PRICE REGULATION AND INCENTIVES*

by

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1. Introduction.

The telecommunications industry has undergone dramatic changes in recent years. New products, new services, and new technologies have been introduced. The costs and the prices of many telecommunications services have also changed substantially. And a variety of new telecommunications suppliers have begun to operate in the industry. In part in response to these changes, regulatory policy in the telecommunications industry has also changed substantially in recent years. Most notably, various alternatives to rate of return regulation have been implemented in many jurisdictions. Relative to rate of return regulation, these alternatives generally focus more on controlling the prices charged by the regulated firm than on controlling its earnings. The precise manner in which prices are controlled varies with the particular alternative that is implemented. These alternatives to rate of return regulation will be referred to as incentive regulation throughout this chapter.[1]

This chapter has three primary purposes: (1) to review the variety of incentive regulation plans that have become more popular in the telecommunications industry in recent years; (2) to assess the potential advantages and disadvantages of these regulatory regimes; and (3) to examine the impact that these regimes have had on the industry.

These issues are explored as follows.[2] Section 2 describes the primary forms of incentive regulation that have been employed in telecommunications industries throughout the world. Section 3 examines the extent to which these alternatives have been implemented in practice. Section 4 reviews the primary advantages and disadvantages of incentive regulation in general. Section 5

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1. Sappington (1994) provides an alternative definition of incentive regulation, and stresses that rate of return regulation, like its alternatives, provides meaningful incentives to the regulated firm.

2. The influence of Sappington and Weisman (1996a) and Bernstein et al. (1996), and thus my coauthors, on the ensuing discussion will be apparent. Their many insights are greatly appreciated.

explores the merits and drawbacks of a primary alternative to rate of return regulation – pure price cap regulation – and examines how it is implemented in practice. Some common modifications of pure price cap regulation are considered in section 6. Section 7 analyzes the measured impact of incentive regulation on performance in telecommunications markets. Conclusions are drawn in section 8.

Because the ensuing discussion focuses on regulatory plans that have been employed in the telecommunications in recent years, it does not offer a comprehensive review of the entire economics literature on incentive regulation.[3] The ensuing discussion also devotes little attention to the important issues of interconnection and access pricing, as these issues are the subject of another chapter in this volume (Armstrong, 2001). Every attempt has been made to provide a comprehensive review of analyses of popular incentive regulation plans, especially price cap regulation. Despite the best of intentions, it is likely that some important relevant works have not been afforded the coverage they deserve. Fortunately, there are now a variety of sources that offer useful and distinct perspectives on incentive regulation.[4] The interested reader is encouraged to read these other sources and the references they provide.

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3. Reviews of the theoretical literature on incentive regulation can be found in Besanko and Sappington (1987), Caillaud et al. (1988), Baron (1989), Laffont and Tirole (1993, 2000), Laffont (1994), and Armstrong and Sappington (2001).

4. These sources include Joskow and Schmalensee (1986), Sappington and Stiglitz (1987), Vickers and Yarrow (1988), Acton and Vogelsang (1989), Beesley and Littlechild (1989), Hillman and Braeutigam (1989), Mitchell and Vogelsang (1991), Train (1991), Armstrong et al. (1994), Blackmon (1994), Brock (1994), Laffont (1994), Crandall and Waverman (1995), Mansell and Church (1995), Crew and Kleindorfer (1996a), Newbery (1999), and Wolfstetter (1999).

2. Forms of Incentive Regulation.

Many alternatives to rate of return regulation are employed in telecommunications industries throughout the world. This section describes the primary alternatives that have been employed in recent years, referring to these alternatives as *incentive regulation*.

2.1. Banded Rate of Return Regulation.

Under banded rate of return regulation, the firm is permitted to keep all of the earnings it generates, provided the earnings constitute a return on capital that is sufficiently close to a specified target rate of return. If realized earnings exceed the maximum authorized level of earnings, the difference between actual and authorized earnings is returned to customers. If realized earnings fall short of the minimum level of acceptable earnings, the firm's prices are raised sufficiently to ensure that projected earnings fall within the band of authorized earnings. Banded rate of return regulation was employed to regulate the intrastate earnings of Chesapeake and Potomac Telephone in Virginia (in the United States) in 1993.

A typical banded rate of return plan is illustrated in Figure 1. The firm's target rate of return is 12% under the plan. The firm retains all of the earnings it generates as long as they constitute a rate of return on capital between 11% and 13%. The firm is not permitted to retain any earnings in excess of 13%, and it is protected against earnings below 11%.

2.2. Earnings Sharing Regulation.

Earnings sharing regulation (sometimes called sliding scale regulation or profit sharing regulation) allows for explicit sharing of realized earnings between the regulated firm and its customers. Earnings sharing regulation has been employed throughout much of the 1990s to govern intrastate telecommunications earnings in California and New Jersey in the United States, for example. The U.S. Federal Commission has also employed earnings sharing regulation to control the earnings that local exchange carriers derive from providing interexchange (long distance) carriers

with access to local networks.

A typical earnings sharing plan is illustrated in Figure 2. The target rate of return is 12%. The firm is authorized to keep all earnings that constitute a rate of return between 10% and 14%. The firm retains half of all incremental earnings between 14% and 16%. The other half of these incremental earnings are awarded to the firm's customers, usually in the form of direct cash payments or lower prices. The firm is not permitted to retain any earnings that constitute a rate of return in excess of 16%. Any such earnings are awarded entirely to the firm's customers.

Just as the firm shares incremental earnings between 14 and 16% with customers under the plan in Figure 2, it also shares with customers reductions in profit when realized earnings constitute a rate of return between 8 and 10%. As realized earnings decline by one dollar in this range, the firm loses only fifty cents. The other fifty cents is paid by customers, usually in the form of higher prices. If realized earnings fall below 8%, customers bear the full brunt of the shortfall, as prices are increased to restore earnings to a level that generates a return of at least 8%.

A comparison of Figures 1 and 2 reveals that earnings sharing regulation is similar to banded rate of return of regulation for realized returns that are close to or far from the target rate of return. For intermediate returns, the firm must share incremental realized earnings with its customers under earnings sharing regulation. This sharing is the distinguishing feature of earnings sharing regulation.

2.3. Revenue Sharing Regulation.

Revenue sharing regulation requires the firm to share with its customers revenues (not earnings) that exceed a specified threshold. Revenue sharing regulation was implemented in the telecommunications industry in the state of Oregon between 1992 and 1996. A typical revenue sharing plan is illustrated in Figure 3. The plan allows the firm to keep all of the revenues it generates, as long as average revenue per access line does not exceed $50. Once revenue per access line exceeds the $50 threshold, the firm is required to share with its customers half of the incremental

revenues that it generates.

2.4. Rate Case Moratoria.

Rate case moratoria are essentially agreements to suspend investigations of the regulated firm's earnings and any associated restructuring of prices to return the firm's projected earnings to target levels. The length of a rate case moratorium is usually specified in advance, and is typically in the range of two to five years. Rate case moratoria have been imposed in the telecommunications industry in many states in the U.S., including Kansas and Vermont.

2.5. Price Cap Regulation.

Price cap regulation places limits on the prices that a regulated firm can charge, but, at least in principle, does not link these limits directly to the firm's realized earnings. Thus, in comparison with banded rate of return regulation and earnings sharing regulation, regulatory control is focused more on prices than on earnings under price cap regulation.[5] Price cap regulation generally goes beyond a rate case moratorium by specifying authorized changes in regulated prices over time. A typical price cap plan will allow the regulated firm to increase its prices, on average, at the rate of inflation, less an offset, called the *X factor*. In principle, the X factor should reflect the extent to which the regulated industry is deemed capable of achieving more rapid productivity growth than is the rest of the economy.[6] Price cap regulation is currently employed by Oftel in Great Britain, by the CRTC

5. As indicated below, the stringency of stipulated price regulations is often influenced by the firm's realized earnings in practice. In this sense, the price cap regimes that are observed in practice are seldom "pure" price cap regimes.

6. See Kwoka (1991, 1993b), Christensen et al. (1994), Tardiff and Taylor (1996), Bernstein and Sappington (1999a,b), and section 5 below for additional discussions of this issue. Tardiff and Taylor (1996) report that the typical X Factor is the U.S. telecommunications industry is roughly 3 percent.

in Canada[7], and by a majority of the 50 state regulatory commissions in the United States. Price cap regulation has also been employed at various times in recent years in Belgium, Bolivia, France, Germany, Honduras, Hong Kong, Ireland, Italy, Japan, Mexico, Panama, The Netherlands, and Peru (OECD, 1999).

2.6. Partial Deregulation.

Partial deregulation is generally accomplished by classifying the services that a firm provides into different categories (e.g., basic, discretionary, and competitive), and removing regulatory controls on those services deemed to be "competitive". Thus, partial deregulation here entails the removal of virtually all regulatory control from some services, rather than the removal of some regulatory control from most or all services. Partial deregulation is generally implemented when competitive pressures are thought to be sufficient to keep the prices and service quality of some services at reasonable levels without direct regulatory controls.

In Great Britain, Oftel divides the interconnection services that British Telecom provides to other suppliers of telecommunications services into four categories: non-competitive services; prospectively competitive services; new services; and competitive services. The prices of non-competitive interconnection services are subject to a more stringent form of price cap regulation (i.e., one with an *X* factor of 8%) than are the prices of prospectively competitive interconnection services (which are subject to an *X* factor of 0%). New interconnection services are not immediately subject to price controls, but Oftel reserves the right to impose controls. The prices of competitive interconnection services are not regulated (Oftel, 2000).[8]

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7. Oftel is Great Britain's Office of Telecommunications. CRTC is the Canadian Radio-Television and Telecommunications Commission.

8. As this discussion of Oftel's regulation of interconnection services suggests, the primary benefits and costs of applying price cap regulation to retail services persist when applying price cap regulation to wholesale services. This observation has led some authors (Laffont and Tirole, 1996) to recommend global price cap regulation, under which all of the regulated firm's services

The criteria employed to distinguish between competitive and non-competitive services are not always specified clearly in practice. However, the U.S. Federal Communications Commission (FCC) has stated sufficient conditions for certain services to be removed from price cap regulation. Regulatory relief is granted for most dedicated transport and special access services, for example, when competitors have collocated and use competing transport facilities in half of the wire centers in a metropolitan area served by a regulated local exchange carrier (FCC, 1999). The FCC also permits each local exchange carrier to remove interstate, intraLATA toll services from price cap regulation once it has implemented full intra- and interLATA toll dialing parity.[9]

Particularly widespread deregulation of telecommunications services was implemented in the state of Nebraska in the United States. Legislative Bill 835 effectively deregulated all telecommunications services in Nebraska in 1987.[10] Only basic local service rates remain subject to direct regulatory oversight, and even this oversight is mild. The Nebraska Public Service Commission will only investigate proposed rate increases for basic local service if these increases

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(including both retail and wholesale services) are placed in a single basket and controlled with a single aggregate constraint on prices. Laffont and Tirole show that if the regulator knows the vector of outputs that the regulated firm would produce if prices for all of its services were set at their Ramsey levels, the regulator can employ these outputs to weight permissible price changes in a global price cap regime. Doing so will induce the firm to employ its knowledge of demand and cost functions to implement prices that converge to their Ramsey levels in a stationary environment. Some complications that can arise under global price cap regulation are discussed in sections 5.6.2 and 5.7.

9. LATAs are geographic areas called local access and transport areas. Interexchange (long distance) carriers are permitted to provide telecommunications services that cross LATA boundaries (i.e., interLATA services), but the major local exchange carriers (the regional Bell Operating Companies, or RBOCs) are generally prohibited from doing so as of the time of this writing. Full intra- and interLATA toll dialing parity is provided when customers are free to designate their preferred carrier and have all of their toll calls carried by this carrier automatically, simply by dialing the number of the party they wish to reach.

10. LB835, 89th Legis., 2d sess., 1986. Codified as sections 86-801 to 86-811, 75-109, 75-604, and 75-609, Reissue Statutes of Nebraska, 1943 (Reissue 1987).

exceed 10% in any year or if more than 2% of the telephone company's customers sign a formal petition requesting regulatory intervention.[11]

2.7. Yardstick Regulation.

Under yardstick regulation, the financial rewards that accrue to a regulated firm are based upon its performance relative to the performance of other firms.[12] Typically, a firm that outperforms its comparison group on specified dimensions is rewarded, whereas the firm may be penalized if its performance is inferior to the performance of the comparison group. For example, a firm may receive a financial reward if the fraction of its customers that register complaints about the service quality they receive is smaller than the corresponding fraction for firms in the comparison group.

If different firms face operating environments that are inherently different, then yardstick regulation can unduly advantage some firms and disadvantage others. Consequently, yardstick regulation is not common in the telecommunications industry.[13] However, two forms of yardstick regulation have been employed.[14] First, price cap regulation can embody yardstick regulation. Recall that under a popular form of price cap regulation, prices are permitted to rise at the rate of inflation, less an offset called the X factor. When the X factor reflects the projected industry productivity growth rate (relative to the corresponding economy-wide growth rate), an individual firm will fare

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11. See Mueller (1993) for additional details.

12. See Shleifer (1985) and Sobel (1999), for example.

13. See Sawkins (1995), Cubbin and Tzanidakis (1998), and Diewert and Nakamura (1999), for example, for analyses of yardstick regulation in other industries.

14. A third form of regulation that might be viewed as yardstick regulation has been employed in Chile since 1987. The benchmark to which Teléphonos de Chile is compared is the performance of a hypothetical efficient firm facing the same operating conditions that Teléphonos de Chile faces. Prices are set every five years to reflect long run incremental costs of the hypothetical efficient firm, while following standard rate of return principles to eliminate extranormal profit. The more efficient are its operations, the greater is the profit that Teléphonos de Chile secures under this form of regulation (Galal, 1996).

well financially when its productivity growth rate exceeds the industry average, whereas it will suffer financially when its productivity growth rate falls short of the industry average. In this manner, price cap regulation can constitute a form of yardstick regulation.

Yardstick regulation has also been employed in New York State to determine the duration of the incentive regulation plan that was implemented in 1995. The plan had an initial expiration date of December 31, 1999. However, the New York Telephone Company was afforded the option of extending the plan for two additional years if it met two conditions: (1) its realized service quality exceeded specified thresholds; and (2) its service prices were at least 4.5% below the prices set by other major telecommunications suppliers, as reflected in the Telephone Communications Producer Price Index (TCPPI).[15] This second condition is a form of yardstick regulation. The reward that New York Telephone was promised for superior performance was the right to continue the prevailing incentive regulation plan. The comparison group to which New York Telephone's price performance was compared was all major telecommunications suppliers, whose prices comprise the TCPPI.

2.8. Options.

Regulators do not always impose a single regulatory plan. Instead, they sometimes afford the regulated firm a choice among plans. For instance, the firm may be permitted to choose among different types of earnings sharing plans or between rate of return regulation and price cap regulation..

The U.S. Federal Communications Commission (FCC) provided the regional Bell Operating Companies (RBOCs) with such a choice in 1995 and 1996. Each RBOC was afforded the three options described in Table 1 and illustrated in Figure 4. Option A required a 4.0% reduction in

15. This index is calculated by the U.S. Bureau of Labor Statistics. The details of New York State's incentive regulation plan can be found in State of New York Public Service Commission (1994).

inflation-adjusted access prices in return for limited earnings sharing opportunities.[16] Option B entailed a 4.7% reduction in these prices in return for expanded earnings sharing. Option C involved pure price cap regulation (with no earnings sharing), with a mandated 5.3% reduction in inflation-adjusted access prices.[17]

Options can be particularly valuable when multiple firms with different innate capabilities are being regulated. Different firms can choose different plans when options are available. For instance, under the options presented by the FCC, an RBOC that is particularly optimistic about its ability to reduce operating costs and increase productivity can choose option C. A less optimistic RBOC can choose option A or option B. Thus, options can help to tailor regulations to the capabilities of the regulated firms. Such tailoring can secure additional gains for consumers while limiting the likelihood of financial distress for the regulated firms.[18]

Having reviewed the primary alternatives to rate of return regulation that are employed in the telecommunications industry, the discussion turns now to a review of recent trends in the implementation of incentive regulation plans.

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16. Access prices are the prices that the RBOC charges to long distance service providers for connecting a call to the RBOC's network.

17. Between 1991 and 1994, the FCC provided the RBOCs with a choice between two earnings sharing plans. Price cap regulation was not an option.

18. Section 6.3 provides additional discussion of regulatory options, explaining how they can be employed to induce a regulated firm to employ its superior knowledge of its operating capabilities in the best interests of its customers. Also see Lewis and Sappington (1989), Sibley (1989), Sappington (1994), and Sappington and Weisman (1996a).

3. Trends in Incentive Regulation.

The purpose of this section is to examine the extent to which various forms of incentive regulation have been employed in the telecommunications industry. The most comprehensive data is available for the United States, so the discussion here will focus on the U.S. experience. The U.S. is not alone, though, in shifting from rate of return regulation to incentive regulation in its telecommunications industry. Indeed, incentive regulation was implemented in the U.S. only after price cap regulation was implemented in Great Britain in 1984.[19] And, as noted above, price cap regulation has been implemented in many countries throughout the world, including Belgium, France, Honduras, Ireland, Italy, Japan, Mexico, Panama, and The Netherlands (OECD, 1999).

Table 2 summarizes the extent to which incentive regulation plans have been implemented by state regulators in the United States since 1985. (All states employed rate of return regulation prior to 1985.) The table focuses on the most popular forms of regulation.[20]

Three distinct patterns are evident from Table 2. First, rate case moratoria were the most popular form of incentive regulation in the mid and late 1980's, when alternatives to rate of return regulation were first implemented in the U.S. telecommunications industry. Second, earnings sharing regulation became particularly popular in the early 1990s, as the popularity of rate case moratoria waned. Third, few states employed price cap regulation until the mid 1990s. However, by 1996, price cap regulation had become the predominant form of regulation, and it remained the predominant form of regulation at the close of the twentieth century.

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19. See Armstrong et al. (1994) for a detailed review and analysis of the price cap regulation regimes imposed on British Telecom between 1984 and 1994. Also see Neri and Bernard (1994).

20. Table 2 does not include separate categories for banded rate of return regulation or revenue sharing because of their limited use. Banded rate of return regulation is recorded as rate of return regulation in Table 2. Oregon's revenue sharing plan, which was coupled with a form of price cap regulation, is recorded as price cap regulation in Table 2.The statistics in Table 2 are derived from BellSouth Services (1987-1992), BellSouth Telecommunications (1993-1995), Kirchhoff (1994-1999), and *State Telephone Regulation Report* (2000).

The patterns exhibited in Table 2 reflect a natural progression from less radical to more radical departures from rate of return regulation. As inflation subsided and major components of cost declined, regulated firms requested rate hearings to raise prices less frequently during the 1980s than they had historically. Consequently, rate case moratoria in the 1980s often served largely to institutionalize the longer time spans between rate reviews that were already occurring under rate of return regulation. When egregious profit did not arise under rate case moratoria, regulators gained the confidence required to experiment with more distinct forms of incentive regulation. Earnings sharing regulation constituted a significant, but still modest, departure from rate of return regulation. The tight bounds on allowable earnings under many earnings sharing plans helped to ensure that earnings would not depart too radically from the levels that would arise under rate of return regulation. (See section 6.) In many cases in the late 1980s and early 1990s, realized earnings turned out to be relatively modest under earnings sharing plans. In a number of instances, earnings did not even rise to the point where the regulated firm was required to share earnings with its customers. This experience, and the knowledge gained by observing performance under less stringent forms of profit regulation, encouraged regulators to implement price cap regulation on a broad scale by the mid 1990s.[21]

Developing competition in the telecommunications industry also enhanced the appeal of price cap regulation. Competition helped to impose discipline on incumbent providers of telecommunications services, so direct regulatory control of earnings was thought to be less crucial. Price cap regulation also served to provide incumbent providers with the expanded pricing flexibility they required to meet competitive challenges while ensuring that prices did not rise too rapidly, on average.

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21. Firms, too, may have been encouraged to solicit or embrace price cap regulation by the fact that earnings often increased under early price cap regimes.

Despite the general transition from rate of return regulation to rate case moratoria to earnings sharing regulation to price cap regulation, this pattern was not universal. As Table 3 reveals, some states (Montana and New Hampshire) have never experimented with an alternative to rate of return regulation. Others (e.g., North Dakota in 1990 and Pennsylvania in 1994) switched directly from rate of return regulation to price cap regulation, and have not altered their mode of regulation since. Other states (e.g., Arizona, New York, and South Carolina) experimented with incentive regulation for a period of time before reverting to rate of return regulation, at least temporarily.[22]

Federal regulation of the RBOCs has moved first from earnings sharing regulation to a choice between earnings sharing and price cap regulation, and then on to price cap regulation. As noted above, the FCC regulations in effect from 1991-1994 provided the RBOCs with a choice between two earnings sharing plans. In 1995 and 1996, the FCC allowed a choice among two different sharing plans and a price cap regulation plan. (Recall Table 1 and Figure 4.) In 1997, the FCC implemented price cap regulation of interstate access charges. All RBOCs were required to reduce inflation-adjusted access charges by 6.5 percent annually, and no sharing of earnings was instituted.

Some caution is advised in interpreting these trends and the classifications reported in Table 2. There is substantial heterogeneity among the regulatory plans within each of the categories listed in Table 2. For example, there are many different types of earnings sharing plans. Earnings sharing may be coupled with price freezes (as in California in 1995), with price cap regulation (as in Rhode Island in 1992), or with other forms of price controls. Furthermore, earnings sharing may be imposed on the regulated firm, or it may be offered to the firm as an option (as under the FCC's access price regulations in 1995 and 1996). In addition, the division of realized earnings between the regulated firm and its customers can vary across earnings sharing plans, as can the range of returns over which

22. Donald and Sappington (1995, 1997) explore some of the reasons why different states choose to implement different regulatory plans in their state telecommunications industries.

sharing occurs.

Even greater variation is evident among the plans classified as price cap regulation in Table 2. The amount by which inflation-adjusted prices must fall (i.e., the X factor) varies across price cap plans, as does the specified duration of the plan.[23] The amount of network modernization or expansion that a firm must undertake in order to qualify for price cap regulation (or rate case moratorium, or other form of incentive regulation) can also vary.[24] The group of services to which price cap regulation applies can also vary across plans, as can the additional restrictions imposed on the prices charged for specific services.[25] Price cap regulation plans also vary in their treatment of the financial impact of significant, unforseen events that are beyond the control of the regulated firm (e.g., extremely severe weather). Some plans include adjustments (called Z factors) to insulate the firm from the financial impact of severe, exogenous events, while others do not.[26]

Regulatory plans in the same category in Table 2 also vary according to the service quality requirements they impose. Although some plans incorporate no explicit monetary rewards or penalties for superior or inferior service quality, other plans do. To illustrate, the price cap regulation plan imposed on New York Telephone in 1995 specifies target levels of service quality on such

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23. In the British water industry, the magnitude of the X factor varies inversely with the capital investment that the regulated firm undertakes (Hunt and Lynk, 1995).

24. To illustrate, New England Telephone was required to spend more than $280 million on network modernization between 1989 and 1991 as a precondition for implementing a rate case moratorium in Vermont. The corresponding requirement for implementing a three-year price cap plan with earnings sharing regulation in California in 1990 was $415 million.

25. In addition to the over-arching restriction on how rapidly prices can rise on average, many price cap plans place stringent limits on increases in basic local service rates for residential customers. It is not unusual for these rates to be frozen for the duration of the price cap plan, as they were for the seven-year plan introduced in New Jersey in 1993. See section 5 for additional discussion of restrictions on individual prices under price cap regulation.

26. Z factors are discussed further in section 5.3.

dimensions as the speed with which interrupted service is restored and the amount of time customers must wait to speak with a customer service representative. Failure to meet the specified targets results in substantial financial penalties under the New York plan, and these penalties increase over time.[27] Under the price cap regulation plan adopted in Illinois in 1995, penalties for poor service quality are imposed in the form of a higher X factor (i.e., a requirement that prices rise less rapidly). The earnings sharing plan adopted in Georgia in1991 incorporated financial incentives for superior service quality in a different manner. Southern Bell was required to surpass specified service quality thresholds (primarily regarding the number of trouble reports per access line) in order to be eligible to share with its customers earnings in excess of those that constituted a 14% return on equity.

Because regulatory plans of the same type can vary substantially in detail, it is difficult to draw any general conclusions about the impact of a specified type of incentive regulation on performance in the regulated industry. However, some attempts have been made to do so. The central conclusions of these studies are reviewed in Section 7.

Before exploring the empirical findings to date, the principles that underlie the design of incentive regulation are discussed in greater detail in sections 4 - 6.

27. New York Telephone was fined $46.1 million in 1996 for failure to meet specified service quality targets.

4. General Issues in the Design and Implementation of Incentive Regulation.

The purpose of this section is to discuss the primary advantages and disadvantages of incentive regulation. The most common reasons for switching from rate of return regulation to some form of incentive regulation are reviewed in section 4.1. Section 4.2 points out that many forms of incentive regulation share important features with rate of return regulation in practice. Potential drawbacks to incentive regulation are discussed in section 4.3.

4.1. Reasons for Incentive Regulation.

The various forms of incentive regulation described in section 2 are often implemented in response to perceived drawbacks to rate of return regulation (RORR). The potential drawbacks to RORR include: (1) limited incentives for innovation and cost reduction; (2) over-capitalization; (3) high costs of regulation; (4) excessive risk imposed on consumers; (5) cost shifting; (6) inappropriate levels of diversification and innovation; (7) inefficient choice of operating technology; and (8) insufficient pricing flexibility in the presence of competitive pressures. These potential drawbacks are now analyzed in turn.

The defining feature of RORR is a matching of allowed revenues to realized costs. This matching limits incentives for the regulated firm to reduce operating costs. Any reduction in costs leads to a corresponding reduction in revenues, so the firm and its managers perceive little gain from exerting the effort required to reduce costs toward their minimum possible levels.

By matching allowed revenues to realized costs, RORR can ensure earnings that are sufficient to guarantee investors a fair return on the capital that they provide to the firm. A fair return is the minimum amount required to convince investors to offer their capital to the regulated firm, rather than pursue alternative investments. A fair return is difficult to identify in practice. In their attempts to ensure that the regulated firm can attract sufficient capital to finance the ongoing investments required to provide high quality service to its customers, regulators may set prices to allow the firm

more than a fair return on its investments. Doing so promotes over-capitalization, as the firm expands capital-intensive investments beyond their cost minimizing level, since the investments give rise to relatively large returns (Averch and Johnson, 1962). Furthermore, because the firm suffers financially when assets are removed from the rate base under RORR, the regulated firm may replace old assets with newer, more efficient assets too slowly under RORR, resulting in operating costs that are unduly high (U.S. Department of Commerce, 1991; Biglaiser and Riordan, 2001).

Since RORR can entail frequent, detailed investigations of the firm's operations and its realized costs, it can be a costly method of regulation. RORR also tends to place substantial risk on consumers. As costs change, prices also change under RORR to maintain the desired balance between revenues and costs. Consequently, in theory at least, it is consumers, not the firm, that bear the risk associated with significant changes in operating costs. In practice, consumers often bear unfavorable risk under RORR but may enjoy little of the favorable risk. When revenues fall or costs rise to levels that drive the regulated firm's actual rate of return below its authorized rate of return, the firm requests a rate hearing to raise prices. In contrast, when revenues rise or costs fall to levels that generate returns in excess of the authorized return, the firm seldom requests a hearing to lower prices (Joskow, 1974). Thus, the risk that consumers bear under RORR can be asymmetrically unfavorable.

RORR can also encourage cost shifting, inefficient technology choices, and inappropriate levels of diversification and innovation when the regulated firm operates in both regulated and unregulated markets. The incentives for cost shifting are apparent. The regulated firm gains one dollar in profit for every dollar of cost actually incurred in producing unregulated services that is counted as having been incurred in providing regulated services. Such cost shifting raises authorized revenues from regulated activities without affecting actual operating costs, thereby increasing the firm's aggregate profit.

The other distortions that RORR can invite are somewhat more subtle. They arise from the matching of revenues and costs in regulated markets that RORR requires. In order to match revenues and costs in regulated markets, the firm's costs of serving its regulated customers must be calculated. Such calculations are difficult when the same inputs (e.g., facilities, personnel, and equipment) are employed to serve customers in both regulated and unregulated markets. Joint production gives rise to common costs that are not directly attributable to operation in one particular market. For instance, when a telephone company delivers both regulated and unregulated services to a customer over the same line from the company's central office to the customer's premises, the cost of installing and maintaining the line is a common cost that is not directly attributable to either regulated or unregulated activities. But under RORR, the common costs are divided between regulated and unregulated activities, often on the basis of the relative sales of regulated and unregulated services.

Such cost allocation can invite a host of undesirable activities (Braeutigam and Panzar, 1989; Brennan, 1990; Crew and Crocker, 1991; Weisman, 1993; Brennan and Palmer, 1994). For instance, the regulated firm will tend to supply too little of its unregulated services when expanded sales of unregulated services reduce the fraction of common costs allocated to regulated activities, and thereby reduce authorized revenues from regulated services. In essence, the cost allocation procedure acts like a tax on unregulated activities, and so restricts their supply. The allocation of common costs can also provide incentives for the regulated firm to adopt other than the least-cost technology. For example, the firm may choose a technology with an inefficiently large component of fixed, common costs if those common costs serve to reduce significantly the variable costs of providing unregulated services. Similarly, if research and development costs are treated as common costs and allocated according to relative sales of regulated and unregulated services, the regulated firm can benefit financially from over-investing in projects designed to enhance profit in unregulated markets and

under-investing in projects designed to improve operations in regulated markets.[28]

Another drawback to RORR is that it can limit unduly the ability of an incumbent supplier to respond to competitive pressures. Under RORR, the prices of some services are intentionally set above their cost of supply while others are set below their cost of supply. For example, basic local telephone service rates for rural residential customers are set below cost in many countries in order to promote universal telephone service. Prices for many services sold to business customers in urban regions are set above cost to help offset the financial deficits incurred in providing rural residential service. Such a pricing structure provides incentives for competitors to serve the lucrative business customers and leave the unprofitable rural customers for the incumbent regulated firm to serve. When RORR requires lengthy, public hearings to revise long-standing pricing structures, the incumbent supplier is often unable to respond adequately to competitive pressures. Consequently, RORR can prevent an incumbent supplier from serving some customers that it could serve at lower cost than its competitors if it had the pricing flexibility to do so.

For all these reasons, RORR has been declining in popularity in recent years. As the discussion in section 2 reveals, price cap regulation (PCR) has replaced RORR in many jurisdictions. (Recall Table 3.) In theory at least, PCR can overcome all of these problems with RORR. By divorcing allowed revenues from realized costs, PCR provides expanded incentives for innovation and cost reduction. When the firm is permitted to retain as profit all of the reductions in costs it achieves, the firm has strong incentives to reduce its operating costs. Incentives for cost-reducing innovation are also enhanced under PCR to the extent that lower prices are induced under PCR than under RORR. The lower prices lead to higher production levels, so a given reduction in marginal cost provides a larger reduction in total cost, and thus a larger increase in profit (Cabral and Riordan, 1989;

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28. Palmer (1991) shows how diversification into unregulated markets can increase the amount of research and development conducted by a regulated firm.

Clemenz, 1991).

PCR can also reduce technological distortions and the costs of regulation. When it does not link authorized earnings to capital or any other particular input, PCR can avoid over-capitalization and related input distortions in production. And if reviews of price cap plans are scheduled infrequently, the costs of regulation can be reduced under PCR. Costs are reduced further when the regulated firm is authorized to change prices within well-specified bounds. By delegating pricing authority in this manner, regulators can avoid many costly and contentious hearings to analyze proposed rate changes.

PCR also shifts risk from consumers to the regulated firm. When it agrees to a price schedule that does not vary with realized costs, the firm bears all the risk – both favorable and unfavorable – associated with cost variation. When it severs the link between authorized revenues and realized costs, PCR also eliminates incentives for shifting accounting costs between regulated and unregulated activities, undertaking inappropriate levels of diversification and innovation, and adopting inefficient technologies (Braeutigam and Panzar, 1989). These undesirable incentives disappear when the firm earns an extra dollar of profit for every dollar of cost reduction it achieves, regardless of whether the reduction is realized in common costs or the costs of providing particular regulated or unregulated services. And when PCR affords the regulated firm significant freedom to vary individual service prices quickly and unilaterally, an incumbent producer will be better able to prevent less efficient competitors from serving customers.[29]

4.2. Incentive Regulation in Practice.

Although PCR and RORR can provide very different incentives in principle, it is not clear that they do in practice (Barnich, 1992; Waterson, 1992). The potential distinctions between PCR and RORR become blurred as they are implemented in practice for a variety of reasons. First, although

29. For additional comparisons of incentive regulation and RORR, see, for example, Acton and Vogelsang (1989), Braeutigam and Panzar (1993), and Liston (1993).

prices may be divorced from realized costs for a period of time under PCR, the two are seldom divorced forever. When the price cap plan is reassessed at its scheduled review, ongoing price regulations are often informed by realized costs and earnings (Beesley and Littlechild, 1989). Some authors recommend that price caps be established at levels that are expected to dissipate a firm's current profit over the course of the next price cap period (Green and Rodriguez Pardina, 1999). When a price cap plan links future prices directly to realized costs and when the time between scheduled reviews of the price cap plan is relatively short, the regulated firm's incentives to reduce costs can be dulled under PCR, just as they are under RORR. Indeed, the incentives may be similar under the two regimes if the length of time between scheduled reviews of the price cap plan is similar to the time between the rate hearings that match prices to costs under RORR.[30]

In some cases, prices are re-set to better match costs even before the time for the scheduled review of the price cap plan has arrived. This was the case, for example, in Great Britain in 1991. Oftel raised the X factor in the price cap plan for British Telecom from 4.5 to 6.25 that year, even though the X factor was scheduled to remain at 4.5 at least until 1992 (Armstrong et al., 1994, pp. 227-8). Credibility problems can arise if regulators unilaterally revise the terms of specified regulatory policy before the scheduled date for reviewing the plan. If such premature intervention is expected, then no matter how strong the financial incentives for cost reduction may appear on paper, they will be seriously compromised in practice (Baron, 1991). Consequently, the potential gains from regulatory policies like price cap regulation may be minimal in settings where regulators cannot credibly promise to abide by the terms of the announced policy. In such settings, regulators are often better served by regulatory regimes (like RORR) that are more congruent with the regulators' limited commitment powers (Levy and Spiller, 1994, 1996).

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30. Some difference in incentives arises even in this case if the time between reviews is endogenous under RORR and if reviews occur only when the firm requests a review to raise prices (Pint, 1992).

Once realized costs influence allowed prices, incentives for cost shifting and inappropriate levels of diversification and innovation re-emerge. The magnitudes may be less pronounced under PCR than under RORR, but the same qualitative effects can arise under the two regimes (Weisman, 1993). In practice, price cap regimes often limit the incumbent firm's ability to change prices at will. For example, the firm is often precluded from raising politically-sensitive rates (such as residential basic local service rates), even if these rates are set below production costs.[31] Price cap regulation plans can also limit the firm's ability to reduce prices, even if the price reductions serve to match the prices of competitors.[32] Thus, PCR, like RORR, does not always afford the incumbent producer complete flexibility to respond to competitive pressures.

Although the distinctions between RORR and PCR in principle can become blurred as the regimes are implemented in practice, there is some evidence that incentive regulation is truly different from RORR, at least as it is practiced in the U.S. telecommunications industry. Magura (1998) examines whether revenues are matched to costs under incentive regulation precisely as they are so matched under RORR. He finds that this is not the case between 1987 and 1994 for 34 local exchange carriers in the U.S. The closer matching of revenues to costs under RORR suggests that the forms of incentive regulation that have been implemented in the U.S. telecommunications industry may enhance incentives for innovation and cost reduction, as they permit the regulated firm to retain some of the cost savings it generates.

4.3. Possible Drawbacks to Incentive Regulation.

Even though incentive regulation may promote innovation and cost reduction both in theory and in practice, incentive regulation is not without its drawbacks. A primary drawback to price cap

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31. Giulietti and Price (2000) find little evidence that price cap regulation has caused a substantial rebalancing of prices to more closely approximate marginal costs of production.

32. This was the case, for example, in the price cap plan that the U.S. Federal Communications Commission implemented for AT&T in 1989 (Mitchell and Vogelsang, 1991, p. 284).

regulation is that it may allow prices to diverge significantly from realized production costs. The resulting allocative inefficiency can reduce aggregate welfare (i.e., the sum of consumers' surplus and profit) substantially. Furthermore, PCR can provide pronounced extranormal profit for the regulated firm, which may have undesirable distributional consequences.

These drawbacks to PCR are most pronounced when: (1) there is considerable variation in possible costs; (2) the regulator values consumers' surplus much more highly than profit; and (3) positive production levels are always desirable, but the regulated firm can choose not to operate with impunity. When factors (1) and (3) prevail, a regulator cannot avoid the possibility that the firm will earn considerable rent under PCR. To induce the firm to operate when costs turn out to be relatively high despite the firm's best efforts to reduce costs, authorized prices cannot be too low. But relatively high prices will afford the firm considerable rent when realized costs are fortuitously low. Consequently, when factor (2) is also present, PCR may not be the best regulatory plan to implement.

Schmalensee (1989) demonstrates that earnings sharing regulation, and perhaps even RORR, can outperform PCR when factors (1) - (3) prevail. Although earnings sharing regulation and RORR limit incentives for cost reduction, they keep prices closer to realized cost and better limit the profit that accrues to the regulated firm. PCR fares better when the regulated firm need only be guaranteed non-negative *expected* profit, rather than non-negative profit for all possible cost realizations. In this case, prices can be lowered to the point where the firm's extranormal profit when realized costs are low are offset by losses when realized costs are high. Gasmi et al. (1994) show that the ability of the firm to set prices below the maximum level authorized by the cap also enhances the performance of PCR. Still, though, some earnings sharing is often preferable to PCR in the presence of distributional concerns and considerable uncertainty about feasible production costs.

As noted above, incentive regulation in general and PCR in particular shift risk from consumers to the regulated firm. Although this shifting of risk can help to motivate the firm to operate

diligently, it can also raise the firm's cost of capital. Investors typically demand higher expected returns as the risk they are asked to bear increases. Consequently, another potential drawback to incentive regulation is that it can raise the cost of capital, thereby increasing an important component of industry operating costs.[33]

A third potential drawback to incentive regulation stems from the strong incentives it can provide to reduce operating costs. One common way to reduce costs is to reduce service quality. For example, a telecommunications supplier may reduce its repair and customer assistance staffs in order to limit the wages and benefits it pays to its employees. Such staff reductions can cause service quality to decline below historic levels. If historic levels of service quality do not exceed ideal levels, then the resulting decline in service quality under incentive regulation can reduce welfare (Liston, 1993).

The pricing flexibility that is often afforded the regulated firm can constitute a fifth drawback to incentive regulation. Although pricing flexibility can enable an incumbent supplier to respond to competitive pressures and thereby prevent operation by a higher-cost rival, the flexibility can also serve to undo cross-subsidies that regulators have implemented to promote equity, fairness, and/or other political objectives. For example, regulators often set the same price for basic local telephone service across large geographic regions, even though the cost of providing the service varies greatly across the regions. In particular, the cost of providing service to an urban customer is often substantially less than the corresponding cost for a rural customer. When the regulated firm is afforded pricing flexibility in these circumstances, it will generally wish to set rates that approximate costs more closely. But by raising the rates on services that are more costly to provide and lowering

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33. Alexander and Irwin (1996) report that firms operating under price cap regulation experience greater idiosyncratic risk than firms operating under rate of return regulation in Canada, Japan, Sweden, the United Kingdom, and the United States. Investors generally require a higher expected return in order to invest in firms with greater idiosyncratic risk, which raises the firms' cost of capital.

the rates on services that are less costly to provide, the firm will undo the cross-subsidies that the regulator has implemented.

The regulated firm may also employ expanded pricing flexibility to deter welfare-enhancing entry into the regulated industry, particularly when average price levels are regulated (as they are under price cap regulation). When average price levels are regulated, a reduction in the price of a product for which the incumbent supplier faces intense competition authorizes an increase in the price of a product for which the firm faces little or no competition. Consequently, the regulated firm may find it profitable to respond aggressively to competitive challenges, even to the point of pricing some products below marginal production costs (Armstrong and Vickers, 1993).

A fourth potential drawback to incentive regulation is the rate shock it can promote. Rate shock arises when regulated prices increase substantially and abruptly. Rate shock can arise under incentive regulation precisely because incentive regulation divorces prices from realized costs for a considerable period of time. If costs rise significantly during this period, and if the cost increase was largely unanticipated at the start of the price cap regime, then prices may need to be increased substantially when the incentive regulation plan is reassessed at its scheduled review date, thereby causing rate shock (Isaac, 1991).

Depending upon how they are designed and sequenced, incentive regulation plans can also provide financial incentives for strategic intertemporal shifting of revenues and costs. To illustrate these incentives, consider a setting where PCR is followed by RORR. Since it is permitted to retain all of the profit it generates under PCR but revenues are matched with realized costs under RORR, a regulated firm in this setting may gain financially if it accelerates revenues and defers costs as the end of PCR and the beginning of RORR approaches (Isaac, 1991). Revenues can be accelerated by, for example, introducing new services relatively rapidly. Costs can be deferred by, for example, postponing routine or precautionary maintenance procedures. By accelerating revenues and deferring

costs, the firm may be able to increase realized profit under PCR, without reducing the level of profit it is afforded under RORR.

Related strategic behavior can arise even when the regulated firm operates only under PCR. To illustrate this fact, suppose that at each scheduled review of the price cap plan, realized costs in the preceding year are employed to assess likely future costs, and thus the most appropriate value for the X factor. In this setting, the firm could gain financially by shifting costs to this test year and by limiting its own cost-reducing efforts in this test year. Pint (1992) documents the substantial welfare gains that can arise if such strategic cost shifting and effort allocation under PCR is mitigated by basing forecasts of future costs on realized costs throughout an entire price cap period, rather than on costs in a particular test year.[34]

These are just some of the forms of strategic behavior that incentive regulation can promote. Additional forms of strategic behavior are analyzed in the next two sections, where some of the key considerations in the design of price cap regulation are discussed in greater detail.

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34. Vogelsang (1989) suggests a similar approach to implementing price cap regulation.

5. Designing Price Cap Regulation.

The purpose of this section is to examine in more detail some of the key considerations in the design of price cap regulation. Recall from section 2 that price cap regulation plans generally permit the regulated firm's prices to rise, on average, at the rate of economy-wide output price inflation less an *X* factor. This restriction can be represented formally as:

$$\dot{p} \leq I - X, \tag{1}$$

where $\dot{p}$ denotes the rate of growth of the prices charged by the regulated firm, I is the economy-wide rate of output price inflation, and X is the X factor.

The discussion in this section begins by explaining (in section 5.1) one rationale for imposing constraint (1) under price cap regulation and, most importantly, how to determine an appropriate value for the X factor. The proper duration of a price cap plan is discussed next (in section 5.2) followed by an assessment (in section 5.3) of the merits of allowing changes to the plan before its scheduled review date. A detailed discussion of how to implement the aggregate price constraint (constraint (1)) follows (in sections 5.4 and 5.5), before additional restrictions on individual service prices, multiple price cap constraints on distinct baskets of services, and service quality regulations are analyzed (in sections 5.6, 5.7, and 5.8).

5.1. Setting the X Factor.

As is evident from expression (1), the X factor imposed in a price cap plan determines the authorized growth rate of inflation-adjusted prices. Therefore, the magnitude of the X factor is a critical determinant of the level of welfare that consumers and the regulated firm achieve under price cap regulation. The higher is the X factor, the lower is the authorized growth rate of prices, and thus the higher is consumers' surplus and the lower is profit, *ceteris paribus*.

To understand the key factors that influence the proper choice of the X factor under price cap regulation (PCR), it is helpful to consider the fundamental role of PCR. Like many forms of

regulation, PCR is often intended to replicate the discipline that competition would impose if it were present in the regulated industry. Competition enables firms to pass on to customers in the form of higher prices unavoidable cost increases (due to higher input prices), but compels firms to deliver to customers in the form of lower prices realized increases in productivity. (Productivity, recall, reflects the ratio of the firm's outputs to its inputs.) Therefore, in a competitive economy, prices rise at a rate equal to the difference between the rate at which input prices rise and the rate at which (total factor) productivity increases.

Now consider a regulated industry within an otherwise competitive economy. The rate of output price inflation outside of the regulated industry will reflect the difference between the rate of input price inflation and the rate of productivity growth in the competitive sectors of the economy. Initially suppose that the regulated industry is deemed capable of achieving the same rate of productivity growth as the other sectors of the economy. Also suppose that the firms in the regulated industry face the same input price growth rates that the competitive firms face. Under these circumstances, once prices are set initially to generate zero extranormal profit in the regulated industry, this profit level can be maintained by allowing industry output prices to rise at the rate of output price inflation elsewhere in the economy. Consequently, in this setting, competitive forces would be replicated in the regulated sector if the X factor were set equal to zero.

In this setting, the discipline of competitive markets would be replicated if the X factor reflected the extent to which the regulated industry is deemed capable of achieving more rapid productivity growth and faces a lower input price growth rate than other sectors of the economy (Kwoka, 1991, 1993b). To illustrate, suppose the regulated industry is deemed capable of achieving a 4 percent annual productivity growth rate, while the expected annual productivity growth rate elsewhere in the economy is 3 percent. Also suppose the prices of the inputs employed elsewhere in the economy are expected to increase by 1.5 percent annually, while the corresponding input price growth rate for the

regulated industry is 0.5 percent. In this setting, the X factor that will provide no expected growth in extranormal profit in the regulated industry is 2: the sum of the higher expected productivity growth rate (4 - 3 = 1) and the lower expected input price growth rate (1.5 - 0.5 = 1) in the regulated industry.

These considerations provide one set of guidelines for determining the X factor in price cap regulation plans. Although these guidelines are instructive, they do not provide all of the information required to implement price cap regulation in practice. In particular, productivity and input price growth rates can be difficult to predict. In practice, historic growth rates are often employed as the best predictors of corresponding future growth rates. Adjustments are common, though, particularly at the start of a price cap regime that follows an extended period in which rate of return regulation (RORR) was imposed on a private, profit-maximizing firm, or in which the telecommunications supplier was a publicly-owned enterprise.[35] Since RORR and/or public ownership can limit incentives for innovation, cost reduction, and productivity growth, historic rates of productivity growth may understate the corresponding rates the regulated industry can reasonably achieve under PCR. Therefore, the X factor imposed in these settings is often increased beyond the level identified above by what is called a *stretch factor*. The stretch factor is an estimate of the amount by which the annual productivity growth rate in the regulated industry will exceed the historic rate because of the incentives for enhanced productivity growth provided by price cap regulation.[36]

Other adjustments to the X factor warrant consideration in some settings. For example, price cap regulation is often applied to only a subset of the services supplied by a regulated firm, but the firm's

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35. British Telecom operated as a public enterprise immediately before it was privatized and subjected to price cap regulation in 1984.

36. The U.S. Federal Communications Commission included a 0.5 stretch factor in its 1989 price cap plan for AT&T. The Canadian Radio-Television and Telecommunications Commission imposed a 1.0 stretch factor on telecommunications suppliers in the price cap plan it introduced in Canada in 1997.

historic measured productivity growth rate typically pertains to its entire operations. If competition in unregulated markets will force the firm to reduce prices more rapidly than its overall productivity growth rate will permit it to do profitably, then it can be appropriate to reduce the X factor in order to allow a higher rate of growth for regulated prices. (Bernstein and Sappington (1999, 2000) characterize the appropriate adjustments.) Emerging competition in the regulated industry can also affect the best value for the X factor. While increased competitive pressures can force the regulated firm to secure a higher productivity growth rate, they can also serve to lower realized productivity growth rates, particularly in the short run. As competitors attract the customers that incumbent suppliers built their networks to serve, the output growth rates for incumbent suppliers can decline more rapidly than their input growth rates decline, leading to a reduction in their realized productivity growth rates. Corrections for these varying effects of competition when setting the X factor can be important (Bernstein and Sappington, 1999, 2000).

In some countries, the data required to calculate productivity and input price growth rates may not be available. Consequently, the X factor cannot be calculated directly in the manner described above. In such settings, an appropriate X factor must be determined by other means. One possibility is to calculate historic changes in the prices of regulated services, and require the firm to implement future changes that are at least as favorable to consumers. A second possibility might be to impose an X factor that appears to have served the needs of all relevant parties well in neighboring countries with similar characteristics. A third possibility arises in countries where similar firms serve different but comparable monopoly markets in the same industry. In such countries, the X factor imposed on each firm might be linked to the productivity growth rates achieved by the other monopoly producers in the industry.[37]

Even in settings where historic productivity and input price data are readily available, regulators

37. This is a form of the yardstick regulation described in section 2.7.

may deem such data to provide unreliable estimates of likely future productivity gains and input price changes. Consequently, the regulators may choose an X factor based upon explicit projections of futures revenues and costs, taking into account both current revenues and costs and anticipated changes in the industry. In particular, the X factor can be determined in much the same way that an allowed rate of return is determined under RORR.[38] To the extent that the X factor is increased to reflect recent improved performance by the regulated firm, this method of calculating an X factor can limit incentives for superior performance. However, to the extent that this methodology provides more accurate estimates of potential productivity gains, it can limit the risk of affording enormous profit to the regulated firm or jeopardizing its financial integrity. Alternative procedures for limiting this risk are discussed in section 6.

5.2. Determining the Length of Time Between Reviews.

The X factor is designed to present a significant but reasonable challenge for the regulated firm. If the X factor is set too low, the firm will earn substantial profit and production levels will be unduly low because prices are set far in excess of realized costs. If the X factor is established at too high a level, the firm may face financial distress. Because it is difficult to identify the ideal X factor in advance, it is wise to limit the period of time for which any specified X factor is in effect. Numerous factors influence the most appropriate length of time between reviews of a price cap plan.

One factor is the regulator's uncertainty about the environment in which he and the firm operate. When the regulator is very uncertain about likely future industry demand and cost conditions, he will find it difficult to specify an X factor that poses a significant but reasonable challenge for the firm. The difficulty is compounded when the regulator is uncertain about the firm's ability to reduce operating costs through its own diligent efforts. To reduce the risk associated with an X factor that

38. See Cave (2000) and Green and Rodriguez Pardina (1999) for details, including details on how current revenues and costs can be adjusted to account for forecast variation in future revenues and costs.

is poorly matched to the firm's environment and capabilities, a relatively short time period between reviews of the price cap plan can be instituted (Mayer and Vickers, 1996).

Of course, depending upon the nature of the price cap review, a short time between reviews can limit the firm's incentive to reduce operating costs. Suppose the review is employed to reset prices and the X factor to levels that eliminate the firm's expected profit during the next price cap period, using any information that the firm's realized performance provides about its ability to secure low future costs. In this setting, the firm will often have little incentive to operate diligently if the time period between reviews of the price cap plan is short. This is because realized cost reductions during a price cap period will only increase profit for a short period of time, and will encourage higher X factors in subsequent periods.[39] The firm may be less reluctant to reveal its ability to secure low production costs if the regulator can credibly promise not to set future X factors to eliminate all expected (extranormal) profit for the firm, based upon its observed performance. One way to implement such a promise is to set the X factor to eliminate average expected profit based upon industry performance rather than the performance of individual firms in the regulated industry. Such a procedure serves to reward firms that secure the lowest operating costs and penalize those with the highest realized costs.[40] When a procedure of this sort is employed, a shorter lag between reviews of the price cap plan can be instituted to keep prices aligned with costs without dulling incentives for cost reduction unduly.

The ideal lag between reviews of a price cap plan will also vary with the firm's ability to reduce

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39. These considerations also arise in determining the optimal regulatory lag under RORR. A longer lag encourages cost reduction, but increases the length of time for which prices exceed operating cost (Bailey and Coleman, 1971; Baumol and Klevorick, 1970; Pint, 1992).

40. If the X factor for a firm is set to eliminate its expected profit based upon the performance of the other firms in the industry rather than upon the industry average, then the link between a firm's current performance and the stringency of the future regulations it faces can be severed completely.

operating costs and with the price elasticity of demand for the firm's product. When demand is inelastic, relatively little economic surplus is sacrificed when prices exceed marginal production costs. Consequently, regulatory reviews to match prices to realized costs are less crucial, and so longer lags between reviews can be implemented to encourage innovation and cost reduction. Therefore, longer lags between reviews of the price cap plan are generally advisable when demand for the service of the regulated firm is inelastic and when the firm is believed to have considerable ability to reduce realized operating costs through its own diligent efforts (Armstrong, Rees, and Vickers, 1995).

The regulator's ability to allow the regulated firm to earn extranormal profit also influences the ideal length of time between reviews of a price cap plan. If political or ideological considerations render extremely high or extremely low profits impossible for the regulator to tolerate, then the price cap plan will have to be reviewed frequently to realign prices and costs. Of course, when a regulator cannot tolerate significant variation in realized profit, he may be better served by a regulatory plan other than price cap regulation (Levy and Spiller, 1996).

The ideal lag between reviews of any regulatory plan will also depend upon the details of the plan. For instance, if politically-sensitive rates (such as residential basic local service rates) are frozen under a price cap plan, then the regulator need not be concerned that these rates will rise unduly before the firm's pricing structure is re-evaluated at the price cap review. Consequently, a longer time between reviews can be advisable. Similarly, if an incentive regulation plan includes elements like earnings sharing that serve to limit extreme variation in profit between reviews of the regulatory plan, then frequent reviews are a less important means of preventing unacceptably large or small levels of profit. In practice, price cap plans tend to be reviewed every four or five years. Over time, as experience with price cap regulation has increased, the typical time between reviews of price cap plans has increased gradually (Kirchhoff, 1994-1999).

5.3. Mid-Stream Corrections: Z Factors.

Extreme variation in profit during a price cap regime can be limited by permitting adjustments to the price cap before the scheduled review of the regime. Such adjustments (referred to as Z factors) are often permitted for events that have three distinguishing features. First, the events and their financial implications are beyond the control of the regulated firm. Second, the events affect the regulated firm disproportionately. Third, the events have pronounced financial impacts.

The first feature – that the events are exogenous – is designed to avoid reimbursing the regulated firm for financial shortfalls that arise from its own mistakes. The second feature that the events affect regulated suppliers disproportionately – avoids double-counting. If an event that raises the costs of regulated suppliers also raises the costs of all other suppliers in the economy, then the inflationary impact of the event will be reflected in the inflation component of the price cap (i.e., the *I* term in expression (1)), so an additional adjustment is not required. The third feature – that the events have large financial implications – limits prolonged and costly regulatory hearings regarding events that are of limited economic importance.

Events that are often characterized by these three features include: (1) new taxes that are levied exclusively on regulated suppliers; and (2) unpredictable natural disasters that increase the operating costs of regulated suppliers disproportionately relative to other producers.

5.4. Implementing the Price Cap Constraint.

As noted above, price cap regulation typically serves to limit the average rate of growth of the prices charged by the regulated firm. Therefore, to implement price cap regulation, it is necessary to specify precisely how the average growth rate of the firm's prices will be calculated. The purpose of this subsection is to: (1) explain why a weighted average of price growth rates is more appropriate than an unweighted average; (2) explore the advantages and disadvantages of different weighting procedures; and (3) examine the merits of affording pricing discretion to the regulated firm under

different weighting procedures. The particular implementation of price cap regulation that is employed most often in practice is reviewed next.

5.4.1. The Rationale for a Weighted Average.

The average growth rate of a firm's prices can be calculated in different ways. For example, an unweighted average of the growth rates of individual prices might be constructed. Although this statistic would be simple to calculate, it would generally fail to reflect accurately the true impact of price changes on consumers. A given price change will have a greater effect on consumers the more of the relevant commodity they are consuming, *ceteris paribus*. Thus, the average rate of growth of prices is best represented by a weighted average of individual growth rates, where the weight placed on each rate reflects its relative impact on consumers. Weights that are commonly employed in practice include the relative quantities and the relative revenues of the products supplied by the regulated firm.

One rationale for quantity weights is the following. Suppose the objective of price cap regulation is to ensure a specified level of consumers' surplus, S^0, over time.[41] Then, after setting prices $(p \equiv (p_1,\ldots,p_n))$ for the n regulated products initially to secure S^0, the regulator would want to ensure that any price changes implemented by the firm did not reduce consumers' surplus, S. For small price changes (dp_i), the relevant restriction is:

$$\sum_{i=1}^{n} \frac{\partial S}{\partial p_i}\, dp_i \geq 0. \qquad (2)$$

Expression (2) states that the combined effect of all of the price changes implemented by the firm is to (weakly) increase consumers' surplus.

With independent demands and no income effects, a small increase in the price of the firm's i^{th} product reduces consumers' surplus by the amount of the product purchased by consumers, so

41. This might be the case if, for example, the rate of output price inflation in the economy and the relevant X factor were both zero.

$\partial S / \partial p_i = -Q_i(p_i) \equiv -q_i$.[42] Therefore, expression (2) can be rewritten as:

$$\sum_{i=1}^{n} (-q_i)\, dp_i \geq 0 \quad \text{or} \quad \sum_{i=1}^{n} q_i\, dp_i \leq 0. \tag{3}$$

Expression (3) says that a set of proposed price changes will not reduce consumers' surplus if the sum of the price changes, each weighted by the relevant quantity of the product sold, is less than or equal to zero (Brennan, 1989; Vogelsang and Finsinger, 1979). Thus, the relevant weighted average of price changes is calculated using current output levels as weights.

5.4.2. Tariff Basket Regulation.

When the demand functions facing the regulated firm are not known precisely (as they seldom are in practice), the amount of output consumers will purchase at any proposed set of prices cannot be predicted perfectly. Consequently, some approximation of expression (3) must be employed in place of the expression itself. One natural approximation replaces output levels at the proposed prices with output levels at the current prevailing prices. Thus, letting p_i^0 denote the current price of the firm's i^{th} product and p_i^1 the corresponding proposed price, expression (3) could be approximated by:

$$\sum_{i=1}^{n} q_i^0 [p_i^1 - p_i^0] \leq 0 \quad \text{or} \quad \sum_{i=1}^{n} p_i^1 q_i^0 \leq \sum_{i=1}^{n} p_i^0 q_i^0 . \tag{4}$$

If expression (4) were to constitute the central constraint under price cap regulation, the firm would be permitted to charge prices $(p^1 \equiv (p_1^1, \ldots, p_n^1))$ that, when evaluated at prevailing output levels $(q^0 \equiv (q_1^0, \ldots, q_n^0))$, do not increase the firm's revenue above its present level $\left(\sum_{i=1}^{n} p_i^0 q_i^0 \right)$. Thus, a Laspeyre's revenue index is not permitted to increase under this form of price cap regulation, which is often referred to as *tariff basket regulation* (Armstrong et al., 1994).

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42. $S(p_1, \ldots, p_n) = \sum_{i=1}^{n} \int_{p_i}^{\infty} Q_i(\tilde{p}_i)\, d\tilde{p}_i$, where $Q_i(p_i)$ is the demand function for the firm's i^{th} product. Therefore, $\partial S(\cdot) / \partial p_i = -Q_i(p_i)$.

Before reviewing the effects of tariff basket regulation, consider the rationale for affording the regulated firm any pricing discretion. The regulator could simply prohibit the firm from altering the initial prices (p^0) that generate consumers' surplus S^0. Doing so would ensure that consumers' surplus never falls below S^0. But doing so would also preclude any increase in consumers' surplus. Viewing current output levels as exogenous to the firm, constraint (4) ensures (weak) increases in both consumers' surplus and profit relative to a requirement that prices remain at p^0 (Armstrong and Vickers, 1991). The increase in consumers' surplus arises for the following reason. Constraint (4) requires that any price increases be at least offset by corresponding price decreases, using prevailing output levels to weight the price increases and decreases. But price changes that satisfy this constraint actually benefit consumers. The benefit arises because consumers reduce their purchases of products whose prices have been increased and increase their purchases of products whose prices have been reduced. Thus, the actual impact on consumers of proposed price changes is more favorable than the impact that is calculated using prevailing output levels. Therefore, pricing flexibility subject to constraint (4) provides gains for consumers relative to the status quo.

Now consider the impact of imposing constraint (4) on the regulated firm each year, so that the relevant restriction it faces on the prices it changes in year t ($p^t \equiv (p_1^t, \ldots, p_n^t)$) is:

$$\sum_{i=1}^{n} q_i^{t-1}[p_i^t - p_i^{t-1}] \leq 0 \quad \text{or} \quad \sum_{i=1}^{n} p_i^t q_i^{t-1} \leq \sum_{i=1}^{n} p_i^{t-1} q_i^{t-1}. \tag{5}$$

For the reason just explained, consumers' surplus (weakly) increases each year when tariff basket regulation of this type is imposed, provided the demand functions facing the regulated firm do not change over time. Furthermore, in a stationary environment, prices converge to levels that maximize consumers' surplus subject to providing a particular level of profit ($\tilde{\pi}$) for the firm (Brennan, 1989; Vogelsang, 1989).[43] The magnitude of this profit ($\tilde{\pi}$) depends upon the initial price levels (p^0). To

43. Neu (1993) illustrates some of the distortions that can emerge when demand functions change over time. He shows that under a price cap constraint like that in expression (5), the regulated

illustrate, if the initial prices are profit-maximizing prices, the firm will implement those prices each year, and $\tilde{\pi}$ will be the level of profit an unregulated monopolist would secure.

To better limit the firm's profit under price cap regulation, a more stringent constraint might be imposed on the firm. For example, instead of restricting prices to generate (weakly) less than the current revenue when evaluated at current output levels as in expression (5), prices might be restricted to those that, when evaluated at current output levels, reduce revenue by at least the amount of current profit. Formally, constraint (6) might be imposed in each year:

$$\sum_{i=1}^{n} p_i^t q_i^{t-1} \leq \sum_{i=1}^{n} p_i^{t-1} q_i^{t-1} - \pi^{t-1}, \text{ where } \pi^{t-1} \equiv \sum_{i=1}^{n} p_i^{t-1} q_i^{t-1} - C(q^{t-1}). \qquad (6)$$

In expression (6), $C(q^{t-1})$ denotes the regulated firm's total cost of producing output vector $q^{t-1} \equiv (q_1^{t-1}, \ldots, q_n^{t-1})$.

When constraint (6) is imposed each year in an environment where demand and cost functions do not change over time, consumers' surplus increases each year and the Ramsey optimum is ultimately secured, provided the firm acts to maximize profit each year (Vogelsang and Finsinger, 1979). At the Ramsey optimum, the highest possible level of consumers' surplus is achieved subject to ensuring zero (extranormal) profit for the firm (Ramsey, 1927). [44]

Despite this attractive feature of constraint (6), the constraint is not without its potential drawbacks. The constraint links allowed prices to realized profit and thus to realized cost.

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firm will often raise prices substantially on services for which demand is increasing. The firm will do so because the true impact of price increases on consumers is understated when (smaller) lagged quantities are used in place of (larger) actual quantities when calculating average price changes. In this sense, the firm is not penalized sufficiently severely for raising the prices of products for which demand is growing, and so excessive price increases are induced. See Fraser (1995) for related insights regarding the effects of exogenous cost changes on prices.

44. Intuitively, convergence to the Ramsey optimum occurs because constraint (6) forces the regulated firm to evaluate relative price changes each year precisely as consumers do. In particular, a price increase on a product for which demand is high reduces significantly the firm's ability to raise other prices, just as it reduces consumers' surplus significantly. (See Train (1991, pp. 156 - 164) for a lucid explanation of this point.)

Consequently, the firm's incentive to minimize production costs may be dulled. Under some conditions, the regulated firm can gain financially from wasting resources in order to inflate its realized costs when constraint (6) is imposed. The higher costs reduce measured profit, and thereby relax constraint (6). The induced increase in costs can be so severe as to cause aggregate welfare in the regulated industry to decline below the level achieved in the absence of regulation (Sappington, 1980).

5.4.3. Strategic Pricing under Tariff Basket Regulation.

The regulated firm may behave strategically to relax a binding price cap constraint even when the constraint does not link allowed prices to realized costs. To illustrate the nature of the strategic behavior, suppose constraint (5) is imposed on the firm each year. Notice that although the lagged quantity weights (q_i^{t-1}) applied to price changes in year t ($p_i^t - p_i^{t-1}$) are beyond the control of the firm in year *t*, the firm can influence these weights through the prices (p_i^{t-1}) it sets in year *t* - 1. In particular, the firm can reduce the weight (q_i^{t-1}) applied to a price increase ($p_i^t - p_i^{t-1} > 0$) on product i in period *t* by increasing the price charged for product i in period t - 1 (which reduces q_i^{t-1}). Similarly, the firm can increase the weight applied to a price decrease in any year by reducing the price of the relevant product in the preceding year. By strategically altering the quantity weights in this manner, the regulated firm can implement gradually cumulative price changes that would be precluded by constraint (5) if the firm attempted to implement the same cumulative changes immediately. The net result of this strategic pricing behavior can be to reduce aggregate welfare substantially (Foreman, 1995; Law, 1997).

Strategic pricing of this form can be particularly advantageous to the regulated firm when it anticipates changes in its operating environment. To illustrate, suppose the firm knows that increasing competition will soon force it to reduce substantially the price it charges for a particular product. To be sure the ultimate price decline is afforded substantial weight (q_i^{t-1}) when calculating

average price changes ($\sum_{i=1}^{n} q_i^{t-1}[p_i^t - p_i^{t-1}]$), the firm can reduce the price (p_i^{t-1}) somewhat before competition compels any reduction. Doing so can provide the firm expanded freedom to raise other prices when constraint (5) is imposed (Brennan, 1989).[45]

Notice that strategic pricing of this form could be avoided if quantity (or revenue) weights were not updated annually to reflect the most recent levels of consumer demand. Instead, the output levels that prevailed at the onset of price cap regulation could be employed as weights throughout the price cap regime, for example. The drawback to using immutable weights is that, eventually, they may not reflect accurately the true impact of price changes on consumers. This drawback is deemed to be sufficiently severe in practice that weights are typically updated annually, despite the incentives for strategic manipulation that such updating can provide.

5.4.4. Strategic Nonlinear Pricing.

Price cap regulation can invite an additional form of strategic pricing when nonlinear pricing is permitted. To illustrate this fact most simply, suppose the regulated firm produces only one product and charges consumers for their consumption of this product according to a two-part tariff. A two-part tariff consists of a lump sum charge (or entry fee, E) and a constant usage price (p). Thus, a consumer who purchase q units of the product pays $E + pq$.

When the price charged for a product has two components (E and p), both components must be controlled in order to impose meaningful restrictions on the firm. One means of controlling both components of a two-part tariff is to restrict calculated average revenue below some specified level (p^0). Since demand is typically impossible to forecast perfectly, current demand ($q^{t-1} \equiv Q(p^{t-1}, E^{t-1})$) might be employed to approximate actual demand ($q^t \equiv Q(p^t, E^t)$) at proposed

45. Foreman (1995) and Law (1997) analyze corresponding strategic behavior when price changes are weighted by lagged relative revenues rather than lagged output levels. Foreman identifies conditions under which strategic weight manipulation is more problematic when relative revenue weights are employed than when quantity weights are employed.

prices (p^t, E^t), as in expressions (4) and (5). Using this approximation, the restriction that calculated average revenue not exceed p^0 in year *t* can be written as:

$$\frac{[E^t + p^t q^{t-1}]}{q^{t-1}} \leq p^0. \tag{7}$$

The numerator in the fraction in expression (7) is an approximation of total revenue at prices (p^t, E^t), where lagged quantity (q^{t-1}) is employed in place of actual quantity (q^t). Dividing this expression by lagged quantity provides calculated average revenue.

Notice that expression (7) is readily rewritten as:

$$p^t + \frac{E^t}{q^{t-1}} \leq p^0. \tag{8}$$

Expression (8) reveals that in calculating average revenue, the proposed entry fee (E^t) is divided by lagged output (q^{t-1}). Therefore, the firm can reduce calculated average revenue by increasing lagged output, which is achieved by reducing historic usage prices (p^{t-1}). Again, then, the firm can strategically manipulate quantity weights in order to relax a binding price cap constraint. Such strategic behavior can cause aggregate welfare to fall below the level that would be secured by requiring the firm to charge p^0 for each unit of output it sells (Sappington and Sibley, 1992).[46] Thus, second degree price discrimination is not always advisable under price cap regulation.[47]

5.4.5. Average Revenue Regulation.

Second and third degree price discrimination can also reduce consumers' surplus when price cap

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46. This particular form of strategic non-linear pricing might be mitigated by weighting the usage charge and the entry fee separately. For example, the entry fee might be weighted by the number of consumers, rather than their consumption levels. Cowan (1997a) analyzes the drawbacks to average revenue regulation of this type when the firm produces multiple products but cannot implement nonlinear pricing. He shows that strategic pricing by the regulated firm can cause welfare to fall below the level achieved in the absence of regulation.

47. Second degree price discrimination (i.e., nonlinear pricing) will not decrease either consumers' surplus or profit if it is authorized along with the mandate that consumers be afforded the option of purchasing on the uniform tariff, p^0 (Sappington and Sibley, 1992; Armstrong, Cowan, and Vickers, 1995).

regulation restricts average revenue below a specified level and when average revenue is calculated using forecast demand (not actual lagged demand). To see why, consider the case where demand can be forecast accurately. In this case, when the firm employs linear pricing (i.e., a fixed charge per unit, p_i), the requirement that the average revenue derived from selling *n* products remain below a specified level (p^0) can be written as:

$$\sum_{i=1}^{n} p_i q_i \Big/ \sum_{i=1}^{n} q_i \;\leq\; p^0, \text{ where } q_i = Q(p_i). \tag{9}$$

The key feature of constraint (9), often referred to as *average revenue regulation*, is that the authorized level of average revenue applies symmetrically to all products.[48] In particular, a higher level of average revenue is not authorized for products that are more costly to produce, and lower levels of average revenue are not imposed on products that can be produced at relatively low cost. Consequently, the firm that operates under average revenue regulation will have strong financial incentive to restrict the output of products that are relatively costly to produce on the margin and increase the output of products that are less costly to produce (Bradley and Price, 1988; Waterson, 1992; Cowan, 1997b). If the products that are relatively costly to produce are also the products that are highly valued by consumers, then imposition of average revenue regulation can reduce consumers' surplus severely, even below the level that would arise in the absence of regulation (Cowan, 1997b).[49]

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48. Since the outputs of different products are summed when calculating average revenue in constraint (9), average regulation is most appropriate in settings where the units of output of different regulated products are commensurate. Average revenue regulation is currently employed in the British electric, gas, and airport industries (Armstrong et al., 1994, 1995; Cowan, 1997a).

49. Crew and Kleindorfer (1996b) show that when total revenue, rather than average revenue, is capped, the regulated firm may be motivated to set prices above their unregulated monopoly levels. The price increases reduce sales, which in turn reduce production costs, and thereby increase the profit the firm can secure while generating the maximum allowed revenue.

In general, consumers' surplus falls when the firm is permitted to charge different prices for different products under average revenue regulation. Consumers' surplus would be higher if the firm were required to charge p^0 for each of its products (Armstrong and Vickers, 1991). Price variation harms consumers in this setting because consumers react to price variation by reducing their consumption of products with high prices and increasing their consumption of products with low prices. Average revenue declines when high prices are weighted less heavily and low prices are weighted more heavily. Therefore, the regulated firm can charge higher prices without violating constraint (9) when third degree price discrimination is permitted than when it is prohibited. These higher prices reduce consumers' surplus.[50]

Reductions in the authorized level of average revenue (p^0) can also cause consumers' surplus to fall under average revenue regulation (Law, 1995). Reductions in p^0 increase the firm's incentive to reduce the sales of products that are relatively costly to produce. If consumers value these products highly, then the reduction in consumer welfare due to the reduced consumption of highly-valued products can outweigh any increase in consumer welfare due to the reduction in average prices that accompanies a reduction in p^0. Thus, a more stringent price cap constraint is not always in the best interest of consumers.[51]

In summary, the precise manner in which the average growth rate of prices is calculated under price cap regulation can affect the performance of the regime, at least in theory. In practice, limited knowledge of ever-changing demand and cost structures may limit the ability of the regulated firm

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50. Armstrong, Cowan, and Vickers (1995) show that, for similar reasons, second degree price discrimination also reduces consumers' surplus when constraint (9) is imposed on the regulated firm.

51. Kang et al. (2000) show that consumers' surplus can fall when a price cap constraint that employs exogenous weights is tightened if the firm's products are complements or substitutes. In contrast, a tighter price cap constraint always increases consumers' surplus when the firm's products are independent.

to act strategically to relax the price cap constraint.

5.5. The Price Cap Constraint in Practice.

Price cap regulation in the telecommunications industry is implemented most often with a variant of tariff basket regulation that differs from expression (5) in some respects, but incorporates the essential advantages and disadvantages of tariff basket regulation discussed above. This variant prohibits an average price index in year *t* of price cap regulation (API^t) from exceeding a specified price cap index for that year (PCI^t). Formally,

$$API^t \leq PCI^t \quad \text{for all} \quad t = 1, \ldots, T, \tag{10}$$

where *T* is the number of years for which price cap regulation is imposed.

The actual price index in year *t* is an index of the prices actually charged by the regulated firm in that year, and corresponds to the term to the left of the equality in expression (1). The price cap index in year *t* specifies the maximum possible value for the actual price index in year *t*, and corresponds to the terms to the right of the equality in expression (1). The key difference between the formulations of API^t and PCI^t that follow and the terms in expression (1) is that the formulations that follow view the price indices in each year as multiples of the relevant indices in the preceding year. For reasons that will be demonstrated shortly, this intertemporal linkage is important because it ensures that the regulated firm is not penalized forever for reducing prices below their authorized level at some point during the price cap regime.[52]

Formally, the actual price index and the price cap index are defined as follows:

$$API^t = API^{t-1}\left[\sum_{i=1}^{n} r_i^t \left(\frac{p_i^t}{p_i^{t-1}}\right)\right], \tag{11}$$

52. Dennis Weisman deserves the credit for this observation.

$$\text{where} \quad r_i^t = \frac{p_i^{t-1} q_i^{t-1}}{R^{t-1}}, \qquad \text{where} \quad R^{t-1} = \sum_{i=1}^{n} p_i^{t-1} q_i^{t-1}; \text{ and} \tag{12}$$

$$PCI^t = PCI^{t-1}[1 + I^t - X^t], \tag{13}$$

where: n = number of products subject to price cap regulation;

p_i^t = unit price of product *i* in year *t* ;

p_i^{t-1} = unit price of product *i* in year $t-1$,

q_i^{t-1} = number of units of product *i* sold in year $t-1$;

R^{t-1} = revenues in year $t-1$ from all products subject to price cap regulation;

I^t = inflation index for year *t*; and

X^t = X factor for year *t*.

Expression (11) states that the actual price index in year *t* is a multiple of the actual price index in year $t-1$.[53] The relevant multiple is a weighted average of the ratio of the prices charged by the firm in year *t* to the corresponding prices in year $t-1$. As expression (12) indicates, the weight (r_i^t) applied to service *i* in calculating this weighted average of relative prices is the fraction of total revenues generated by service *i* in year $t-1$.

Expression (13) states that the price cap index in each year is a multiple of the price cap index in the preceding year. The relevant multiple in year *t* is one plus the difference between the relevant estimate of inflation for year t (I^t) and the *X* factor for year t (X^t).[54]

Expressions (10), (11), and (13) imply that the critical restriction on prices in year *t* of price cap regulation can be written as:

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53. The actual price index for the year prior to the start of price cap regulation is defined to be 100. The price cap index for this year is also defined to be 100.

54. Although the value of the *X* factor need not be the same in every year of a price cap regime, it typically is in practice.

$$API^t = API^{t-1}\left[\sum_{i=1}^{n} r_i^t \left(\frac{p_i^t}{p_i^{t-1}}\right)\right] \leq PCI^{t-1}[1 + I^t - X^t] = PCI^t. \quad (14)$$

Dividing the middle two terms in expression (14) by API^{t-1} provides:

$$\sum_{i=1}^{n} r_i^t \left(\frac{p_i^t}{p_i^{t-1}}\right) \leq \frac{PCI^{t-1}}{API^{t-1}}[1 + I^t - X^t]. \quad (15)$$

If the regulated firm sets prices at their maximum authorized levels in year t - 1, then $API^{t-1} = PCI^{t-1}$. In this case, expression (15) can be written as:

$$\sum_{i=1}^{n} r_i^t \left(\frac{p_i^t - p_i^{t-1}}{p_i^{t-1}}\right) \leq I^t - X^t. \quad (16)$$

Expression (16) corresponds exactly to expression (1), where the rate of growth of the firm's prices ($\dot{p}$) is calculated using relative revenue weights.[55]

Expression (15) reveals that if the regulated firm chooses to set prices below their maximum authorized level in some year, it is permitted to set compensating higher prices in subsequent years. Notice that if the firm sets prices below their authorized levels in year $t-1$, the price cap index will exceed the actual price index in that year (i.e., $\frac{PCI^{t-1}}{API^{t-1}} > 1$). Consequently, the firm will be authorized to implement price increases in year t that exceed the relevant difference between the inflation index and the X factor ($I^t - X^t$). Because it is not penalized forever for setting particularly low prices one year, the firm will be more willing to reduce prices below authorized levels some years, which can be advantageous for consumers.

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55. In an attempt to provide special price protection for small consumers, Oftel's price cap regulation plan for British Telecom employs relative revenue weights that reflect only the expenditures of these consumers. (Small consumers are those eighty percent of all customers who spend the least on telecommunications services.) When relative revenue weights do not reflect the expenditures of large customers, price reductions provided exclusively to large customers do not automatically authorize price increases on services sold primarily to small customers.

5.6. Additional Restrictions on Individual Price Levels.

Although price cap regulation limits the rate at which regulated prices can increase on average, it does not necessarily preclude substantial changes in individual prices. If the aggregate price constraint (as captured in expression (1), for example) is the only constraint that is imposed, then the price of any one service can rise dramatically as long as the prices of other services decline by a sufficiently large amount. Intense opposition to a price cap plan can emerge if it permits the prices of certain key services to rise too rapidly. Therefore, price cap plans often incorporate additional restrictions on the rate at which the prices of selected services can change. These additional restrictions typically take the form of price ceilings, price floors, and pricing bands.

5.6.1. Individual Price Ceilings.

Ceilings are often imposed on the prices of certain regulated services. In the telecommunications industry, for example, the price of basic local telephone service for residential customers is often frozen for some period of time, and then permitted to rise only slowly thereafter. Restrictions of this type commonly reflect political realities, even if they are at odds with economic principles. Regulators are often compelled to please their constituents, particularly their most vocal constituents. If highly visible rates that most customers must pay (such as basic local telephone service rates) rise too quickly, widespread consumer dissatisfaction can arise. To prevent or mitigate such dissatisfaction, separate restrictions on key service rates are common, even if the restrictions preclude prices from rising toward relevant production costs.

5.6.2. Price Floors and Imputation.

Price floors on individual service rates are also common under price cap regulation. Typically, the price of a regulated service is not permitted to fall below the regulated firm’s long run incremental cost of supplying the service. This restriction prevents the firm from establishing non-

compensatory rates in order to deter the operation of more efficient suppliers.[56]

Price floors in excess of long run incremental cost are often imposed when a regulated firm supplies an essential input to alternative producers and also supplies a retail product in direct competition with these producers. To illustrate why, suppose a regulated telecommunications firm supplies basic network access to competing unregulated providers of long distance telephone service. Each unit of access costs the regulated firm c^a to supply, and the firm charges p^a for each unit of access it supplies. Suppose the regulated firm also sells long distance telephone service to customers. Each unit of long distance service requires one unit of access, and costs the firm $c^a + c^d$ in total to supply. If the regulated firm were free to reduce the price it charged for long distance service to the level of the incremental cost of providing this service $(c^a + c^d)$, the firm might be able to disadvantage its competitors by implementing a price squeeze. A price squeeze would occur if the regulated firm set the price it charges competitors for network access (p^a) above $c^a + c^d$, and then reduced its price for long distance service toward $c^a + c^d$. Such pricing would ensure that competitors could not profitably match the price that the regulated firm established for long distance service.

To preclude such price squeezes, when price floors are established, the costs that the regulated firm imposes on its retail competitors are commonly treated as costs that the regulated firm incurs itself. To illustrate, the regulated price floor for long distance service in this setting would be the sum of the price charged to competitors for access (p^a) and the incremental cost of supplying long distance service, given access (c^d). By treating the costs imposed on competitors as costs incurred by the regulated firm in this manner (a procedure knows as *imputation*), prize squeezes can be

56. See, for example, Vickers (1997).

avoided, thereby securing a more level playing field for retail competition.[57]

5.6.3. Pricing Bands.

Sometimes, price floors are established at levels that exceed relevant incremental cost (including imputed cost) and are coupled with price ceilings. The result is a pricing band that restricts the extent to which the price for a service can be either raised or lowered. Typically, pricing bands specify a maximum percentage by which the price for a service can be raised or lowered annually from initial levels. For example, the pricing band may prohibit price increases or decreases of more than 10 percent in any year.

The primary purpose of pricing bands is to slow the rate at which prices change under price cap regulation. In this sense, pricing bands can add stability to a price cap plan. They do so, however, at the cost of limiting the ability of incumbent suppliers to move prices toward relevant production costs and to respond to competitive pressures.

5.7. The Number of Baskets.

Price changes on individual services can also be limited by placing services into distinct baskets, each with its own restriction on average price levels. The greater the number of distinct baskets into which services are placed, the less pricing flexibility the regulated firm is afforded.

To illustrate, telecommunications services purchased primarily by residential customers might be placed in one basket, while services purchased primarily by business customers might be placed in a different basket. By separating services in this manner, the regulated firm is not afforded the opportunity to offset substantial price increases on services sold to residential customers with price

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57. Notice that price cap regulation does not necessarily preclude price squeezes. Aggregate restrictions on overall price levels admit substantial increases in some prices (e.g., for network access) provided they are offset by decreases in other prices (e.g., for long distance service). Therefore, imputation rules and/or distinct baskets of wholesale and retail services (see section 5.7) may be advisable if global price cap regulation, as proposed by Laffont and Tirole (1996), is adopted.

decreases on services sold to business customers, for example. Thus, the use of separate baskets is another means of providing price protection for particular groups of customers or for consumers of particular groups of services. Such protection can be particularly important when the regulated firm faces different competitive pressures on different groups of products. Separate baskets can reduce the incentive the regulated firm might otherwise have to set the prices of services facing intense competition below incremental production cost and compensate for the ensuing reduction in earnings by increasing the prices of services for which competition is less intense (Armstrong and Vickers, 1993).[58]

Separate baskets for wholesale and retail services can also limit incentives for price squeezes. When reductions in the prices of retail services do not authorize increases in the prices charged to competitors for essential inputs, price squeezes may become less profitable for, and thus less attractive to, a regulated supplier of both wholesale and retail services.

One disadvantage of placing services in distinct baskets and imposing a separate price cap constraint on each basket is that the separation limits the regulated firm's ability to realign prices to more closely approximate production costs. Consequently, establishing distinct baskets and separate caps can prevent the regulated firm from setting prices that converge to Ramsey levels (as it might otherwise do when a constraint like expression (6) is imposed).[59]

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58. It is generally preferable to replace regulatory control with the discipline of competition when competition provides adequate protection for consumers. In practice, though, it is often difficult to determine precisely when adequate, sustainable competitive pressures have developed. Furthermore, the regulated firm may lobby to include competitive services in the basket of price-capped services, since their inclusion can authorize the firm to raise prices on non-competitive services to offset price reductions on competitive services. Thus, for a variety of reasons, regulatory control can persist beyond the point at which it is no longer warranted.

59. This is, in part, the reason that Laffont and Tirole (1996) recommend global price cap regulation, under which all of the regulated firm's services (both retail and wholesale services) are placed in a single basket and controlled with a single aggregate constraint.

5.8. Service Quality.

Although price cap regulation plans typically focus on regulating service prices, they also commonly regulate service quality. Service quality regulation is often thought to be particularly important under price cap regulation because the enhanced incentives for cost reduction that price caps provide can render certain reductions in service quality particularly profitable. On the other hand, by enabling regulated suppliers to retain more of the revenue that they generate in the market place, price cap regulation may render increases in certain dimensions of service quality particularly profitable. Thus, it is not clear *a priori* whether price cap regulation provides enhanced or diminished incentives for service quality relative to rate-of-return regulation.

In settings where a standard price cap regulation plan and competition together are thought to provide inadequate incentives for service quality, suitable modifications of price cap plans can be implemented. For example, key dimensions of service quality (e.g., the time a customer must wait to receive assistance with a billing problem) can be identified and a target level of performance can be specified for each dimension. Suitable financial rewards and penalties can then be implemented for service quality that exceeds or falls short of specified targets.[60] Rewards and penalties can be delivered in a variety of ways. For instance, financial rewards can be effected by raising the cap on allowed prices if service quality surpasses specific thresholds. Financial penalties might be imposed either by reducing the authorized overall rate of price increases or by requiring the regulated firm to compensate customers directly for the inconvenience they incur when the quality of service they receive falls below specified levels. For instance, local telephone companies may be required to pay customers a fixed daily fee and/or provide them with temporary wireless telecommunication service

60. Berg and Lynch (1992) and Lynch et al. (1994) explain the merits of basing rewards and penalties on an index of service quality performance measures rather than on individual service-specific performance measures.

if wireline service is not installed in a timely fashion.[61]

5.9. Conclusions.

Although the over-arching constraint on prices under price cap regulation (constraint (1)) is relatively simple conceptually, its implementation raises a host of complicating considerations, as do the other constraints (on individual service prices, quality, etc.) that price cap plans typically impose. In practice, pure price cap plans are often modified in a variety of ways in an attempt to improve their performance. Some common modifications are discussed in the next section.

61. See Rovizzi and Thompson (1992).

6. Hybrid Regulatory Plans.

Pure price cap regulation severs the link between allowed prices and realized costs. Therefore, as noted above, it can result in extremely high or extremely low earnings for the regulated firm. Regulators are typically averse to unusually high earnings, in part because constituents may view high earnings as a sign that the regulator favored the firm unduly when designing the price cap regime. Particularly low earnings can also be troubling for both the regulator and the firm, in part because low earnings can threaten the firm's ability to attract capital and provide high quality service to customers on a continuing basis.

There are a variety of ways in which price cap regulation plans can be structured to avoid extreme profit levels for prolonged periods of time. As noted in section 5, a short time span between reviews of the price cap plan can be instituted, and the reviews can be structured primarily to align prices and costs. Alternatively, or in addition, mid-term modifications of the cap (Z factors) can be permitted for major unanticipated events that are beyond the control of the regulated firm.

This section analyzes in more detail three of the additional modifications of pure price cap regulation described in section 2 that can help to limit extreme profit variation during a price cap regime. The three modifications are earnings sharing, revenue sharing, and regulatory options, all of which have been employed to varying degrees in the telecommunications industry.

6.1. Earnings Sharing Plans.

Recall from section 2 that earnings (or profit) sharing plans require the regulated firm to share with its customers a portion of the earnings that it generates in the market. A typical earnings sharing plan is illustrated in Figure 2. Under that plan, the firm must deliver to its customers half of each additional dollar of earnings it generates when earnings constitute a rate of return between 14% and 16%. Higher incremental earnings accrue entirely to customers. As it does under pure price cap regulation, the firm retains all incremental earnings when its rate of return is between 10% and 14%.

Incremental earnings can be shared in a variety of ways. Two common procedures are direct payments to customers (typically in the form of a credit on their bill) and changes in the prices of key services (such as basic local telephone service). Direct payments to customers have the advantage of demonstrating clearly to consumers the benefits that the incentive regulation is delivering to them (Sappington and Weisman, 1994b; 1996a, p.186). Price adjustments can offer the advantage of aligning prices more closely with costs, thereby increasing total surplus in the industry.[62]

6.1.1. The Fundamental Trade-off.

Regardless of the manner in which earnings are shared, the requirement to share earnings with customers alters the regulated firm's incentives to minimize operating costs and increase revenues. When the firm bears substantial unmeasured costs in improving operating efficiency, the firm's incentives to improve its operations can be dulled by earnings sharing.[63] This is the fundamental trade-off associated with earnings sharing. Earnings sharing reduces the incidence of extreme earnings but dulls the firm's incentives for outstanding performance.[64]

If earnings are shared by moving prices closer to realized cost, then a small amount of earnings sharing increases aggregate welfare (the sum of consumers' surplus and profit). This is because the losses from diminished incentives to minimize production costs are small relative to the gains from better aligning prices and costs when small amounts of earnings sharing are introduced (Lyon, 1996). More pronounced earnings sharing can reduce welfare by reducing substantially the firm's incentive to reduce its operating costs. However, even though pronounced earnings sharing can reduce

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62. Sometimes, though, shared earnings are employed to move the prices of popular services – like basic local telephone service – further below their incremental cost of production.

63. Relevant unmeasured costs include those associated with increased managerial effort or a more stressful working environment, for example.

64. If the earnings moderation secured by an earnings sharing provision convinces the regulator to implement price cap regulation for a longer period of time, then earnings sharing may result in a less pronounced diminution of the firm's incentives for outstanding performance.

aggregate welfare, it can increase consumers' surplus by transferring realized surplus from the firm to its customers. Therefore, as noted in section 4, more pronounced earnings sharing is generally optimal the more highly consumers' surplus is valued relative to profit. Earnings sharing can be particularly valuable in securing surplus for consumers when the regulator faces considerable uncertainty about the firm's ability to reduce operating costs and when costs are initially high, so the potential for cost reduction is substantial (Schmalensee, 1989; Lyon, 1996).[65] In contrast, when the firm's ability to reduce costs is thought to be particularly pronounced, less profit sharing is generally advisable in order to motivate the firm to deliver a substantial amount of cost-reducing effort (Lyon, 1996).

6.1.2. The Nature of Sharing Arrangements.

Although most earnings sharing plans that are implemented in practice resemble the plan depicted in Figure 2, basic economic principles suggest that a different plan would provide stronger incentives for the firm to pursue substantial reductions in operating costs. A key feature of the plan in Figure 2 is the fact that when the firm's earnings exceed the target rate of return (12%), the fraction of incremental earnings awarded to the firm declines with the level of earnings it generates. In particular, the firm receives first all, then half, and finally none of its incremental earnings as market returns rise toward 14%, then toward 16%, and finally above 16%. When higher returns stem primarily from realized cost reductions, this pattern of earnings sharing promises smaller incremental rewards for additional cost reduction the greater the amount of cost reduction already achieved. If it becomes increasingly more difficult to achieve further cost reduction the greater the level of cost reduction already achieved, then the diminishing incremental rewards promised by an earnings sharing plan like the one depicted in Figure 2 will fail to provide strong incentives for particularly

65. Gasmi et al. (1994) report that simple profit sharing plans coupled with downward pricing flexibility for the firm can often closely approximate optimal incentive structures.

extensive cost reductions. An earnings sharing scheme that promised a greater share of incremental earnings to the firm the higher the level of earnings it achieves would better serve this purpose (Blackmon, 1994, pp. 60 - 62; Lyon, 1996). However such schemes run the risk of delivering profits to the firm that are deemed to be unduly large, and so, in part for this reason, are uncommon in practice.[66]

6.1.3. Investment Incentives.

In addition to reducing the regulated firm's incentive to reduce operating costs and increase revenues, earnings sharing plans can provide undesirable investment incentives to the firm. To see why, consider again the earnings sharing plan illustrated in Figure 2. When the firm generates earnings in the market that constitute a return of approximately 10%, the firm faces asymmetric returns from additional investment projects. If a project fails and reduces returns below 10%, the firm bears only half of the associated costs. In contrast, the firm reaps all of the gains if the project increases returns above 10%. When it enjoys the full upside potential of projects but bears only a fraction of their downside risk, a firm may find it profitable to undertake projects with low (even negative) expected net present discounted value (NPDV). A firm may also find it profitable to undertake projects that are unduly risky (Blackmon, 1994, pp. 66 - 68).

For analogous reasons, the regulated firm operating under the earnings sharing plan in Figure 2 may choose not to pursue projects with positive expected NPDV when its current earnings constitute a return of approximately 14%. At this point, the firm can bear the full cost of a failed project but receive at most half of the returns from a successful project. Thus, when they incorporate abrupt changes in the marginal returns to improved performance, earnings sharing plans can induce

66. Davis (2000) reports that under the earnings sharing plan implemented for San Diego Gas and Electric in 1999, the company is afforded a larger fraction of incremental earnings as earnings increase between 25 and 300 basis points above the approved rate of return.

undesired investment behavior.[67] One way to limit the extent of this behavior is to include numerous small changes, rather than a few large changes, in the rate at which earnings are shared between the regulated firm and its customers (Blackmon, 1994, pp. 67-68).

6.1.4. Cost Shifting.

Earnings sharing schemes can also provide incentives for the regulated firm to shift costs from one year to the next. To see why, suppose a regulated firm is operating under the earnings sharing plan depicted in Figure 2. Also suppose the firm is currently generating a 9% return in the market, but anticipates earning a 12% return next year. In this situation, the firm can gain financially by shifting costs from next year to the current year, perhaps by accelerating routine maintenance expenditures, for example. Since the firm bears only half of any realized cost increase when its earnings provide a return of 9% but benefits by the full amount of any realized cost reduction when its earnings provide a 12% return, the firm gains financially from shifting costs intertemporally in this manner.

6.1.5. The Regulator's Incentives.

Earnings sharing plans can also affect the incentives of the regulator, just as they affect the incentives of the regulated firm. In particular, earnings sharing plans can alter the regulator's incentive to disallow realized production costs when calculating earnings and to promote entry into the regulated industry.

Consider, first, the regulator's incentive to disallow costs. If a cost incurred by the regulated firm is not counted as such when calculating the firm's earnings, then measured earnings increase. Consequently, if the firm's earnings are in the range where nontrivial earnings sharing is mandated (e.g., if they constitute a rate of return between 14% and 16% under the plan depicted in Figure 2),

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67. Earnings sharing plans can improve investment incentives when regulators are otherwise inclined to force the firm to bear the downside risk of failed investments and limit the firm's returns from successful investments (Lyon, 1995).

the regulator can secure a greater direct payoff for consumers by declaring some costs to have been incurred imprudently, and thereby disallow those costs.[68] The regulator who values consumers' surplus more highly than profit will find it attractive to disallow costs under earnings sharing plans unless doing so raises the firm's cost of capital by more than the corresponding direct gains secured for consumers. By increasing the regulator's incentive to disallow costs in this manner, earnings sharing plans can induce the regulated firm to undertake too little surplus-enhancing investment (Sappington and Weisman, 1994a, 1996c).

Now consider the impact of earnings sharing plans on the incentives of regulators to promote entry into the regulated industry. Recall that under pure price cap plans, prices do not vary with the earnings of the regulated firm. In particular, the regulator is under no obligation to raise prices in the regulated industry as the firm's earnings fall. This fact may encourage the regulator to facilitate entry into the industry in order to secure even lower prices for consumers. The regulator may be more reluctant to encourage entry when an earnings sharing plan is in place because the plan can obligate the regulator to raise industry prices in order to mitigate any major impact of entry on the earnings of the incumbent firm.[69] Since earnings sharing plans can better align the interests of the regulator and the regulated firm in this manner, the firm may ensure higher *ex post* returns by agreeing *ex ante* to share earnings with customers (Weisman, 1994).

6.1.6. Summary.

In summary, earnings sharing offers a host of benefits and costs.[70] It can help to avoid extreme

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68. See Howe (1983, 1985), Kolbe and Tye (1991), Lyon (1991, 1992), and Encinosa and Sappington (1995), for example, for analyses of regulatory prudence policy.

69. Lehman and Weisman (2000) provide empirical evidence of this effect.

70. An additional cost of an earnings sharing plan is the resources it consumes in measuring earnings. Such measurement is generally not straightforward. Earnings can be difficult to measure in part because operating costs generally include depreciation costs, and depreciation costs can vary with the estimated value of the firm's assets, which in turn vary with regulatory

profit realizations, but only at the cost of dulling the firm's incentives for cost reduction and distorting its investment incentives. Earnings sharing plans can also affect the regulator's incentives to disallow costs and promote entry into the regulated industry. As noted in section 3, the recent trend in the U.S. telecommunications industry is away from earnings sharing plans and toward pure price cap plans. This trend may reflect in part reduced uncertainty about the ability of incumbent telecommunications suppliers to increase their earnings when afforded substantial incentive to do so.

6.2. Revenue Sharing Plans.

Profit variation can also be dampened under price cap regulation plans by imposing revenue sharing rather than earnings sharing. As illustrated in Figure 3, a typical revenue sharing plan requires the regulated firm to share with its customers incremental revenue in excess of a specific threshold level.

Because they mandate the sharing of revenues, not profits, revenue sharing plans do not reduce the regulated firm's incentive to minimize its operating costs. In addition, unlike earnings sharing plans, revenue sharing plans provide no incentives for the regulator to disallow production costs incurred by the firm. It is also not necessary to measure earnings under price cap regulation plans that incorporate revenue sharing. Therefore, revenue sharing plans avoid some of the key drawbacks that plague earnings sharing plans.

Revenue sharing plans are not without their own potential drawbacks, however.[71] Most

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policy (Mayer and Vickers, 1996). Earnings sharing plans can also provide the regulated firm with inappropriate incentives to diversify into unregulated markets and to shift costs across markets, depending upon how cost allocation rules are structured (Weisman, 1993; Chang and Warren, 1997).

71. As noted above, Crew and Kleindorfer (1996b) show that when a binding ceiling is placed on the firm's total revenue, the firm may set prices above their monopoly levels in order to secure the maximum authorized revenue while limiting output, and thus cost.

importantly, because the firm bears the full cost of generating revenues above the specified threshold but receives only a fraction of the associated benefit, the firm will generally have insufficient incentive to generate these incremental revenues. Such insufficient incentive can manifest itself in a variety of ways. For instance, the regulated firm may not install the capacity required to satisfy all demand that is expected to materialize. In addition, the firm might reduce the quality of service it provides when reduced service quality reduces operating costs. The firm might also alter relative prices. It might, for example, lower prices on services with inelastic demand and raise prices on services with elastic demand. Doing so can increase the firm's earnings by reducing aggregate output and thus operating costs (Sappington and Weisman, 1996c).

The merits of revenue sharing vary according to the environment in which it is imposed. In an environment where the potential for cost reduction is thought to be substantial and where realized demand is largely beyond the control of the regulated firm, revenue sharing may be preferable to earnings sharing as a means of avoiding extreme profit realizations. In contrast, where service quality is highly valued, costly to provide, difficult to monitor, and serves as a primary determinant of consumer demand, revenue sharing may not be the best way to limit variation in realized profit.

6.3. Regulatory Options.

The choice between different regulatory plans – rate of return regulation, pure price cap regulation, earnings sharing regulation, revenue sharing regulation, etc. – can be a difficult one. The ideal regulatory plan depends upon the environment in which it is implemented, and perfect information about the regulated industry is almost never available. Fortunately, a regulator need not always select the single most appropriate regulatory plan. Instead, the regulator can allow the regulated firm to choose one regulatory regime from a carefully designed menu of regimes. Doing so can often secure the key advantages of the regulatory plans without incurring all of their disadvantages. It can also employ the regulated firm's superior knowledge of its operating

environment to select a plan that is advantageous for consumers.

To illustrate this point most simply, consider the following example (drawn from Sappington and Weisman (1996a, pp. 158-162)). The example illustrates how, by affording the firm a choice between rate of return regulation (RORR) and pure price cap regulation (PCR), the regulator can secure a higher level of expected consumers' surplus than if the regulator limited himself to implementing either RORR or PCR.[72] The gain in consumers' surplus arises because when RORR is made available as an option, the regulator can offer the firm a more demanding price cap plan without risking financial distress for the firm.

The example has the following features. The regulated firm knows precisely the maximum possible improvement in its productivity growth rate under price cap regulation. Call this maximum level of improvement x_m. The regulator does not share the firm's knowledge of x_m. Thus, if it were to impose PCR, the regulator would be forced to choose an *X* factor, denoted *x*, not knowing with certainty whether the selected *X* factor, *x*, is smaller than x_m, and thus readily achieved by the firm, or whether *x* exceeds x_m, so that the price cap plan will force the firm to suffer financial insolvency.[73] The regulator's beliefs about the firm's capabilities, x_m, are represented by the distribution function $F(\tilde{x})$, which denotes the probability that x_m is less than or equal to any specified *X* factor, $\tilde{x}$.

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72. More generally, a regulator might design an entire menu of regimes without restricting *a priori* the nature of permissible regimes, and allow the firm to choose one regime from the menu. In such a setting, the menu of regimes will typically include a variety of different earnings sharing plans and one plan with no earnings sharing (e.g., a price cap regulation plan). See, for example, Baron and Myerson (1982), Laffont and Tirole (1986, 1993), and Lewis and Sappington (1989).

73. In practice, insolvency is unlikely to result immediately. Instead, the firm that cannot achieve productivity gains of at least *x* may be forced to reduce service quality and allow its capital stock to deteriorate in the short run. As time progresses, the firm will have difficulty attracting new capital, and may eventually be forced to terminate operations. This entire process will be referred to as "insolvency" in the ensuing discussion.

RORR is initially practiced in the industry, and consumers receive net benefits $\overline{B}$ under RORR. If the regulated firm becomes insolvent, consumer benefits fall to the lower value, $\underline{B}$. If the firm is solvent under PCR, consumer benefits rise to $[1 + x]\ \overline{B}$. Thus, consumer benefits are higher the more ambitious the productivity offset, x, as long as the regulated firm is solvent.

To calculate the gains that arise when PCR is offered as an option rather than mandated, it is useful to compare two distinct problems. In the first problem, the regulator chooses the value for the X factor to maximize expected consumer benefits when the regulated firm is required to operate under PCR. The second problem adds RORR as an option. Formally, these two problems are the following:

Problem 1. Mandatory Price Cap Regulation.

$$\underset{x}{\text{Maximize}} \quad F(x)\,\underline{B} + [1 - F(x)]\ \overline{B}[1 + x].$$

Problem 2. Optional Price Cap Regulation.

$$\underset{x}{\text{Maximize}} \quad F(x)\,\overline{B} + [1 - F(x)]\ \overline{B}[1 + x].$$

As their formulations reveal, these two problems differ only in the level of consumer benefits that are generated if the specified X factor, x, exceeds the maximum potential productivity improvement of the firm. When PCR is mandated (Problem 1), the firm will be insolvent when $x > x_m$, and the smaller level of benefits, $\underline{B}$, will result. When RORR is retained as an option (Problem 2), the higher benefits, $\overline{B}$, are generated when $x > x_m$. Recall that $F(x)$ is the regulator's assessment of the likelihood that x_m is less than x, so the firm is expected to opt for RORR with probability $F(x)$ in Problem 2. With the complementary probability, $1 - F(x)$, the firm is expected to choose PCR, resulting in consumer benefits of $\overline{B}[1 + x]$.

It is straightforward to verify that the regulator will select a more demanding productivity offset

(x) when PCR is offered as an option than when its adoption is mandated.[74] Consumers suffer less when RORR rather than insolvency arises if the firm cannot achieve the productivity gains required under PCR. Consequently, the regulator is more willing to implement a productivity target that exceeds the firm's capabilities. It is also readily shown that a higher level of expected consumer benefits results when the higher productivity offset is selected in Problem 2.

The magnitude of the expected gain from introducing price cap regulation as an option rather than mandating its adoption depends on the nature of the uncertainty about the firm's ability and on the loss incurred if the regulated firm becomes insolvent. To illustrate, suppose the regulator is certain that the firm's maximum potential productivity gain (x_m) is between 1 and 5 (percent). Within this range, however, all possible realizations are equally likely.[75] It can be shown that in this setting, the regulator will set $x = 2.5$ when PCR is optional. He will set $x = 2 + .5\underline{B}/\overline{B} < 2.5$ when PCR is mandated. The corresponding levels of expected consumer benefits are $2.56\,\overline{B}$ when PCR is optional, and $.25[\underline{B} + 9\overline{B} + .25(\underline{B})^2/\overline{B}]$ when it is mandatory. Therefore, if, for example, $\underline{B} = .25\,\overline{B}$, so the consumer benefits generated when the firm is insolvent are one quarter of the corresponding benefits that are secured under RORR, the regulator will set $x = 2.5$ when PCR is optional and $x = 2.125$ when it is mandated. Expected consumer benefits will be approximately eleven percent higher when PCR is offered as an option rather than mandated. Thus, the gains from providing choices to the firm when implementing incentive regulation plans can be substantial.

The gains from options can be even larger when regulation is being designed for more than a single regulated firm. The ideal regulatory plan for one firm may be largely inappropriate for another firm. Consequently, by affording multiple regulated firms a choice among regulatory options, a

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74. Formally, if x_1 denotes the (unique, interior) solution to Problem 1, x_1 is given by $\overline{B}[1 - F(x_1)] = [\overline{B}[1 + x_1] - \underline{B}]\,F'(x_1)$. Also, if x_2 denotes the (unique interior) solution to Problem 2, then x_2 is given by $\overline{B}[1 - F(x_2)] = \overline{B}\,x_2\,F'(x_2)$.

75. Formally, $F(x) = .25[x - 1]$ for all $x \in [1, 5]$.

regulator can treat all firms identically *ex ante* while securing *ex post* differences in regulatory policies that best serve consumers. As noted in section 2, the Federal Communications Commission afforded different options to the major local exchange carriers in the United States. By doing so, it was able to better tailor regulatory policy to the different operating circumstances of the different carriers.

Although a regulator can secure gains for consumers by allowing a regulated firm to choose among regulatory options, ongoing unfettered choice among options is not always advisable. Such choices can invite strategic behavior on the part of the firm. To illustrate, suppose the firm were permitted to choose freely between a PCR plan and a RORR plan each year. Then the firm might find it profitable to alternate between the two plans each year, and shift expenditures from years in which it operates under PCR to years in which it operates under RORR. By doing so, the firm can increase profit under PCR without reducing profit under a RORR regime that matches allowed revenues to measured costs. To limit the firm's ability to impose excessive costs on consumers in this manner, the firm might only be permitted to choose RORR after selecting PCR if profits are sufficiently low for a sufficiently long period of time under PCR.

6.4. Conclusions.

This chapter has reviewed some of the ways in which pure price cap regulation plans can be modified in order to retain the central advantages of price cap regulation while avoiding some of its main disadvantages. None of these modifications is without its own potential drawbacks, though, and some can serve to blur the practical distinctions between rate of return regulation and its alternative.

Having reviewed the primary alternatives to rate of return regulation that are employed in practice, the discussion turns now to the measured impact of incentive regulation plans.

7. The Impact of Incentive Regulation.

The purpose of this section is to summarize existing knowledge regarding the impact of incentive regulation on performance in the telecommunications industry.[76] Performance has many dimensions, including prices, operating costs, network modernization, productivity, profit, service quality, and telephone subscription rates. Each of these dimensions is examined in turn. Most of the empirical studies to date examine the effects of incentive regulation in state telecommunications markets in the United States. This is because the significant variation in regulatory policy across the fifty states constitutes a natural experiment that lends itself to econometric analysis. There is a great need to conduct corresponding empirical analyses in other countries around the world.

7.1. Prices.

The evidence regarding the impact of incentive regulation on prices is mixed. Mathios and Rogers (1989) find that AT&T set prices for intrastate, interLATA telephone calls that were approximately 7 percent lower in states where it was afforded limited pricing flexibility than its states where it faced strict rate of return regulation, holding other factors constant.[77] Although this early finding may suggest that incentive regulation encourages price reductions, Mathios and Rogers' finding may also be testimony to the effects of competition. If state regulators granted AT&T expanded pricing flexibility precisely in those states where it faced the greatest pressure from competitors, then the observed price reductions may be due more to competition than to incentive

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76. The discussion in this section draws heavily from Kridel et al. (1996). See Abel (2000) for a complementary review of the empirical literature on the effects of price cap regulation.

77. Recall that LATAs are geographic areas in the U.S. called local access and transport areas, and that interexchange carriers can provide telecommunications services that cross LATA boundaries (i.e., interLATA services), but the major local exchange carriers (the regional Bell Operating Companies or RBOCs) presently cannot.

regulation.[78] The authors did not control for the possible endogeneity of the regulatory regime.[79]

Kaestner and Kahn (1990) provide some corroborating evidence. They report that between 1986 and 1988, AT&T's intrastate toll prices were lower by 18 percent in states where the company was afforded pricing flexibility than in states where it faced strict rate of return regulation. Even more pronounced price reductions were observed in states where AT&T's toll prices were largely deregulated. Kaestner and Kahn employ proprietary data on non-AT&T market share in an attempt to separate the effects of competition from the effects of incentive regulation. This procedure is admirable, but perhaps not entirely successful. Increased competition may have led to relaxed regulation in the time period under study, so the observed reduction in prices may not be due entirely to incentive regulation. The authors also explain that the observed decline in deregulated prices may be due to "demonstration effects," i.e., in an attempt to demonstrate the merits of deregulation to all regulators, AT&T intentionally set prices below profit-maximizing levels.[80]

In a more recent study that examines a longer time period (1980-1991), Tardiff and Taylor (1993) find that the intraLATA toll prices set by the regional Bell Operating Companies (RBOCs) in the United States are approximately 5 percent lower on average under incentive regulation than under rate of return regulation. The largest decline in intraLATA toll prices was observed under earnings sharing regulation, in part, perhaps, because price reductions are the means by which

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78. Abel (1999) and Banker et al. (1995, 1996) find that growing competition has compelled major price reductions in the U.S. telecommunications industry in recent years. Knittel (1997) also provides evidence which suggests that competition may have led to lower local telephone rates between 1984 and 1993.

79. As noted above, Donald and Sappington (1995, 1997) examine the determinants of the choice of regulatory regime.

80. See Sappington and Weisman (1996b) for a more complete discussion of demonstration effects and other factors that merit consideration when attempting to assess the impact of incentive regulation on industry performance.

relevant earnings are shared with customers. Prices were actually higher under deregulation, price cap regulation, and rate case moratoria than under rate of return regulation. Higher toll prices under these regimes may have served to offset lower basic service rates. Basic local service rates are often the most visible and the most politically sensitive rates. Consequently, regulated firms may either have been required to keep these rates low as a pre-condition for incentive regulation, or they may have kept the rates low voluntarily in order to garner increased support for continued incentive regulation.

Blank et al. (1998) report that intraLATA toll prices charged by the RBOCs were approximately 12 percent higher under incentive regulation than under rate of return regulation as of December 31, 1991, after controlling for other possible causes of price variation. In particular, the authors employ several proxies for competition, including: (1) whether intraLATA toll competition is permitted in the state; and (2) the fraction of total access lines in the state that are business access lines (since competition for business customers is often particularly intense). The authors find that competition tends to reduce intraLATA toll rates by almost as much as incentive regulation increases them. The authors suggest that the expanded pricing flexibility that often accompanies incentive regulation may enable the regulated firm to raise intraLATA toll prices in return for lowering the prices of other services.

The price for basic local telephone service appears to have declined modestly under some forms of incentive regulation. Although Tardiff and Taylor (1993) report no significant decline in these prices under incentive regulation, broadly defined, prior to 1992, Crandall and Waverman (1995) find these prices to be lower by approximately 10 percent under price cap regulation than under rate of return regulation. The authors examine basic local service rates between 1987 and 1993. Ai and Sappington (1998) derive similar conclusions in their analysis of U.S. local service rates between 1991 and 1996.

Magura (1998) reports the largest estimated impact of incentive regulation on basic local service rates. Using data on U.S. basic local service rates between 1987 and 1994, Magura finds that incentive regulation is associated with a 17 percent decline in rates. The author attributes this decline to a reduction in operating costs under incentive regulation.

Undoubtedly, basic local service rates are determined by political and strategic factors as well as economic factors. Notice, for example, that basic local service rates in Nebraska have remained largely unchanged for twelve years, despite being largely deregulated in 1987. It seems likely that U.S. West intentionally kept basic local service rates far below profit maximizing (and authorized) levels in Nebraska in order to foster support for reduced regulatory control in other jurisdictions where it operates.

Braeutigam et al. (1997) provide an important extension of this line of research. The authors point out that not all incentive plans within a specified category are identical. For instance, some price cap regulation plans require the regulated firm to reduce basic local service rates at the outset of the price cap regime, while others do not. Similarly, some plans require particular types of infrastructure investment and network modernization, while others do not. Braeutigam et al. Find little impact of incentive regulation, broadly defined, on basic local service prices in the United States between 1987 and 1993. However, prices are significantly lower under plans that require initial price reductions, and are significantly higher under plans that impose substantial investment requirements. This work illustrates the importance of defining "incentive regulation" precisely when examining its impact empirically.

Armstrong et al. (1994) report fairly dramatic reductions in British Telecom's toll prices under price cap regulation between 1984 and 1993. For example, inflation-adjusted peak-period toll calls fell by more than 60 percent during the period. In contrast, the basic monthly access charge for local service (the line rental rate) increased in real terms by approximately 5 percent. The authors point

out that competitive pressures likely played a significant role in the observed decline in toll prices. However, they do not attempt to isolate the impact of competition, price cap regulation, and other factors econometrically. [81]

7.2. Operating Costs.

Proponents of incentive regulation stress its ability to foster cost reduction by the regulated firm. When prices are permitted to diverge from realized production costs, the regulated firm can benefit financially when its production costs fall. Consequently, incentive regulation may induce the regulated firm to undertake the actions required to reduce operating costs.

To date, however, the relevant empirical evidence on this issue is mixed. Shin and Ying (1993) find that incentive regulation is associated with a slight (1 percent) increase in operating costs in the U.S. telecommunications industry between 1988 and 1991. Ai and Sappington (1998) find no link between incentive regulation and operating costs between 1991 and 1996.While Ai and Sappington simply regress total cost on historical cost and other possible determinants of cost, Shin and Ying estimate the parameters of a multiproduct translog cost function. They do so using observations on 50 U.S. local exchange companies (including the RBOCs) between 1988 and 1991. The authors disaggregate total operating costs into capital costs and other costs.

As noted above, Magura (1998) finds that U.S. basic local service rates are approximately 17 percent lower under incentive regulation than under rate of return regulation. Under the assumption that basic local service rates are priced residually (i.e., they are set as low as possible while generating a fair return for the firm, after setting prices for other services to maximize net revenues), Magura suggests that the lower local service prices may reflect pronounced declines in fixed

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81. Wolak (1996b) examines average revenue per access line for incumbent operators in selected U.S. states. He finds significantly lower average revenue in states that have typically promoted competition in their telecommunications industries. Wolak does not control for differences in incentive regulation plans in his five-state sample.

operating costs under incentive regulation.

The diverse findings in the literature, including the mixed results regarding the impact of incentive regulation on operating costs, may be explained by a variety of factors. First, lasting effects of incentive regulation on costs may take more time to develop than is reflected in available time series data. Second, firms may produce a different array of products and services under incentive regulation, which can affect production costs. Third, to the extent that incentive regulation is implemented when competition is more pronounced and to the extent that competition raises operating costs (via reducing scale economies or increasing advertising costs, for example), higher operating costs might be expected under incentive regulation regimes. Fourth, although many telecommunications firms reduced the size of their labor force when they began to operate under incentive regulation, the labor force reductions may have actually increased short term labor costs. This is because labor force reductions are typically achieved by paying employees to terminate their employment voluntarily, and the associated expenditures are often recorded as short term costs (Kridel et al., 1996)

7.3. Network Modernization.

As noted above, incentive regulation has been linked to increased network modernization. Greenstein et al. (1995) report substantial increases in the deployment of fiber optic cable and modern switching equipment under incentive regulation in general and price cap regulation in particular between 1986 and 1991.[82] To illustrate, the authors estimate that price cap regulation leads to a 100 percent increase in the deployment of fiber optic cable relative to rate of return regulation. The corresponding increases under rate case moratoria and earnings sharing regulation are estimated

82. Taylor, Zarkadas, and Zona (1992) provide some corroborating evidence. The authors estimate that incentive regulation accelerated substantially the deployment of modern switching and transmission equipment in the U.S. telecommunications industry in the late 1980s and early 1990s. In contrast, Tardiff and Taylor (1993) find little evidence that incentive regulation accelerates network modernization.

to be 40 percent and 50 percent, respectively. However, if an earnings sharing requirement is appended to a price cap regulation plan, there is virtually no increase in fiber deployment relative to rate of return regulation.

Ai and Sappington (1998) report a less dramatic, but still positive impact of incentive regulation on network modernization. The authors find that between 1992 and 1996, price cap regulation, earnings sharing regulation, and rate case moratoria are all associated with telecommunications networks that contain a larger fraction of modern network switches. Price cap regulation and earnings sharing regulation are also linked to networks with a higher fraction of fiber optic cable.[83]

Ai and Sappington (AS)'s smaller estimates of the impact of incentive regulation on network modernization may stem in part from the longer and more recent time period the authors study. Conceivably, pronounced increases in network modernization may occur at the onset of incentive regulation, while subsequent increases are less pronounced. It is also possible that particularly large increases in network modernization were mandated during the early years of incentive regulation. Neither Greenstein et al. nor AS differentiate among incentive regulation plans according to the extent of network modernization the plans mandate.

The smaller effects of incentive regulation on network modernization that AS find may also reflect in part the authors' direct measure of competition. AS include as an explanatory variable the number of miles of fiber optic cable that competitive access providers (CAPs) have installed in the state.[84] Greenstein et al. employ alternative measures of competitive pressures, such as whether

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83. Ai and Sappington also find that aggregate investment is slightly higher under earnings sharing regulation than under rate of return regulation. The authors do not distinguish between earnings sharing plans and price cap regulation plans with an earnings sharing requirement, as Greenstein et al. do.

84. AS implicitly treat the entire state as the relevant operating territory of the RBOC on which regulation is imposed. Greenstein et al. (1995) employ more precise measures of each RBOC's operating territory.

CAPs are authorized to operate in the state and whether intraLATA toll competition is permitted in the state.[85]

7.4. Total Factor Productivity.

There is mixed evidence regarding the extent to which incentive regulation spurs productivity growth. Productivity is the ratio of a firm's outputs to the inputs it employs in production. Thus, productivity measures the firm's efficiency in transforming inputs into outputs. A firm's total factor productivity growth (TFPG) rate is a measure of the rate at which its productivity is increasing.

Kwoka (1993a) reports a substantial increase in British Telecom's TFPG rate immediately after the onset of privatization and price cap regulation. He estimates that BT's productivity increased by 21.8% between 1984 and 1987, and that 22% of this increase was due to the change in ownership and regulatory structure.[86] Kwoka attributes 52% of the increase to the impact of expanded output and scale economies, and the remaining 26% of the increase to technical change.

Schmalensee and Rholfs (1992) estimate that AT&T's higher TFPG under price cap regulation between 1989 and 1991 resulted in extra benefits of more than $1.8 billion for AT&T and its customers. While a significant portion of this sum may be attributable to the effects of price cap regulation, much of it is likely due to the effects of competition.[87] Tardiff and Taylor (1993) estimate

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85. Wolak (1996b) compares infrastructure modernization in three U.S. states that have historically fostered industry competition (California, New York, and Illinois) with two states that have tended to be less supportive of competition (Arkansas and Texas). He finds that modernization proceeded more rapidly in the former states initially, but that initial differences on most dimensions ultimately disappeared. Woroch (2000) finds that investment by competitive local exchange carriers in fiber rings around major cities in the United States spurred corresponding investment by incumbent local exchange carriers between 1983 and 1992.

86. In contrast, Kwoka (1993a) estimates that the initial impact of the divestiture of AT&T was to reduce the company's TFPG rate. The positive effects of competition and scale economies, though, outweighed the negative impact of divestiture.

87. Empirical estimates of the impact of competition on TFPG rates in the telecommunications industry vary. Crandall (1991, p. 69) reports a significantly higher TFPG rate in the U.S.

that the TFPG rate of large telecommunications firms in the U.S. increased by 2.8 percentage points under incentive regulation prior to 1992. This substantial increase is attributable in roughly equal parts to an increase in the growth rate of outputs and a decrease in the growth rate of inputs under incentive regulation. Of course, if the firms that choose to operate under incentive regulation are those that are particularly capable of increasing their TFPG rates substantially, then the 2.8 percentage point increase likely exceeds the corresponding average increase that would arise if incentive regulation were applied to all firms.

In a more recent study, Resende (1999) finds no evidence that incentive regulation increases productivity growth rates. Resende examines these rates for the major local exchange companies in the U.S. telecommunications industry between 1988 and 1994. The author estimates a translog cost function in order to decompose observed changes in productivity growth rates into effects due to technical change, operating scale, price levels, and incentive regulation. Once the first three effects are controlled for, incentive regulation has no additional impact on the observed productivity growth rate in Resende's sample. The author points out that his sample exhibits considerable heterogeneity and his analysis presumes the firms to operate on the efficiency frontier. Consequently, he suggests that his finding of no overall impact of incentive regulation on productivity growth rates "should be considered with caution" (Resende, 1999, p. 42).[88]

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telecommunications industry between 1971 and 1983 than between 1961 and 1970. Staranczak et al. (1994) find no significant relationship between facilities-based competition and TFPG in ten OECD countries between 1983 and 1987.

88. Dennis Weisman has suggested one reason why the initial productivity gains from incentive regulation might be limited. Firms face legal and institutional constraints as they attempt to reduce their work force in response to increased incentives for cost reduction. These constraints often compel the firms to offer similar incentive retirement packages to all employees. If the most highly-skilled employees have the most attractive employment options at other firms, then they may be particularly likely to accept the retirement package offered by the regulated firm. Consequently, the downsizing may reduce average labor productivity in the regulated firm, *ceteris paribus*.

Majumdar (1997) examines the impact of various incentive regulation plans on a measure of technical efficiency rather than total factor productivity growth. Employing an approach developed by Banker et al. (1984), Majumdar constructs a measure of the relative efficiency of 45 local exchange companies in the United States between 1988 and 1993.[89] The efficiency measure relates to the companies relative performance in transforming inputs (switches, lines, and employees) into outputs (local, intraLATA toll, and interLATA toll calls), and requires no explicit assumptions about the firms' production technologies. Majumdar finds that: (1) price cap regulation is associated with significant improvement in efficiency after a lag of two years; (2) the positive impact of price cap regulation is diminished when earnings sharing provisions are added to price cap regulation; and (3) earnings sharing regulation alone is associated with a long-term reduction in measured efficiency.

As Majumdar (1997) points out, it is important to determine whether his findings persist in studies that employ a longer time series and more recent data. Alternative measures of efficiency should also be explored. In addition, the endogeneity of the selected regulatory regime should be accounted for explicitly. Better controls for the competitive pressures the firms face and relevant differences in their operating conditions (e.g., customer population density) would also be useful.

7.5. Earnings.

There is some evidence that the earnings of the regulated firm increase when it operates under incentive regulation, particularly price cap regulation. The Federal Communications Commission (1992) reports that AT&T's average annual rate of return was 13.2 percent under the first thirty months of price cap regulation, whereas its prescribed rate of return was 12.0 percent just prior to the imposition of price cap regulation in July 1, 1989. Tardiff and Taylor (1993) find no significant

89. Majumdar (1995), Jha and Majumdar (1999), Fraquelli and Vannoni (2000), and Resende (2000) employ related methodologies and find that competition and/or incentive regulation have motivated suppliers of telecommunications services to increase their operating efficiencies in recent years.

relationship between earnings and incentive regulation, broadly defined, between 1984 and 1990.

Armstrong et al. (1994, pp. 204-5) report that British Telecom's rate of return on capital increased from less than 17 percent in 1984 (when price cap regulation was instituted) to more than 21 percent in 1991 and 1992. Of course, this increase reflects a variety of effects, including the change from public to private ownership of BT. Ai and Sappington (1998) report that RBOC earnings were higher (by approximately 16%) under price cap regulation than under rate of return regulation between 1991 and 1996. However, they do not find evidence of higher earnings under other forms of incentive regulation. Of course, studies of the effects of regulatory policy on earnings are difficult to conduct because firms often have significant discretion in allocating revenues and costs across time periods.

7.6. Service Quality.

Incentive regulation can promise the regulated firm substantial financial reward for realized cost reductions. Consequently, the possibility arises that a firm that operates under incentive regulation may be tempted to reduce service quality unduly in order to reduce operating costs.[90] The evidence on this issue is mixed.

AT&T experienced some large-scale service outages while operating under price cap regulation in 1990 and 1991. However, after careful study of the circumstances surrounding the outages, the U.S. Federal Communications Commission (1992) reported no evidence of a link between price cap regulation and AT&T's service quality. Tardiff and Taylor (1993) also find no evidence that incentive regulation promotes reduced service quality in the U.S. telecommunications industry.

Armstrong et al. (1994) report widespread dissatisfaction with the service quality provided by British Telecom (BT) during the early years of price cap regulation. An audit by the regulatory body

90. Norsworthy and Tsai (1999) stress the need to account for realized service quality when designing reward structures for regulated firms.

Oftel revealed that although BT's service quality was not as poor as it was generally perceived to be, it could have been substantially higher than it was on many dimensions. BT was required to publish certain service quality performance statistics twice each year, and was also subjected to financial penalties for poor service quality. Increased competition was also encouraged, and appeared to have had its intended effect. To illustrate, 17 percent of BT's pay telephones were out of order on average in 1986. The corresponding statistic in 1987 was 23 percent. In 1987, BT's primary competitor, Mercury, was authorized to provide pay telephone service. By 1989, less than 5 percent of BT's pay telephones were out of order (Rovizzi and Thompson, 1992).

Ai and Sappington (1998) find that during the mid 1990's, the service quality provided by the RBOCs in the United States was lower on some dimensions under incentive regulation than under rate of return regulation. Most notably, the RBOCs remedied reported service problems more slowly under price cap regulation, earnings sharing regulation, and rate case moratoria than they did under rate of return regulation. Residential customers also reported more service problems (per access line) under earnings sharing regulation than under rate of return regulation.

But Ai and Sappington (1998) also report higher service quality on some dimensions under incentive regulation. For example, residential and business customers both registered fewer complaints with their public utility commission under price cap regulation, earnings sharing regulation, and rate case moratoria than under rate of return regulation. Residential and business customers also received more timely installation of new telephone service under earnings sharing regulation. In addition, commitments to install new telephone service for business customers were met more frequently under rate case moratoria. Improved service quality may arise under rate case moratoria in part because of demonstration effects. Rate case moratoria are often implemented as temporary regulatory regimes while the details of alternative regimes are negotiated. Consequently, when it operates under a rate case moratorium, a regulated firm may take special precautions against

service quality deterioration, to ensure that support for an attractive future regulatory regime is not eroded.

7.7. Universal Service.

The evidence to date suggests that certain forms of incentive regulation may increase telephone penetration rates (i.e., the fraction of households with a telephone), at least in the United States. Tardiff and Taylor (1993) find that the telephone penetration rate is approximately 1 percentage point higher in states where earnings sharing regulation is imposed than in states where rate of return regulation is employed, after controlling for other relevant factors. Ai and Sappington (1998) find a similar increase under rate case moratoria relative to rate of return regulation. Conceivably, the lower prices that incentive regulation plans induce or mandate could promote increased telephone penetration rates. Regulated firms might also undertake special efforts under incentive regulation to promote universal service in order to garner popular support for favorable future regulatory regimes. This effect may be most pronounced under rate case moratoria, since these regimes often serve as transitions to alternative forms of incentive regulation, such as earnings sharing or price cap regimes.

It is particularly important to control for the effects of competition when assessing the impact of regulation on telephone penetration rates. Although competition can undo cross subsidies that have been implemented to promote access to the telephone network (e.g., pricing basic local service below cost), it can also reduce the average level of service prices and thereby increase the net gains that consumers perceive from securing access to the network. Consequently, the impact of competition on universal service is ambiguous, *a priori*. The works of Hausman et al. (1993) and Wolak (1996a) suggest that increased competition is associated with increased telephone penetration rates in the United States. Barros and Seabra (1999) report mixed evidence in other OECD countries.

None of these studies examines the effect of the regulatory regime on universal service rates.[91]

7.8. Summary.

In summary, the studies to date provide varied evidence regarding the impact of incentive regulation on performance in the U.S. telecommunications industry. Incentive regulation appears to increase the deployment of modern switching and transmission equipment, to spur an increase in total factor productivity growth, and to foster a modest reduction in certain service prices. There is little evidence, though, that incentive regulation leads to a significant reduction in operating costs. There is some evidence that earnings may be higher under price cap regulation. There is little evidence of a systematic decline in service quality under incentive regulation.

Overall, incentive regulation appears to affect industry performance, but the effects are generally not dramatic. This may be the case because the key differences among the various forms of incentive regulation in practice are often less pronounced than their different classifications on paper might suggest. For instance, as noted in section 4, if prices are re-set at the end of each price cap period to eliminate any extranormal profit that the firm may have generated during the prevailing phase of the price cap regime, then price cap regulation may function much like rate of return regulation with a specified regulatory lag.[92] Knowing that exceptional current performance will call forth more exacting future standards, the regulated firm may rationally choose not to operate at peak efficiency, even though it might receive a short-term financial reward for doing so.

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91. Eriksson et al. (1998) report that targeted subsidies based on financial need have been a more cost-effective means of increasing telephone subscribership in the U.S. than have corresponding untargeted subsidies. Cain and MacDonald (1991) find that moderate increases in the price of unmeasured local service have limited impact on telephone subscription rates in the U.S. when the rate for measured local service is low. Neither of these studies measure the impact of incentive regulation on telephone subscription.

92. See Baron (1991), Pint (1992), and Liston (1993) for additional discussion of this observation.

8. Conclusions.

The telecommunications industry has experienced and continues to experience a shift from rate of return regulation to a variety of forms of incentive regulation, including price cap regulation. By focusing more on the control of prices than the control of earnings, incentive regulation plans can provide stronger incentives for the regulated firm to reduce its production costs and increase its operating revenues. By affording the firm greater flexibility in setting prices, incentive regulation plans can also empower incumbent suppliers to meet emerging competitive challenges more effectively.

Of course, no regulatory plan is a perfect substitute for the discipline of competitive markets. Therefore, although price cap regulation, for example, can offer some advantages over rate of return regulation, price cap regulation is not without its own potential drawbacks. For instance, it can facilitate extreme earnings for the firm, it may provide inadequate incentives for service quality, and it can invite strategic pricing to relax the price cap constraint. Ever aware of these potential dangers, regulators often modify price cap plans in ways that render them less distinct from rate of return regulation. Common modifications include earnings sharing requirements, revenue sharing requirements, Z factors, and short time spans between reviews that serve to match anticipated revenues to realized operating costs.

In part because of these modifications and the resulting difficulty in measuring all relevant differences among regulatory plans, the estimated impact of incentive regulation on performance in telecommunications markets has generally not been dramatic. There is some evidence of higher earnings, more rapid network modernization, and lower prices for certain services under incentive regulation, but there is little evidence of significant change in operating costs, service quality, aggregate investment, or telephone penetration rates under incentive regulation.

Of course, incentive regulation is a relatively recent phenomenon in the telecommunications

industry. Therefore, current estimates of the impact of incentive regulation may not reflect accurately its true long term impact. More accurate estimates must await the arrival of a longer time series of data. More comprehensive data sets will also admit finer classifications of incentive regulation plans. Finer classifications will facilitate a better understanding of the impact of individual elements of incentive regulation plans. Systematic identification of the environments in which particular regulatory plans have the most pronounced and the most favorable impact on industry performance awaits future research.

Future empirical work must distinguish more clearly between the effects of incentive regulation and the effects of competition. Additional theoretical work on the impact of competition would also be valuable. Most analyses in the literature take as given the set of regulated products and services that are regulated. In practice, one of the most difficult tasks that regulators face in today's telecommunications industry is determining when it is appropriate to substitute market discipline (and antitrust scrutiny) for regulatory control (Barnich, 1992). Simple, practical rules to govern this decision would be useful. Simple rules for adjusting regulatory policy as competition emerges would also be valuable.[93]

It is also important to recognize that the extent of market competition in a particular telecommunications industry is seldom entirely exogenous. Regulatory rules typically play a central role in determining the extent and nature of competition.[94] The optimal design of incentive regulation in the presence of both actual and potential competition is an issue that warrants more attention in the coming years.

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93. In order to tailor regulatory policy to the extent of market competition, regulators must be able to assess accurately the degree of prevailing market competition. On-going extensive data collection by regulatory agencies is likely to prove valuable in this regard (Bernstein et al., 1996).

94. See Laffont and Tirole (1993, 1999) for useful reviews of the literature on the optimal design of competition for the right to operate in a specified market.

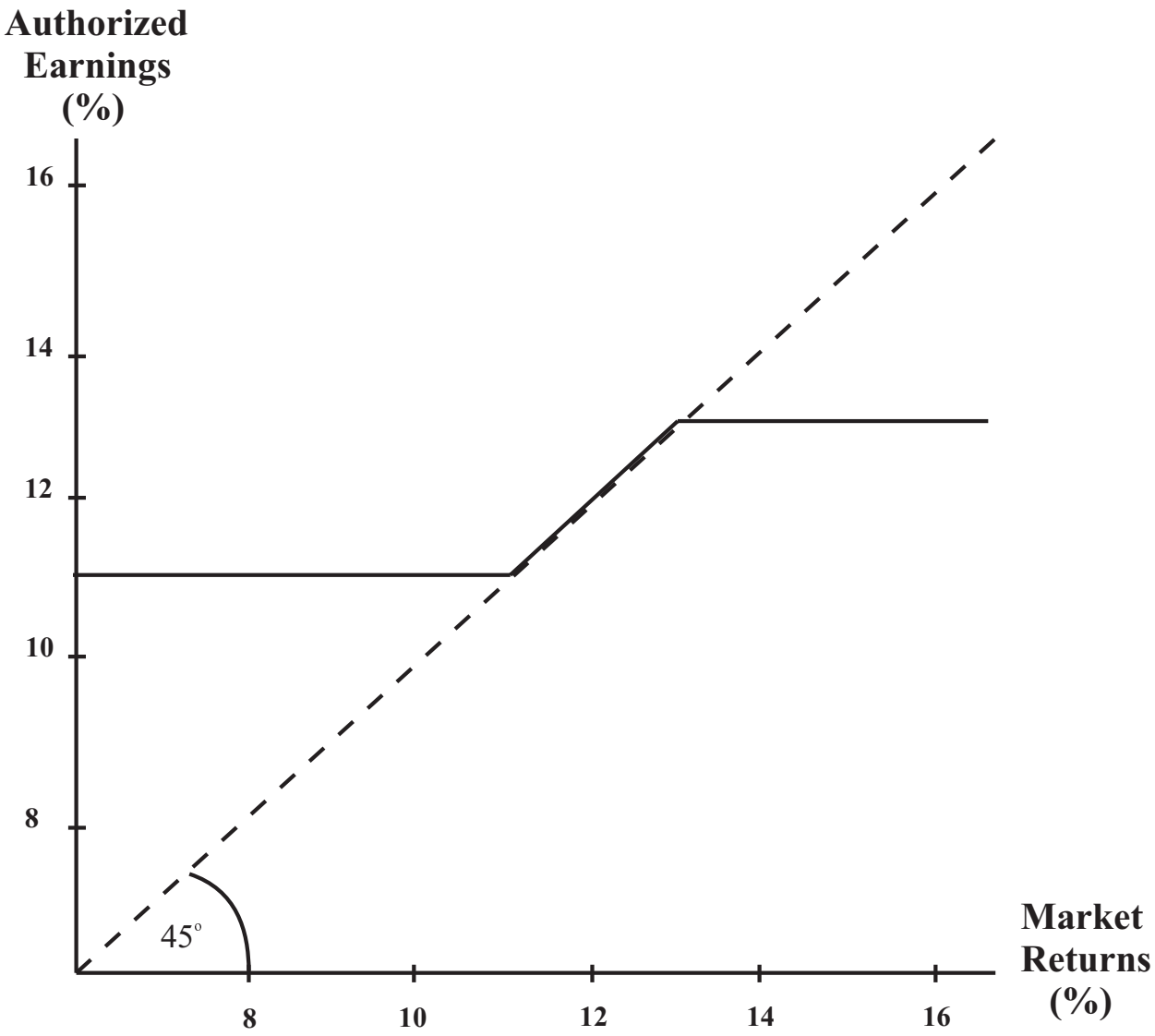

Figure 1. Banded Rate of Return Regulation.

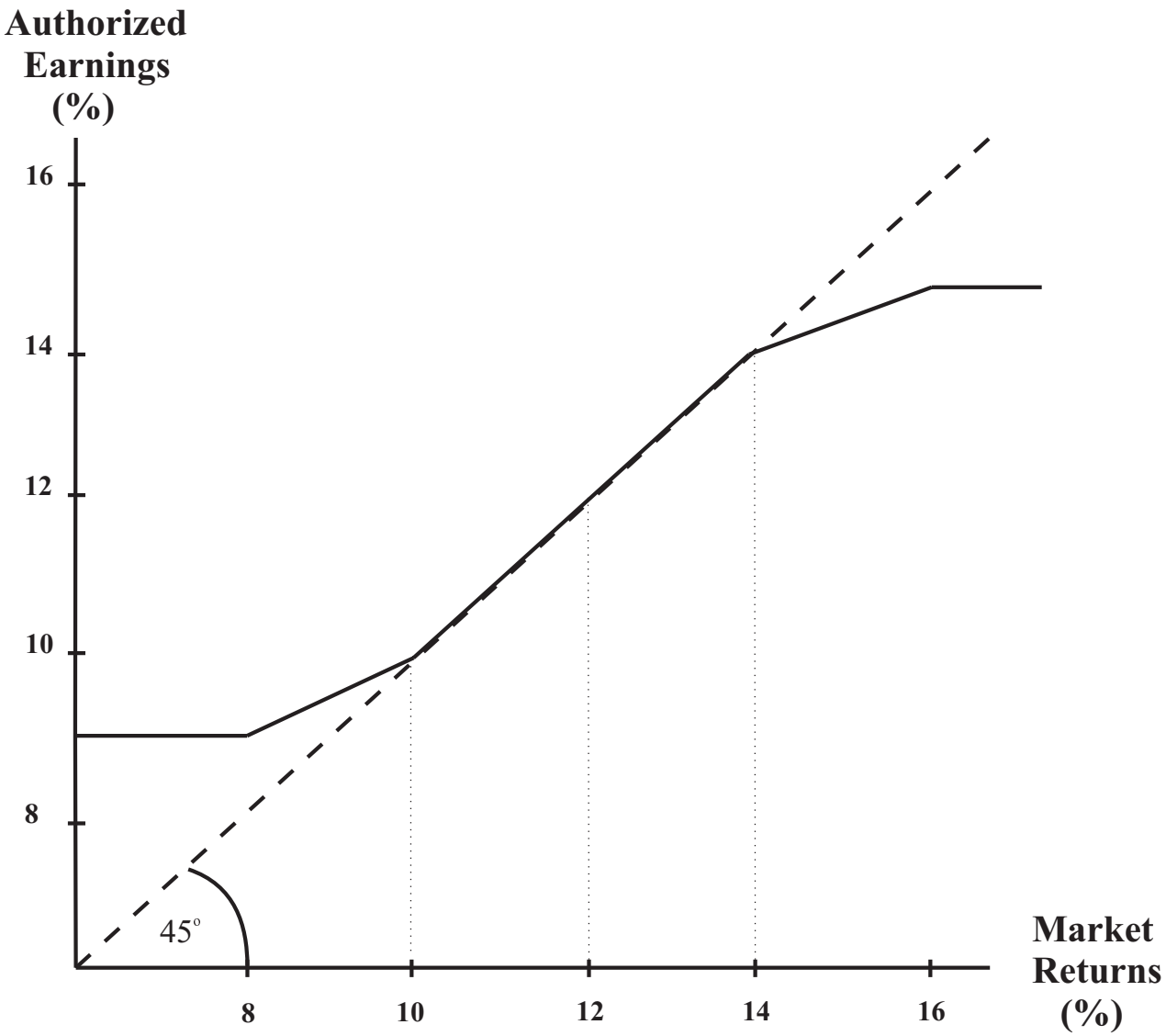

Figure 2. Earnings Sharing Regulation.

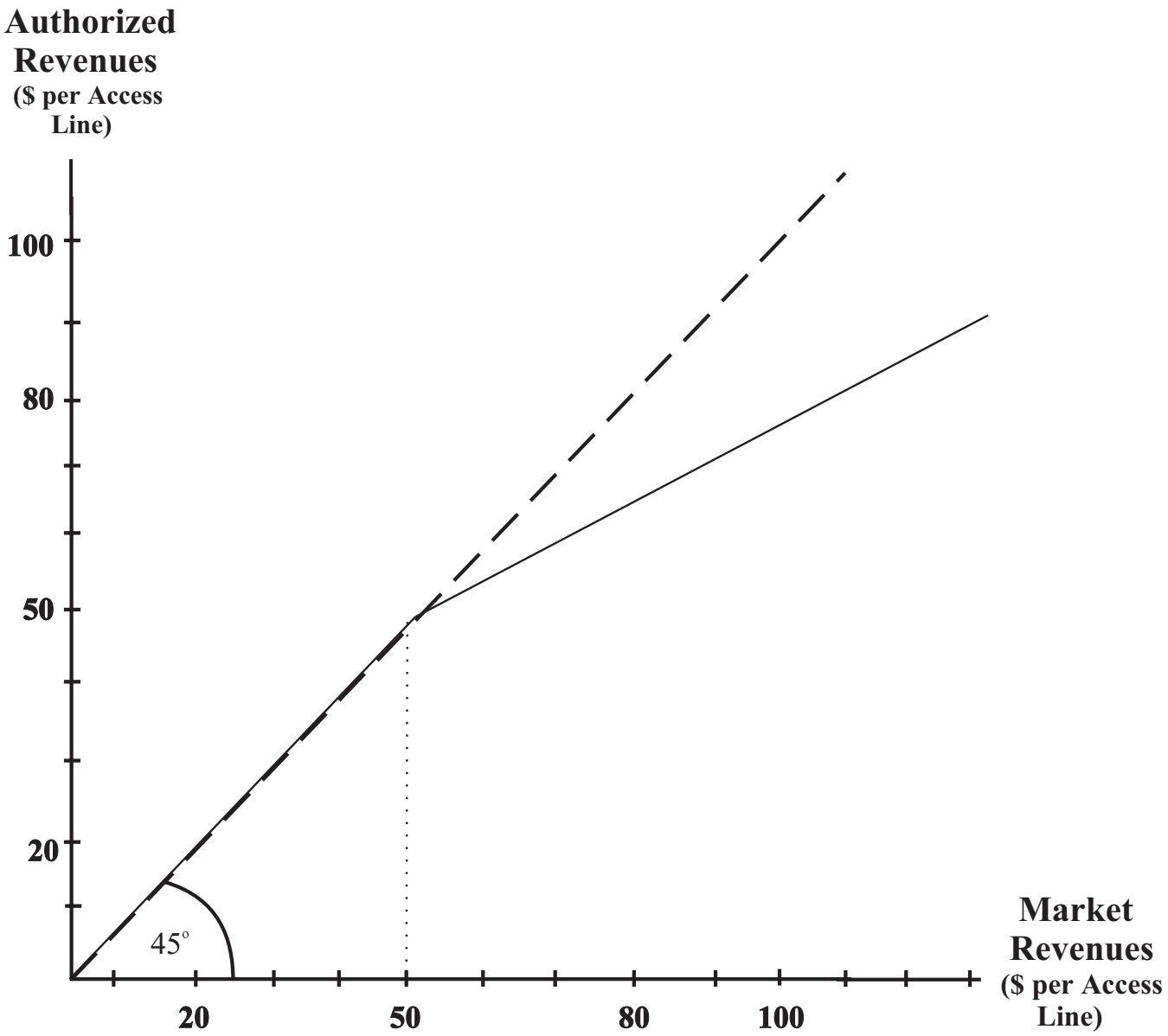

Figure 3. Revenue Sharing Regulation.

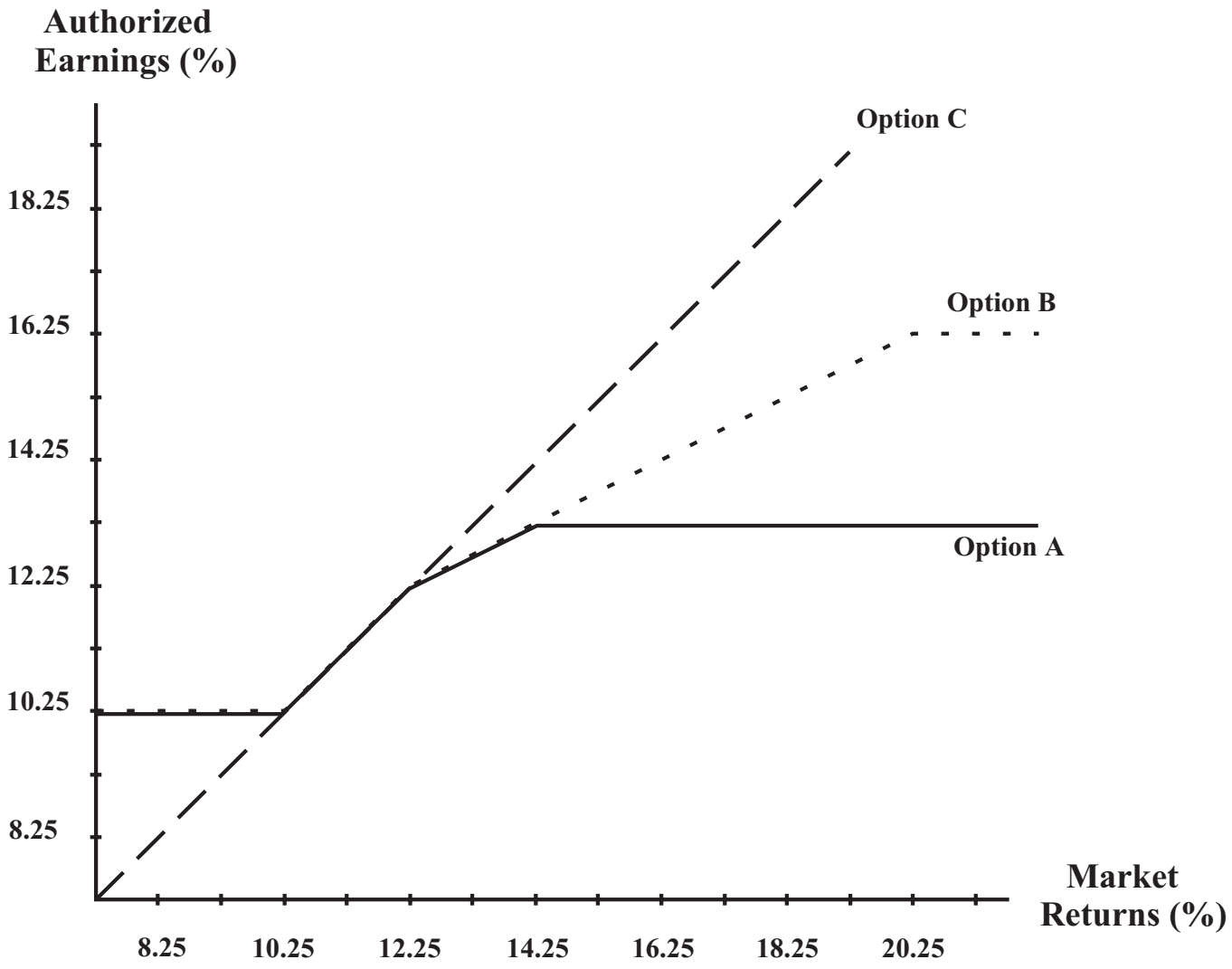

Figure 4. Regulatory Options Under the FCC's 1995 Plan.

Option	Minimum Retained Earnings	50/50 Sharing of Returns	Maximum Retained Earnings
Option A 4.0% X factor	**10.25**	**12.25-14.25**	**13.25**
Option B 4.7% X factor	**10.25**	**12.25-20.25**	**16.25**
Option C 5.3% X-factor	**none**	**none**	**none**

Table 1. Options in FCC's 1995 Access Price Regulations.

Year	Rate of Return Regulation	Rate Case Moratoria	Earnings Sharing Regulation	Price Cap Regulation	Other
1985	50	0	0	0	0
1986	45	5	0	0	0
1987	36	10	3	0	1
1988	35	10	4	0	1
1989	29	10	8	0	3
1990	23	9	14	1	3
1991	19	8	19	1	3
1992	18	6	20	3	3
1993	17	5	22	3	3
1994	20	2	19	6	3
1995	18	3	17	9	3
1996	14	4	5	24	3
1997	12	4	4	28	2
1998	13	3	2	30	2
1999	11	1	1	36	2
2000	7	1	1	40	2

Table 2. Number of States Employing the Identified Form of Regulation.

REGULATORY POLICY	STATES
Persistent ROR Regulation	MT, NH
ROR Followed by Incentive Regulation, With No Subsequent Return to ROR Regulation. (Date of Switch to Incentive Regulation in Parentheses)	AL(87), CA(90), FL(87), ID(87), IN(94), KS(90), KY(89), LA(88), MD(89), MI(90), MN(90), MS(90), NE(87), NV(91), NJ(87), ND(90), OH(95), OK (99), PA(94), RI(87), TX(91), VA(89)
ROR Followed by Incentive Regulation, with a Subsequent Return to ROR Regulation	AZ, AR, CT, DE, GA, IL, ME, MO, NM, NY, OR, SC, SD, VT, WA, WI

Table 3. Patterns of State Regulatory Policy Between 1984 and 2000.

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