PRICE CAP AND REVENUE CAP REGULATION

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I. INTRODUCTION

Price cap and revenue cap regulation are forms of incentive regulation, which is the use of rewards and penalties to induce the utility company to achieve desired goals and in which the operator is afforded some discretion in achieving goals (1,2). With price cap regulation, the company's average price increase is restricted by a price index that generally includes an inflation measure (such as the U.S. Gross Domestic Product Implicit Price Deflator) and an offset that generally reflects expected changes in the company's productivity.[1] With *pure price caps*, the regulator never directly observes the operator's profits. This form of price caps is rare and indeed may never be practiced except in instances where the regulator is prohibited by law from observing costs and adjusting prices. Most price cap regimes base prices on past costs or expected costs, and prohibit the regulator from adjusting prices according to new information for a set period of time, typically 4-6 years.

Price caps were first developed in the United Kingdom in the 1980s to be the regulatory framework for the country's newly privatized utilities. The basic idea behind the country's price cap regulation was that the regulator would be at an information disadvantage relative to the utilities in terms of knowing how efficiently the utilities could operate. By adopting price cap regulation and allowing utilities to keep for a period of time profits they received by improving efficiency, the government believed the companies would reveal their efficiency capabilities. In turn this would allow the regulator to eventually set regulated prices that reflected the companies'

[1] Revenue cap regulation is the same as price cap regulation except that the company's revenue is restricted by the inflation-productivity index. In this chapter I simplify my discussion by focusing on price cap regulation.

true abilities. Price cap regulation did not work out entirely as planned, so adjustments have been made to the point that the U.K.'s price cap regulation looks a lot like U.S. rate of return regulation.[2]

There are three important elements of an incentive regulation plan: (1) the reward/penalty structure; (2) allowing the company an opportunity to choose its goals; and (3) allowing the operator latitude in how it will achieve its goals. An example of a reward/penalty structure would be allowing the company to retain higher (lower) profits if it increases (decreases) its operating efficiency. Allowing the company a role in choosing its goals is referred to as "a menu of options" whereby the regulator matches greater potential rewards with more ambitious goals. For example, the company may be allowed to choose between a goal of decreasing costs by 5 percent and keeping 50 percent of the profits it receives above its cost of capital, and a goal of decreasing costs by 10 percent and keeping 100 percent of the profits it receives above its cost of capital.[3] If the company chose the goal of decreasing costs by 10%, the operator would have the latitude to do this by, for example, negotiating lower input prices from suppliers, decreasing overhead, improving network reliability, obtaining lower-cost capital, or some combination of methods.

[2] Excellent summaries of the U.K experience can be found in several studies (3, 4, 5). A critical difference between U.S.-style rate of return regulation and U.K.-style price cap regulation are that the U.K. regimes have fixed time periods between price reviews, while under rate of return regulation price reviews are triggered by high or low earnings (relative to the cost of capital).

[3] A company's cost of capital is the interest that the company pays on its debt plus the return that it must provide to shareholders to ensure they continue to invest in the company.

The benefits of price cap regulation include providing companies with incentives to improve efficiency, dampening the effects of cost information asymmetries between companies and regulators, and decreasing the incentives to over-invest in capital and cross-subsidize relative to rate of return regulation. However, in some instances service quality and infrastructure development have suffered under price cap regulation. Furthermore it is difficult for regulators to keep commitments that allow companies to retain profits above their cost of capital.

The remainder of this chapter is organized as follows. The next section describes the theory underlying price cap regulation. Section III describes establishing the price index. Section IV discusses how regulators structure price baskets. Section V summarizes some cases. Section VI is the conclusion.

II. UNDERLYING THEORY

Regulators and other policy makers have certain energy goals for their countries, including near-universal availability of service, affordable prices, and quality service. Achieving these goals requires that utilities incur costs and exert effort. The difficult question for regulators is how much cost and effort will be required? Utilities generally know more about the answers to these questions than regulators. For example, a company generally knows more than its regulator about how much it would cost to provide a certain level and quality of network expansion. This is because the regulator cannot directly observe the operator's innate abilities and its degree of effort.

These problems are called information asymmetry or principal-agent problems. An information asymmetry arises from the company having information – namely about the utility's innate ability to achieve performance goals at a specific cost and the amount of effort the employees exert -- that the regulator does not have. The name "principal-agent" arises from the nature of the relationship -- the regulator (the principal) has goals that she wants the operator (the agent) to achieve. The company may agree with some of the principal's goals, but companies generally have other interests, such as maximizing profits for their shareholders and limiting the amount of effort exerted. To solve these problems, the regulator offers the operator financial rewards for controlling costs and/or exerting effort.

III. THE BASIC PRICE RESTRICTION

With price cap regulation, prices are initially set to allow the company to receive its cost of capital. Thereafter, prices are allowed to rise, on average, at the rate of inflation, less an offset, namely

$$\%\Delta p \leq I - X \ ,$$

where %Δp is the average percentage change in prices allowed in a year, I is the inflation index, and X is the offset. The key issues are: What is the "offset"? What is the measure of inflation? And, what does it mean that prices are allowed to rise on average? (6)

The underlying logic of the price cap restriction is that it emulates the competitive market. In a competitive market, prices reflect the costs of production. Prices rise when production costs unavoidably rise. Prices decline with productivity increases. As a result, in a competitive economy, the economy-wide inflation rate reflects unavoidable increases in production costs, which

accounts for productivity gains. If the regulated company is just like the average firm in the economy, its prices should rise at the general rate of inflation (7).

Therefore, the *X*-factor should represent the difference between the regulated firm and the average firm in the economy. There are two key differences to consider, namely, the regulated company's ability to improve productivity, and changes in its input costs. If the regulated company can improve its productivity more than the average firm in the economy, or if the regulated company's input prices increase less than input prices for the average firm, this would imply $X > 0$. The opposite situations would imply $X < 0$. If the regulated firm is just like the average firm, this would imply $X = 0$. For example, consider a situation in which the average firm in the economy improves its productivity by 3 percent per year and its input prices increase 1 percent per year. Further assume that the regulated firm can improve its productivity by 5 percent per year and its input prices actually decrease 2 percent per year. The appropriate *X*-factor would be

$$X = (5-3)-(-2-1) = 5 .$$

There are two basic approaches for establishing an *X*-factor, namely, the historical approach and the forecast approach. The historical approach compares estimates of the Total Factor Productivity (TFP) for the average firm in the economy to estimates for the regulated company. The *X*-factor is set equal to the difference between the TFP estimates after adjusting for differences in input prices. A modification to this approach adds a stretch factor, *S*, that accounts for the effects of historic regulation and/or anticipated changes in industry conditions. Examples of explicit stretch factors include 0.5 percent for AT&T by the Federal Communications Commission and 1 percent for local exchange telephone companies in Canada.

The forecast approach is a three-step process. The first step is to determine the rate base for year *t*, where *t* is the first year of the new pricing regime, according to the formula

$$B_{t-1} = B_0 + \sum_{i=1}^{t-1} \left(Capex_i - d_i \right),$$

where $t = 0$ is the initial rate base of the company, for example, at the time of privatization; $Capex_i$ is the additional investment in rate base in year *i*; and d_i is the depreciation expense in year *i*. The next step is to project cash outflows (Capex), operating expenses (Opex), and non-operating expenses (Nopex), and unit sales for each year of the new pricing regime. The last step is to estimate the *X*-factor that will equate the present value of the cash flows of the company with the change in shareholder value using the formula

$$\sum_{j=t}^{n+t} \frac{P_j Q_j - Opex_j - Capex_j - T_j \pm Tr}{\left(1+WACC\right)^j} = B_{t-1} - \frac{B_{n+t}}{\left(1+WACC\right)^n},$$

where P_jQ_j is the projected revenue for year *j*, $Opex_j$ is the forecasted operating expenses for year *j*, $Capex_j$ is the projected capital expenditures for year *j*, T_j is the projected taxes for year *j*, B_j is the rate base at end of year *j*, *Tr* represents cash transfers between the government and other entities (not counted in revenue, operating expenses, or capital expenditures), *WACC* is the weighted average cost of capital, and *n* is the length of time price cap plan is in effect (8). The WACC is the return the company is allowed to receive on its assets and includes both the cost of debt the company uses to finance its rate base and the cost of equity. The cost of debt is simply the weighted average of the interest rates that the company pays on its long-term corporate bonds. The cost of equity is the return that shareholders need to ensure that they continue to finance the company (9).

The U.K. used this approach in setting prices for Hydro Electric (HE) in 1995 (10). Table 1 shows the Monopoly and Merger Commission's (MMC) present value calculation for HE's price control

for the period 1995/96 to 1999/2000. The first three lines contain its allowances for operating costs, network capital expenditure and non-operational capital expenditure. These cash flows were discounted at 7 percent (the MMC's assumption about the cost of capital) which came to £457.9 million. The MMC then added the present value of the opening less closing asset values of the distribution business, which represented another £128.2 million, giving a total of £586.1 million.

Table 1. MMC's Calculation of HE's Distribution Business Costs (1994/95 Prices).

	1995/96	1996/97	1997/98	1998/99	1999/2000	Total
Operating Costs	60.7	59.5	58.3	57.1	56.0	
Network Capital Expenditure	43.5	43.2	43.8	44.1	44.6	
Non-operational Expenditure	6.7	5.6	5.3	5.6	5.0	
Total	110.9	108.3	107.4	106.8	105.6	
PV of Costs at 7%	107.2	97.8	90.7	84.3	77.9	457.9
PV of Asset Values a 7%	563.0				-434.8	128.2
						586.1

Asset values were calculated by taking an opening balance in 1990/91 and rolling this forward by adding net distribution network capital expenditure. This was defined as network capital expenditure less depreciation. By the end of 1994/95 this gave a total of £563 million and £610 million by the end of 1999/2000. The latter figure had a present value in 1995/96 of £434.8 million.

The opening balance of £523.4 million in 1990/91 was consistent with the figure used by the government in setting the original price control and the initial market value of HE. Table 2 shows

the roll forward of the opening balance to £563 million at the start of the price control period in 1995/96.

Table 2. MMC's Calculation of HE's Distribution Asset Base (1994/95 Prices).

	1990/91	1991/92	1992/93	1993/94	1994/95
Opening Value	523.4	534.6	534.4	536.1	545.1
Depreciation	(27.2)	(27.9)	(28.7)	(29.7)	(31.0)
Network Capital Expenditure	38.4	27.7	30.4	38.7	48.9
Closing Value	534.6	534.4	536.1	545.1	563.0

The total of £586.1 million in Table 1 represented the present value of the revenue that the MMC considered HE would need to raise in order to cover its allowable cash outflows and earn a 7-percent return on its asset value. The MMC calculated that the continuation of the existing price control would raise revenue with a present value of £462.1 million, which fell short of this amount. However, in the case of HE's distribution business there was an additional source of revenue, the hydro benefit, which could be transferred from the generation business in accordance with HE's license. Taking this into account the MMC decided an appropriate relationship would be established and maintained if HE's price control required it to reduce prices by 0.3 percent in 1995/96 followed by reductions of 2 percent per year for the next four years. Table 3 shows the MMC's projections of distribution business revenue. The present value of revenue and hydro benefit is £586.1 million, which is equal to the present value of costs and return on assets shown in Table 1.

Table 3. MMC's Projections of HE's Distribution Business Revenue (1994/95 Prices).

	1995/96	1996/97	1997/98	1998/99	1999/2000	Total
Regulated Revenue	105.2	104.6	103.8	102.9	102.1	
Unregulated Revenue	5.5	5.3	5.1	5.0	4.8	
Hydro Benefit	29.2	29.2	29.2	29.2	29.2	
Total	139.9	139.0	138.1	137.2	136.2	
PV of Revenue at 7%	135.2	125.6	116.6	108.2	100.4	586.1

The inflation index in the basic price restriction is generally one that is a good approximation of the previous year's inflation, reflects general price movements in the economy, is not focused on a particular segment of the economy, and is reliable and available in a timely manner. The regulator compares this price index to the average price change proposed by the company to determine if the proposed price change is acceptable. The average price change is the weighted average change in prices, where a price's weight is the proportion of the company's revenue that the price generates. For example, assume a company has two services, service 1 and service 2. Service 1 provides 60 percent of the company's revenue and service 2 provides 40 percent. The company proposes to increase the price of service 1 by 10 percent and the price of service 2 by 5 percent. The resulting average price change is: (0.6 * 10% + 0.4 * 5%) * 100 = 8%. If the basic restriction (inflation-minus-*X*) is 8 percent or larger, the regulator approves the pricing proposal.

Extraordinary events may affect the utility disproportionately compared to the average firm in the economy. In these instances regulators consider applying to the basic price cap formula an adjustment called an exogenous factor. Exogenous factors, also called *Z*-factors, reflect the effects of rare, one-time events whose occurrence and impacts are beyond the control of the regulated

company and that affect the company differently than the average firm in the economy. An example might be a special tax placed on electric utilities. These exogenous factors increase or decrease the price index, depending on how the extraordinary event affected the utility.

IV. SERVICE BASKETS

A service basket is a group of services placed under a common inflation-minus-*X* restriction. Services that the regulator wants to protect from price increases or decreases relative to certain other services are placed in a separate basket. For example, if the regulator does not want the company to change urban prices relative to rural prices, the regulator might place urban prices in one basket and rural prices in another.

The company is allowed to change the relative price levels of the services within a basket, subject to two possible restrictions. The first type of restriction is a limit on individual prices. Regulators may apply such a restriction by placing an absolute restriction on the price (e.g., the price per kWh for residential electricity cannot exceed $0.05) or a percentage restriction (e.g., the price per kWh for residential electricity cannot increase more than 10 percent per year).

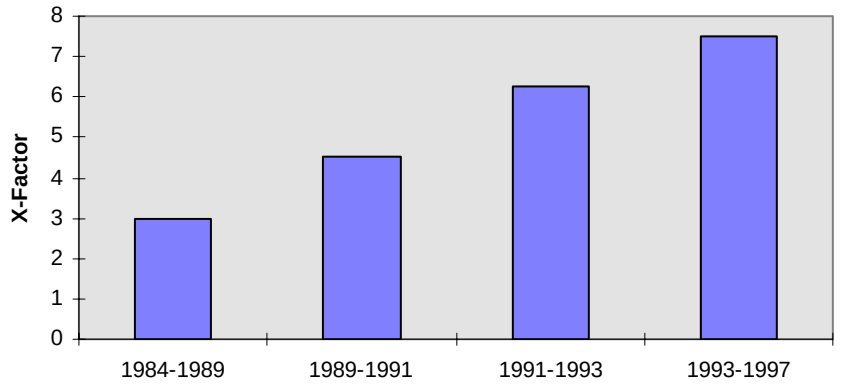
Regulators may also apply caps to subsets of services within a basket. For example, the regulator may apply a restriction of inflation-minus-5 to all services and a sub-restriction of inflation-minus-3 to residential services. In this case, the company's average overall price would need to decrease 5 percent in real terms and residential prices would have to decrease 3 percent in real terms.

V. CASE STUDIES IN PRICE CAPS

Most applications of price cap regulation have been in telecommunications. Berg and Foreman (11) provide one of the earliest studies of the effects of price cap regulation, focusing on the U.K. regulation of British Telecom (BT), and the Federal Communications Commission's price cap regulation of AT&T and the Bell Operating Companies. The U.K. implemented price regulation for BT in 1984. There were four basic reasons why the U.K. adopted price regulation for BT: (1) price regulation would provide BT with incentives to decrease costs; (2) because BT had been a government-owned service provider, information necessary for rate of return regulation was not available; (3) the U.K. wanted to minimize the amount of adversarial litigation that had characterized U.S. rate of return regulation; and (4) the U.K. believed that regulation would service primarily as a brief transitional mechanism to full competition.

The chart in Box 1 shows how the U.K. regulator changed the *X*-factor for BT over time. This was the general trend except for the 1997-2001 pricing decision. This growth in *X* may have related to the regulator's concomitant expansion of services covered under price caps (see Box 2), but it may also have reflected the regulator's increasing knowledge of how BT could improve its operating efficiency. The chart in Box 2 shows changes in services or elements subject to price control. Each price review has resulted in increasing numbers of services being subject to the price cap constraint. The chart in Box 3 shows the percentage of BT's turnover that is under price control for each period. This percentage grew from 48% during the first period to 71% during the 1993-1997 period.

Box 1. Oftel's X-Factors for BT



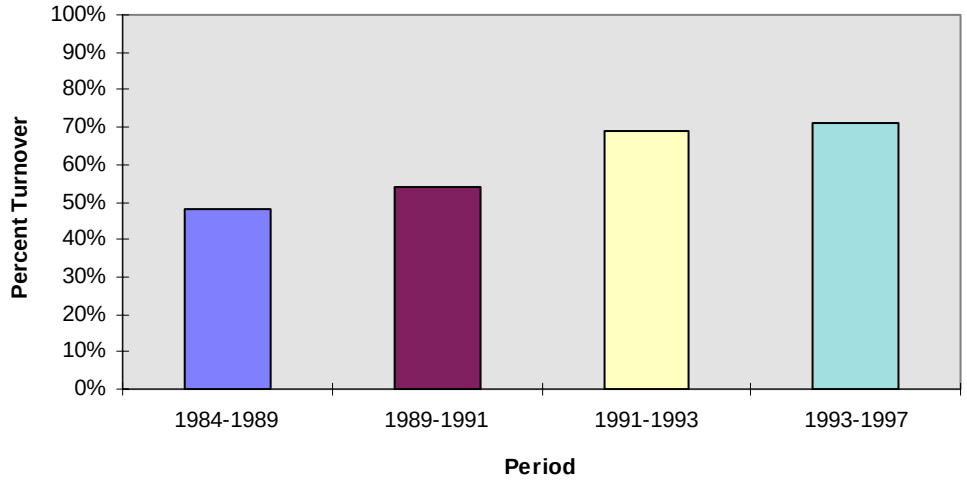
Source: Berg and Foreman (1995)

Box 2. Changes in Services Subject to Price Cap

Period	Exchange Line Rentals	Domestic Calls	Operator Assisted Calls	International Calls	Connection Charges
1984-1989	x	x			
1989-1991	x	x	x		
1991-1993	x	x	x	x	
1993-1997	x	x	x	x	x

Source: Berg and Foreman (1995)

Box 3. Percent BT's Turnover Under Price Control



Berg and Foreman (11) conducted their review using traditional rate evaluation criteria of simplicity and public acceptability, freedom from controversy, revenue sufficiency, revenue stability, price stability, fairness in apportionment of total costs, avoidance of undue rate discrimination, and encouragement of efficiency. They concluded the following:

- *Simplicity and public acceptability*. It is unlikely that price caps resulted in simplicity and administrative savings. Design of price caps required attention to service baskets and price bands, floors, and ceilings. The desire to increase public and other stakeholder acceptability created the need for additional control features. Each feature has provided an opportunity for increased debate and litigation.

- *Freedom from controversy*. All the terms of price caps were controversial, including service quality, how to handle "excessive" returns, and public perceptions of the legitimacy of the regulation. Earnings sharing assessments in the U.S. were sensitive to the same arbitrary cost allocations as rate of return regulation. Bell Operating Companies were given optional regulatory contracts and generally chose the lower productivity factors even though these included higher earnings sharing requirements.

- *Revenue sufficiency*. Competition complicated this objective. This would have been true regardless of the method of regulation. Weisman (12) concluded that regulators have less interest in revenue sufficiency once the price cap deal is struck.

- *Revenue stability*. This objective became one of *net* revenue stability (i.e., net income) under price cap regulation. As a result, using price caps increases the importance of making cross-subsidies explicit.

- *Price stability*. The price cap formula explicitly improves price predictability and stability relative to other prices in the economy by aligning price changes with changes in general inflation indices

- *Fairness in apportionment of total costs*. Initial prices were part of a political compromise, so it was not immediately clear that price regulation results were different than rate of return regulation results with respect to this view of fairness.

- *Avoidance of undue rate discrimination*. Price caps use ceilings and floors to contain price discrimination. The U.K. regulator made three general changes to the price cap regime over time relative to this issue: (1) increased the *X*-factor, perhaps in response to high earnings by BT; (2) added special constraints to some prices, such as residential exchange line rental; and (3) added additional services and baskets (such as the median residential bill) over time.

- *Encouragement of efficiency*. BT was allowed significant opportunity for rate rebalancing. Attenborough (13) found a total welfare gain of £2 billion per year in 1990/91 prices and 30 percent of this gain was from more efficient rate design. Price regulation allowed companies to improve economic efficiency by aligning prices with

marginal costs, but competitive pressure, political constraints, and non-efficiency-related regulatory objectives may prevent this from happening in other situations.

VI. CONCLUSION

Incentives and opportunities to improve efficiency are generally greater under price cap regulation than under rate of return regulation. This does not mean, however, that price cap regulation is the right form of regulation in all situations. Compared to rate of return regulation, price cap regulation decreases regulators' concern for revenue adequacy because they have less direct control over revenues. Also, regulators may come under pressure from consumer groups to break their commitment to allow higher earnings if the regulated company improves efficiency: consumers may view the higher profits as evidence that the regulator is not tough enough on the utility or isn't knowledgeable. This challenge to regulatory legitimacy has led some regulators to roll back profits that they once said companies could keep.

When choosing a regulatory scheme, regulators should weigh these potential problems and benefits of price cap regulation against the corresponding costs and benefits of rate of return regulation. They may find that neither form of regulation is adequate by itself and adopt a hybrid system that applies different aspects of different forms of regulation to craft a regulatory scheme that makes sense for the regulator's institutional, political, and economic situation (6).

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