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THE PERFORMANCE OF THE STATE TELECOMMUNICATIONS INDUSTRY UNDER PRICE-CAP REGULATION: AN ASSESSMENT OF THE EMPIRICAL EVIDENCE

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EXECUTIVE SUMMARY

By the year 2000, over 75 percent of the state public utility commissions in the United States had selected price-cap regulation to constrain the operations of the major telephone companies within their states. Since the majority of these decisions were made in the mid-1990s, several state commissioners now face renewal decisions. In addition, many of the state public utility commissions that continue to use traditional rate-of-return regulation are contemplating a switch to price-cap regulation. Therefore, understanding the affects of this popular form of incentive regulation in the United States telecommunications industry will prove useful to state commissioners confronting decisions about the type of regulation they will choose to implement in the new millennium. This report focuses just on price caps at the state level and does not analyze any other forms of incentive regulation.

By providing an up-to-date review of the empirical econometric academic literature on price caps, this report provides a comprehensive assessment of the performance of the telecommunications industry under price-cap regulation. This review focused on seminal research contributions as well as empirical research completed since the passage of the 1996 Telecommunications Act. In order to add context to this review, the theoretical properties of price-cap regulation are compared to the price-cap plans found in practice. In most cases, the theoretical ideal

of price-cap regulation has been greatly modified once applied. In addition, this report provides a uniform framework to critique empirical research about the impact of price-cap regulation intended to assist commission staff tasked with evaluating empirical evidence put forth during regulatory hearings.

Two distinct themes arise from the empirical evidence put forth to date. First, the behavioral response by telephone companies has generally been more pronounced under pure price-cap regulation than under hybrid price-cap plans that contain an earnings-sharing component. This important finding provides evidence in support of the idea that regulated firms respond to the incentives they face, and is consistent with the body of theoretical literature analyzing incentive regulation.

Second, the industry as a whole has responded favorably to the incentives created by price-cap regulation. In particular, price-cap regulation is associated with lower telephone prices, higher productivity, more network modernization, and firm financial performance that is no worse than that realized under alternative methods of regulation. Third, the results for service quality are best characterized as mixed: price-cap regulation is associated with fewer customer complaints, but longer repair times. Fourth, the empirical research has uncovered a relationship between the adoption of price-cap regulation and the competitive transition now taking place in the local telephone industry. Price-cap regulation is associated with less net entry by competitors, smaller cumulative competitive fringes, and has also been shown to

influence the level at which arbitrated interconnection prices are set by state commissions. This is a particularly promising line of inquiry for new research aimed at understanding how price-cap regulation affects industry performance.

The report concludes that new and improved research is necessary before definitive conclusions about the performance of the United States telecommunications industry under price-cap regulation can be made.

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FOREWORD

Price-cap regulation has become the regulatory regime of choice in the United States telecommunications industry. It is important to understand what impact this popular form of incentive regulation has had on the performance of this industry, especially for those state commissions currently considering switching to or renewing price-cap plans. This report is intended for the technical staff at commissions and assesses the empirical econometric literature analyzing the effect of price-cap regulation on several dimensions of industry performance.

Sincerely,

Raymond W. Lawton, Ph.D.
Director, NRRI
September 2000

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INTRODUCTION

Price-cap regulation has gained wide acceptance by regulators of many industries around the world. In the telecommunications industry, price-cap regulation was introduced in 1984 in Great Britain to constrain the operations of British Telecom. Since then countries such as Australia, Canada, France, Germany, Mexico, and Sweden have all followed with their own version of price-cap regulation.[1] In the United States, price-cap regulation was first introduced by the Federal Communications Commission (FCC) in 1989 to regulate the prices AT&T charged for long-distance services.[2] In 1991, the FCC continued this trend and began using price-cap regulation to limit the prices local exchange carriers (LECs) could charge interexchange carriers (IXCs) for access to their networks.

While price-cap regulation gained popularity at the national level during the 1980s, its rate of adoption was not mirrored at the state level. As late as 1990, when experiments with incentive regulation in general were quite common (over 45 percent of the state public utility

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[1] See Xavier (1995) for an international comparison of the performance of the telecommunications industry under price-cap regulation.

[2] By 1995, however, price-cap regulation had been replaced in favor of the constraints provided by competition for all long-distance services provided by AT&T except Basket 1 international services (Edelman 1997, pg. 542).

commissions in the United States had adopted some form of incentive regulation by 1990), fewer than 8 percent of the states had selected price-cap regulation to constrain the dominant telecommunications companies within their jurisdiction.[3] Since then, however, price-cap regulation has gained significant attention at the state level. Table 1 provides a state-level description of the adoption of price-cap regulation relative to incentive regulation during the decade of the 1990s.[4]

By 1995, over 43 percent (a gain of over 36 percent from 1990) of the state public utility commissions had adopted price-cap regulation, while the number of commissions selecting some form of incentive regulation increased to 63 percent (only an 18 percent gain from 1990). This fact indicates that price-cap regulation was now becoming the regulatory regime of choice for state public utility commissions moving away from traditional rate-of-return regulation for the first time, as well as for those that had previously experimented with another form of incentive regulation. Today, price-cap regulation is the most common method of regulatory constraint employed at the state level in the United States telecommunications industry. By 1999, nearly 77 percent of the state

[3] See MacDonald, Norsworthy, and Fu (1994) and Abel (1999b) for contrasting explanations of this regulatory phenomenon.

[4] The adoption of a particular regulatory regime rarely, if ever, occurs as an exogenous event within a commission only to be thrust upon an industry. Instead, a regulatory bargain is often struck between the regulators and firms involved. In many cases, the firms themselves were quite active in lobbying for this form of incentive regulation.

TABLE 1
The Adoption of Price-Cap Regulation for Major Telephone Companies by State Public Utility Commissions in the 1990s

Year	Total Number of State PUCs Using Price-Cap Regulation	Total Number of State PUCs Using Incentive Regulation
1990	4	23
1991	4	23
1992	7	26
1993	7	28
1994	10	28
1995	22	32
1996	31	36
1997	35	37
1998	35	37
1999	37	39

NOTE: Tardiff and Taylor (1993) define incentive regulation plans as those that contain one or more of the following characteristics: (1) banded rate-of-return, (2) earnings sharing, (3) price caps, or (4) complete deregulation. Therefore, service-specific pricing flexibility and rate freezes alone do not qualify as incentive regulation. This definition is used to classify the states using some form of incentive regulation. A state is classified as having adopted price-cap regulation if a price-cap plan for incumbent local exchange carrier (ILEC) services was in effect during the year. Price-cap plans with initial rate freezes or having an earnings sharing component are included. Plans reported as rate freezes or earnings sharing plans are not.

SOURCES: [1] *A Time-Series and Cross-Sectional Classification of State Regulatory Policy Adopted for Local Exchange Carriers*, NRRI (1998); [2] *State Telephone Regulation Report*, Warren Publishing (1999).

public utility commissions had selected incentive regulation (39 commissions), and 95 percent of these plans (all but two) contained a price-cap component.

The purpose of this report is to assess the current state of knowledge regarding the performance of the United States telecommunications industry under this popular form of incentive regulation.[5] Research of this nature is valuable to both academics and practitioners. While a large theoretical body of literature analyzing the advantages and drawbacks of price-cap regulation has developed over time, relatively little is known about how it performs in practice. Therefore, understanding the actual impact of price-cap regulation is necessary before the theoretical debate can be settled.

On a practical level, research of this nature can help to guide future policy decisions. Indeed, many of the state public utility commissions that adopted price-cap regulation in the mid-1990s now face renewal decisions. At the time of this writing, Illinois and Pennsylvania were reviewing their price-cap plans for the purposes of renewal. Price-cap plans in Alabama, the District of Columbia, Maine, Nevada, New York, Ohio, and Wisconsin expire in 2000, and price-cap plans in Delaware,

[5] See Berg and Foreman (1996) or Kridel, Sappington and Weisman (1996) for similar studies reviewing the empirical evidence surrounding incentive regulation in general. This report includes studies that were conducted after those papers were published and differs from those papers by focusing solely on the evidence for price-cap regulation.

Massachusetts, Mississippi, New Jersey, and Rhode Island expire in 2001 (Kirchoff 1999a, 1999b). Additionally, state public utility commissions that have never used price-cap regulation may want to learn more about its potential impact before implementing it within their states. Furthermore, research of this nature can be useful to regulators overseeing industries similar to the telecommunications industry (for example, electric power, natural gas, water) as price-cap regulation continues to emerge. An up-to-date review of the empirical studies of the effect of price-cap regulation accomplishes these objectives by helping to achieve a consensus about this important subject.

This report is organized as follows. In the next section, the theoretical properties of pure price-cap regulation are discussed to facilitate a basic understanding of how price-cap regulation is likely to perform in practice. In addition, this section contains some discussion of how the actual price-cap plans implemented in the United States differ from the ideal theoretical construct originally formulated. This makes interpreting any empirical results that deviate from expectations built on theory easier to understand. In the section that follows, some of the flaws prevalent in existing empirical studies of price-cap regulation are discussed. This provides a basis from which an in-depth review of the impact of price-cap regulation in the United States telecommunications industry can be built and provides a set of criteria from which state commissions can draw when evaluating statistical evidence put forth in

regulatory hearings aimed at implementing or extending price-cap plans. The result of this compilation is then provided.

The United States telecommunications industry continues to be regulated by a two-tiered (federal-state) structure. For the purposes of this report, an emphasis is placed on reviewing those papers that have analyzed industry outcome measures influenced by state-level regulation. The specific dimensions of LEC performance examined include: (1) pricing behavior in both local and local toll markets, (2) productivity, (3) network modernization, (4) financial performance, (5) service quality and (6) the development of competition in local telephone markets. The report closes with concluding comments and directions for new and improved research.

THE BASIC STRUCTURE OF PRICE-CAP PLANS

Before jumping into a discussion of how price-cap regulation has performed in the United States telecommunications industry, it is important to understand the basic structure of price-cap regulation in theory and practice. Describing how price caps work in theory allows one to make predictions about what outcome measures are most likely to be affected and how this method of regulation will perform. Examining how price caps are actually implemented provides a basis for fully understanding the evidence put forth to date about their performance.

Price-Cap Regulation in Theory [6]

Like many forms of incentive regulation used in the telecommunications industry, price-cap regulation is designed to provide competitive incentives to regulated firms under the assumption that effective competition is not feasible.[7] Price-cap regulation departs from the other regulatory methods in the mechanism used to accomplish this objective. Under pure price-cap regulation, the price a regulated firm charges, rather than its earnings, is controlled by regulators. Maximum price levels (that is, price ceilings) are established *ex-ante* of any cost realization, and the regulated firm retains the earnings above the cost it incurs.

In theory, a pure price-cap plan has several advantages relative to conventional methods of regulation. Surprisingly to some, achieving *allocative efficiency* is not necessarily one of the major advantages of

[6] A full discussion of the theoretical properties of price-cap regulation is beyond the scope of this report. Interested readers should consult Pint (1992), Braeutigam and Panzar (1993), and Liston (1993) for theoretical studies comparing the properties of price-cap regulation and rate-of-return regulation. Additionally, Cabral and Riordan (1989), Brennan (1989), and Clemenz (1991) provide theoretical studies describing the cost reducing incentives and welfare implications created under price-cap regulation.

[7] Effective competition implies that the competition present in a market will influence and discipline market performance (for example, prices or profits).

this form of regulation.[8] That is, there is no guarantee that the price set will approximate incremental costs. In fact, if the price cap actually produces the correct incentives to the regulated firm, it is not likely that the price set will reflect incremental costs in subsequent time periods unless the price cap is adjusted to reflect gains in productivity.

Instead, the major benefits of price-cap regulation arise through the design of the regulatory mechanism and the behavior created by the incentives it provides to regulated firms. First, cost-minimizing behavior is encouraged since the regulated firm is now the dollar-for-dollar residual claimant to all earnings above its costs. It is believed that this results in greater *production efficiency*.[9] This is important since the potential gains in production efficiency typically outweigh the potential losses in allocative efficiency that may occur.[10] Second, it is expected that a firm under this form of regulation will be more likely to make investments in modern infrastructure and research and development (R&D) since it reaps the rewards associated with the risk involved. Thus,

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[8] Allocative efficiency occurs when a set of goods or services is produced and consumed at a level that maximizes net social welfare (that is, the sum of consumer surplus and producer surplus) at a given point in time. It is achieved when price is set equal to marginal cost.

[9] Production efficiency occurs when a set of goods or services is produced at the lowest possible cost given the technology that is feasible at a given point in time.

[10] Put simply, for an equal sized price increase or reduction in marginal cost, the area contained in a rectangle is larger than the area contained in the corresponding triangle. See Tardiff and Taylor (1993) for a good explanation and analysis of this point.

price-cap regulation reinforces behavior that leads to greater innovation and, possibly, *dynamic efficiency*.[11] Third, many of the distortions created by linking the regulated price to a firm's *ex-post* cost realization are mitigated. For example, alleged misbehaviors due to cost-based regulation (such as gold-plating, shifting costs from unregulated to regulated services, and inefficient diversification) are no longer profitable under this form of regulatory constraint. Finally, it has been suggested that this form of regulation will decrease the monitoring costs associated with more traditional forms of regulation (for example, conducting rate cases).

Because the incentives created under price-cap regulation are different from those created by forms of regulatory constraint that control earnings, one can expect to see differences in observable market outcomes arising from the adoption of price-cap regulation. The theory behind the design of price-cap regulation certainly lends itself to rigorous empirical testing. For example, one might quite straightforwardly predict that firms will have lower production costs, increased productivity, and be more apt to make investments in modern infrastructure under price-cap regulation than under more traditional forms of regulation. On the other hand, the direction real prices will move or how service quality will be affected is not entirely clear. The variation across states regarding the choice of regulatory regime creates a natural experiment to test the predictions arising in the theoretical literature.

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[11] Dynamic efficiency occurs when production efficiency is achieved through time.

The Basic Equation

Price-cap plans often require the regulated firm's average, inflation-adjusted prices to fall annually by a specified percentage productivity offset commonly referred to as an X-factor.[12] This productivity offset represents the percentage reduction in prices that the regulated firm is deemed technologically capable of implementing without jeopardizing its financial integrity.[13] The standard formula takes the following form:

PCI = INFPI - X +/- Z

Where,	PCI	/	Price Cap Index
	INFPI	/	Inflation Price Index
	X	/	Productivity Offset
	Z	/	Exogenous Factor Adjustments

Under the simplest version of price-cap regulation, the regulated firm is given substantial freedom to set rates for individual services that

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[12] The price level is indexed by an inflation-rate adjustment mechanism. Common forms include the Gross Domestic Product Price Index (GDP-PI), the Gross National Product Price Index (GNP-PI), and the Consumer Price Index (CPI). Of these, the most frequently used index is the GDP-PI.

[13] See Bernstein and Sappington (1999) for a theoretical discussion of the guiding principles that should be considered when setting this X-factor. In addition to analyzing a baseline case, extensions are made to adjust for (1) when only a subset of a regulated firm's services are subject to price-cap regulation,
(2) when the service being produced is an intermediate good, and (3) when structural changes, such as increased competition, are present.

are often grouped into baskets. The regulated firm can raise its rates for some services (or a basket of services), provided that it lowers its rates on other services (or baskets of services) sufficiently to ensure that real, overall, average rates decline by the required amount.[14]

It is this increased flexibility in setting prices that makes price-cap regulation appealing to regulated firms. Firms benefit directly by rebalancing prices to reflect their underlying economic costs or by increasing their productivity above that set in the X-factor. In addition, having a greater ability to set prices affords regulated incumbents the ability to meet challenges arising from increased competition for the provision of telecommunications services, an aspect of this form of regulation that will grow in importance in the new millennium.

Price-Cap Regulation in Practice

In the purest form of price-cap regulation, no sharing of realized earnings occurs–thus the name "pure price-cap" regulation. As adopted

[14] Kang, Weisman and Zhang (2000) demonstrate that consumers do not always benefit from tightening the price-cap constraint through increases in the X-factor. Instead, the net effect depends on whether demand for services across baskets is independent or interdependent. They demonstrate that consumers always benefit if demand is independent across baskets, but that consumers may suffer welfare losses when demand is interdependent across baskets. Given that the demand for telephone services across baskets is likely to be related, this finding suggests that the widespread use of ratcheting (that is, increasing the productivity offset in a price-cap plan) of in the telecommunications industry may actually be leading to welfare losses.

in the United States, this is rarely the case. Some states implementing price-cap regulation require an earnings-sharing component between consumers and the regulated firm.[15] Hybrid plans of this nature, of course, dampen the incentives for cost-reducing activity, as the regulated firm no longer receives the full (that is, dollar-for-dollar) earnings reward arising from lower costs or increased productivity. In addition, adding an earnings-sharing component partially reconnects prices and earnings. In extreme cases, the incentives created under hybrid price-cap plans do not differ significantly from those created by traditional rate-of-return regulation. Therefore, the hybrid nature of price-cap regulation, as applied, complicates empirical research centered on measuring the differences across regulatory regimes.

Moreover, the form of regulation used in a particular jurisdiction is rarely, if ever, decided upon independently by regulators and imposed exogenously on regulated firms. Instead, a bargain is struck between the regulators and firms in question. In exchange for the adoption of price-cap regulation, regulated firms often agree up front to reduce (or freeze) their prices for a specific period of time, meet certain quality-of-service standards, or make investments to modernize their

[15] Earnings-sharing plans afford the regulated firm greater flexibility and earnings potential relative to conventional rate-of-return regulation by specifying a range of earnings (or losses) in which the regulated firm can share realized profits (or losses) with consumers. How this sharing occurs varies substantially across plans. Sometimes the sharing is on a 50-50 basis and sometimes the sharing is dependent upon the degree of earnings (or losses) the regulated firm incurs. Components such as these are typically included with price-cap plans as a way for regulators to control the earnings accruing to the regulated firm.

infrastructure.[16] It is important to understand the circumstances under which a price-cap plan is adopted before one can conduct accurate empirical research of the true impact of price-cap regulation.

POTENTIAL PITFALLS OF THE EMPIRICAL LITERATURE

A surprisingly small amount of empirical research focusing on the effects of price-cap regulation in the telecommunications industry currently exists. This is due to several sources of potential difficulty. As documented in Table 1, the public policy experiment with incentive regulation generally, and price-cap regulation in particular, are both fairly recent phenomena. Recall, the widespread adoption of price-cap regulation at the state level did not begin until 1994 or 1995. Due to the *ex-post* nature of empirical research, it is often the case that not enough time has elapsed to accurately measure the impacts of particular regulation plans. In addition, regulatory and company jurisdictions often overlap in unsystematic ways in the telecommunications industry. This complication makes constructing viable empirical tests of the effect of regulation extremely difficult. Finally, as with most empirical research,

[16] It is also not unusual to find performance benchmarks regarding service quality or infrastructure investment included as a precondition to triggering the earnings-sharing mechanism in a hybrid plan.

collecting accurate and reliable data is a painstaking process that many researchers do not wish to undertake.

Despite these and other possible difficulties in conducting empirical investigations into the causes and effects of price-cap regulation, some empirical studies have emerged to create a new slice of academic literature. Before moving to a discussion of particular papers, some of the common problems identified in this early research are presented.[17] These pitfalls are discussed in terms of incentive regulation in general, but apply equally to studies concentrating only on the effect of price-cap regulation. The most widely violated empirical pitfalls are listed below:

The Uni-dimensional Yardstick Pitfall

This pitfall occurs when a researcher concludes that incentive regulation (or price-cap regulation) is a failure simply because she or he fails to identify an impact on one particular dimension of interest (for example, price or investment). Incentive regulation has several goals and targets many important dimensions of performance. Therefore, it is important to look at the whole picture before passing judgment on the merits of a particular regulatory plan. Fortunately, avoidance of this pitfall is easy since it only requires the researcher or reader to identify a set of goals to which performance measures can be compared.

[17] Identification of the first seven empirical pitfalls discussed is attributed to David E. M. Sappington and Dennis Weisman (1996, pp. 273-289).

The Causality Pitfall

Although framed in a discussion of empirical studies of price-cap regulation, this pitfall is common in all empirical work. It involves confusing the concepts of causation and correlation. In all empirical work, it is important to realize that only correlations can be identified. Therefore, a more thorough investigation of the problem is required before one can conclude that causation exists from price-cap regulation to a particular measure of industry performance. Understanding the limits of regression analysis allows researchers and readers to avoid this pitfall.

The Competition Effect Pitfall

In the empirical studies of incentive regulation (and price-cap regulation) to date, it is this pitfall that is violated most regularly. Furthermore, since competition continues to develop in this industry once shielded from entry, the need for understanding this pitfall will only grow with time. The *Competition Effect Pitfall* occurs when a researcher attributes to incentive regulation (or price-cap regulation) an effect on industry performance without controlling for the presence of competition. In this case, it is quite possible that competition is the *real* driving force behind industry performance—not incentive regulation (or price-cap regulation). This is an easy trap in which to fall since incentive regulation

(and price-cap regulation to a larger extent) is designed to create incentives similar to those provided in a competitive marketplace.

On the surface, the avoidance of this problem appears to be quite easy: the researcher should include a measure of competition in all studies measuring the impact of incentive regulation (or price-cap regulation) on industry performance. However, selecting measures of competition that actually serve as a proxy for the amount and degree of competition in the telecommunications industry is a difficult task.[18] Therefore, avoiding this pitfall is more complicated than it first appears. What is likely to result, instead, is partial avoidance of this problem depending on the ability of a researcher to develop accurate and complete measures of competition for the U.S. telecommunications industry.

The Mandated vs. Motivated Pitfall

As discussed earlier, companies sometimes agree to mandated actions as a condition to entering into an incentive regulation plan. These agreements are particularly common for the case of price-cap regulation. For example, several companies agreed to make infrastructure investments or maintain service quality standards on the

[18] Empirical measures of competition in the academic literature tend to be either rule based (for example, a dummy variable indicating if competition is allowed) or market based (for example, the number of competitors holding numbers in a market). Market-based measures of competition are likely to be more accurate proxies than rule-based measures of competition.

condition that they be granted some form of incentive regulation plan. A researcher falls into the *Mandated vs. Motivated Pitfall* when he or she attributes observed actions (for example, infrastructure investment or changes in service quality) to incentive regulation that are actually mandated by regulators as a *quid pro quo* for adopting incentive regulation (or price-cap regulation). Completely avoiding this pitfall may be impossible since it requires separating the mandated from incentive-driven impacts of a regulatory plan. Understanding the circumstances under which a plan is adopted helps to alleviate this problem.

The Demonstration Effect Pitfall

This pitfall recognizes the potential for strategic behavior by firms subject to incentive regulation plans (or price-cap plans). It occurs when a researcher does not account for the possibility that the firm is acting in a way to convince regulators that incentive regulation works with plans of exploiting its new found freedom and flexibility at a later date. Although recognizing this potential problem is important, properly controlling for it may prove to be difficult or impossible. Nonetheless, it is important to keep this particular pitfall in mind when evaluating the success (or failure) of alternative forms of regulation.

The Measurement Timing Pitfall

Some types of behavior expected from the implementation of incentive regulation plans may take longer to develop than others. For example, the realization of infrastructure investments and productivity changes may take longer to materialize than changes in price or service quality. In conducting empirical research, it is important to make sure the time period selected is adequate for the question that is being addressed. Oftentimes, only a few years have elapsed since the regulatory change under investigation occurred. This is likely to be a persistent problem due to the rapid changes taking place in this dynamic industry. Ultimately, however, the researcher (and reader) must weigh the trade-off resulting from conducting research that may suffer from this pitfall and having no research on the subject at all. As long as this possibility is explicitly recognized, research of any reasonable time span can be valuable.

The Sequencing Pitfall

A more subtle pitfall amounts to a failure to account for the inter-temporal effects caused by incentive regulation plans. Because firms are assumed to be rational, the observed responses may be due to a dynamic strategy to game the regulators, rather than a straightforward

reaction to the intended incentives created. For example, a firm may attempt to shift costs across time if the incentive regulation plan rewards lowering current costs. However, in reality, the costs are incurred in future time periods. Again, being aware of this potential problem is important, but avoiding it completely may be an impossible task.

To these already established pitfalls, it is possible to identify two more potential areas of concern.

The Aggregation Effect Pitfall

This pitfall can be considered the cross-sectional counterpart to the *Measurement Timing Pitfall*. It occurs when the unit of analysis is either too large or too small to accurately address the question posed. Largely due to data limitations, most of the existing empirical studies measuring the impact of incentive (and price-cap) regulation on industry performance rely on state-level observations. Sometimes this level of aggregation poses no problem. For example, conducting a state-level analysis may be appropriate for examining how the introduction of incentive (or price-cap) regulation has influenced service availability within a state.

However, for other important measures of industry performance, a state-level analysis may not be appropriate. For example, when analyzing the impact of incentive (or price-cap) regulation on pricing

behavior or the development of competition, a more precise unit of observation would be at the market level, and states generally have several markets. In this case, using a state-level analysis masks some important effects induced by the non-regulatory explanatory variables in the specification. On the other hand, a state-level analysis may be too disaggregated if you are studying the investment behavior in the telecommunications industry since these decisions are likely made at the holding company level. Holding companies typically span several states. Therefore, using a state-level analysis may produce meaningless results if the dependent variable is not well defined. Again, the researcher (and reader) must weigh the trade-off resulting from conducting research that may suffer from this pitfall and having no research on the subject.

The Classification Effect Pitfall

Many forms of incentive regulation have been adopted by state regulators over time. Even now, while nearly 75 percent of the state public utility commissions use a form of price-cap regulation within their jurisdictions, substantial variation exists across plans. In reality, 51 different forms of regulation are being used by the 51 state public utility commissions around the country. This bit of reality makes the classification of incentive regulation (and price-cap) plans a difficult, and often times ad hoc, process for empirical purposes. This pitfall occurs

when the classification of incentive regulation (or price-cap regulation) plans is done without a specific definition or principle in mind. Any grouping necessarily generalizes incentive regulation plans into a category. However, it is only a problem when small changes in the classification decision rule significantly alter the results of the research. The combination of *ex-ante* care and thought with an *ex-post* sensitivity analysis is a good way to overcome this potential problem.

Summary

Conducting sound and convincing empirical research measuring the impact of price-cap regulation on the performance of the U.S. telecommunications industry is a difficult exercise. This observation is reinforced by the large number of ways an empirical researcher can go astray in the process. Understanding the potential pitfalls that may arise while conducting this type of research allows the reader to make an informed judgement about the merit of the conclusions put forth in this relatively new strand of academic literature. With this framework now firmly set, it is possible to objectively review the current state of knowledge regarding price-cap regulation and the performance of the U.S. telecommunications industry.

AN ASSESSMENT OF THE EMPIRICAL LITERATURE

Although still in its infancy, a literature measuring the impact of price-cap regulation on measures of performance in the U.S. telecommunications has started to form. Some measures of performance (for example, prices) have been evaluated more thoroughly than others (such as, service quality). Some measures have been neglected altogether (the direct administrative cost of price-cap regulation), while others have only recently become important (for example, the development of competition) due to legislative or technological changes. Therefore, it may still be too early to develop definitive conclusions about the success or failure on this popular form of incentive regulation. It is useful, however, to assemble the current state of knowledge in this area for the purposes of verifying theoretical propositions and informing regulators faced with policy decisions. This discussion begins with one of the most fundamental measures of industry performance: price.

Prices in Local and Local Toll Markets

A major concern of state regulators is likely to be whether price-cap regulation has kept telephone rates down. A summary of the evidence from recent research regarding pricing behavior is contained in Table 2. As can be seen, the evidence is mixed.

TABLE 2
Summary of the Evidence:
The Effect of Price-Cap Regulation on
Local and Local Toll Pricing

Study	Time Period	Conclusion	Potential Pitfalls
Tardiff and Taylor (1993)	1980-1991 (except 1984-1986)	No significant impact on local or local toll prices attributable to price-cap regulation. However, local toll prices are 4.0 to 8.0 percent lower under incentive regulation in general.	Competition Effect Aggregation Effect Mandated-Motivated Effect
Ai and Sappington (1998)	1990-1995	Price-cap regulation is associated with 7.6 percent lower local residential prices. No effect found for local business prices.	Aggregation Effect Mandated-Motivated Effect
Blank, Kaserman and Mayo (1998)	1991	No significant impact on local toll prices attributable to price-cap regulation. The presence of competition is associated with 7.8 to 10.4 percent lower local toll prices.	Measurement Timing Aggregation Effect
Abel (1999a)	1994-1997	Price-cap regulation is associated with 3.7 percent lower local residential prices and 2.3 percent lower local business prices.	Mandated-Motivated Effect

Tardiff and Taylor (1993) provide the first attempt to measure the impact of price-cap regulation on the pricing behavior of incumbent local exchange carriers (ILECs).[19] This is an elaborate study that examines the impact of incentive regulation (generally defined), as well as each form of incentive regulation (individually), on several dimensions of ILEC performance.[20] In this section, attention is given to their analysis of how price-cap regulation impacted the pricing behavior of ILECs in local and local toll markets. For organizational exposition, a discussion of the

[19] Research by Mathios and Rogers (1989) is considered the first attempt to analyze empirically the impact of incentive regulation on prices in the U.S. telecommunications industry. They found lower prices associated with the adoption of more flexible regulation. However, their analysis did not address price-cap regulation specifically and only considered prices for intrastate long-distance services provided by AT&T (not local or local toll services). See Mathios and Rogers (1990) and Kaestner and Kahn (1990) for related inquiries.

In other related research, Edelman (1997) fails to show any impact of price-cap regulation on interstate long-distance rates. Using a switching regression approach, she provides evidence to suggest that price-cap regulation imposed on AT&T from 1989 to 1995 did not affect interstate long-distance rates. Instead, Edelman shows that the emergence of equal access technology and the subsequent mandate of its use by the 1982 consent decree actually caused rates to fall by more than the predicted long-run trend. Based on this result, Edelman argues that the emergence of equal-access competition was more important to the observed decline in long-distance rates than the advent of price-cap regulation. This study is different from the studies reviewed here because it focuses on interstate long-distance service pricing, which is under the FCC's jurisdiction.

[20] The other forms of incentive regulation considered include banded rate-of-return, earnings sharing, price freezes, price caps, pricing flexibility on competitive services, and deregulation.

results obtained for the other measures of ILEC performance will be considered under the corresponding topic as appropriate.[21]

To conduct their analysis, Tardiff and Taylor assemble a panel data set covering the years between 1980 and 1991 (excluding 1984-1986 since these years followed the divestiture of AT&T). Therefore, the authors make an effort to avoid the *Measurement Timing Pitfall*. The data set is comprised of observations from all of the Regional Bell Operating Companies (RBOCs), as well as Cincinnati Bell and Southern New England Telephone (SNET). It is a state-level analysis that employs observations from 48 states (Alaska and Hawaii are excluded) plus the District of Columbia. Therefore, this study may suffer from the *Aggregation Pitfall* since states do not accurately reflect local or local toll markets.

Tardiff and Taylor estimate a pooled model consisting of the type of regulation employed and a full set of dummy variables to control for cross-sectional effects (both state and company dummy variables are included) and time-specific effects. It is important to note that this type of specification treats the regulation in place for a state during a year as exogenous (that is, determined outside the model).[22] As mentioned

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[21] The other measures of LEC performance include financial performance, productivity, investment and modern infrastructure deployment, service availability, and service quality.

[22] Until recently, treating the choice of regulation as exogenous was common in this line of research. Therefore, this potential problem is pointed out here instead of each time it occurs. See Smart (1994) and Donald and Sappington (1995 and 1997) for studies demonstrating the potential endogeneity (continued...)

earlier, the choice of regulation employed in a given state is often the result of a regulatory bargain between regulators and firms. Thus, it may not be appropriate to treat such a decision as exogenous, since doing so may bias the estimates. Therefore, statistical testing of the presence of endogenous regulation regressors is one direction for improvement for this literature.

No other control variables (such as, population, level of competition, density, political environment) are employed in this analysis. Tardiff and Taylor argue that the need to control for additional explanatory variables is less important with panel data than with either cross-sectional or time-series data. However, as pointed out by Kridel, Sappington and Weisman (1996), several variables (including competition) may vary over states, firms and time. Therefore, a more complete specification would improve this research. In addition, this study may suffer from the *Competition Effect Pitfall* since no attempt is made to explicitly control for competitive activity. However, this may be a minor concern (especially for local telephone service) given that the time period under investigation was, for the most part, not marked by any real competitive pressure.

Unfortunately, the results of the analysis are disappointing given the potential contribution this study has to offer. Rather than fully developing one or more of the areas under investigation, the authors cast their net too broadly and spread the analysis too thin. Tardiff and

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[22] (...continued)
of incentive regulation plans.

Taylor are unable to find any impact from the presence of incentive regulation on local telephone pricing, and are able to show only small (4 to 8 percent) negative effects on intraLATA toll pricing. Moreover, no distinguishable impact on either local or local toll prices is found when focusing only on price-cap regulation. Nonetheless, this paper offered many interesting ideas and stands as the initial contribution to directly consider the impacts of incentive regulation on the pricing behavior in local telephone markets.

In research building on the initial analysis by Tardiff and Taylor, Ai and Sappington (1998) estimate the impact of three popular forms of incentive regulation (price caps, earnings sharing, and rate case moratoria) on a host of different performance measures for local telephone companies. The observations included in the data set are from the operations of the RBOCs (and SNET) in the 48 continental United States and the District of Columbia for the time period 1990-1995. Therefore, this study attempts to avoid the *Measurement Timing Pitfall*.

One aspect of this analysis is whether local telephone prices vary systematically with the prevailing regulatory regime. They perform their analysis for both business and residential local telephone prices. The explanatory variables they employ include a lagged value of the dependent variable, a variable to control for general economic activity in a state (the unemployment level), a variable to measure the intensity of competition in a state (the percentage of fiber cable held by competitive access providers (CAPs)), a variable to measure state regulatory policy toward competition in the telecommunications industry (a dummy

variable indicating whether local toll competition was permitted), a variable to measure state political sentiment, plus firm and time-specific dummy variables.[23] Their main finding is that price-cap regulation is associated with 7.6 percent lower residential rates than rate-of-return regulation. No statistically significant effect is found for business rates.

In addition to using more recent data, they make two important improvements to the study by Tardiff and Taylor. First, they use a more complete econometric specification in their model, including both a rule-based and market-based variable of competition. Thus, they successfully avoid the *Competition Effect Pitfall*. Second, they explicitly test whether the regulation in place is an endogenous variable.[24] On the downside, this portion of their study may suffer from the *Aggregation Effect Pitfall* since it is also conducted at the state level. Local telephone markets (defined as local access and transport areas (LATAs)) are typically smaller than states. Therefore, both the measure of price and

[23] Ai and Sappington take into consideration the potential for multi-collinearity in a specification that combines variables to control for the demographic, economic, political, and regulatory environment with firm and time-specific dummy variables. To minimize this problem, they exclude from their analysis highly correlated explanatory variables. The variables discussed above pass their test and are included as explanatory variables in much of their analysis.

[24] Using a Hausman specification test, they fail to reject the null hypothesis of no endogeneity. This evidence provides some confidence in the results of studies that treat the choice of regulation as exogenous. However, it does not mean that future studies should ignore the appropriate statistical testing of this issue.

competition used here may not be accurate since the market in question is not properly defined.

Due to recent changes in regulation and technology, competition has developed in the U.S. telecommunications industry. This trend makes understanding how the presence of both regulation and competition act to determine market outcomes crucial to designing policy for the telecommunications industry. It also creates a need for new theoretical models containing both regulation and competition, and empirical work based on the predictions of these new models.

To capture the underlying factors of RBOC local toll pricing, Blank, Kaserman and Mayo (1998) develop a generalized model of dominant firm pricing to account for the presence of regulation in nascent competitive markets. This model extends the traditional dominant firm-competitive fringe model of market structure and allows them to develop a reduced-form price equation to motivate an empirical investigation of local toll pricing by the RBOCs. Although they fall short of explicitly modeling the impact of regulation and competition of dominant firm pricing, the model does provide structure to their empirical analysis and, for that reason, should be considered an important contribution to the literature.

Blank, Kaserman, and Mayo employ a cross-sectional analysis using data from 1991 to test the predictions of their generalized model of dominant firm pricing. The dependent variable is the price of a five-minute, daytime, weekday local toll call carried by the RBOC in each of the 48 continental United States for three mileage bands (25, 50, and 75

miles), increasing the sample size to 144 observations.[25] The authors use two separate models to consider the impact on local toll prices of incentive regulation generally and price cap regulation specifically. These are both modeled as dummy variables. To measure competition, they use the number of competitors with equal access dialing in a state, a measure of local switch bypass, and a variable indicating whether or not resale is blocked. Thus, the authors avoid the *Competition Effect Pitfall* by including one rule-based and two market-based measures of competition. In addition, the authors test for the strategy of raising a rival's costs by including the price charged to carriers for access to the network. The remaining explanatory variables included are designed to control for the variation in costs and market demand that exists, and the mileage band to which the dependent variable corresponds.

The results of this analysis suggest that competition is driving much of the pricing behavior in local toll markets. They find that allowing local toll competition is associated with price reductions ranging from 11 to 15 cents for a five-minute call, and that the presence of facilities-based competition results in 7.8 to 10.4 percent lower local toll prices. Contrary to Tardiff and Taylor (1993), Blank, Kaserman and Mayo find

[25] Constructing the data set in this fashion may introduce both heteroskedasticity (when the error terms have different variances) and mutual correlation (when the error terms are correlated) into the model. The presence of one or both of these statistical problems results in a non-spherical variance-covariance matrix. Although parameter estimates tend to remain unbiased when this occurs, the standard errors associated with the parameter estimates are no longer accurate, making tests of statistical significance virtually meaningless. Blank, Kaserman and Mayo use the method of Feasible Generalized Least Squares to correct for this potential problem.

higher local toll prices associated with incentive regulation in general and no significant effect associated with price-cap regulation. Due to the cross-sectional nature of their analysis the results may be tainted by the *Measurement Timing Pitfall*. In addition, their unit of analysis (states) may not accurately reflect local toll markets, making their analysis susceptible to the *Aggregation Effect Pitfall*. However, these are minor issues in an otherwise insightful study.

Abel (1999a) extends the work of Blank, Kaserman and Mayo (1998) to analyze the pricing behavior of dominant firms in local telephone markets. To motivate his empirical research, Abel builds a theoretical model to explicitly predict the impact of price-cap regulation and fringe competition on the prices charged by dominant firms. Contrary to the predictions of the traditional dominant firm-competitive fringe model of market structure, this hybrid model shows that the presence of fringe competition need not reduce the price charged by a regulated dominant firm. This outcome depends on how tight the price-cap constraint is set by regulators. When the price-cap constraint is set tight, it remains binding with fringe competition. In addition, when this case occurs, the market share of the competitive fringe is also expected to be less than otherwise predicted. On the other hand, when the price-cap constraint is set loose, it becomes non-binding with fringe competition. Only in the latter case should one expect to see any impact of competition on the price charged by a dominant firm.

Abel then turns to an empirical analysis of local telephone pricing to sort out the predictions of his model. A structural model similar to the one developed by Blank, Kaserman and Mayo is employed to bridge the gap between the theoretical and empirical sections of this research. From this structural model, an estimable reduced-form pricing equation is developed.

To conduct this analysis, Abel builds a panel data set consisting of observations from local telephone markets in the United States for the years 1994-1997. Thus, he is careful to avoid the *Aggregation Effect Pitfall*, but may fall prey to the *Measurement Timing Pitfall*. The analysis is conducted for both business and residential local telephone services. The dependent variable employed is the price charged for local telephone service by the ILEC in each local telephone market sampled. The ILECs are largely comprised of RBOCs, but observations for SNET, Cincinnati Bell and Rochester Telephone are also included for a more complete analysis.

Several explanatory variables are included to fully specify the econometric model employed. They include a binary variable indicating the presence of price-cap regulation, a market-based measure of competition indicating the number of CLECs in each local telephone market, a vector of demand variables (comprised of population, population growth and per capita income), a vector of cost variables (comprised of density and the average cost of labor per hour), and a vector of political variables (comprised of a measure of business customer intensity, whether the state commissioners are elected or

appointed and an index of the political affiliation of the state commission). Also included in the specification is a variable interacting the regulation and competition variables to test the hypothesis that both constraints will not act together to influence price. The addition of market and time-specific dummy variables completes the econometric specification.

For both business and residential local telephone pricing, the same pattern of results emerges. In contrast to Blank, Kaserman and Mayo, price-cap regulation is driving the prices set in local telephone markets, not competition. The likely cause of this difference is the degree of competition in local and local toll markets at the time of each study. Abel reports that markets in which the ILEC is constrained by price-cap regulation are associated with 3.73 percent lower residential prices and 2.28 percent business prices. He finds no impact from the introduction of competition from CLECs. This observed pattern of pricing behavior provides support for the extended dominant firm-competitive fringe model developed, and suggests that regulators have systematically adopted tightly binding price-cap regulation in the United States local telephone industry. Interestingly, these findings suggest that doing so may also be contributing to the slow development of local competition. Further discussion of this theoretical insight is contained later in this report.

Overall, prices seem to have been kept in check under price-cap regulation. In fact, several studies report lower telephone prices associated with the adoption of this popular form of incentive regulation.

Interpreting these findings in light of the competitive environment now present in this industry and investigating the possible impact of the *Mandated vs. Motivated Pitfall* would improve this line of research.

Productivity

In theory, the primary advantage of price-cap regulation relative to rate-of-return regulation is to increase production efficiency. Examining the variation in ILEC productivity associated with the choice of regulatory regime is a natural place to search for evidence of this prediction. Two out of the three studies that address productivity find a strong positive relationship, while the third finds a positive, but insignificant impact. Table 3 contains a summary of the evidence regarding telephone company productivity.

Tardiff and Taylor (1993) again provide the jumping off point for research addressing this question. Using the basic model of telephone company performance discussed in the previous section, Tardiff and Taylor examine the impact of incentive regulation (as a whole and by regime) on two dimensions of productivity. The first dimension is total factor productivity (TFP). TFP is a common measure of firm productivity and is defined as the annual growth in the volume of output minus the annual growth in the volume of inputs. The second dimension of productivity they consider is labor productivity. They employ two alternative measures of this dimension: (1) inflation-adjusted compensation per access line and (2) output growth minus labor input growth. The latter measure is known as partial factor productivity (PFP).

TABLE 3
Summary of the Evidence:
The Effect of Price-Cap Regulation on
Local Telephone Company Productivity

Study	Time Period	Conclusion	Potential Pitfalls
Tardiff and Taylor (1993)	1980-1991	Price-cap regulation is associated with positive, but insignificant, impacts on both Total Factor Productivity and Labor Productivity.	Competition Effect
Majumdar (1997)	1998-1993	Price-cap regulation is associated with strong, but lagged, improvements in productivity measured through Data Envelopment Analysis.	Competition Effect Measurement Timing
Roycroft (1999)	1986-1998	The introduction of state price-cap regulation combined with the first federal price-cap plan is associated with improvements in productivity of 5.3 percent and 5.6 percent when combined with the second federal price-cap plan. Individually, state price-cap regulation accounts for a 4.0 percent productivity improvement, the first federal price-cap plan is associated with a 1.3 percent improvement, but the second price cap plan has no significant effect on productivity.	Competition Effect

The results of this research tend to support the theory put forth. Tardiff and Taylor report that the adoption of incentive regulation is associated with improvements in TFP on the order of 2.8 percentage points. Furthermore, they suggest that this finding is attributable to an equal combination of higher output growth and lower input growth. In addition, this research suggests that ILECs facing some form of incentive regulation could produce the same output as ILECs not facing incentive regulation with 6 to 7 percent less labor input. Finally, Tardiff and Taylor report positive, but insignificant, effects on both measures of productivity when the specific kinds of incentive regulation (including price caps) are examined individually.

The results specific to regulatory regime in this early contribution by Tardiff and Taylor may be partially explained by the simplicity of their approach. Majumdar (1997) employs a more sophisticated approach to examine the impact of various forms of incentive regulation (that is, pure price caps, price caps with earnings sharing, and earnings sharing) on the production efficiency of a panel (1988-1993) of 45 local telephone companies. His analysis provides deeper insight about how the specific incentive regulation plans act to influence firm productivity.

Majumdar employs a two-stage approach to answer the question: has the introduction of incentive regulation had an effect on the economic performance of local telephone companies in the United States? In the first stage, he uses a technique called data envelopment analysis (DEA) to generate firm-specific parameters of production

efficiency.[26] From these, firms are scored on a zero-to-one scale (one being the best) ranking the efficiency of each firm relative to both its own potential and the performance of other firms. These scores are then used in the second stage of his research as the dependent variable in a multiple regression analysis aimed at explaining the variation that exists in production efficiency.

Majumdar uses a pooled model to correct for cross-sectional heteroskedasticity and time-wise autoregression to estimate his regression model. The explanatory variables he selects fall into four categories: regulatory effects, technology effects, institutional and environment effects, and firm-level characteristics. A noticeable omission from these explanatory variables is any attempt to control for competition. Therefore, this study may fall prey to the *Competition Effect Pitfall*. He estimates a base-line model that excludes the control variables as well as a model with these variables included.

[26] Data envelopment analysis (DEA) is a linear programming-based technique that converts multiple input and multiple output measures into a single measure of relative performance. A major advantage of this analytical approach is its flexibility. Unlike regression analysis, no assumptions are required about functional form or the nature of the underlying technology used by firms. Instead, the data are allowed to drive the results. In addition, instead of fitting a plane through the center of the data as is done in multiple regression analysis, DEA constructs a piece-wise linear surface to rest on top of the observations in the data. It should be noted, however, that the results of this method are driven by the choice of inputs and outputs and can be sensitive to outliers in the data.

Two additional aspects of this study are worth pointing out. First, Majumdar attempts to disentangle behavioral differences arising from the addition of an earnings-sharing component to price-cap regulation plans. In theory, pure price-cap regulation provides superior incentives to regulated firms than does the hybrid plan. Whether this is true is ultimately an empirical question. Second, Majumdar allows for the possibility of delayed effects of introducing incentive regulation by specifying models with no lags, one-year lags, and two-year lags on the regulation variables.

The results of this study provide strong evidence that firms are responding to the incentives they face. In addition, it is clear that some time is needed before an accurate assessment of the impact of price-cap regulation can be accomplished. Majumdar reports a strong, but lagged, positive impact on productivity from introducing a pure price-cap plan. A more immediate positive impact on productivity is associated with the hybrid price-cap with earnings-sharing plans. However, this impact tends to be smaller than that associated with pure price-cap regulation. Finally, productivity declines are associated with the adoption of a pure earnings-sharing plan. All of these finding are in direct support of the theory of incentive regulation.

The fact that local telephone companies face a two-tiered (federal and state) system of regulation in the United States has been largely ignored in most of the empirical research. Since federal regulation is applied uniformly to local telephone companies, this oversight may not cause a real problem when attempting to isolate the

impact of state-level regulation on telephone company performance, since it is captured by using temporal dummy variables. In addition, this lack of variation creates a practical problem of identifying changes in performance related to federal regulation. When analyzing the variation that exists in telephone company productivity, however, it may be important to consider the impact of changes in federal regulation.

Roycroft (1999) recognizes the need to control for changes in federal and state regulation in his analysis of local telephone company productivity.[27] Using a panel data set comprised of observations from 13 local telephone companies for the years 1986-1998, Roycroft examines the impact on TFP of several combinations of federal and state regulation. The time period selected for his analysis overcomes some of the shortfalls associated with earlier studies of this nature. First, the relatively long time-series (13 years) allows for enough time to pass to accurately measure changes in productivity due to the adoption of various incentive regulation plans. Thus, Roycroft is careful to avoid the

[27] Resende (1999) also recognizes the need to control for regulatory changes at the federal level in his analysis of the impact of incentive regulation on local telephone company productivity. His analysis, however, treats incentive regulation as a general category instead of as individual plans. This is because the main objective of his study is the calculation of a productivity measure appropriate for regulated industries, rather than estimating the impact of various regulatory regimes. Estimation of a translog cost function is required to provide the necessary components to decompose the total factor productivity of 36 local telephone companies for the period 1988-1994. This decomposition allows Resende to properly separate effects attributable to technical change, regulation and scale. He reports positive, but insignificant effects associated with the adoption of price-cap regulation by the FCC for interstate access charges in 1991 and the presence of incentive regulation at the state level.

Measurement Timing Pitfall. Second, a large portion of the data is for the 1990's—the period over which most states adopted price-cap regulation. This makes estimating the impact of price-cap regulation, in particular, feasible. Third, this data set includes observations that both predate and postdate passage of the Telecommunications Act of 1996. Therefore, the results obtained may be more applicable to the environment now in place in the telecommunications industry.

The dependent variable employed in this study is a measure of TFP growth calculated by disaggregating results produced by the FCC's estimation model at the holding company level to the state level. Roycroft creates seven interaction variables to capture the different combinations of state and federal regulation each local telephone company could face during the time period selected. The possible jurisdictional constraints he defines include: state rate-of-return, state price cap, state incentive, federal rate-of-return, federal price cap 1, and federal price cap 2.[28] The possible combinations of regulatory regime in effect during the study include: state rate-of-return/federal rate-of-return,

[28] The distinction between federal price cap 1 and federal price cap 2 is based on differences in the productivity offset and use of earnings sharing. The original 1991 plan set a baseline productivity offset of 3.3 percent and included an earnings-sharing component. However, LECs could select an offset of 4.3 percent in combination with the possibility of keeping more of their profits with superior performance. This plan was modified in 1995 to increase the productivity offsets from which the LECs could choose and allow for more earnings flexibility. In 1997, the productivity offset was increased further to 6.5 percent for all companies and earnings sharing was eliminated. Price cap 1 covers the period 1991-1997, while price cap 2 covers the year 1998. Since the 1995 change was considered a modification to the1991 plan, Roycroft treats it as part of price cap 1.

state rate-of-return/ federal price cap 1, state incentive regulation/federal rate-of-return, state incentive regulation/federal price cap 1, state incentive regulation/federal price cap 2, state price cap/federal price cap 1, and state price cap/federal price cap 2. Since TFP measures are driven by changes in the growth of outputs and inputs, Roycroft also controls for the possibility of unusual output growth due to the increased use of the Internet or from the introduction of local competition and for technology improvements. He also includes a dummy variable to control for potential impacts of passage of the Telecommunications Act of 1996, the possibility of cost shifting at the state level, and effects attributable to the holding company (only Ameritech, Bell Atlantic, and Pacific Telesis are included in the analysis).

Although the variable measuring passage of the 1996 Act may be considered a rule-based measure of competition, it is not at all clear that the this variable acts as a valid measure of competition since in applies uniformly to all markets. In addition, Roycroft does not include a market-based measure of competition to explicitly control for the presence of local toll or local competition in his analysis. This may cause the results to be susceptible to the *Competition Effect Pitfall*. Therefore, the results of this study should be interpreted with caution given that competition was present in both local toll and local markets for the most recent portion of the time period under investigation.

Roycroft employs a cross-sectionally correlated and time-wise autoregressive model to estimate the panel data in his analysis.

Relative to the periods when both state and federal rate-of-return plans were in place, the results of this analysis suggest that introducing price-cap regulation at both the federal and state level have led to significant improvements in productivity. The introduction of state price-cap regulation combined with the first federal price-cap plan generate improvements in productivity on the order of 5.3 percent and combined with the second federal price-cap plan generate improvements in productivity on the order of 5.6 percent. In addition, state rate-of-return plans coupled with the first federal plan generate a 1.3 percent increase in productivity relative to rate-of-return regulation at both levels of jurisdiction.

Roycroft also reports estimates from additional regressions designed to explore the impact on productivity of state price-cap (and incentive) regulation while the first federal price-cap plan was in effect and to assess the impact of introducing the second federal price-cap plan. The results indicate that the introduction of state price-cap regulation during the first federal price-cap plan led to 4.0 percent increases in productivity. Interestingly, no significant effect on productivity is attributed to changing the federal price-cap plan in 1997.

Based on the existing research, it appears that the theoretical predictions about firm performance under price-cap regulation have been realized as measured by this important dimension of performance. However, it has not yet been determined if these changes are short run demonstration effects or long run improvements in efficiency. Only additional research benefitting from the passage of time can address this shortfall.

Network Modernization

The United States telecommunications industry has witnessed rapid technological innovation since the AT&T divestiture. The rate at which the diffusion of this new technology occurs contributes to the modernization of the existing network and to overall social welfare. This fact makes achieving an economically efficient level of investment in modern infrastructure an important issue for public policy. Theoretically, the incentives created under traditional cost-plus regulation are not conducive to such risky investment since the corresponding reward is truncated at an allowed rate of return. A natural question to ask, then, is whether the adoption of price-cap regulation has led to higher rates of modern infrastructure investment.

The most common measures of network modernization include investment in new switching technologies (such as, digital stored program control (DSPC) switches), investment in new network technologies (like, Signaling System 7 (SS7) and integrated services digital network (ISDN)), and investment in new transmission technologies (for example, fiber-optic cable). DSPC is a modern switching technology that supports advanced network services (including, call waiting, caller ID, or variable ringing patterns) and provides for increased network reliability. SS7 is a modern signaling technology that allows for more efficient use of the network by creating two channels within a single line. It is designed to support ISDN and other advanced network services. ISDN is a technology that integrates voice, data, text and video on a

single network providing all-digital, end-to-end connectivity. Fiber-optic cable is a high speed transmission mechanism that serves as a high quality alternative to traditional copper wire lines. Many industry observers consider fiber optics the building block of an all-digital network. A summary of the evidence related to network modernization is contained in Table 4.

Taylor, Zarkadas and Zona (1992) were the first to study the relationship between regulatory environment and the diffusion of new technology in the United States telecommunications industry. They analyze the period 1980-1994 using industry-wide data for 21 local telephone companies that were at one time part of the Bell system. The data set consists of both actual (1980-1989) and company estimated (1990-1994) levels of modern infrastructure investment. While these estimates can reasonably be interpreted as planned levels of investment, no one could accurately predict the changes that would occur on the regulatory side of the equation during this time period. In addition, since the estimates are from the company itself, both the Demonstration Effect Pitfall and *Sequencing Pitfall* may be present. Therefore, some caution should be used when interpreting the results of this study.

A pooled time-series cross-sectional model is estimated with the dependent variable set as the ratio of new technology to old technology for access lines connected to digital switching facilities, access lines from which SS7 and ISDN services can be provided, and for fiber-optics transmission. The control variables used in this analysis are limited to

TABLE 4
Summary of the Evidence: The Effect of
Price-Cap Regulation on Network Modernization

Study	Time Period	Conclusion	Potential Pitfalls
Taylor, Zarkadas and Zona (1992)	1980-1989	No significant impact on network modernization attributable to price-cap regulation. However, incentive regulation in general is associated with accelerated deployment of digital switching, fiber optics, ISDN and SS7.	Demonstration Effect Sequencing Effect Mandated-Motivated Effect Classification Effect
Tardiff and Taylor (1993)	1980-1991	Price-cap regulation is associated with less investment in digital switching and SS7, but not with ISDN or fiber optics.	Competition Effect
Greenstein, McMaster and Spiller (1995)	1987-1991 (for fiber optics) 1989-1991 (for digital switching, ISDN and SS7)	Pure price-cap regulation increases long-run deployment of fiber-optic cable 100 percent and increases the deployment of fiber-optic cable, ISDN, and SS7 by more than 100 percent over a base year. These effects are greatly reduced when price-cap regulation is combined with an earnings sharing component.	Measurement Timing Mandated-Motivated Effect
Ai and Sappington (1998)	1992-1996	Price-cap regulation is associated with 3.3 percent more network lines served by DSPC switches, 7.4 percent more lines served by ISDN technology, and 0.31 percent more lines that are fiber optic.	Measurement Timing Mandated-Motivated Effect

firm and time-specific dummy variables, a dummy variable indicating whether facilities-based local toll competition is permitted, a dummy variable indicating whether reseller-based competition is permitted, and a set of dummy variables corresponding to the method of regulation in place. Therefore, an attempt is made to correct for the *Competition Effect Pitfall*. The effect of incentive regulation in general and each form of incentive regulation on network modernization are analyzed.[29]

The results of this study provide evidence to support the proposition that the adoption of incentive regulation significantly improves the rate of diffusion of modern infrastructure. They report that the adoption of any form of incentive regulation is associated with an 11-month acceleration in the deployment of digital switching and fiber-optic transmission and a 5-month acceleration in the deployment of ISDN and SS7 technologies. In addition, the authors suggest that this acceleration will increase over time. No significant effect on network modernization is attributed to the adoption of price-cap regulation in particular. This lack of association is likely due to the fact that price-cap regulation was not widely used at the state level at the time this paper was written. They do, however, report significantly higher rates of infrastructure deployment in all areas of network modernization for firms facing flexible pricing or banded rate-of-return regulation. Finally, these results are

[29] Taylor, Zarkadas and Zona define incentive regulation to mean any deviation from traditional rate-of-return regulation. They specify six categories of regulatory reform that include banded rate-of-return, earnings sharing, flexible pricing, indexed price caps, social contracts and deregulation.

robust to specifications containing controls for the introduction of local toll competition.

Tardiff and Taylor (1993) update the study of network modernization conducted by Taylor, Zarkadas and Zona by using more recent information to classify regulatory regimes and introducing a new definition of regulatory reform that specifically focuses on profit incentives. Rather than categorizing any deviation away from traditional rate-of-return regulation as an incentive regulation plan, Tardiff and Taylor include only plans that directly affect the earnings of the firm. They find no significant effects on any measure of modern infrastructure investment associated with this newly defined general incentive regulation variable. This finding highlights the consequences of the *Classification Effect Pitfall* and should be considered an interesting contribution of this study. In contrast to the original study, however, Tardiff and Taylor find a *negative* relationship between the adoption of price-cap regulation and investment in digital switching and SS7 technology. However, the small number of price-cap states at the time of their study suggests that these findings may not be robust.

The most detailed and thorough investigation of this dimension of performance was conducted by Greenstein, McMaster and Spiller (1995). The distinguishing feature of this research is the unit of observation selected. Due in large part to data availability, prior research focused on corporate-level infrastructure investment. Greenstein, McMaster and Spiller's research differs in that it relates ILEC-specific investment patterns to ILEC-specific regulatory,

demographic, and economic characteristics. This approach permits more accurate isolation of the effect of state regulation on network modernization. In addition, their data set includes observations from 101 major local telephone companies (that is, all of the RBOCs, GTE, SNET, Rochester Telephone, Contel and United), making it the most comprehensive collection of data that has been assembled.

The time period analyzed depends on the measure of network modernization employed. The time period 1986-1991 is used for their analysis of the deployment of fiber-optic cable. Unfortunately, accurate data at the unit of observation they select for the other measures of infrastructure investment start in 1989. Therefore, the time period 1989-1991 is used for their analysis of the deployment of DSPC switches, ISDN, and SS7 technology. This is quite a short time period since decisions regarding infrastructure investment are likely to be long-run in nature. Thus, one should be careful to interpret this research with the *Measurement Timing Pitfall* in mind.

Greenstein, McMaster and Spiller relate these dependent variables to a complete specification of explanatory variables. These variables can be grouped into the following categories with the actual variables in parentheses: state incentive regulation (price-cap regulation, price freezes, and earnings-sharing plans are compared), general regulatory and competitive environment, economic/demographic characteristics, and holding company effects (dummy variables for each RBOC and GTE is included). Recognizing the potential bias that might be created from doing so, Greenstein, McMaster and Spiller decide to

treat the choice of regulatory regime as exogenous—arguing that, in the presence of high quality control variables, behavioral endogeneity is not inconsistent with statistical exogeneity.

With this rich data set, Greenstein, McMaster and Spiller specify two econometric models to explain the deployment of modern infrastructure.[30] The first model is a partial adjustment model which assumes the current level of investment is a weighted average of the long-run desired level and a lagged value. This approach allows one to make statements regarding the long-run stock level of infrastructure across ILECs. However, since a relatively long time-series is needed to accurately estimate such a model, it is estimated only for the deployment of fiber-optic cable. The results of this portion of their analysis suggest that adopting price-cap regulation would have increased the long-run deployment of fiber-optic cable by 100 percent, whereas price-cap regulation combined with an earnings-sharing component removes the incentive to deploy fiber-optic cable.

The second model is a baseline growth model that produces estimates for the effect of individual regressors on changes in infrastructure deployment from a specified base year. This approach allows one to make statements regarding the stock level over the base year within ILECs. The base year of 1987 is used for fiber optics, and

[30] Where appropriate, Greenstein, McMaster and Spiller use a TOBIT procedure to estimate these models. This procedure corrects for the potential truncation of the error term that is caused by using data with a large number of dependent variables having the value of zero. This was the case for ISDN and SS7 in their analysis.

the base year of 1989 is used for digital switching, ISDN and SS7. They find that pure price-cap regulation increases the deployment of fiber-optic cable , ISDN, and SS7 by more than 100 percent over the base year. This effect is significantly reduced when the price-cap variable is interacted with the earnings-sharing variable for the case of fiber optic deployment and is not changed for ISDN or SS7 deployment. No significant effect from price-cap regulation is attributed to the deployment of DSPC switches.

These important findings raises questions about the merits of combining these two popular forms of incentive regulation. However, before concluding that hybrid regulation is a failure, it is important to understand the goal of using such a plan. Jumping to this conclusion without such an understanding would be falling prey to the *Uni-Dimensional Yardstick Pitfall*.

Ai and Sappington (1998) provide the most recent study of the determinants of network modernization in the telecommunications industry. As did Greenstein, McMaster and Spiller, they employ a partial adjustment model to estimate RBOC investment data for the years 1992-1996. This partial adjustment model allows for the likely possibility that the observed level of network modernization is actually a weighted average of the current and desired level of infrastructure investment in a specific year.

Several measures of the level of network modernization are introduced as dependent variables in this analysis. These include the percentage of DSPC and ISDN switches in an RBOC's state network,

the percentage of access lines in an RBOC's state network served by DSPC and ISDN, and the percentage of total sheath kilometers of fiber optic cable in an RBOC's state network. Ai and Sappington do not include any measure of SS7 deployment since it was "effectively mandated" by federal regulation during the time period studied. The explanatory variables include those in the basic model (described earlier) plus a variable to control for deviations in observed investment caused by selling portions of an RBOC's local network.

All three forms of incentive regulation investigated (price caps, earnings sharing, and rate case moratoria) are associated with higher levels of network modernization. Price-cap regulation is associated with 3.3 percent increase in network lines served by DSPC switches, a 7.4 percent increase in network lines served by ISDN technology, and a 0.31 percent increase in network lines that are fiber optic. This last percentage change may seem small, but it translates into almost 300 more kilometers of fiber optic cable deployment per year. As reported in Greenstein, McMaster and Spiller, no significant relationship is reported for price-cap regulation and the deployment of modern switches. However, this may just reflect the efficiency of new technology being introduced.

In combination, the research reviewed here appears to suggest that providing regulated firms with more earnings flexibility will lead to increased levels of network modernization. This relationship is indeed encouraging. However, as mentioned earlier, it is often the case that up-front agreements regarding the level of infrastructure investment are

struck between the firm and regulator before the firm is permitted its desired method of regulation. Therefore, it is not clear whether the effects shown above are attributable in full to the incentives created under new forms of regulation. Failing to control for this possibility is a clear case of the *Mandated vs. Motivated Pitfall*. Future research on this dimension of performance should attempt to differentiate investment behavior based on this important distinction.

Financial Performance

Price-cap regulation presents a drastically different set of incentives to regulated firms than does traditional rate-of-return regulation. In particular, this form of regulation is thought to enhance incentives to reduce operating costs and increase earnings.[31] Therefore, one should expect to observe systematic differences in financial performance for regulated firms that have switched to price-cap regulation. However, one must also consider the likelihood of the *Demonstration Effect Pitfall* in this area of performance since firms enjoying the earnings freedom associated with price-cap regulation may look for ways to hide superior financial performance from regulators. Possible measures of firm financial performance include costs,

[31] In the short run, however, firm financial performance may decrease if it is devoting resources to network modernization or improvements in service quality.

revenues, and profits. Table 5 contains a summary of the evidence regarding firm financial performance.

Major incumbent telephone companies are required to report information about their operating costs and operating revenues to the FCC. From this information, it is possible to compute a measure of profit. However, it is well known from the industrial organization literature that many difficulties arise when using measures of financial performance

TABLE 5
Summary of the Evidence:
The Effect of Price-Cap Regulation on
the Financial Performance of Local Telephone Companies

Study	Time Period	Conclusion	Potential Pitfalls
Tardiff and Taylor (1993)	1984-1990	No meaningful impact of price-cap regulation on any dimension of financial performance considered: net income, total operating revenues, or net revenues.	Demonstration Effect
Ai and Sappington (1998)	1992-1996	Price-cap regulation is associated with 16.1 percent higher profits per line, but no relationship found regarding revenue per line, cost per line, or investment per line.	Demonstration Effect

derived from industry accounting records.[32] For example, differences in accounting practices between firms within the telecommunications industry may make comparisons of this nature meaningless. More importantly, however, is the fundamental problem that accounting profits are not equivalent to economic profits since opportunity cost is not taken into consideration. With these concerns noted, it is still interesting and informative to consider whether the adoption of price-cap regulation varies systematically with the available measures of financial performance.

Tardiff and Taylor (1993) analyze the variation in financial performance that exists among RBOCs for the years 1984-1990. They choose net income, total operating revenues and net revenue (revenues minus expenses) as their measures of financial performance. This portion of their comprehensive analysis is conducted at the holding company level. Since the operations of these holding companies span state boundaries, it is likely that a holding company faces many different forms of regulation. To address this problem, Tardiff and Taylor design a regulatory variable weighted by the number of lines served under a specific regulatory regime and add the total number of lines as a variable in their basic model to control for any scale effect that might result. Although they find a negative impact on revenues associated with the adoption of incentive regulation, they are not able to demonstrate any meaningful effect associated with the adoption of price-cap regulation on

[32] See Schmalensee (1989) for more detail regarding the use of accounting data in studies of industry structure, conduct, and performance.

any dimension of RBOC financial performance. Recall, however, that very few states had selected price-cap regulation during the time period under investigation.

The only other research to address the overall financial performance of telephone companies under alternative regulation is Ai and Sappington (1998).[33] They select revenue per line, cost per line, profit per line (calculated by subtracting cost per line from revenue per line), and total investment in telecommunications plant per line as their measures of financial performance. Over the time period 1992-1996, they find 16.1 percent higher profits per line associated with the adoption of price-cap regulation, but find no systematic relationship between revenue, operating costs or telecommunications plant investment associated with the choice of regulatory regime or amount of competition.

At a minimum, telephone companies under price-cap regulation appear to be performing no worse financially than telephone companies under other forms of regulation. However, the fact that researchers have not been able to show a more profound effect on financial performance associated with price-cap regulation is somewhat surprising and warrants further investigation. Developing measures of financial

[33] Shin and Ying (1993) provide the only known study devoted solely to examining the impact of incentive regulation on the operating costs of local telephone companies. Through simulation analysis, they find small discrete increases in operating costs associated with the adoption of price-cap regulation. A full discussion of their study is not warranted due to the preliminary nature of their findings. However, a more complete discussion of this research is provided in Kridel, Sappington and Weisman (1996).

performance that more accurately reflect economic theory, simply adding data from more recent time periods, and controlling for the likelihood of a demonstration effect are all directions for future research.

Service Quality

Service quality degradation is a common concern among regulators considering the use of price-cap regulation for their incumbent local telephone companies. This fear arises for two reasons. First, many believe that rate-of-return regulation provides a perverse incentive to produce an inefficiently high level of service quality since it is cost-plus in nature. Replacing this method of regulation with one designed to mimic a competitive marketplace naturally leads to lower service quality. Second, it is believed that a regulated firm could increase short-run profits by reducing operating costs through decreases in service quality while maintaining the regulated price. This is especially true in a market structure offering very little in the way of choice to consumers. Therefore, an important question for empirical analysis is the impact of price-cap regulation on service quality.[34] However, very little empirical research has been conducted addressing this important question. The

[34] It is worth noting that observing lower levels of service quality associated with price-cap regulation does not necessarily mean social welfare has been harmed. First, if rate-of-return regulation does produce inefficiently high levels of service quality, a reduction may actually be welfare enhancing. Second, if the reduction in service quality is associated with lower operating costs and prices, social welfare may actually improve.

most likely reason is the difficulty in devising sound measures of service quality suitable for empirical research. Table 6 contains a summary of the evidence related to service quality.

Tardiff and Taylor (1993) again provide the first attempt to quantify the relationship between the adoption of various forms of incentive regulation and service quality. They investigate whether states with incentive regulation have different levels of service quality relative to those without and whether explicit quality standards make a difference in performance.

TABLE 6
Summary of the Evidence:
The Effect of Price-Cap Regulation on
Service Quality

Study	Time Period	Conclusion	Potential Pitfalls
Tardiff and Taylor (1993)	1990	Service quality no worse in states with incentive regulation (including price caps) than without.	Demonstration Effect Measurement Timing Classification Effect
Ai and Sappington (1998)	1992-1996	Price-cap regulation is associated with fewer complaints about service quality, but longer repair times.	Demonstration Effect

The measure of service quality used in this research is an index developed by Mercer Management Consulting that summarizes telephone company service quality performance based on several measures important to regulators. They include installation commitments met, average missed installations, initial trouble reports, repeat trouble reports, switch downtime, customer complaints to regulators, and overall customer satisfaction. The states were then divided into three categories: states with incentive regulation plans having quality standards, states with incentive regulation plans that are absent quality standards, and states without incentive regulation. Thus, this categorization may suffer from the *Classification Effect Pitfall* since differences across regulatory regimes are likely to be masked.

Comparisons were made across these classifications for the year 1990. Overall, Tardiff and Taylor report that companies in states with incentive regulation plans absent any service quality component perform no worse than companies in states without incentive regulation. Based on the service quality index developed by Mercer Management Company, the regulator's concern about declining quality does not seem to hold. Of course, the *Measurement Timing Pitfall* may be in effect here.

However, to add confidence to Tardiff and Taylor's conclusion some modifications to the study are necessary. For example, it would be straightforward to control for other factors that could lead to variation in service quality. Doing so would be an obvious direction for improvement. In addition, a useful extension would be to examine how

each dimension of service quality used to compute the overall index changes with the adoption of incentive regulation. On a similar note, focusing the analysis on specific forms of incentive regulation might reveal some interesting patterns masked by aggregating each regulatory regime into one group. This is especially important today given the recent trend toward adopting price-cap regulation.

Ai and Sappington (1998) attempt to implement each of these improvements in their update to the original study by Tardiff and Taylor. The specific measures of service quality they investigate include the percentage of commitments to install new telephone service that were met before a specified deadline, the average number of business days between the time an order to install new service is placed and the time the order is completed, the number of trouble reports made to the local telephone company, the average number of hours required to correct these reported problems, and the number of service quality complaints filed with the state public utility commission. For each of these measures of service quality, a separate analysis was conducted for residential and business customers.

One factor that may also partially explain the variation in service quality in the local telephone industry is the modernization of the telephone network in place. Ai and Sappington add a variable to their basic specification to control for this possibility. This variable is defined as the fraction of RBOC access lines that were served by digital switches lagged two years. The analysis was conducted for the years 1992 and 1996 for all of the service quality variables other than the time required

to correct a problem. For this measure, data were available only for the time period 1995-1996. So the *Measurement Timing Pitfall* may apply to results for this measure of service quality.

The results obtained from this analysis are best characterized as mixed. Ai and Sappington find that it takes, on average, five hours longer to resolve trouble reports by residential consumers in states with price-cap regulation than in states with rate-of-return regulation. Similar findings are also reported for both earnings-sharing plans and rate case moratoria. However, the number of complaints per access line decline by 29.9 percent for residential customers and 44.3 percent for business customers in states adopting price-cap regulation relative to those states with rate-of-return regulation. Again, this pattern holds for the other forms of incentive regulation analyzed in this study. Therefore, more research in this area is warranted.

No definitive conclusion regarding the impact of price-cap regulation on service quality can be made at this time. On a positive note, this lack of consensus suggests that the sudden fallout in service quality predicted by theory has yet to materialize. Nonetheless, room for improvement along this dimension of performance exists.

The Development of Competition in Local Telephone Markets

The explicit regulatory barriers to entry that acted to shield incumbent local exchange carriers from competitive entry to their markets have now been removed by the Telecommunications Act of

1996. Indeed, this industry once served solely by regulated monopoly providers of local telephone services has now been transformed into an industry consisting of incumbent dominant firms (ILECs) facing entry by fringe competitors (CLECs). Nonetheless, many have been critical of the pace at which competition has progressed in the last miles of the United States telecommunications industry. An important question to investigate, then, is what has determined the development (or lack thereof) of competition in local telephone markets? Furthermore, it is important to understand how state-level policies have influenced the natural progression unleashed by this federal legislation.

Lehman and Weisman (2000) provide the first hint that the development of competition in the local telephone industry can by influenced by the choice of state-level regulation by investigating the variation in arbitrated interconnection prices in states with and without price-cap regulation. Prior to 1996, state regulators could explicitly control the amount of competition within their jurisdictions by deciding whether or not to allow competitive entry. Of course, passage of the Telecommuni-cations Act of 1996 removed this option from a state regulator's decision set. However, the Act does empower state regulators to set the interconnection prices for unbundled network elements sold to new entrants if arbitration is required. Thus, while state regulators can no longer explicitly control the amount of entry within their jurisdiction, they can do so implicitly by influencing the cost of entry through the terms and conditions of interconnection (that is, setting higher interconnection prices creates higher barriers-to-entry and vice versa).

Lehman and Weisman consider 36 completed and distinct arbitration decisions for the RBOCs from 34 states through mid-1997. Thus, one must be aware of the *Measurement Timing Pitfall*. They regress the average unbundled loop rate on a proxy value suggested by the FCC, the ratio of business to residential local telephone prices, a dummy variable indicating whether the state commissioners are elected or appointed, and a dummy variable signifying the presence of price-cap regulation.

Overall, the specified empirical model performs well, explaining a great deal of the variation in arbitrated interconnection prices. In addition, all of the included explanatory variables are of the expected sign. Of particular interest here, the authors find that the interconnection prices determined through arbitration are set significantly lower when price-cap regulation has been adopted in a state than otherwise.[35] This evidence leads Lehman and Weisman to conclude that price-cap regulation, as it is currently designed, amounts to an incomplete contract between state regulators and telecommunications firms. In other words, they argue that regulators can circumvent their price-cap commitment by setting an artificially low price floor for wholesale prices which induces excessive competitive entry relative to the theoretically efficient level.[36]

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[35] Similar results are reported from a regression with the arbitration results measured in relation to embedded cost.

[36] See Abel and Witkind-Davis (2000) for a complete discussion of how distorted wholesale prices can influence the development of competition in the local telephone industry.

This study improves our understanding of price-cap regulation and demonstrates one potential flaw in the design of this popular form of regulation that without design modifications in the future, would only be exacerbated as competition continues to develop in this nascent competitive industry.

Abel (1999b) provides the first empirical examination of the actual pattern of entry observed in the local telephone industry since passage of the Telecommunications Act of 1996.[37] Using the dominant firm-competitive fringe framework developed in Abel (1999a), he seeks to explain the amount of net fringe entry and cumulative fringe size facing incumbent dominant firms in local telephone markets. His results indicate that new firms seeking entry into local telephone markets have responded to the distortions created by economic regulation.

To conduct the analysis, Abel develops a panel data set for the time period 1994-1997 using LATAs as the unit of observation. To account for the fact that some state commissions did not permit entry to their local telephone markets before passage of the Act, some observations are omitted for the 1994-1995 time period. Given that the development of competition is a relatively recent phenomenon, this analysis should be thought of as one that captures the very beginning of the competitive transition now underway. However, one could also argue that this study may fall prey to a *Measurement Timing Pitfall* since

[37] See Abel and Clements (1999) and Zolnierek, Eisner and Burton (1999) for related studies examining the determinants of entry in local telephone markets.

it captures only the very beginning of what is likely to be a lengthy transition to a more competitive market structure. On a positive note, this study likely avoids the *Aggregation Effect Pitfall* since LATAs (rather than states) provide a more accurate representation of local telephone markets.

To handle the panel nature of his data, Abel uses a fixed-effects model to estimate a set of reduced-form equations. He specifies two empirical models is the analysis. The dependent variable in the first model is the number of new entrants entering a local telephone market during each year. The dependent variable for the second model is the cumulative size of the competitive fringe developing in a local telephone market during each year. The explanatory variables employed are the same in each empirical model. They include a binary variable indicating the presence of price-cap regulation, a vector of variables measuring the profit opportunities available to a new entrant (both profit level per line and the change in profit level per line), a vector of demand variables, a vector of cost variables, and a vector of political environment variables.

On a reassuring note, the results of this analysis suggest that the demand and cost characteristics of local telephone markets are important determinants of the entry decision of facilities-based competitors. This finding confirms what most industry observers have believed all along about the determinants of local telephone competition. However, his analysis also uncovers a surprising relationship between the choice of regulation and development of competition in the United States local telephone industry. Abel reports that the presence of price-

cap regulation in a local telephone market is associated with almost 60 percent less net fringe entry and competitive fringes that are nearly 40 percent smaller than in local telephone markets with other forms of regulation.

Readers should be careful to avoid the *Causality Pitfall* when interpreting the results of this study. Empirical research does not identify the cause of the regularity discovered, it only identifies that correlation in the data exists. There are at least two explanations for this finding based on the theory motivating the empirical research. First, it is likely that the added flexibility afforded to ILECs facing price-cap regulation has allowed them to better prepare for and react to challenges by new entrants through their pricing strategies. Second, the lower retail prices associated with adopting price-cap regulation have muted the incentive to enter markets having this kind of regulation. This explanation emphasizes the importance of considering the second-order effect of adopting price controls. While price caps have succeeded in lowering prices (a first-order effect), this has led to smaller competitive fringes (a second-order effect).[38] Notice, however, both of the explanations put forth to reconcile the empirical evidence rely on more than just the presence of price-cap regulation. Future research attempting to provide a better understanding of the relationship between the incentives created under price-cap regulation and the development of competition

[38] The logic of this argument is similar to the logic put forth for binding price controls in general. For example, binding price ceilings on gasoline keep prices low, but also lead to shortages. Thus, the benefits of the first-order effect are outweighed by the harm caused by the second-order effect.

would be very useful in light of the current trends witnessed in the local telephone industry.

There is little doubt that the introduction of competition to this industry will fundamentally change the design (and perhaps necessity) of the regulation used. Recall that price-cap regulation was originally designed to provide competitive incentives to regulated monopoly firms under the assumption that competition was not feasible. As described above and summarized in Table 7, the current implementation of price-cap regulation, whether directly or indirectly, is having an impact on the structural evolution of the local telephone industry. Now that the industry structure has changed, so too will the design of the regulation used.

CONCLUDING COMMENTS

The empirical research put forth to date suggests that the United States telecommunications industry has responded, for the most part, favorably to the incentives created through price-cap regulation. Using unique and original data, empirical researchers have been able to identify behavioral responses arising from differences in regulation along an impressive array of performance measures. Equally impressive is the fact that the majority of these measured behavioral responses are consistent with economic theory.

Under price-cap regulation, telephone prices have either fallen or remained the same, productivity has generally increased, modern

TABLE 7
Summary of the Evidence:
The Effect of Price-Cap Regulation on
the Development of Local Telephone Competition

Study	Time Period	Conclusion	Potential Pitfalls
Lehman and Weisman (2000)	1996-1997	Arbitrated interconnection prices are set significantly lower in price-cap states than rate-of-return states, making the current design of price-cap regulation equivalent to an incomplete contract.	Measurement Timing
Abel (1999b)	1994-1997	Local telephone markets with tightly binding price-cap regulation have witnessed 60 percent less net fringe entry and contain 40 percent smaller competitive fringes than markets with less stringent regulation.	Measurement Timing Causality

infrastructure has been deployed at a more rapid pace, and firms have performed at least as well financially relative to the other methods of regulation available. The results for service quality are best characterized as mixed; and it appears that price-cap regulation, as it is currently implemented, has influenced the development of competition in the local telephone industry.

In addition, the evidence so far suggests that the response has been more pronounced under pure price-cap regulation compared to hybrid plans having an earnings-sharing component. This result is particularly true along the productivity and network modernization dimensions. Therefore, the existing evidence suggests that it is likely that the introduction of price-cap regulation in the United States telecommunications industry has produced benefits to consumers, producers, and regulators alike.

Of course, new, improved research is required before a complete understanding of the impact of price-cap regulation can be gained. Given the relatively recent trend toward price-cap regulation in this industry, simply having more recent data to analyze will lead to improved research in this area. In addition, controlling for the potential endogeneity of price-cap regulation, using measures other than dummy variables to represent price-cap regulation, and controlling for the mandated components of price-cap plans may prove to be interesting.

The increased presence of competition in this industry provides the most fruitful direction for new research. First, future empirical research should be motivated by models of market structure that combine both price-cap regulation and competition. Doing so will improve the design and interpretation of this research. Second, as competition develops, superior market-based measures should be developed to control for its effects. Thus, future research of this nature will be able to more precisely identify the contribution of price-cap regulation to observed behavior. Finally, the influence on the

development of competition caused by the behavioral responses created by the incentives that exist under this popular form of regulation is not well understood. Therefore, it may prove interesting to explore this line of research. Fortunately, the current stock of empirical research provides a solid foundation from which future scholars can build and future regulators can learn.

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