives regulators a relatively simple way to limit monopoly pricing through close monitoring of the firm's profits. Regulators attempt to achieve this goal by directly setting prices, not the rate of return.[11] In theory, regulated prices combined with restricted entry allow second-best prices to be enforced. Second, in the presence of cost uncertainty and asymmetric information about the capabilities of regulated firms, ROR generally performs better since it depends in part on actual costs.[12] Finally, by using deliberate cross subsidization, regulators can achieve non-economic goals like universal service.[13]

Since the 1960s, ROR regulation has been criticized for causing serious efficiency problems. The first theoretical criticism of ROR regulation was suggested in the seminal work conducted by Averch and Johnson (1962). They argued that regulated firms under ROR may have an incentive to expand their rate base uneconomically (over-investment, or "A-J effect") if the allowed rate of return on capital (rate base) is higher than the cost of capital. Many subsequent studies have shown that firms under ROR regulation have

[10] The fully distributed cost pricing will be discussed in the following section. The ROR formula can be represented as Revenue Requirement = Total Cost = Variable Costs + ROR × Rate Base.

[11] Joscow (1973).

[12] Schmalensee (1989).

[13] Liston (1993).

little incentive to manage inputs efficiently or to adopt cost-reducing innovations because cost decreases and increases are passed on to customers.[14]

ROR regulation could also create problems when firms serve both regulated and unregulated markets. For example, under ROR a multi-market firm serving both regulated and unregulated markets may have incentives to set artificially high internal transfer prices and shift the costs of supplying unregulated products to the regulated accounts, i.e., cross-subsidize.[15] As a consequence, predatory pricing may occur in the unregulated markets.[16]

ROR regulation also has administrative efficiency problems. Regulators can suffer from informational asymmetries, i.e., regulators cannot detect misrepresented or disguised cost data which regulated firms manipulated to secure higher prices or rates of return. The administrative costs of regulation are also substantial and growing.[17]

Some of ROR's theoretical weaknesses and efficiency problems may be alleviated by the way it actually is implemented. In practice, regulators do not set a rate-of-return, but a price which is not modified continuously but only at longer intervals. In other words, there are considerable regulatory lags. Joskow (1973) found an 18-24 month lag. Between rate hearings, the firm is the residual claimant for its cost savings and revenue increases. In fact, there is a form of incentive regulation to institutionalize these regulatory lags called rate freeze. Rate freezes are agreements between regulators and regulated firms not to raise (or lower) the price of a regulated service for a specified period of time. In addition, Gilbert and Newbery (1988) argue that cost minimizing

[14] Mathios and Rodgers (1989).
[15] Brennan (1989).
[16] Liston (1993).
[17] Braeutigam and Panzar (1989).

behavior can be introduced into an ROR regime if regulators can exclude idle capacity from the rate base to avoid A-J effects.

1.1.3 Price-cap Regulation

The problems with ROR regulation led to the adoption of various forms of alternative incentive-based regulation. The most popular alternative is price cap regulation. As of 1997, 30 out of 51 states had adopted price cap regulation. Price cap regulation sets a ceiling on price[18] that a regulated firm can charge but allows pricing flexibility within this constraint. The caps are determined using price indices, which are defined for one or several baskets of services chosen by regulators. These indices are then adjusted by a factor, X, which is set in advance, but updated at regular intervals. Under pure price caps, profits are not constrained. The firm retains all of its profits under this regime, so the need for fully distributed cost is obviated.[19]

Compared to ROR regulation the biggest advantage of price caps, in theory, is that price caps provide a regulated firm with a stronger incentive to minimize costs and to adopt efficient technological improvements. This is because under price caps regulators do not regularly pass through to consumers actual increases or decreases in the regulated firm's costs. In addition, the firm has no incentive to expand its rate base uneconomically because the regulator specifies neither a rate base nor a maximum rate of return on invested capital.

Besides managerial efficiency improvements, price cap regulation is claimed to improve allocative efficiency through changes in the price structure. Bradley and Price

[18] Price can be average price, single price, or average revenue, depending on specification.
[19] Weisman (1993).

(1988) and Vogelsang (1988) show that individual prices of a regulated firm under price caps may evolve toward second-best Ramsey levels[20] if the regulated firm maximizes profits under the price constraint, defined as a limit on the increase of a chained Laspeyres price index[21] for its services. Brennan (1989) finds that this may not occur when conditions of demand change. Neu (1993) also finds that when conditions are truly static, prices under price caps converge to a Ramsey structure. In a case study simulating a realistic situation, the author shows that the price of a regulated firm's basic telephone service, which has low price elasticity (0.25) and is growing at a low rate (3%), under either ROR or price cap regulation remains quite similar. However, he also demonstrates that if exogenous growth rates of demand differ substantially across services, price caps can cause a welfare loss larger than ROR regulation can.[22]

Finally, since price cap regulation, in theory, does not make explicit use of accounting data, it tends to reduce the problems created by information asymmetries. Price cap regulation may also reduce the associated administrative costs of regulation.[23]

There are some drawbacks attributed to price cap regulation. Many scholars are concerned that under price caps firms have an incentive to lower service quality inefficiently to reduce costs and increase profits.[24] As a consequence, the quality of the produced services may decrease and/or innovations in quality may be postponed.

Another problem arises from the difficulty of implementing price caps in the context of information asymmetries. When there is considerable uncertainty about cost

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[20] Ramsey pricing will be discussed in the following section.
[21] Prices are weighted by last period's quantities.
[22] Pricing under price cap regulation will be discussed in the following section in detail.
[23] Einhorn (1991).
[24] Brennan (1989).

fluctuations, regulators may have to set the cap on prices so high that transfers of surplus to customers are eliminated.[25] If large shocks of cost and/or demand occur, and the price cap does not reflect these shocks, allocative efficiency tends to suffer and the firms' financial viability may be endangered.[26]

Price cap regulators also have great discretion to specify the following factors: (1) an appropriate price index (PI); (2) a productivity offset (X); (3) design of baskets[27], and (4) a time span for the agreement.[28] This entails a greater potential for capture of the regulatory process by the regulated firms[29] as well as the problems created by information asymmetries.

1.1.4 Earnings Sharing

Earnings sharing plans have been a popular form of incentive regulation. Earnings sharing provides a regulated firm with expanded earnings flexibility but requires the firm to share a portion of the earnings above a certain threshold with its customers.

Earnings sharing is known to have an intermediate incentive power between ROR (low) and price caps (high).[30] In the modeling literature, two important components of intermediate power incentive contracts are identified: (1) uncertainty on the part of the regulator and (2) the regulator's dislike of large profits or rents accruing to the firm.

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[25] Schmalensee (1989).

[26] To alleviate this problem, regulators have adopted indexed price caps. Indexed price-cap plans in the U.S. LECs consist of three components: (1) a productivity offset (X), also known as the X-factor, which is stable over a long period of time; (2) the annual change in United States output prices as measured each year by the Gross Domestic Product price index (GDPPI); and (3) annual change in costs (Z) due to exogenous events such as regulatory separations or accounting changes. The following equation is a mathematical representation of the price-cap formula:

$$PCI_t = PCI_{t-1}[1 + GDPPI_{t-1} - X] + Z_{t-1}$$ (Tardiff and Taylor, 1996).

Other formulae are also possible.

[27] A basket refers to a group of services that has distinctive properties with its own individual price cap.

[28] MacDonald, Norsworthy, and Fu (1994).

[29] Liston (1993).

[30] Laffont and Tirole (1993).

Under these conditions, earnings sharing has some advantages over ROR regulation and price caps.[31]

Sappington and Sibley (1992) find that small amounts of earnings sharing may improve welfare relative to some forms of price-cap regulation when investment is observable. Lyon (1996) presents a formal model of earnings sharing regulation and its benefits relative to rate-of return regulation and price-cap regulation. The author shows that relative to price caps, some degree of earnings sharing always increases expected welfare. He also suggests the benefits of earnings sharing over pure price-caps are greatest when the firm's initial cost is high and cost-reducing innovations are difficult to achieve.[32] Burn, Turvey, and Weyman-Jones (1998) show that a sliding scale mechanism could be applied to an index of a multi-product firm's prices that would allow it to self-select a Ramsey price structure for individual products.

On the other hand, Weisman (1993), in a multi-product setting, shows that various distortions which result when common costs are allocated across products can be avoided by the use of price caps, but not by the use of earnings sharing regulation.

In sum, in terms of managerial efficiency, price cap regulation seems to have the strongest incentives to encourage a regulated firm to minimize costs and adopt efficient technological improvements. In terms of allocative efficiency, theoretical studies show that prices under price caps converge to a Ramsey structure when conditions are truly static. In theory, under ROR regulation, the goal of regulators would be setting second best prices. However, regulatory efficacy has been questioned due to information

[31] Burns et al. (1998).
[32] The proofs of these arguments are omitted since they are beyond the scope of this study. They involve sophisticated mathematics.

asymmetries and the potential for capture of the regulators by the regulated firms. Under price cap regulation, second best pricing can be achieved only if demand is stable, which is not always the case in the telecommunications industry. Earnings sharing is also claimed to allow a regulated firm to self-select a Ramsey price under certain conditions. The following section discusses pricing behavior under alternative regulatory regimes in detail.

1.2 Pricing Rules under Alternative Regulatory Regime

1.2.1 Ramsey Pricing

Ramsey pricing is second-best pricing in the case of a multi-product firm, which maximizes the sum of consumer and producer surplus and simultaneously minimizes the deadweight loss given the constraint of non-negativity of profits for the firm. In other words, Ramsey prices can be derived from solving the following problem:

Max Welfare = Consumer Surplus + Producer Surplus (Revenue -Cost), subject to Revenue = Cost.

To formalize the above problem, suppose that y_i is the level of output of the ith service produced by the n product firm. Let p_i be the price of the ith output, $\mathbf{q}$ the vector of outputs: $\mathbf{q} = (q_1, \ldots, q_n)$, and $\mathbf{p}$ the vector of the prices: $\mathbf{p} = (p_1, \ldots, p_n)$. Let $q_i(\mathbf{p})$ be the demand schedule for the ith service, and $G(\mathbf{q})$ be the consumer surplus at the output vector $\mathbf{q}$. $G_i'(q_i) = p_i(q_i)$. Net consumer surplus S_i is $G_i - p_iq_i$. Let $C(\mathbf{q})$ represent the firm's long run cost function. Finally, note that $\pi = \mathbf{p} \bullet \mathbf{q} - C(\mathbf{q})$ corresponds to the economic profit of the firm. The Ramsey pricing problem can be formally represented as follows.

$$\max_{\mathbf{p}} T = S(\mathbf{q}) + \mathbf{p} \bullet \mathbf{q} - C(\mathbf{q}), \text{ subject to } \pi = \mathbf{p} \bullet \mathbf{q} - C(\mathbf{q}) \geq 0$$

where T = the sum of consumer and producer surplus.

Let λ be the non-negative Lagrange multiplier associated with the profit constraint. To maximize T, the following condition must hold:

$\partial T/\partial p_i + \lambda\ \partial\pi/\partial p_i = 0$ for all i.

For simplicity, consider the special (and most famous) case in which all demands are independent, and let the price elasticity of demand for output i with respect to price p_j be denoted by ε_{ij} and defined in the usual way as $(\partial y_i/\partial p_j)\,(p_j/y_i)$. Then after some algebra, the conditions for optimality can be expressed in the following form:

$$\{\frac{p_i - \partial C / \partial q_i}{p_i}\}\varepsilon_{ii} = \{\frac{p_j - \partial C / \partial q_j}{p_j}\}\varepsilon_{jj} = -\frac{\lambda}{1+\lambda}, \forall i, j.$$

This relationship is the most well-known form of the Ramsey pricing rule. The terms in brackets represent the extent to which price deviates from marginal cost in the subscripted markets, and is often referred to as "markup" of price over marginal cost. The product of this markup and the corresponding elasticity of demand is known as the "Ramsey number." The equation indicates that the Ramsey number in each market must be equal. This relationship represents the famous "inverse elasticity rule," since it indicates that a lower markup must be associated with a more elastic demand when the breakeven constraint is binding.[33] By the same token, under Ramsey pricing, a higher markup will be associated with a less elastic demand when the breakeven constraint is binding.

[33] Braeutigam (1989).

1.2.2 Fully Distributed Cost (FDC) Pricing under ROR Regulation

In practice, regulators have used fully distributed cost (FDC) pricing under ROR regulation. The FDC pricing consists of a whole set of approaches to allocating common costs to services. Once this allocation is done, prices are set so that each service just covers its fully distributed cost. Although allocations have been done in dozens of ways in different regulatory proceedings, three approaches have been used most frequently: the relative output method, the gross revenue and the attributable cost method. Algebraically, the fully distributed cost of service i can be written as

FDC_i = Attributable Cost of $i + f_i \times$ Common Cost

where f_i is the fraction of Common Cost attributed to the service i.

The fraction (f_i) is given by the term:

f_i = Output of i/Total Output (under the relative output method),

f_i = Revenue of i/Total Revenue (under the gross revenue method), or

f_i = Attributable cost of i/Total Attributable Cost (under attributable cost method).

FDC pricing has been criticized due to the fact that different FDC allocation methods are essentially arbitrary, thus leading to widely different results. In addition, there is no effort in FDC pricing to increase economic efficiency. The practice also focuses heavily on cost and little on conditions of demand (including demand elasticities) which are important in determining the size of the deadweight losses from any pricing policy.[34] However, FDC prices are generally viewed as fair because every consumer pays his/her attributable costs and a share of the attributable costs.[35]

[34] Brown and Sibley (1986).
[35] Michell and Vogelsang (1991).

1.2.3 Pricing under Price Cap Regulation

Price cap regulation sets a ceiling on the average price that a regulated firm can charge but allows pricing flexibility within this constraint. The caps are determined using price indices, which are defined for one or several baskets of services chosen by regulators. These indices are then adjusted by a factor, X, which is set in advance, but updated at regular intervals. For example, the constraints are summarized by the RPI – X rule, i.e. annual price increases are limited to a maximum of the increase in the retail price index less X percent. The tariff basket constraint is a Laspeyre index limitation in which prices (p_i^1) in year 1 may only be chosen from those that satisfy:

$$\frac{\Sigma p_i^1 q_i^0}{\Sigma p_i^0 q_i^0} \leq \frac{RPI^1}{RPI^0} - X$$

This is essentially similar to the regulation regime which Vogelsang and Finsinger (1979) show will eventually lead to a profit maximizing monopoly adopting Ramsey pricing (V-F mechanism). Vogelsang and Finsinger suggest that the monopolist should only be allowed to choose for a new period from the set of prices that would have resulted in zero profits with the quantities sold being those of the previous time period.

$$\frac{\Sigma p_i^1 q_i^0}{\Sigma p_i^0 q_i^0} \leq 1 - \frac{\text{Profits in year 0}}{\Sigma p_i^0 q_i^0}$$

Allowing for an inflationary element in costs, this is the same as the tariff basket RPI – X approach with X varying from period to period according to the size of profits. If profits are at an acceptable level and X is set to reflect an overall cost-saving ability through improvements in managerial or technological efficiency, then the RPI – X tariff basket approach is exactly equivalent to the V-F mechanism.[36]

In another formal notation, suppose the regulated firm maximizes profit subject to the constraint that aggregate consumer surplus not fall below S^o. The Lagrangian is

$$\max_q L(q) = p \bullet q - C(q) - \lambda(S - S^o),$$

and the associated first-order conditions for each q_i are

$$\frac{\partial L}{\partial q_i} = p_i + p_i' q_i - \frac{\partial C}{\partial q_i} - \lambda(p_i - p_i - p_i' q_i) = 0.$$

Rearranging terms gives

$$\{\frac{p_i - \partial C / \partial q_i}{p_i}\}\varepsilon_i = 1 + \lambda, \forall i.$$

As with Ramsey prices, the price-cost margins are inversely proportional to the elasticity of demand.[37]

1.2.4 Comparative Analysis of Pricing Rules

The pricing rules can be summarized as follows:

Ramsey Pricing

$$p_{it} = (\frac{1}{1 - \alpha_i / \varepsilon_i})c_i$$

where α_i = Ramsey number c_i is the marginal cost of service *i* and

$$\varepsilon_i = (\frac{\partial q_{it} / \partial p_{it}}{q_{it} / p_{it}}), \forall i.$$

Fully Distributed Cost Pricing

$P_{it} = (1 + m_i)\, c_i$, for all *i*

[36] Bradley and Price (1988).

where c_i is the marginal cost of service i and m_t is a unique percentage margin on top of each marginal cost c_i at time t.

Pricing under Price Caps

$$p_{it} = \left(\frac{1}{1-\beta_{it}/\varepsilon_i}\right)c_i$$

where $\beta_{it} = (1-\lambda_t \frac{q_{it-1}}{q_{it}}), \forall i.$[38]

This pricing rule is derived from the regulated firm's problem to choose q^1 to maximize constrained profit:

$$L(q^1) = P^1 \times q^1 - c(q^1) - \lambda\,(p^1(q^1) \times q^0 - p^0q^0).$$

First-order conditions imply that in each market i,

$$\frac{p_i^1 - c_i^1}{p_i^1} = \frac{1}{\varepsilon}\left(1 - \frac{\lambda q_i^0}{q_i^1}\right).$$[39]

Depending on the regime applied, the variables α_t, m_t, and β_t need to be determined at each time t. From the above equation, we can see that the value of the margin in the Ramsey solution depends on the value of ε_i. From this follows that FDC prices, other things being equal, have a definite relationship to Ramsey prices. If the price elasticity is high, the FDC price of the service concerned will tend to be higher than the Ramsey price. If the elasticity is low, the FDC prices will in contrast tend to be lower. We can see that also price cap prices are placed in a definite relationship to Ramsey prices. The price cap price of a service will tend to be higher than the Ramsey

[37] Brennan (1989).
[38] Neu (1993).
[39] Brennan (1989).

price if the service has relatively high growth and, therefore, β_{it} is larger than α_t, and vice versa for a service with relatively low growth.

In general, in the case of a basic telephone service that has relatively low growth and low price elasticity, the FDC price tends to be lower than the price cap price. On the contrary, in the case of an advanced telephone service that has relatively high growth and high price elasticity, the FDC price tends to be higher than the price cap price. The general validity of claims about the effects of incentive regulation on pricing behavior, however, becomes an empirical issue as Acton and Vogelsang (1989) say.

1.3 Empirical Studies

Empirical studies on the effects of incentive regulation on key performance indices in the telecommunication industry have shown mixed results.[40] By employing one reduced-form model, most empirical studies try to estimate the effects of incentive regulation on one performance indicator, such as prices,[41] infrastructure investment,[42] profits,[43] productivity,[44] costs,[45] service quality,[46] telephone penetration[47] and product innovation.[48]

According to Kridel et al. (1996), empirical studies so far have shown:

- Infrastructure investment, productivity, profit levels, telephone penetration, and product innovation have increased slightly under incentive regulation.

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[40] Kridel, Sappington and Weisman (1996) provide a comprehensive survey on empirical studies of the effects of incentive regulation in the telecommunication industry.
[41] Mathios and Rogers (1989), Kaestner and Kahn (1990), Tardiff and Taylor (1993), Blank, Kaserman, and Mayo (1995), Flannery (1996), and Ai and Sappington (1998).
[42] Greenstein, McMaster, and Spiller (1995), Taylor, Zarkadas, and Zona (1992), Tardiff and Taylor (1993), and Ai and Sappington (1998).
[43] Tardiff and Taylor (1993), and Ai and Sappington (1998).
[44] Christensen, Schoech, and Meitzen (1994), Tardiff and Taylor (1993), and Ai and Sappington (1998).
[45] Shin and Ying (1993), and Ai and Sappington (1998).
[46] Tadiff and Taylor (1993).
[47] Tadiff and Taylor (1993).
[48] FCC (1992).

- Prices, costs, and service quality are not affected by incentive regulation.

So far, there has been no explicit empirical study on the effects of incentive regulation on market power in the telecommunications industry. This section will review studies of the impacts of incentive regulation on profit levels and prices, which are related to the issue of market power (or pricing behavior).

There are only two studies that empirically examine the effects of incentive regulation on profit level. The two studies show mixed results. Tardiff and Taylor (1993) found no statistically significant relationship between incentive regulation broadly defined and net income for the year 1984 through 1990. Ai and Sappington (1998), however, observed that net income per billable access line was 16.1 per cent higher under price cap regulation than under rate-of- return regulation for the year 1992 through 1996.

These studies suffer from the same problems traditional empirical studies of industrial organization have. Detecting market power and measuring its effects on firms' performance have been the focus of many empirical studies in industrial organization over many years. By employing the "Structure-Conduct-Performance" paradigm with cross-sectional industry data, traditional empirical studies of industrial organization most extensively used several measures of "profitability" to infer that high profitability resulted from exercises of market power. The most widely used measures were "excess return on sales," "rate of return on equity (or assets)," "price-cost margins," and "Tobin's q."[49] However, these methods have been criticized due to the flaws in accounting data,

[49] *Excess return on sales* is the ratio of economic profits to sales revenue ((total revenue - total cost)/total revenue).. *Rate of return on equity* is calculated as profits after tax divided by equity. *Rate of return on assets* is calculated as: (profits - tax + interest)/assets. *Price-cost margins* refers to (price - marginal cost)/price. Since marginal costs are not usually available, (total revenue - variable cost)/total revenue is used for the price-cost margins assuming long-run constant returns to scale. *Tobin's q* is defined as the ratio of the market value of a firm to the replacement value of its assets.

endogeneity problems, and interpretation problems of high profitability (market power or efficiency).

First, accounting profits are not equal to economic profits. Using the reported accounting profits, therefore, may lead to a biased estimate of a firm' s profitability. Theoretically, economic profits are revenue minus the opportunity costs of inputs. Reasonably good data exist on revenues, labor costs, and the cost of materials. However, accurately measuring the annual opportunity costs of assets such as plant and equipment, advertising, and R&D is difficult.

Second, causal links are not unidirectional in the real market. A firm's performance can be influenced by market structure and/or conduct, but the opposite directions can be also true. When right hand variables are endogenous, the coefficients of the variables may be systematically biased.[50]

Finally, high profitability of a firm can be a result of its superior efficiency rather than exercises of market power. This criticism can be applied only to cross-sectional inter-industry studies.[51]

Looking directly at the price, on the other hand, could avoid serious accounting problems, thus providing a more attractive way to detect market power. Mathios and Rogers (1989) conducted a pioneering study of the effects of incentive regulation on

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[50] Greene (1997).

[51] The cross-sectional industry-level structure-conduct-performance (SCP) studies conducted mainly in the 1970s showed that higher average profit levels are associated with highly concentrated industries. The Chicago school economists argued that the statistical relationship between market concentration and profitability might be the result of efficiency rather than arising from collusion among leading firms. They contended that the *observed* relationship between concentration and profits *at the industry level* might merely reflect the *true* relationship between market share and profits *at the firm level* assuming that more efficient firms earn both higher profits and a large market share as a result of their superior efficiency. This is because high market shares, by definition, lead to high levels of industry concentration and because profits of large firms (assumed to be the more profitable firms) receive more weight than profits of smaller firms in the calculation of the industry average level of profits. (Waldman and Jensen, 1998)

telecommunications prices. The authors found that in 1987 intrastate long-distance prices were lower under regulatory regimes that allowed AT&T more pricing flexibility. Using data including observations on 40 states over the period 1986-1988, Kaestner and Kahn (1990) derived a similar conclusion. Their results indicated that pricing flexibility and deregulation had a significant negative effect on the intrastate toll price of AT&T daytime service. Tardiff and Taylor (1993) conducted a similar study using a longer time period (nine years covering the period from 1980 to 1991 with the exception of 1984-1986). The study showed mixed results. IntraLATA toll prices under some form of incentive regulation tended to be lower by 4 to 8 percent, but there was no significant effect of incentive regulation on local prices.

Blank, Kaserman, and Mayo (1995) also examined the effects of incentive regulation on intraLATA toll prices using data covering the 48 contiguous states in 1991. In contrast to Tardiff and Taylor (1993), they found that incentive regulation tended to increase intraLATA toll rates. Flannery (1996) investigated the effects of incentive regulation on intrastate telephone prices using state-level price data for 1985 and 1988-1993. She, however, found that local rates under incentive regulation were statistically lower than under rate-of-return regulation. Ai and Sappington (1998) conducted a comprehensive study on the effects of different forms of incentive regulation on eight dimensions of RBOCs' performance including local service rates between 1990 and 1996. The authors observed that price cap regulation is associated with lower basic service rates for residential customers while there was no significant relationship between price cap and basic service rates for business customers.

Although looking directly at price rather than profitability is theoretically appealing and reduces the flaws in accounting data, it cannot eliminate the endogeneity problems. One reduced form equation that is not theoretically sound cannot yield consistent estimates of structural parameters when some right-hand-side variables are endogenous.[52] Moreover, as discussed in the theoretical section, demand conditions are essential in determining allocative efficiency of price cap regulation. To estimate long-run equilibrium, demand equations and supply relations should be simultaneously estimated, which is not possible by employing only one reduced form equation.

As a consequence, the empirical studies so far conducted cannot explain why prices increase or decrease even when they could luckily detect price changes (or differences) under alternative price regulatory regimes. Price changes under incentive regulation could be due to changes in costs, quality, the elasticity of demand, or the exercise of market power, which are all endogenous variables. By employing one reduced-form model, a researcher cannot successfully find the real reasons for price changes.

This problem occurs because price itself does not say much about the regulated firms' pricing behavior. Although looking at prices is a more attractive way to examine market power than looking at profitability, prices should be examined with marginal cost if we want to investigate the effects of incentive regulation on regulated firms' pricing behavior. However, since marginal cost is not observable, the price-cost margin cannot be measured but needs to be estimated by employing new estimation techniques.

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[52] Schmalensee (1989).

CHAPTER 2

METHOD

2.1 Structural Model of Market Power

In the economic literature, market power is defined as firms' ability to set price above marginal cost.[53] To assess the degree of market power in the local telephone industry, this study employs a structural model of competition, allowing for a simultaneous determination of demand, cost and conduct, which has been developed in the "new empirical industrial organization (NEIO)" studies. Oligopoly theory and comparative statics are used to specify the equations of the model to be estimated and identify the degree of market power.

Bresnahan (1989) provides a good survey of this approach. This new approach has been the focus of empirical work in the contemporary industrial organization (IO) field. The new approach has taken a markedly different view of what can be observed and how economic quantities are to be measured than the previously dominant empirical method in the field, the structure-conduct-performance (SCP) paradigm, did. The main ideas underlying the NEIO studies are:

- Price-cost margins are not taken to be observable since economic marginal cost (MC) cannot be directly or straightforwardly observed. A researcher can infer MC from firm behavior or can use differences between closely related markets to identify the effects of changes in marginal cost.

[53] As Tirole (1995) observes, an economist's definition differs from a policy-maker's definition. Policy makers generally mean market power as pricing above average cost.

- NEIO studies try to specify and estimate the behavioral equations by which firms set price and quantity.
- Because of institutional details, industries are so individual that researchers cannot learn anything useful from broad cross-section studies of industries.

The model derived from NEIO for this study starts with an inverse demand curve of the form:

$$P_{it} = D\,(Q_{it}, Y_{it}, Z_{it}, \varepsilon_{it}) \tag{1}$$

where *i* is the market subscript, *t* is the time period, Q is the quantity demanded, Y is a vector of exogenous factors that can shift demand, Z is a vector of endogenous quality factors that can shift the demand function, and ε represents random fluctuations in demand. In a similar manner, a total cost function takes the form:

$$C_{it} = C\,(Q_{it}, W_{it}, Z_{it}, \mu_{it}) \tag{2}$$

where W is a vector of factor prices and Z is a vector of endogenous quality factors that can shift the cost function and μ represents random shocks in cost.

The first-order condition for a profit-maximizing monopoly is given by:

$$\frac{\partial P_{it}(\cdot)}{\partial Q_{it}} Q_{it} + P_{it}(\cdot) - \frac{\partial C_{it}(\cdot)}{\partial Q_{it}} = 0 \qquad (3)^{54}$$

This equation can be rewritten as more general supply relations describing price- or quantity-setting conduct outside the perfectly competitive model:

$$P_{it} = C_1\,(Q_{it}, W_{it}, Z_{it}, \mu_{it}) - D_1\,(Q_{it}, Y_{it}, \varepsilon_{it}) \bullet Q_{it} \bullet \theta_{it} \tag{4}$$

[54] Since revenue = P(•)Q, marginal revenue = $\partial P(\bullet)/\partial Q \times Q + P(\bullet)$. Profit = Revenue − Cost = P(•)Q − C(•). The first order condition for a profit-maximizing monopoly is $\partial(P(\bullet)Q - C(\bullet))/\partial Q$. Since $\partial P(\bullet)/\partial Q = D_1(\bullet)$ and $\partial C(\bullet)/\partial Q = C_1(\bullet)$, $D_1(\bullet)Q + P(\bullet) - C_1(\bullet) = 0$. $\rightarrow P(\bullet) = C_1(\bullet) - D_1(\bullet)Q$.

Where C_l is the marginal cost function and D_l is the partial derivative of demand function with respect to quantity. The parameter θ measures the degree of competition (or market power). If $\theta = 0$, prices equal marginal costs and the industry is perfectly competitive (P = MC). If $\theta = 1$, prices equal marginal revenues and the industry is a monopoly (MR = MC, since $P + D_lQ = MR$). The value θ is expected to be in range between zero to one under price regulation, assuming that firms' monopolistic pricing is constrained by regulators.

To assess the effects of regulation on conduct, I formulate a conduct function:

$$\theta_{it} = f(R_{it}, v_{it}) \qquad (5)$$

where R is a vector of regulatory and market characteristics. The quality of the local telephone service is also an endogenous variable in this model:

$$Z_{it} = f(P_{it}, Q_{it}, V_{it}, u_{it}) \qquad (6)$$

where V is a vector of exogenous variables that influence the choice of quality.

The empirical implementation of the model will estimate the demand (1), supply relations (4), and quality (6) equations simultaneously subject to the conduct function (5).

2.2 Data and Measurement

The variables used in this study can be classified into five categories: (1) service prices and outputs, (2) demand variables, (3) cost variables, (4) quality variables, and (5) regulation and market characteristics. To estimate the effect of the regulatory environment on LECs' market power, state-level data for local exchange carriers are vital. For example, service prices at the level of holding company with multi-state operations would not be of much use in isolating the impact of the state-specific regulatory environment. The state LEC-level data are collected from diverse sources including the FCC's ARMIS (Automated Reporting Management Information System) database on the FCC's web site on the Internet. There are about 1,300 companies that provide local telephone services in the United States. About 50 LECs that earn over $100 million in annual revenue are required to file information with the FCC. They account for more than 90 percent of the nation's local telephone service. These 50 LECs have filed information about 120 state operating companies with the FCC.

State-level economic information is collected mainly from the BEA's (Bureau of Economic Analysis) Regional Economic Information System on the BEA's web site. Regulatory information is collected from the NRRI's (*National Regulatory Research Institute*) report. Local competition data are collected from the FCC's *Local Competition* reports, 95-98.[55] The study period will begin in 1991 and end in 1997.

Service prices and output: PRICE is the monthly average rate charged by a LEC for residential flat-rate local service. The PRICE data is collected from the FCC's *Reference Book* prepared by the Industry Analysis Division (IAE) of the FCC. The IAE conducts an annual survey of telephone rates for local service in 95 urban areas of the United States.[56] The state-level rate data are calculated from the city-level rate data in *Reference Book*. The PRICE data are deflated using the Consumer Price Index (CPI) of all goods with a base year of 1991.

As an output variable, LINES refers to the number of residence non-life access lines. The data is collected from the ARMIS 43-01 report (Row 2110). The number of access lines is preferred to the number of subscribers since there is an increasing

[55] The *Local Competition* reports have historical data

[56] The cities surveyed are those that were included in the Bureau of Labor Statistics' (BLS) Consumer Price Index (CPI) in 1988.

tendency for subscribers to get a secondary line for Internet access. Annual average values of residence non-life access lines (LINES) are derived from the average of the current year (*t* year) lines and the previous year (*t-1* year) lines.

Demand variables: Besides price and service quality variables, three more variables that can shift the demand are employed: population, income and connection fees. POP refers to market population measured by the number of people in the territory served by a LEC in a state. INCOME reflects average personal income per capita in constant (1991) dollars. CONNFEE reflects connection fees charged by a LEC for residential local service.

Cost variables: Factor inputs to run a local telephone company include capital equipment and labor. WAGES represents a measure of labor cost, referring to average annual wages per employee in a state served by a LEC for the telecommunications industry. POPDEN is used as a proxy for measuring capital cost. The POPDEN data are calculated from population (POP) divided by the square miles of land area of the state served by a LEC. The data on land area are derived from U.S. Department of Commerce's *Statistical Abstract* (1990 - 1998). Higher population density is likely to reduce input costs since the cost of providing each household with local service is expected to increase with the distance from the local exchange office. The cost variables, WAGES and POPDEN, have been used for modeling the cost functions of telecommunication firms.[57] METERS, as another proxy for measuring capital cost, refers to total sheath kilometers per line, measuring the total length in kilometers of all loop and interoffice cables divided by the residence non-life lines (LINES). METERS is derived

[57] Mathos and Rogers (1989) and Evans and Heckman (1983).

from the FCC's ARMIS 43-07 report (Row320). BUSRATIO represents the ratio of business lines (single and multi) to the total lines. The BUSRATIO variable is used to control the degree of potential subsidization from the business rates to the residential rates.

Quality variables: To assess service quality, three different variables are adopted. COMMIT refers to the percentage of a firm's commitments met during the period. COMMIT is calculated by dividing the number of installation orders completed by the commitment date by the total number of installation orders. TROUBPL is defined as the number of customer trouble reports divided by residential lines. The total for customer trouble reports is derived from the sum of initial and repeat trouble reports less the number of no-trouble-found when investigating a trouble report. The trouble reports measure the number of circuit-specific trouble reports referred to the ILEC by customers and/or end users during the period. COMPPL measures the number of complaints about service quality that customers file with their state or federal regulatory authorities divided by the number of residential lines. The number of complaints consists of federal and state complaints filed by residential users. The term complaints does not include complaints relating to billing, operator service providers, 900 or 976 services.[58] The service quality data are derived from the FCC's ARMIS 43-05 report.

Regulation and market characteristics: Incentive regulation is categorized in three forms: price caps (PCAP), earnings sharing (ESHARE), and rate freeze

[58] Factor analysis resulted in no factor, implying each service quality variable has uniqueness.

(RFREEZE). PCAP refers to indexed price cap regulation.[59] ESHARE represents a form of incentive regulation under which an LEC should share realized earnings in excess of authorized levels with its customers. RFREEZE refers to agreements between regulators and regulated firms not to raise (or lower) the price of a regulated service for a specified period of time.

Before the Telecommunications Act of 1996, which eliminated all legal restrictions on local competition, many states allowed CAPs (Competitive Access Providers) to provide local telephone services. ENTRYREG captures whether local competition was allowed in a state served by a LEC. ENTRY refers to whether actual entry occurred. All the regulatory and market variables take binary forms.

2.3 Model Specification and Estimation

2.3.1 Model Specification

To estimate the parameters, the demand function is assumed to take the form:[60]

$$P = e^{\alpha 0}Q^{\alpha 1}Y^{\alpha 2}Z^{\alpha 3}e^{\varepsilon} \quad (1a)$$

The derivative of demand function with respect to Q is:

$$\partial P(\bullet)/\partial Q = D_1 = \alpha_1 P/Q \quad (1b)$$

Using (1b), equation (4) can be simplified to:

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[59] Although the basic idea of price caps is simple, their implementation is complex. In practice, price caps are implemented in four steps: (1) The regulator directly sets a ceiling for prices to be changed by the regulated firm. (2) The price ceilings are defined for baskets of services offered by the regulated firm. Different ceilings may apply to each basket. (3) The price indices for these baskets are adjusted periodically by a preannounced adjustment factor that is exogenous to the regulated firm. (4) In intervals of several years, the adjustment factors, baskets, and weighting schemes for the indices are reviewed and possibly changed (Acton and Vogelsang, 1989).

[60] The constant elasticity of demand is the most used assumption in the demand modeling. The adequacy of the specification is also tested by regression diagnostics including residual-versus-fitted plots test. After taking the natural log of both sides, equation (1a) becomes:

$\log P_{it} = \alpha_0 - + \alpha_1 \log Q_{it} + \alpha_2 \log Y_{it} + \alpha_3 \log Z_{it} + \varepsilon_{it}. \rightarrow \log Q_{it} = \alpha_0/\alpha_1 + 1/\alpha_1 \log P_{it} + \alpha_2/\alpha_1 \log Y_{it} + \alpha_3/\alpha_1 \log Z_{it} + 1/\alpha_1 \varepsilon_{it}.$

In the above equation, the coefficient of PRICE, $1/\alpha_1$, is the price elasticity of demand. In the double-log equation, the magnitude of coefficient of the log variables implies that a percent change in each predictor variable led to the percentage change in the dependent variable, holding the other variables in the equation constant.

$$P_{it} = C_1(\cdot) - \theta\, \alpha_1 P + \tau_{it}, \tag{4a}$$

or

$$P_{it} = (C_1(\cdot) + \tau_{it})/(1 + \theta\, \alpha_1) \tag{4b}$$

The marginal cost function is also assumed to take the form:

$$C_1 = e^{\beta 0} Q^{\beta} 1 W^{\beta 2} Z^{\beta 3} e^{\mu} \tag{2a}$$

After using (2a) and taking the natural log of both sides, equation (4b) becomes

$$\log P_{it} = \beta_0 - \log (1 + \theta\, \alpha_1) + \beta_1 \log Q_{it} + \beta_2 \log W_{it} + \beta_3 \log Z_{it} + \mu_{it}. \tag{4c}$$

Since $\ln (1 + \theta\, \alpha_1)$ is approximately equal to $\theta\, \alpha_1$ for the relatively small values of $\theta\, \alpha_1$, the equation (4c) can be simplified to the following equation:

$$\log P_{it} = \beta_0 - \theta\, \alpha_1 + \beta_1 \log Q_{it} + \beta_2 \log W_{it} + \beta_3 \log Z_{it} + \mu_{it}. \tag{4d}$$

Finally, the quality function takes the form:

$$\log Z_{it} = \gamma_0 + \gamma_1 \log P_{it} + \gamma_2 \log Q_{it} + \gamma_3 \log V_{it} + u_{it} \tag{6a}$$

The empirical implementation of the above model involves the simultaneous estimation of equation (1a), (4d) and (6a) subject to (5) from the Section 3.1 by three-stage least squares. Therefore, four equations make up the full model: demand function (1a), supply relations (4d), pricing conduct function (5), and quality function (6a) including two quality variables. These five equations contain the following variables:

$$\log LINES_{it} = \gamma_0 + \gamma_1 \log PRICE_{it} + \gamma_2 \log POP_{it} + \gamma_3 \log INCOME_{it} + \gamma_4 \log CONNFEE_{it} + \gamma_5 \log TROUBPL_{it} + \gamma_6 \log COMPPL_{it} + \nu_{it} \tag{7}$$

$$\log PRICE_{it} = \beta_0 - \theta_{it}\, 1/\gamma_1 + \beta_1\, LINES_{it} + \beta_2\, WAGE_{it} + \beta_3\, POPDEN_{it} + \beta_4\, METERS_{it} + \beta_5\, BUSRATIO_{it} + \beta_6\, TROUBPL_{it} + \beta_7\, COMPPL_{it} + \tau_{it} \tag{8}$$

$$\theta_{it} = \delta_0 + \delta_1\, PCAP_{it} + \delta_2\, ESHARE_{it} + \delta_3\, RFREEZE_{it} + \delta_4\, PCES_{it} + \delta_5\, ESRF_{it} + \delta_6\, PCRF_{it} + \delta_7\, ENTRYREG_{it} + \delta_8\, ENTRY_{it} \tag{9}$$

$$\log TROUBPL_{it} = \phi_0 + \phi_1 \log LINES_{it} + \phi_2 \log PRICE_{it} + \phi_3 \log METERS_{it} + \phi_4 \log WAGE_{it} + \phi_5 \log POPDEN_{it} + \phi_6\, PCAP_{it} + \phi_7\, ESHARE_{it} + \phi_8\, RFREEZE_{it} + \phi_9\, PCES_{it} + \phi_{10}\, ESRF_{it} + \phi_{11}\, PCRF_{it} + \phi_{12}\, ENTRYREG_{it} + \phi_{13}\, ENTRY_{it} + u_{it} \tag{10}$$

$$\log COMPPL_{it} = \phi_0 + \phi_1 \log LINES_{it} + \phi_2 \log PRICE_{it} + \phi_3 \log METERS_{it} + \phi_4 \log WAGE_{it} + \phi_5 \log POPDEN_{it} + \phi_6\, PCAP_{it} + \phi_7\, ESHARE_{it} + \phi_8\, RFREEZE_{it} + \phi_9\, PCES_{it} + \phi_{10}\, ESRF_{it} + \phi_{11}\, PCRF_{it} + \phi_{12}\, ENTRYREG_{it} + \phi_{13}\, ENTRY_{it} + u_{it} \tag{11}$$

Appendix A provides definitions of the variables used in the equations system, the units of the variables and their expected signs.

2.3.2 Model Estimation

To estimate the above equations system simultaneously, the three-stage least squares (3SLS) method is employed. The three-stage least squares method estimates systems of structural equations where some equations contain endogenous variables among the exploratory variables. In the equations system used in the study, variables such as PRICE, LINES, TROUBPL and COMPPL are considered endogenous and used as the exploratory variables as well as the dependent variables. In this case, the disturbances are correlated with the endogenous variables, thus violating the assumptions of ordinary least squares (OLS). Furthermore, the disturbances across the equations in the equations system tend to be correlated. The 3SLS method uses an instrumental approach to produce consistent estimates and generalized least squares (GLS) to account for the correlation structure in the disturbances across the equations.

The three-stage least squares method can be described as follows:

- Stage 1: Estimate reduced-form coefficients by OLS and compute the predicted values ($\hat{Y}$) for each equation for instrumental variables.
- Stage 2: Replace each of the right-hand-side (RHS) endogenous variables with their reduced form predictions and obtain a consistent estimate for the covariance matrix of the equation disturbances.[61]
- Stage 3: Perform a generalized least squares (GLS) estimation using the covariance matrix estimated in the second stage. This third stage is expected to lead to more efficient estimation because it uses the system information that the error terms from the different equations in the system should be correlated.

Another estimation problem rises from the panel (time-series cross-sectional) data set which has heterogeneity across units. The basic framework for modeling differences in behavior across units in the panel data set is the following regression form:

$$\mathbf{y}_{it} = \alpha_i + \beta \mathbf{x}_{it} + \varepsilon_{it}, \qquad (12)$$

where $\mathbf{y}$ reflects the dependent variables of a local exchange company i ($i = 1, 2, \ldots, N$) at time period t ($t = 1, 2, \ldots, T$), α_i individual effects, $\mathbf{x}$ a matrix of explanatory variables, i.e., $[x_1, x_2, \ldots. x_k]$ and ε a well-behaved error term.

If we could assume that the α_i's are the same across all units (i.e., $\alpha_1 = \alpha_2 = \ldots = \alpha_n$), ordinary least squares (OLS) would provide consistent and efficient estimates of α and β by

$$\mathbf{y}_{it} = \alpha + \beta \mathbf{x}_{it} + \varepsilon_{it}. \qquad (13)$$

[61] This method should purge the equation of simultaneity (the predictions should be correlated with the variables themselves but uncorrelated with the structural error terms in the equation where they appear.

However, a panel data set tends to have cross-sectional variation, or heterogeneity (i.e., the α_i's are not the same across all units). In this case, equation (13) is inappropriate. There are two basic frameworks used to deal with this problem: the fixed and the random effects approach.

The fixed effects approach takes α_i to be a group-specific constant term in the regression model, thus, in (12), each α_i is an unknown parameter to be estimated. Equation (12) can be written as

$$\mathbf{y} = \mathbf{D}\alpha + \mathbf{X}\beta + \varepsilon. \tag{14}$$

where **D** reflects a matrix of dummy variables, i.e., $[d_1, d_2, \ldots.. d_n]$.

Equation (14) is usually referred to as the least squares dummy variable (LSDV) model. If n is small enough, the model can be estimated by OLS with K regressors in X and n columns in D, as a multiple regression with n + k parameters. If n is large enough, the coefficient b can be estimated by the within-groups estimator:

$$y_{it} - \bar{y}_i = \beta(x_{it} - \bar{x}_i) + (\varepsilon_{it} - \bar{\varepsilon}_i) \tag{15}$$

If there are any regressors that do not vary within the groups, the LSDV estimator can not be computed because the regressors are perfectly collinear with the fixed effect dummy variables, which prevent computation of the LSDV estimator. With an F-test, we can test the significance of the group effects, or the null-hypothesis that the group effects (α_i) are all equal ($\alpha_1 = \alpha_2 = \ldots = \alpha_n$).

The random effects approach specifies that α_i is a group-specific disturbance, similar to ε_{it}. Thus, equation (12) can be reformulated as

$$\mathbf{y}_{it} = \alpha + \beta\mathbf{x}_{it} + u_i + \varepsilon_{it}, \tag{16}$$

where u_i is the random disturbance characterizing the ith observation and is constant through time. This model violates the assumptions of OLS about the disturbances (E [ε] = 0 and E [$\varepsilon\varepsilon'|X$] = $\sigma^2 I$). Thus, the generalized linear regression (GLS) model needs to be used to get efficient estimation of parameters.[62] Since the GLS estimator is a matrix weighted average of the within- and between-units estimators, the random effects estimator turns out to be equivalent to the estimation of:

$$(y_{it} - \theta \bar{y}_i) = (1 - \theta)\alpha + \beta(x_{it} - \theta \bar{x}_i) + [(1 - \theta)u_i + (\varepsilon_{it} - \theta \bar{\varepsilon}_i)] \tag{17}$$

where θ is a function of σ^2_u and σ^2_ε ($\theta = 1 - (\sigma_\varepsilon / \sqrt{T\sigma^2_u + \sigma^2_\varepsilon})$). If $\sigma^2_u = 0$, meaning u_i is always 0, $\theta = 0$ and OLS could be applied. Alternatively, if $\sigma^2_\varepsilon = 0$, meaning ε_{it} is 0 (i.e., all variation across units would be due to the different u_i), $\theta = 1$ and equation (17) would be equivalent to the fixed-effects model (equation (15)).

The question of whether an effect is fixed or random is extremely delicate. The major criteria are as follows:

- The number of statistical units. When N is large and T is small, the number of parameters to be estimated in a fixed effects model is large relative to the total number of available data points, hence the resulting estimates of all the parameters are unreliable. In this case, the random effects model is preferable.

- The nature of the sample. When the sample is closed and exhaustive (as in the case of geographical regions or industrial sectors), fixed effects are natural candidates.

[62] Compared with GLS, OLS places too much weight on the between-units variation. OLS includes all variation in the variation of X, rather than apportioning some of it to random variation across groups attributable to the variation u_i across units.

•The underlying causes. If individual effects are related to a large number of non-observable random causes, then the random interpretation is clearly indicated.

•The type of inference. If the investigator wants to make inference with respect to population characteristics, he should adopt a random specification. If he wants to make inference only with respect to effects in the sample, he should opt for a fixed effects model.[63]

Given the fact that T of the sample is relatively large (7 years) and that the sample is closed and fairly exhaustive, this study will adopt the fixed-effects model for estimation.

[63] Balestra (1996).

CHAPTER 3

RESULTS AND INTERPRETATION

3.1 Descriptive Analysis

Table 2 and 3 provide summary statistics of price and cost variables.

Table 2. Descriptive Statistics (Price and Cost)

Variable	Obs	Mean	Std. Dev.	Min	Max
PRICE	266	18.62	3.41	11.06	28.63
CONNFEE	266	36.95	10.98	8.40	69.41
LINES	266	1,865,438	1,656,715	157,187	7,614,328
POP	266	6,375,367	6,010,592	528,964	32,300,000
INCOME	266	19,623	3,195	13,377	30,196
WAGE	266	23,531	3,706	17,890	38,564
POPDEN	266	426.72	1,471.67	5.55	9,730.57
BUSRATIO	266	13.09	5.42	3.98	40.77
METERS	266	18.98	8.01	7.92	51.65
CPI	266	2.70	0.48	1.70	3.30

Note: All monetary variables are deflated using the consumer Price Index (CPI) of all goods with a base year of 1991.

The monthly rate for unlimited local residential service monotonously declined from 20.30 in 1991 to 17.24 in 1997. This was a decrease of 15.04 percent with an annual average of 2.67 percent. The connection fee also declined from 41.71 in 1991 to 33.68 in 1997. This was a decrease of 19.24 percent with an annual average of 3.49 percent. On

Table 3. Descriptive Statistics by Year (Price and Cost)

Variable	Statistics	1991	1992	1993	1994	1995	1996	1997
PRICE	Mean	20.30	19.32	19.24	18.60	18.13	17.54	17.24
	S.D.	3.72	3.70	3.39	3.39	3.05	2.88	2.82
CONNFEE	Mean	41.71	39.22	38.02	36.69	35.03	34.31	33.68
	S.D.	12.34	12.09	11.29	10.47	10.19	9.37	9.21
LINES	Mean	1,752,927	1,778,489	1,810,336	1,849,520	1,894,338	1,950,853	2,021,601
	S.D.	1,635,765	1,630,623	1,630,871	1,648,479	1,672,923	1,721,686	1,767,971
POP	Mean	6,176,127	6,247,714	6,316,369	6,379,626	6,441,354	6,502,187	6,564,194
	S.D.	5,907,104	5,982,328	6,037,565	6,078,871	6,119,885	6,174,601	6,242,165
INCOME	Mean	18,652	19,032	19,224	19,528	19,923	20,210	20,791
	S.D.	3,094	3,125	3,089	3,093	3,140	3,222	3,328
WAGE	Mean	22,976	23,477	23,336	23,353	23,557	23,681	24,335
	S.D.	3,457	3,654	3,655	3,683	3,754	3,861	4,008
POPDEN	Mean	436	434	432	428	423	419	415
	S.D.	1,568	1,544	1,524	1,495	1,459	1,425	1,398
BUSRATIO	Mean	13.05	12.87	12.71	13.02	13.33	13.19	13.46
	S.D.	4.00	4.00	4.05	4.83	5.87	7.06	7.37
METERS	Mean	19.25	19.28	19.31	18.86	18.92	18.95	18.28
	S.D.	8.66	8.71	8.68	7.53	7.57	7.53	7.88
CPI	Mean	3.10	2.90	2.70	2.70	2.50	3.30	1.70
	S.D.	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Note: All monetary variables are deflated using the consumer Price Index (CPI) of all goods with a base year of 1991 the other hand, the number of residential non-life lines increased by 2.41 percent annually during the study period. Population, income and wage increased at annual rates of 1.02, 1.83, and 0.97 percent, respectively.

Summary statistics for regulatory and market variables are presented in Table 4 and Table 5. On average, three major price regulatory regimes of ROR, price caps, and earnings sharing are almost equally distributed in the sample. Table 5 shows that the percentage of states using ROR regulation declined from 50 percent in 1991 to 18 percent in 1997. During the same period, the percentage of states using price cap regulation rapidly increased from 5 percent in 1991 to 68 percent in 1997. The percentage of states using earnings sharing increased from 39 percent in 1991 to 50 percent in 1993 but rapidly decreased to 13 percent in 1997.

Table 4. Descriptive Statistics (Regulation and Market Entry)

Variable	Observations	% Occurrence
ROR	266	0.32
PCAP	266	0.33
ESHARE	266	0.35
RFREEZE	266	0.13
PCES	266	0.09
ESRF	266	0.07
PCRF	266	0.02
ENTRYREG	266	0.47
ENTRY	266	0.33

Table 6 and 7 show summary statistics of service quality variables.

Table 5. Descriptive Statistics by Year (Regulation and Market Entry)

Variable	Statistics	1991	1992	1993	1994	1995	1996	1997
ROR	Mean	0.50	0.42	0.37	0.34	0.24	0.21	0.18
	S.D.	0.51	0.50	0.49	0.48	0.43	0.41	0.39
PCAP	Mean	0.05	0.13	0.13	0.21	0.50	0.63	0.68
	S.D.	0.23	0.34	0.34	0.41	0.51	0.49	0.47
ESHARE	Mean	0.39	0.42	0.50	0.42	0.39	0.16	0.13
	S.D.	0.50	0.50	0.51	0.50	0.50	0.37	0.34
RFREEZE	Mean	0.13	0.13	0.13	0.16	0.11	0.13	0.11
	S.D.	0.34	0.34	0.34	0.37	0.31	0.34	0.31
PCES	Mean	0.05	0.08	0.08	0.08	0.18	0.08	0.05
	S.D.	0.23	0.27	0.27	0.27	0.39	0.27	0.23
ESRF	Mean	0.08	0.08	0.11	0.11	0.05	0.05	0.03
	S.D.	0.27	0.27	0.31	0.31	0.23	0.23	0.16
PCRF	Mean	0.00	0.00	0.00	0.00	0.03	0.05	0.05
	S.D.	0.00	0.00	0.00	0.00	0.16	0.23	0.23
ENTRYREG	Mean	0.08	0.11	0.13	0.24	0.74	1.00	1.00
	S.D.	0.27	0.31	0.34	0.43	0.45	0.00	0.00
ENTRY	Mean	0.00	0.00	0.00	0.21	0.37	0.79	0.97
	S.D.	0.00	0.00	0.00	0.41	0.49	0.41	0.16

Table 6. Descriptive Statistics (Service Quality)

Variable	Obs	Mean	Std. Dev.	Min	Max
COMMIT	266	98.54	2.69	73.95	100.00
TROUBIN	266	563,631	603,647	25,253	3,487,765
TROUBRE	266	100,542	110,531	3,517	717,141
TROUBNO	266	182,337	194,554	4,074	969,708
TROUBTOT	266	481,836	529,583	21,567	3,194,381
TROUBPL	266	247.93	89.63	35.56	1,231.38
COMPFED	266	15.13	129.54	0.00	1,505.00
COMPST	266	397.37	1,013.53	2.00	9,127.00
COMPTOT	266	412.50	1,118.30	2.00	10,530.00
COMPPL	266	234.96	341.56	2.13	2,012.19

Table 7. Descriptive Statistics by Year (Service Quality)

Variable	Statistics	1991	1992	1993	1994	1995	1996	1997
COMMIT	Mean	98.3	99.0	98.9	98.7	97.4	98.8	98.7
	S.D.	3.9	0.7	0.8	0.9	5.6	0.7	0.7
TROUBIN	Mean	621,695	586,356	562,978	529,432	564,415	541,720	538,820
	S.D.	660,602	668,395	649,388	604,331	635,901	510,701	517,926
TROUBRE	Mean	82,987	76,358	95,439	111,127	109,260	120,593	108,028
	S.D.	123,898	97,380	105,355	126,165	115,128	111,374	91,567
TROUBNO	Mean	150,363	165,928	170,173	181,909	195,321	212,514	200,149
	S.D.	190,050	191,285	191,411	198,420	203,531	201,814	193,162
TROUBTOT	Mean	554,319	496,786	488,245	458,651	478,354	449,799	446,699
	S.D.	602,115	585,756	574,121	534,652	557,192	423,806	434,672
TROUBPL	Mean	314.88	257.92	254.83	230.35	231.26	226.92	219.33
	S.D.	169.13	67.37	67.77	73.36	64.76	37.44	46.67
COMPFED	Mean	5.13	2.97	10.39	9.05	41.00	37.05	0.32
	S.D.	21.97	16.40	60.46	52.35	243.98	227.58	0.77
COMPST	Mean	257.16	259.68	307.92	400.39	566.39	599.87	390.18
	S.D.	683.55	733.39	930.02	1,160.81	1,235.43	1,500.44	492.66
COMPTOT	Mean	262.29	262.66	318.32	409.45	607.39	636.92	390.50
	S.D.	702.32	749.52	989.07	1,210.88	1,455.38	1,717.51	492.84
COMPPL	Mean	160.39	144.88	164.67	241.63	371.32	327.50	234.32
	S.D.	173.23	156.42	217.43	348.44	527.19	460.15	275.07

The mean value of the percentage of commitments met was very high (98.54) and consistent during the period as indicated by the low variances. Due to the low variances, the COMMIT variable was deleted from the equations. The number of trouble reports per residential line decreased from 314.9 in 1991 to 219.3 in 1997. This was a decline of 30.35 percent at an annual rate of 5.62 percent. The number of complaints per residential line, however, increased at an annual rate of 10.69 percent, from 160.4 in 1991 to 371.3 in 1995. Complaints then decreased to 234.3 in 1997. The data for the service quality variables, in particular trouble reports, seems to have lots of noise, which makes the credibility of the data low.

3.2 Parametric Analysis

Table 8 presents three-stage least squares estimates of the regression equation (8) for supply relations. The results are basically as expected. Many of the variables influencing marginal costs are statistically significant at least at the .05 level. The coefficient of LINES, WAGE, METERS, and COMPPL are statistically significant at the .01, .05, .01 and .01 level, respectively. The coefficient of LINES (-0.150) shows that, holding other cost-related variables included in the equation constant, prices, on average, decreased by 1.5 percent as residential lines increased by 10 percent. This result implies that marginal cost decreases as output increases, i.e., there are economies of scale (or increasing returns to scale) in residential local exchange service.

As expected, WAGE has a positive effect on marginal costs. The coefficient estimate (0.792) suggests that for a 10 percent increase in the real average annual wages per employee, prices increase by 7.9 percent, holding other variables constant. METERS also has a positive relationship with marginal costs. Prices, on average, increased by 3.9

Table 8. Three-Stage Least Squares Estimates: Supply Relations (Price)

Variables	Coefficient.	Std. Err.	z	P>|z|
LINES	-0.150 ***	0.050	-3.018	0.003
WAGE	0.792 **	0.324	2.444	0.015
POPDEN	-0.039	0.049	-0.795	0.427
METERS	0.391 ***	0.070	5.616	0.000
BUSRATIO	-0.035	0.082	-0.426	0.670
TROUBPL	0.196	0.149	1.314	0.189
COMPPL	-0.424 ***	0.140	-3.034	0.002
PCAP	0.187 *	0.099	1.898	0.058
ESHARE	0.180 **	0.078	2.308	0.021
RFREEZE	-0.013	0.102	-0.125	0.900
PCES	-0.517 ***	0.190	-2.724	0.006
ESRF	0.033	0.116	0.286	0.775
PCRF	0.244	0.150	1.627	0.104
ENTRYREG	0.027	0.054	0.499	0.618
ENTRY	0.056	0.049	1.144	0.253

Note: *, **, *** indicate values that are systematically different from zero at .10, .05 and .01 significance levels, respectively.

percent for each 10 percent increase of total sheath kilometers per person, holding other variables constant. The result is also as expected because marginal costs would increase as the number of sheath kilometers per person increases.

The coefficient of COMPPL is – 0.424, implying that for a 10 percent increase in the number of complaints per line the price decreased by 4.2 percent. The coefficients of POPDEN, BUSRATIO, and TROUBPL are not statistically significant at the .05 level.

The main results of interest are the coefficients on regulatory and market variables. The coefficients of PCAP, ESHARE and PCES are statistically significant at the .10, .05 and .01 level, respectively. The coefficients of PCAP and ESHARE show that, controlling for costs and service quality, prices were approximately 18 percent higher under price caps and earnings sharing.

On the other hand, the coefficient of PCES suggests that prices were 51.7 percent lower under a combination of price caps and earnings sharing. The coefficients of RFREEZE, ESRF, PCRF, ENTRYREG, and ENTRY do not statistically differ from zero at the .10 significance level. The effects of combined regulation such as PCES, ESRF and PCRF should be cautiously interpreted. Since the percentage of occurrence is so small, idiosyncratic variance affected by uncontrolled factors in a state could yield a biased estimation. For example, rates in California showed an extraordinary pattern. The rates were around 13 dollars a month from 1991 to 1994 under PCES and increased to around 17 dollars from 1995 to 1997. The Public Utilities Commission of California replaced price cap regulation with rate freeze in 1996. The rate might have increased due to uncontrolled factors instead of changing price regulation.

The coefficients of regulatory/market variables are equal to the change in the product of regulatory/market effects (δ_i) in the equation (10) and the elasticity of demand ($1/\gamma_1$). To isolate the regulatory/market effects from the effects of changes in the demand elasticity, we need to estimate the elasticity of demand and the change in the elasticity of demand during the study period. The degree of the elasticity of demand is also critical in interpreting the price changes under the alternative price regulatory regimes.

Table 9 presents the three-stage least squares estimates of the regression equation (7), the demand equation.

The estimated price elasticity is 0.17 (the coefficient of PRICE $\times$ (-1)), which is fairly close to the price elasticity (0.25) that Neu (1993) used in his simulation study. The coefficients of slop dummy variables (the products of PRICE and regulatory/market variables) estimate changes in price elasticity.[64] The results show that there was no significant change in price elasticity under the alternative regulatory and market conditions. The results imply that price increases or decreases estimated in the supply relations equation (8) can be attributed solely to increased or decreased exercises of market power that were made possible by the change in price regulation.

As described above, the value of changes (δ_i) in the exercise of market power under alternative regulatory/market conditions can be estimated by using the estimated parameters of regulatory/market variables in the supply relations equation (8) and the estimated price elasticity from the demand equation (7). For example, the value of

[64] For example, the price elasticity under price cap regulation is the coefficient of PRICE plus the coefficient of the PCAP slop dummy variable (the product of PRICE and PCAP) since, under price cap regulation, PCAP = 1.

Table 9. Three-Stage Least Squares Estimates: Demand Equation (Lines)

Variables	Coefficient	Std. Err.	z	P>|z|
PRICE	-0.171 **	0.082	-2.072	0.038
POP	0.956 ***	0.069	13.780	0.000
INCOME	0.604 ***	0.099	6.116	0.000
CONNFEE	0.074 ***	0.023	3.266	0.001
TROUBPL	-0.051 ***	0.018	-2.833	0.005
COMPPL	0.007	0.005	1.323	0.186
Constant	-6.026 ***	0.950	-6.343	0.000
PRICE × PCAP	-0.003	0.002	-1.297	0.195
PRICE × ESHARE	0.000	0.002	-0.030	0.976
PRICE × RFREEZE	-0.009 ***	0.003	-2.848	0.004
PRICE × PCES	-0.003	0.004	-0.707	0.480
PRICE × ESRF	0.002	0.004	0.459	0.646
PRICE × PCEF	-0.003	0.004	-0.628	0.530
PRICE × ENTRYREG	0.000	0.002	0.013	0.990
PRICE × ENTRY	0.006 ***	0.002	3.414	0.001

Note: *, **, *** indicate values that are systematically different from zero at .10, .05 and .01 significance levels, respectively.

changes (δ_l) in the exercise of market power under price cap regulation is the product of the parameter of PCAP (0.187) and the estimated price elasticity (0.17).

The degree of market power (θ) increased by 0.032 (0.187×0.17) under price cap regulation and by 0.031 (0.180×0.17) under earnings sharing regulation. The degree of market power, however, decreased by 0.088 (-0.517×0.17) under the combination of price cap and earnings sharing regulation. The effects of price cap and earnings sharing regulation on the exercise of market power are positive as expected. The comparative analysis of pricing behavior shows that, under incentive regulation such as price cap and earnings sharing regulation, regulated firms tend to set prices higher above marginal cost for basic local service that has low elasticity of demand and low growth.

In the case of normal goods and services that do not have economies of scale, this increased exercise of market power should be avoided since it surely leads to an increase of deadweight loss. However, with the existence of economies of scale, this pricing behavior could reduce allocative inefficiency by converging to Ramsey pricing. Although empirical studies examining whether economies of scale exist in the local telephone industry have shown mixed results, this study finds that scale economies do exist in the residential local telephone industry. From the allocative efficiency point of view, the higher markup for the residential local service with a less elastic demand could be encouraged because the price would converge to second-best Ramsey price. This pricing would result in simultaneously maximizing net economic benefits and minimizing the deadweight loss given the constraint of non-negativity of profits for the regulated firm.

Although the high markup for low-elasticity basic residential service could reduce allocative inefficiency, it would also produce large income transfers from residential consumers to large business users of high-elasticity advanced services. This result would not be desirable for regulators who put more value on fairness.

Most demand-shifting variables are statistically significant at the .01 level with expected signs. The coefficient of population is 0.956, implying that for 10 percent increases in population, the residential non-life line demand increased by 9.56 percent, holding other variables constant. The result correctly reflects the high level of penetration of residential local service. INCOME also had positive effects on demand. The coefficients of CONNFEE and TROUBPL are minimal although they are statistically significant at the .01 level. These results suggest the effects of connection fees and trouble reports on the residential non-life line demand are negligible.

Table 10 and 11 present three-stage least squares estimates of service quality using equation (10) (Trouble Reports) and (11) (Complaints), respectively. The coefficients in the trouble reports equation show there was no significant difference among alternative price regulatory regimes. However, the statistically significant coefficients of the PCAP, ESHARE and PCES variables in the complaints equation implies that price caps and earnings sharing negatively affected service quality. However, the combined regulation of price cap and earnings sharing positively affected quality. The noise in the data on service quality means these results should be accepted cautiously.

Table 10. Three-Stage Least Squares Estimates: Service Quality (Trouble Reports)

Variables	Coefficient	Std. Err.	z	P>|z|
LINES	-2.614 **	1.272	-2.055	0.040
PRICE	1.179 **	0.480	2.453	0.014
METERS	-0.688 ***	0.216	-3.191	0.001
WAGE	0.325	1.402	0.232	0.817
POPDEN	3.160 **	1.446	2.186	0.029
PCAP	0.018	0.051	0.345	0.730
ESHARE	0.025	0.049	0.523	0.601
RFREEZE	-0.004	0.091	-0.046	0.963
PCES	-0.114	0.082	-1.387	0.165
ESRF	-0.046	0.111	-0.414	0.679
PCRF	-0.173	0.126	-1.370	0.171
ENTRYREG	0.053	0.050	1.056	0.291
ENTRY	0.038	0.049	0.768	0.443
Constant	22.845	12.377	1.846	0.065

Note: *, **, *** indicate values that are systematically different from zero at .10, .05 and .01 significance levels, respectively.

Table 11. Three-Stage Least Squares Estimates: Service Quality (Complaints)

Variables	Coefficient	Std. Err.	z	P>|z|
LINES	-1.368	4.411	-0.310	0.756
PRICE	-1.597	1.343	-1.189	0.234
METERS	-0.110	0.779	-0.141	0.888
WAGE	1.419	4.305	0.330	0.742
POPDEN	2.435	5.041	0.483	0.629
PCAP	0.466 **	0.184	2.536	0.011
ESHARE	0.442 **	0.179	2.478	0.013
RFREEZE	0.016	0.338	0.048	0.962
PCES	-1.268 ***	0.288	-4.401	0.000
ESRF	0.041	0.406	0.100	0.920
PCRF	0.486	0.465	1.045	0.296
ENTRYREG	0.081	0.183	0.442	0.658
ENTRY	0.112	0.164	0.684	0.494
Constant	(dropped)			

Note: *, **, *** indicate values that are systematically different from zero at .10, .05 and .01 significance levels, respectively.

CONCLUSIONS

Despite increasing competitiveness in the local telephone industry, price regulation is still in place to protect consumers from monopolistic exploitation. Incentive regulation, in particular price cap regulation, has been replacing traditional rate-of-return regulation not only in the United States but also in other countries. There have been some theoretical studies of how alternative price regulatory regimes affect the pricing behavior of regulated firms. However, few empirical studies have addressed the same question.

This study aims at empirically addressing the question of how incentive regulation affects pricing behavior of regulated firms. More specifically, this study intends to examined whether price changes (or differences) after the adoption of incentive regulation were due to an increased or decreased exercise of market power by controlling for changes in cost, service quality, and the elasticity of demand.

Section 2 briefly reviewed theoretical and empirical studies related to incentive regulation and pricing behavior. Incentive regulation is widely seen as a regulatory reform to cope with market power while encouraging regulated firms to adopt more efficient behavior. Incentive regulation, in particular price cap and earnings sharing regulation, is claimed to have better productive, allocative and administrative efficiency. This study focused on allocative efficiency related to pricing behavior. Incentive regulation is praised as having better allocative efficiency since under incentive regulation second-best Ramsey pricing can be achieved when demand is stable. Previous empirical studies on the effects of incentive regulation on prices failed to provide empirical support for this theoretical claim because of methodological problems.

In section 4, a structural model detecting pricing behavior was developed. The model is derived from the "new empirical industrial organization (NIEO)" paradigm which can estimate and identify the degree of market power (pricing behavior) by using a system of behavioral equations based on oligopoly theory and comparative statics. To handle simultaneous biases in the behavioral equation model, the three-stage least squares estimator was used. To control for unobservable state-specific variables, a fixed effects model was employed using a panel data set.

The results show firms under price cap and earnings sharing tend to set prices higher above marginal cost than under rate-of-return regulation, holding cost, service quality, and price elasticity constant. This increased exercise of market power could lead to a welfare loss if economies of scale did not exist in the industry. The results, however, also show the existence of economies of scale in residential local telephone service. The higher markup for low-elasticity local service could thus result in better allocative efficiency since the FDC-based price under ROR regulation tends to be lower than the second-best Ramsey price.

From the efficiency point of view, incentive regulation such as price caps and earnings sharing can be considered regulatory tools that improve allocative efficiency as the theoretical studies claim. However, despite the advantages of allocative efficiency, the higher markup for the basic residential local service could produce large income transfers from residential consumers to large businesses using high-elasticity advanced services, thereby undermining another regulatory goal, fairness or equity. However, since residential local rates have generally been decreasing, the efficiency gain from incentive regulation seems to outweigh the loss in equity.

Further research is needed to get a more conclusive assessment of the consequences of the increased exercise of market power under incentive regulation. First, the effects of incentive regulation on allocative efficiency can be correctly evaluated by examining price structures. Advanced telecommunications services for business users should be included in the analysis. In addition, the existence of scale economies in the local telephone industry should be verified by employing more precise measures for marginal costs, especially marginal capital costs. More accurate measures of service quality should also be developed and used in the equation system to correctly control for service quality.

APPENDICES

APPENDIX A

APPENDIX A

TABLE 1. DESCRIPTIONS OF VARIABLES

Variable Names	Definitions	Units	Expected Signs
Supply Relations			
LINES	The number of residence non-life access lines	The number of lines	?
WAGE	Average annual wages per employee	U.S. dollars in 1991 value	+
POPDEN	The population (POP) divided by the square miles of land area	Population per square miles	–
METERS	Total sheath kilometers per residential line	Kilometers per line	+
BUSRATIO	The ratio of business lines (single and multi) to total lines	Percentage	–
TROUBPL	The number of total customer trouble reports divided by the residential lines	The number of trouble reports per line	–
COMPPL	The number of complaints divided by the number of residential lines	The number of complaints per line	–
Demand Equation			
PRICE	The monthly average rate for residential flat-rate local service	U.S. dollars in 1991 value	–
POP	The number of people in a state	The number of people	+
INCOME	Average personal income per capita	U.S. dollars in 1991 dollars	+
CONNFEE	Connection fee for residential local service	U.S. dollars in 1991 dollars	–

Table 1 (cont'd)

TROUBPL	The number of total customer trouble reports divided by residential lines	The number of trouble reports per line	–
COMPPL	The number of complaints divided by the number of residential lines	The number of complaints per line	–
Behavioral			
PCAP	Indexed price cap regulation	Binary	+
ESHARE	Earnings sharing	Binary	+
RFREEZE	Rate freeze	Binary	+
PCES	Interaction effect of PCAP and ESHARE	Binary	+
ESRF	Interaction effect of ESHARE and RFREEZE	Binary	+
PCEF	Interaction effect of PCAP and RFREEZE	Binary	+
ENTRYREG	Local competition was allowed	Binary	–
ENTRY	actual entry occurred	binary	–
Quality Equations			
LINES	The number of residence non-life access lines	The number of lines	+
PRICE	The monthly average rate for residential flat-rate local service	U.S. dollars in 1991 value	–
METERS	Total sheath kilometers per residential line	Kilometers per line	+
WAGE	Average annual wages per employee	U.S. dollar in 1991 value	+
POPDEN	The population (POP) divided by the square miles of land area	Population per square miles	–

Table 1 (cont'd)

PCAP	Indexed price cap regulation	Binary	+
ESHARE	Earnings sharing	Binary	+
RFREEZE	Rate freeze	Binary	+
PCES	Interaction effect of PCAP and ESHARE	Binary	+
ESRF	Interaction effect of ESHARE and RFREEZE	Binary	+
PCEF	Interaction effect of PCAP and RFREEZE	Binary	+
ENTRYREG	Local competition was allowed	Binary	?
ENTRY	Actual entry occurred	Binary	?

APPENDIX B

APPENDIX B

TABLE 12. PRICE REGULATION ADOPTED FOR MAJOR LOCAL EXCHANGE CARRIERS

State	Year	Primary Regulation
Alabama	1984–1988	ROR
	1988–1995	ROR with Earnings Sharing
	1995–1998	Price Caps
Alaska	1984–1991	ROR
	1992–1998	ROR
Arizona	1984–1998	ROR
Arkansas	1984–1987	ROR
	1988–1989	Rate Freeze
	1990–1996	ROR
	1997–1998	Price Caps
California	1984–1989	ROR
	1990–1995	Price Cap with Earnings Sharing
	1996–1998	Rate Freeze with Earnings Sharing
Colorado	1984–1992	ROR
	1993–1997	Earnings Sharing
	1998	ROR
Connecticut	1984-1986	ROR
	1987-1989	Earnings Sharing
	1989-1990	ROR
	1991-1993	Earnings Sharing
	1993-1995	ROR
	1996-1998	Price Caps
Delaware	1984-1987	ROR
	1988-1990	ROR with Rate Freeze
	1991-1994	ROR
	1994-1998	Price Caps
D.C.	1984-1992	ROR
	1993-1996	Earnings Sharing with Rate Freeze
	1997-1998	Price Caps

Table 12 (cont'd)

Florida	1984-1987 1988-1994 1995-1997 1998	ROR Earnings Sharing with Rate Freeze Price Cap with Earnings Sharing Price Caps
Georgia	1984-1990 1991-1995 1995-1998	ROR Earnings Sharing Price Caps
Hawaii	1984-1998	ROR
Idaho	1984-1998 1988-1995	ROR Revenue Sharing
Illinois	1984-1988 1989-1990 1990-1994 1995-1998	ROR Earnings Sharing ROR Price Caps
Indiana	1984-1993 1994-1998	ROR Price Caps
Iowa	1984-1998	ROR
Kansas	1984-1989 1990-1998	ROR Rate Freeze
Kentucky	1984-1987 1988-1993 1994 1995-1998	ROR Earnings Sharing ROR Price Caps
Louisiana	1984-1991 1992-1996 1996-1998	ROR ROR with Earnings Sharing Price Caps
Maine	1984-1995 1995-1998	ROR Price Caps
Maryland	1984-1989 1988-1992 1990-1995 1996-1998	ROR Rate Freeze Earnings Sharing Price Caps

Table 12 (cont'd)

Massachusetts	1984-1994	ROR
	1995-1998	Price Caps
Michigan	1984-1989	ROR
	1990-1991	Earnings Sharing
	1992-1995	Hybrid: Service Oriental Regulation
	1995-1998	Price Caps
Minnesota	1984-1990	ROR
	1990-1995	Earnings Sharing
	1995-1998	ROR
Mississippi	1984-1989	ROR
	1990-1995	ROR with Earnings Sharing
	1996-1998	Rate Freeze
Missouri	1984-1989	ROR
	1990-1994	Earnings Sharing
	1994	ROR
	1994-1997	Rate Freeze
	1997-1998	Price Caps
Montana	1984-1998	ROR
Nebraska	1984-1986	ROR
	1987-1998	Deregulation
Nevada	1984-1991	ROR
	1991-1996	Earnings Sharing
	1997-1998	Price Caps
New Hampshire	1984-1998	ROR
New Jersey	1984-1986	ROR
	1987-1993	Rate Freeze
	1993-1994	Rate Freeze with Earnings Sharing
	1995-1998	Price Caps with Earnings Sharing
New Mexico	1984-1989	ROR
	1990-1992	Earnings Sharing
	1993-1998	ROR

Table 12 (cont'd)

New York	1984-1986	ROR
	1987-1990	Earnings Sharing with Rate Freeze
	1991-1992	ROR
	1993-1995	Earnings Sharing
	1995-1998	Price Caps
North Carolina	1984-1995	ROR
	1996-1998	Price Caps
North Dakota	1984-1989	ROR
	1990-1998	Price Caps
Ohio	1984-1994	ROR
	1995-1998	Price Caps
Oklahoma	1984-1998	ROR
Oregon	1984-1991	ROR
	1992-1996	Price Caps with Revenue Sharing
	1996-1998	ROR
Pennsylvania	1984-1993	ROR
	1994-1998	Price Caps
Rhode Island	1984-1988	ROR
	1989-1991	Earnings Sharing
	1992	ROR
	1992-1995	Price Caps with Earnings Sharing
	1996-1998	Price Caps
South Carolina	1984-1991	ROR
	1992-1993	Earnings Sharing
	1993-1995	ROR
	1996-1998	Price Caps
South Dakota	1984-1995	ROR
	1996-1998	Price Caps
Tennessee	1984-1989	ROR
	1990-1995	Earnings Sharing
	1996-1998	Price Caps*

Table 12 (cont'd)

Texas	1984-1989	ROR
	1990-1995	Rate Freeze with Earnings Sharing
	1995-1998	Price Caps
Utah	1984-1997	ROR
	1997-1998	Price Caps
Vermont	1984-1987	ROR
	1988-1993	Rate Freeze
	1994-1998	ROR
Virginia	1984-1994	ROR
	1995-1998	Price Caps
Washington	1984-1989	ROR
	1990-1994	Price Cap with Earnings Sharing
	1995-1998	ROR
West Virginia	1984-1987	ROR
	1988-1998	Rate Freeze
	1995-1998	Price Caps
Wisconsin	1984-1986	ROR
	1987-1989	Earnings Sharing with Rate Freeze
	1990	ROR
	1990-1994	Hybrid: Productivity Incentive
	1994-1998	Price Caps
Wyoming	1984-1995	ROR
	1996-1998	Price Caps

* Due to BellSouth's appeal, the company has never technically operated under price cap plan.
Source: Abel, Jaison R. and Michael E. Clements (1998).

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