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Resetting Price Controls
for Privatized Utilities
A Manual for Regulators
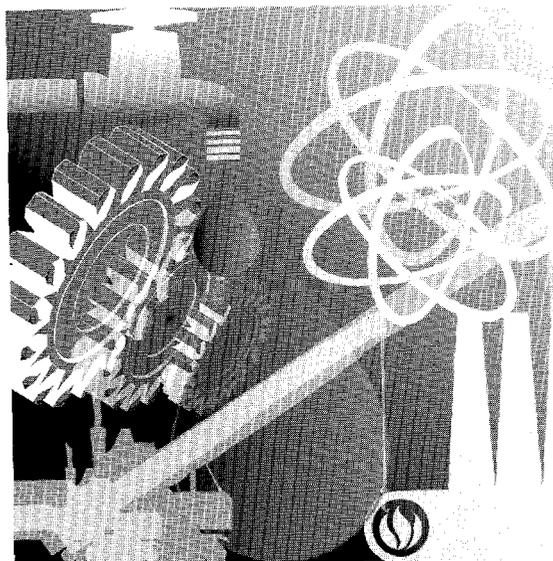
Richard Green

Martin Rodriguez Pardina

EDI DEVELOPMENT STUDIES

Resetting Price Controls for Privatized Utilities

A Manual for Regulators

Richard Green
Martin Rodriguez Pardina

Richard Green is a senior research officer in the Department of Applied Economics at the University of Cambridge in the United Kingdom.

Martin Rodriguez Pardina is director of the Center for the Economic Study of Regulation at the Universidad Argentina de la Empresa in Buenos Aires, Argentina.

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Foreword

In many developing countries private companies are replacing government agencies as owners and operators of infrastructure services. Governments must now develop new skills in economic regulation of these private providers to protect consumer interests, while also ensuring that the companies remain economically and financially sound and have incentives to operate efficiently.

To make fair and sound decisions, regulators must have access to adequate, good quality information on the performance of the private sector providers. However, little relevant data has been available from the public enterprises; most of it has to be generated during the design of the privatization process. Information required for effective regulation should be identified early in this process. To do so effectively, regulators must know how the information will be used in practice.

This manual, which is the first of a series of learning materials for infrastructure professionals, provides new economic regulators with practical guidance on how to proceed in this fairly technical new field. It addresses a need among practitioners that neither the recently published academic literature nor the general literature on infrastructure privatization have met. The material has benefited from the suggestions of practitioners inside and outside the World Bank. EDI welcomes any comments that will help further its relevance and usefulness.

Vinod Thomas
Director
Economic Development Institute

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Richard Green

Department of Applied Economics
Sidgwick Avenue
Cambridge CB3 9DE UK

RJG10@econ.cam.ac.uk
tel +44 1223 335261
fax +44 1223 335299

Martin Rodriguez-Pardina

Centro de Estudios Económicos
de la Regulación
Buenos Aires, Argentina

marp@uade.edu.ar
tel: 54-1-379 76 91
fax: 54-1-379 74 88

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Introduction and Summary: Revising Price Controls

This volume describes the tasks that an economic regulator should undertake when revising the price control for a regulated company. The aim of regulation is to protect consumers, while ensuring that the company remains viable and has an incentive to operate efficiently. This means that the term *price control* does not imply that the regulator is actually dictating the prices the company can charge—controlling its behavior—but that the control is a constraint on the overall level of the company's prices. As long as it complies with this constraint, the company is free to choose its prices, and it has every incentive to act as efficiently as possible. The regulator must ensure that the constraint is not too harsh, for the company must remain viable, although if the constraint is too loose, consumers will pay unnecessarily high prices, which is likely to be undesirable.

The basic principle of price control regulation, discussed in section 2, is that prices should be set, in real terms, for a predetermined period. During this time, the company is free to keep any additional profits it can realize by operating more efficiently. It is also exposed to the risk of losses if it becomes inefficient. At the end of the period, however, a new control will be required. The new control should enable the company to make adequate profits in the final year of the period to which it applies.

The regulator should start to reset the control at least two years before a new control is scheduled to come into effect. A lot of information will be required, and it will have to be checked and processed before the regula-

tor can propose a new control. Most systems of regulation include an appeal mechanism to protect the company against an excessively zealous regulator, which means that the regulator will have to make his proposals in time to allow an appeal, should the company wish to make one. This implies that the regulator should make his proposal at least nine months before the control is due to take effect, to allow six months for an appeal and some time to implement the eventual decision. (The procedures the regulator should follow are discussed in section 3.)

The regulator should start by asking the company for information on its present and projected operating costs, its assets, its investment plans, and its demand forecasts. (These are discussed in sections 6–8.) Some of this information may have to be produced for the review, and the company must be given an adequate time to provide the information. Once the regulator has the information, it must be assessed. At the very least, it should be consistent—if the company plans large investments to meet new demand, the demand forecast should reflect this. The regulator should also check that the company is not predicting an excessive level of operating costs or investment. It will probably be necessary to employ specialists (either in house, or consultants) to assess at least some of the company's investment plans. The company's operating costs might be compared to those of other similar enterprises.

Once the regulator has adequate cost data, these figures can be combined to provide a forecast of the company's revenue requirements. These will be equal to the company's operating costs, plus depreciation, plus a return on the company's assets (including both existing assets and new investment). The revenue requirements can also be expressed as operating costs, plus investment, plus the change in the present value of the company's assets over the period. (Section 5 offers examples of both approaches, which give the same answer.) The rate of return is critical in determining the amount of revenue needed, and ways to determine an appropriate rate of return are discussed in section 9.

The regulator must also select the form of price control to implement. A price-basket control sets specific weights for a number of prices and controls their weighted average. With a revenue-yield control, there is no need to list individual prices, and the weights involved are effectively the current quantities sold by the company. The regulator must decide whether to exclude selected sales from the control (perhaps sales to large consumers) and whether to allow the company to pass some costs straight through to consumers, rather than including their expected level in the control. (These issues are covered in section 4.)

Figure 1-1. The Timetable for Resetting a Price Control

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┌─────────────────────────────┐
│     Request Information      │
│      (2 years ahead)         │
└─────────────────────────────┘
              │
              ▼
┌─────────────────────────────┐
│  Assess and Amend Information│
│     (18 months ahead)        │
└─────────────────────────────┘
```

| Operating Costs | | Demand Forecasts |

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┌──────────────┐        ┌─────────────────────────┐
│  Asset Base  │        │  Determine Form of Cap  │
└──────────────┘        │    (c 15 months ahead)  │
                        └─────────────────────────┘
┌──────────────┐                    │
│  Investment  │                    ▼
└──────────────┘        ┌─────────────────────────┐
                        │ Select Candidate Price Cap│
┌───────────────────────┐│   (c 12 months ahead)   │
│ Determine Rate of Return││                        │
│   (c 15 months ahead)   │└─────────────────────────┘
└───────────────────────┘            │
            │                         ▼
            ▼                ┌─────────────────────────┐
┌───────────────────────┐   │ Predict Resulting Revenue│
│ Calculate Revenue Needs│   └─────────────────────────┘
└───────────────────────┘
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┌─────────────────────────────┐
│  Compare with Revenue Needs, │
│    Check Cash Flows, etc.    │
└─────────────────────────────┘
   If Appropriate        If Not
              │
              ▼
┌─────────────────────────────┐
│      Propose Price Cap       │
│   (at least 9 months ahead)  │
└─────────────────────────────┘
```

Company Accepts   Company Rejects

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                        ┌─────────────────────────┐
                        │     Appeal Mechanism     │
                        │    (9–3 months ahead)    │
                        └─────────────────────────┘
┌─────────────────────────────┐
│      Implement Price Cap     │
│   (at least 1 month ahead)   │
└─────────────────────────────┘
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Given the form of the control, the regulator can estimate the amount of revenue that would be produced by different values of its parameters, given the demand forecasts. Once the regulator has chosen a set of parameters that appear to yield an appropriate amount of revenue, the company's cash flows should be projected to ensure that these are also adequate. Once the regulator is satisfied with the control, it can be presented to the company as a formal proposal.

If the company is willing to accept the proposed control, the regulator can effect formal implementation. If not, the appeal mechanism should be invoked, so that an independent body can determine the appropriate level for the control. The regulator and the company should already have prepared most of the information required for the appeal, but the process could still require up to six months. Once the appeal is finished, the regulator will need some time to formally implement the proposals, and the company will need to set prices that are consistent with the control. If we allow up to two months for this phase of the process, and recognize that the company must be given time to decide whether to appeal, we can see that the regulator will have to announce the proposed control at least nine months before it is expected to take effect (see figure 1-1).

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The Philosophy of Price Controls

Regulation should have several aims. The first of these should be sustainability—the regulated company must be able to finance its operations, and any required investment, so that it can continue to operate in the future. Two other aims are equity and efficiency. Equity is related to the distribution of welfare among members of society. The objective of sustainability already implies that shareholders should not receive "too low" a return (and defines this in terms of the reward necessary to ensure continued investment in the utility), while equity implies that their returns should not be "too high." We could define "too high" relative to the rewards that shareholders could receive from other investments with a similar degree of risk. Equity also concerns the payments by consumers. The objective of equity toward shareholders puts bounds on the payment by consumers as a whole, but we should also be concerned about the payments by smaller groups. Equity may require that no group of consumers bears a disproportionately large part of the payments to the utility, relative to the costs they impose upon it.

There are two sides to the objective of efficiency. Allocative efficiency requires goods to be distributed to those who will receive the greatest benefit from them. In a market economy, this can be done by ensuring that prices are close to the marginal cost of producing each good. In deciding whether or not to purchase a good at the prevailing price, consumers reveal how much they value it. If the price is high, only consum-

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ers with high valuations will buy the good, which ensures that a good that is expensive to produce is only allocated to those who value it highly. If demand is greater than the amount that can be produced for a given price, allocative efficiency requires an increase in the price to reduce the demand and to allow more resources to be used in production.

Productive efficiency requires goods and services to be produced as cheaply as possible—that is, using the minimum of resources. It is important to note that this applies to items of a given quality, for it will often be possible to reduce a company's costs by reducing the quality of its output. Water unfit for drinking is not the same product as drinking water, so that reducing the amount of treatment is not a way of providing the same product more cheaply, but of providing an inferior product instead.

There will often be tradeoffs between these objectives. Allocative efficiency implies that prices should be close to marginal costs, but a utility's marginal costs are likely to be much lower than its average costs, implying that marginal-cost pricing will not be sustainable. Sustainability, which requires higher prices, must come first, but this can lead to conflicts between equity and allocative efficiency. The latter implies that prices should be increased most, relative to marginal costs, when this will not have much impact on the amount consumed. Very price-sensitive customers should face prices that are close to their marginal costs, so that the quantities they demand remain close to the quantities they would take with marginal-cost pricing. Unfortunately, this pricing rule (known as Ramsey pricing) implies that luxury uses of a commodity would face relatively low prices, while essential uses should face higher prices. This is likely to conflict with the predominant view of equity.

There can also be a conflict between productive efficiency and the other objectives. Allocative efficiency requires prices to be close to costs, as do equity and sustainability. Productive efficiency will often require the utility to seek improvements in its productivity, and it is likely to want an incentive to make the effort worthwhile. In a market economy, the prospect of profit is the standard incentive, which means that prices should exceed costs. The incentive for productive efficiency appears to conflict with our other objectives.

This conflict arises because regulation is an example of *a principal-agent problem*. The regulator (the principal) wishes to induce the firm (the agent) to act in particular ways, but is hampered by insufficient information. If the regulator knew what the firm's costs would be, were it productively efficient, he could set prices to cover these costs and force the firm to be efficient in order to sustain itself. The other objectives—equity and

allocative efficiency—would then be met. In practice, the regulator would never have enough information to use this approach. The regulator may well be able to audit the firm's costs ex post, but he cannot tell what they will be ex ante, and he will never know what they might have been if the firm had taken actions to reduce them. In part this is because an outside regulator will never know as much as the firm, but the firm itself may be genuinely uncertain about its costs ex ante.

The regulator must design some sort of rule that relates the firm's prices to its costs, which will give the firm a tradeoff between risk and incentive. If the price is kept close to the out-turn costs, the firm faces little risk, but it has little incentive to reduce its costs. The firm's consumers do face a risk of high prices if costs are high, but since most consumers spend relatively little of their income on any one firm's products, they will generally be able to bear this risk. This approach places the importance of sustainability and equity above that of productive efficiency.

If the price does not vary with observed costs, the firm has much stronger incentives to keep costs down, but is exposed to much greater risks if it cannot do so. This might appear to place productive efficiency above equity and sustainability. In practice, however, regulators should make "cautious" assumptions, so that the firm is almost certain to be sustainable and efficiency improvements bring about extra profits, rather than mere sustainability. These gains could then be passed on to consumers through future price reductions, so that consumers would eventually pay less than with a system of regulation that offered fewer incentives. It is the potential for efficiency improvements that reconciles the apparently conflicting objectives of providing profits as an incentive for productive efficiency and promoting allocative efficiency and equity.

Rate of Return Regulation

For many years, the dominant method of regulation was the *rate of return* method. The regulated company was allowed to charge prices that would cover its operating costs and give it a fair rate of return on the fair value of its capital. When the prices moved out of line with the company's costs, it could ask for a new set of prices. This regulatory compact seemed to guarantee that the company could recover its costs and that the cost of capital would be relatively low, but it did not give the company any strong incentives to keep its costs down.

In an attempt to encourage efficiency, some regulators in the United States adopted the practice of *prudential reviews*, which were designed to

assess if investment was necessary. If an investment was not "used and useful," the regulator would not allow it to enter the rate base. While a prudential review might appear attractive in theory, in practice it could lead to micromanagement by the regulator, who attempts to second-guess the company's management, which is unlikely to be desirable. Furthermore, there is a risk that the review will be conducted with too much hindsight and will disallow investments that turned out to be unnecessary, but were rational at the time the decisions were made. A second feature of the system, which may have given the companies an incentive for efficiency, was the emergence of *regulatory lags*. Appeals of new rates were delayed for so long in the regulatory system that the company was forced to continue its former prices for years at a time. When cost increases are no longer rapidly transferred to prices, the company has a much stronger incentive to keep costs down.

Regulatory lag was an unfortunate side effect of bureaucratic problems, and it would not be sensible to design a system that relies on unintended delays to produce incentives. Some U.S. regulators included indexation clauses in the prices they allowed their companies to charge, so that changes in fuel prices, for example, could be passed on to consumers without the delays involved in determining a new set of rates. Nevertheless, the idea that introducing a lag between cost changes and price changes can produce incentives turned out to be valuable. In a theoretical piece, Vogelsang and Finsinger showed that basing a company's allowable prices in one year on its costs in the previous year could provide the company with the incentive to adopt a pattern of prices that converged on the efficient level.[1]

RPI – X Regulation

The *RPI – X* system of regulation has formalized regulatory lag to give companies an incentive to operate efficiently in the interval between reviews. The idea is that the company is required to keep the weighted increase in a basket of its prices to less than the increase in a specified price index, less *X* percent, so that the prices decline by *X* percent a year in real terms. In the United Kingdom, the consumer price index specified is known as the retail price index (*RPI*), and hence the nickname. When a

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1. I. Vogelsang and J. Finsinger, "Regulatory Adjustment Process for Optimal Pricing by Multiproduct Monopoly Firms," *Bell Journal of Economics* 10(1)(1979): 157–71.

company is privatized, X should be set to pass the expected growth in productivity back to consumers. If the company did not expect the price control to be changed in the future, its prices would be independent of its actions, and it would have every incentive to reduce its costs.

Soon after $RPI - X$ was adopted, there were claims that it was a very different system from rate of return regulation, with much better incentives. These claims were largely based on the hope that the first price control (for British Telecommunications) would not need to be reset, because competition would replace regulation. This hope met with disappointment, and many companies now have price controls that will be maintained for the foreseeable future. In practice, the company knows that its price control will be revised, and that the revision will take its costs into account. This means that regulation through price controls has much in common with rate of return regulation, but it still gives companies a better incentive to keep costs down.

First, most price controls are scheduled to last for four or five years, so that any reduction in costs cannot be passed through into the price control for some time, allowing the company to receive a higher profit in the interim. Most companies use simple rules of thumb, such as payback periods. Any project with a payback period shorter than the term of the price control will be viable, if it is started early in the cycle.

Second, once the prices are revised, they may not fall to the level of the firm's costs immediately. The firm's incentives will be strongest if it knows that the new price control will be set so that its prices equal its expected costs only in the final year of the new period. Until then, prices move smoothly from their present level to the new target. With a five-year review period, this would allow the firm to keep 80 percent of the saving in the first year, a saving that would fall to 20 percent in the fourth year. Regulators in the United Kingdom have generally preferred not to weaken incentives by making one-off price reductions. When one-off reductions have been made, this has generally been in response to particularly high profits at the end of the previous period, with the implication that the firms have already received an adequate reward for their cost reductions (see box 2-1).

Third, while rate of return regulation has been based on the firm's actual costs, a price control system gives the regulator the option of setting prices based on the costs of an efficient firm. If the regulator believes that a company's costs are needlessly high, a price control can be set that is below the level of these costs. It must be stressed that this option must be used with caution, for an overzealous regulator could set an impossi-

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Box 2-1. The Present Value of Cost Savings

A permanent annual cost reduction of $1 million is worth $10 million, discounted at an annual rate of 10 percent. Savings during the first year are worth $1 million; during the second year, $0.9 million; during the third year, $0.81 million; and so on. (Each payment is worth 10 percent less, because it is received a year later.) The present value of the first five years of savings is $4.1 million, which is a significant portion of the total. Many projects that seem worthwhile for a return of $10 million over many years will also be worthwhile for this smaller return over the shorter period. Simple present value analysis might suggest that the company should spend up to $10 million in return for a saving of the same amount, and that to do less would be inefficient, but in practice the company is unlikely to place much weight on savings forecast for the distant future. Most companies use simple rules, such as payback periods, to determine whether an investment is worthwhile.

The present value of the second five years of savings is $2.4 million. If the prices are set to the firm's expected costs in the first year of the new price control period, the firm will not keep any of these savings, but the regulator may choose a more gradual approach. The new price control could be set so that its prices equal its expected costs only in the final year of the new period. Until then, prices would move smoothly from their present level to the new target. With a five-year review period, this would allow the firm to keep 80 percent of the saving in the first year; this would fall to 20 percent in the fourth year. This allows the firm to keep $1 million out of the $2.4 million in savings in the second five years. (The undiscounted proportion is 40 percent, but more of the savings are kept in the early years, which are valued more highly after discounting.) Ten years is a long time for many firms, and this price control would allow the firm to keep 80 percent of the present value of the savings over a ten-year period. Even if the firm were only allowed to keep the saving for the first five years, it would still receive 63 percent of the present value over the ten-year period. This implies that even a one-off cut at the end of the period would still leave a significant incentive to reduce costs early in that period.

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bly tight target for a hypothetical efficient firm. It is much better, if possible, to use an actual firm as the efficiency benchmark. The system of yardstick regulation advocated by Shleifer (1985) is based on this idea.[2] Within a group of comparable firms, the price that each is allowed to

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2. A. Shleifer, "A Theory of Yardstick Competition," *Rand Journal of Economics* 16(3)(1985): 319–27.

charge is based on the costs of the rest of the group. This makes each firm's price exogenous to the firm's costs, providing the maximum incentive to reduce costs, while allowing the firm to pass on the effect of anything that affects the costs of the whole group. This is perhaps the best way of resolving the conflict between risk and incentive described at the start of this section, as long as the uncertainty over costs affects all the firms equally. If there is little correlation among the firms' costs, yardstick regulation may not help much. Furthermore, yardstick comparisons are complicated. They can be used when price controls are reset, but it is unlikely that they will be amenable to inclusion in the formula that determines prices during the control period.

Sometimes, if there are significant costs that are both uncertain and genuinely beyond the firm's control, it may be appropriate to include a cost pass-through term. This raises the firm's prices by the amount of the uncontrollable costs, reducing the firm's exposure to risk. The disadvantage of this approach is that the firm no longer has an incentive to find ways of hedging this risk, because it can pass it on to customers instead.[3] The nickname "$RPI - X + Y$" has sometimes been applied to formulae of this type.

In many ways, the biggest difference between price controls and rate of return regulation is one of emphasis. Regulators must not ignore the rate of return when they reset a company's price cap, but the price cap is an indirect, rather than a direct, control on the rate of return. Rate of return regulation has depended on formulae designed to ensure that the regulated company receives the *right* amount of revenue, and it has often been bogged down in legal arguments. Much of this volume will describe the equivalent formulae that should be used to calculate the amount of revenue appropriate under a price control. The formulae are only a guide to the level of the price control, however, and there is still room for judgment. The regulator must decide whether to set prices so that they equal the company's predicted costs at the end of the review period or over the period as a whole. The regulator may look at the company's cash flow, as well as the discounted value of its costs and revenues. The regulator may use the formulae to check the impact of alternative assumptions about factors such as the growth of demand, and might adopt a price control that seems slightly generous on the *base case* assumptions, because otherwise the company would be in a difficult position if the alternative

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3. As mentioned above, consumers' welfare may not be significantly affected by this risk, as long as they spend only a small proportion of their income on the regulated product. In that case, the cost pass-through allocates risk to those best-suited to bear it.

assumptions came true. Finally, if the company knows that a formula will be used in a mechanistic manner, it will have an incentive to attempt to manipulate the inputs to that formula. It may be that giving some discretion to the regulator can reduce this incentive. This discretion must not be overstated, because the company must remain confident that it can recoup its investment, but it should allow the regulator to use his judgment of what is fair in the circumstances, rather than simply following a set of rules.

Profit-Sharing Regulation

One of the benefits of incentive regulation is that the firm may well respond to the prospect of higher profits by reducing its costs. The regulator can pass these savings on to consumers in the future, but the incentive depends on allowing the firm to earn higher profits for a time. These profits may be very unpopular, and this unpopularity may be amplified if the firm is in foreign ownership. There have been suggestions that a form of profit-sharing regulation could overcome this problem by sharing the benefits of cost reductions more rapidly. The regulator would use a prediction of the firm's costs to set prices, and would then monitor the actual costs. If these proved to be less than the prediction, prices would be reduced to absorb part of the saving. Another way of expressing this is that the firm would have to cut prices if it was on target to make more than the expected level of profits, although the cut would only "give back" part of the excess profits.

We do not discuss these schemes in detail here. They would require detailed monitoring of the company's annual costs and profits and could be cumbersome to implement. The company's incentives to reduce costs would be weakened, although there have been suggestions that this could be countered by lengthening the period between regulatory reviews, when the base level of prices is set. This would probably get us back to the original problem of diverging prices and costs: profit sharing might reduce the *rate* at which costs diverged from prices, but if the period between reviews was proportionately lengthened (to maintain incentives), the average *gap* between prices and costs would be just as great.

One possible compromise, however, has been suggested by Ian Byatt, a British regulator. If a company earning high profits wishes to reduce

prices below the maximum allowed by its price control, then the regulator will allow it to "bank" the resulting revenue (almost as a kind of capital investment), adding it to the next period's allowable revenue and smoothing out the firm's profit stream. Provided that the firm is confident that it will be allowed this extra revenue in the future, this mechanism might avoid the political problems of high profits.

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Procedures for Resetting a Price Control

In this section, we outline the procedures a regulator should follow when resetting a price control. A general outline is provided, but the details will depend on the legal framework in each industry and country. We have therefore included boxes that offer examples of the procedures followed in the United Kingdom and Argentina. In general, however, there are four stages in resetting a price control:

- Information gathering
- Analysis and decisionmaking
- Announcement (and possible appeal)
- Implementation.

To calculate the timetable, the regulator must work backward from the implementation stage. It is advisable to allow some slack in the timetable, in case some stages take longer than anticipated.

Information Gathering

This first stage may well need to begin two years before the new price control takes effect. There are three aspects to the information gathering process:

- Gathering detailed information from the firm
- Gathering information and views from other interested parties
- Communicating with the firm and other parties.

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The regulator will need specific information from the regulated company. The regulator ought to receive general accounting information, including past data, as a matter of course, and the information request for the price control review should concentrate on the future. The company should be asked for a business plan, including projections of its future demand, operating costs, and investment needs. The company may well need two or three months to prepare this plan and should be given adequate notice of the information requirements at an early stage.

Two-way communication during the process of resetting the price control is important. If relations with the firm are good, the quality of information is likely to be enhanced, and difficult issues may be discussed and resolved at an early stage. If other parties are asked for their views, and

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Box 3-1. Consultation Papers: The U.K. Approach

At an early stage of each review, a regulator in the United Kingdom will issue a consultation paper that sets out the main issues to be covered in the review. This will be publicized and distributed widely (free of charge), and will avoid technical language where possible. The paper will give the background to the review, discussing the industry and the company's regulated business. It is likely to include some indicators of demand, turnover, and profitability. The paper will solicit opinions on any aspect of the price control that might be seen as controversial, even if the regulator already has a preferred option based on past experience (although the paper will often indicate this). Examples could include the length of the review period, the form of weights to be used in the control, or whether any costs should be passed through to consumers. The regulator might also invite views on quality standards. Respondents will be given a named official to contact and a closing date for replies, normally between one and two months after the paper is issued. The named official will acknowledge all replies, but is unlikely to have time for detailed correspondence.

Respondents are given the option of replying in confidence, but any reply that is not clearly marked as confidential is regarded as public, and copies are placed in a reference room at the regulator's office (and perhaps at other locations). Companies with a serious interest in the outcome could easily justify sending someone to read the responses. Alternatively, the regulator will sometimes publish a further consultation paper that includes at least a summary of the substantive replies.

informed of the regulator's thinking, they are more likely to accept the final outcome of the review. The firm can be kept informed by letters and meetings with the regulator, while other parties may be kept informed with public hearings (as in Argentina) or with consultation papers and progress reports (as in the United Kingdom) (see boxes 3-1 and 3-2).

Box 3-2. Public Hearings: The Argentine Approach

The electricity and gas laws command the commission to call for a public hearing before adopting specified decisions on topics such as tariff reviews, mergers and acquisitions, transmission grid expansions, fines and infringements in general, and antitrust issues. Public hearings are formal procedures that are designed to achieve the following:

* All interested parties are to be given the chance to present their points of view on the subject in question before the regulators.
* A consensus is to be created among the public in regard to the legality and convenience of the adopted decisions.
* Transparency of government decisions is to be guaranteed in relation to the regulated company in such a way that the audience perceives this relation as honest and fair.

The commission may also call for a public hearing when it wants to gather all relevant opinions before making other decisions. This may avoid future conflicts when many parties with different interests are involved.

Experience so far shows that, in general, lack of experience and cultural tradition regarding public participation mechanisms has turned the public hearing into merely a formal procedure rather than an instrument to improve the information gathering and decisionmaking processes. Furthermore, the commissions do not seem to show much interest in participation by consumers or civilian organizations. In contrast to the United States, this is a result of a general lack of education regarding consumer protection. Nevertheless, the defense of consumers' interests is one of the principles imposed on the commissions by the law.

The public hearing, like all new institutions that concern participation in public issues, is not widely developed in Argentina, a country that is not accustomed to the democratic mindset, and for many years had a huge public sector that managed the utilities under a monopolistic system, without proper controls from any authority. The changes are now being implemented, however, although still in small steps.

Analysis and Decisionmaking

Once the firm has submitted its information, it must be analyzed by the regulator's staff. The information should be checked for internal consistency and to ensure that it is in the format required. This could be particularly important when several firms are being analyzed together. The firm's projections can then be used in the spreadsheets described later in this volume to calculate the amount of revenue that would be required by the firm's projections.

It is unlikely to be appropriate to take those projections at face value. Every regulated firm will know that its revenues will depend on predictions of its costs and investment needs, and will therefore have an incentive to inflate those predictions. Furthermore, the lower the estimated level of demand, the higher the level of prices needed to raise a given amount of revenue. The regulator should therefore obtain independent evidence about the firm's predictions when possible.

The first requirement is to ensure that the firm's information is internally consistent, so that the projections of demand yield the output levels that are used to derive cost predictions and investment needs. The demand forecasts should also be consistent with other forecasts made by the industry, and with forecasts of the level and pattern of gross domestic product (GDP) growth in the economy. This does not mean that the forecast should be identical to those made by others (other parts of the country may be growing more rapidly, implying greater increases in demand), but any differences should be explicable.

Some evidence on costs can be obtained by the regulator by looking at other firms' costs. If several firms are regulated together—this is the principle of yardstick regulation—the regulator will have the power to obtain detailed information on each firm. The regulator may also be able to obtain high-level information about the costs of firms in the same industry in other, comparable, countries. Additional information will probably have to come from efficiency studies by specialized consultants. Engineering consultants may be particularly helpful in the assessment of the company's investment plans and in determining whether the cost and quantity of investment seem reasonable.

It is quite likely that this analysis will raise further questions to be discussed with the company, and the regulator must allow enough time for such discussions to take place. Some information may not be held in the desired form, and it will take time for the company to create it. If several

companies are being considered together, the regulator must allow extra time to analyze the additional data and to hold multiple meetings.

Once the adjusted data are available, they can be used to calculate the amount of revenue required in each year. The price control is unlikely to be expressed in revenue, however, but in the prices the company is allowed to charge. By this stage, the regulator must determine whether any changes in the form of the price control are appropriate. These could include broadening or reducing the coverage of the control or changing the weights used for different prices. The revenue requirement must then be converted into prices, given forecasts about the growth of demand and the revenue that will be obtained from nonregulated activities.

These calculations should indicate the level of prices needed in each year to produce enough revenue to cover the costs incurred in that year (including a return on capital). One approach to a price control is to set a control that aims to recover this pattern of revenue, with some smoothing between years to avoid excessive fluctuations in prices. The second approach is to concentrate on the prices that are indicated for the final year of the review period and set a control that moves smoothly between the present price level and the target for the final year. The regulator must choose between the two approaches, and neither is necessarily better than the other. In general, the company's incentives to reduce costs will be greater if the second course is chosen, enhancing productive efficiency. If prices are presently well above the desired level, however, this approach might produce significantly more revenue than the company requires, harming allocative efficiency and possibly raising distributional concerns.

Announcement

Once the regulator has decided on the new price control, it should be announced. The announcement will be very market-sensitive, because it could have a significant impact on the regulated company's profits. Even an announcement of "no change" is news, because it rules out changes. In general, the sooner the announcement is made, the better. An early announcement gives the company more time to react to the control, and, if necessary, for an appeal to take place. It also reduces the potential for rumors and leaks. The exception is that when the regulator is working on several related controls, the results should be released together.

The regulator may wish to release information on possible outcomes during the course of the review. This allows the regulator to discuss pos-

sible options with the firm(s) and to hear other parties' reactions before the proposals are finalized. It will reduce the risk and impact of leaks, and may also have the political advantage of allowing people to become used to the proposals before they are announced formally, which may defuse opposition to controls that are likely to be controversial.

In any case, once the regulator's final proposals are released, the firm should be given an adequate length of time to decide whether to accept or reject them. (This assumes that there is a formal appeal mechanism to protect the firm against an overzealous regulator.) A month seems reasonable. If the firm accepts the proposals, the regulator should move on to the final stage, that of implementation. If the firm rejects the regulator's proposals, the appeal process should be invoked.

Box 3-3. Announcements in the United Kingdom

In the United Kingdom, regulators generally announce their major decisions with a short statement, for use by the media, and a longer paper, which sets out the decision in detail, and explains it. The short statement may well be based on the executive summary of the longer paper. This longer paper is intended to contain enough information to allow an informed observer to understand the regulator's decision. This does not mean that it will include all the information used by the regulator, because the firm is likely to have given the regulator some information it regards as commercially confidential. Even if the firm has no competitors, its suppliers might be able to take advantage of information on the firm's investment plans, for example, if they showed the amounts the firm expected to pay for particular pieces of equipment. U.K. regulators have the right to disclose information of this kind if it will aid them in the performance of their duties, but they generally use the right sparingly, only giving out the information that is needed to understand the decisions made. When several companies are being regulated together, the use of aggregated information can strike the right balance between understanding and confidentiality.

The day before the announcement is made, the regulator will send a copy of the statement to the Stock Exchange after the market has closed for the day. (The date of the announcement is generally known in advance.) These statements are released to the market (over an electronic bulletin system) at 7:30 a.m., before trading starts. The regulator is then free to give interviews to the early morning news programs. Later in the day, the regulators typically hold a press conference and a meeting with financial analysts to

The details of the appeal process will be country-specific, but the essence will be that an independent body is required to adjudicate the new price control. This body should be allowed up to six months to make its decision, which means that the regulator's final proposals must be published at least seven months before the company needs to set its prices. The appeal body will receive evidence from the regulator, the company, and other interested parties. It may be helpful if the regulator can emphasize points where a consensus has been reached with the company. Once the appeal has been decided, the regulator will be required to implement the decision. (For examples of announcement and appeal procedures, see boxes 3-3–3-5.)

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present and explain their decision. The dealings with the Stock Exchange ensure that all market participants receive the information simultaneously. In the United Kingdom, the media are interested in regulation, because the decisions affect the prices paid for utility services by practically all consumers. Most utilities are quoted companies, and financial analysts are interested in their performance. If the regulated company were owned by a foreign company, there might not be a need for an analysts' meeting, for example. Copies of the full statement are available at the press conference, which means that it must be printed before the announcement is made, by a printer who will respect the confidential nature of the information.

In the past, many regulators have released key information in confidence to the regulated companies the day before it is made public. This has been regarded as a matter of courtesy, and it gives the companies an opportunity to make an informed comment once the results are released. Matters of fact have generally been checked in advance by showing the companies parts of the draft statement (without conclusions). The problem is that this greatly increases the number of people with access to price-sensitive information, and hence the chance of a leak. (It is more likely that a larger group will include someone willing to leak information dishonestly, and a sizable group also reduces the chance of being discovered, since there are more suspects.) In practice, few companies are willing to make substantive comments at twenty-four hours' notice. It may therefore be best not to give the company advance warning of the results of the review, although this remains a matter for individual regulators' judgment.

Box 3-4. Appeals in the United Kingdom

Each company's price control is contained in its license, and the rules for changing the license are laid down in the law that established the regulatory system for the industry. The license can be changed by agreement between the regulator and the company; in most cases, the companies have accepted the controls proposed by their regulators. If a company refuses to accept the price controls proposed by its regulator, the decision is passed to the Monopolies and Mergers Commission (MMC), the United Kingdom's competition authority. The MMC has about 30 part-time members, appointed by the government for renewable three-year terms, with a full-time chairman and a staff of civil servants, including economists and lawyers. The regulator must make a formal referral to the MMC, asking it to determine whether the existing license condition might be expected "to operate against the public interest" and, if so, whether amendments to the license could prevent this. The MMC will normally be given six months for its inquiry, although this period can be extended. A group of between four and six members of the commission is selected for each inquiry. Only these members are responsible for the report, but the term MMC is still generally used.

The MMC will ask interested parties (including the regulator, the company, and relevant branches of government) for evidence and will also advertise more generally to allow others to submit their views. The group will also hold meetings with the most important parties and may visit some of the company's facilities. After considering the evidence, the group will produce a report that contains sections with factual information on the company and its industry; the views of the company, the regulator, and other interested parties; and the MMC's conclusions. The report is signed by the members of the group that produced it. Dissenting reports are possible, but rare (and there has not been one in a price control report). This report is sent to the regulator and the company, and then published by the regulator (excluding commercially confidential material, but noting where it has been removed).

If the MMC has not found that the existing license condition is against the public interest, the regulator cannot change it. If the MMC has found that the condition may be expected to operate against the public interest, it will also propose amended conditions to rectify this failure. In this case, the regulator is allowed to change the company's license, taking account of the MMC's recommendations. Regulators have generally accepted the MMC's recommendations in full, but they may still have some discretion, and the legal position is unclear.

Box 3-5. Appeals in Argentina

Decisions by the Regulatory Agency can be appealed administratively to the secretary of state for energy, and only after this has been done is a judicial appeal to the federal courts possible.

The administrative appeal, called an *alzada*, is resolved by the secretary of energy. The electricity law gives the secretary the power to decide the legitimacy of any resolution taken by the regulator, although the secretary should not decide on the merits of the decision.

A jurisdictional decision is one in which the regulator has adjudicated a dispute between two parties, acting as an independent third party. In this case, the energy secretary can analyze the remedy to see whether it would result in evident arbitrariness, crass error, or gross infringement of law.

In these cases, the secretary of energy is normally capable only of revoking the appealed resolution of the regulator. Nevertheless, when the public interest justifies it, the secretary can also directly modify or change the regulator's decision. In practice, the secretary of energy has changed resolutions of the regulator through changing the applicable criteria, or has directly changed them by issuing resolutions on the topics involved.

Apart from this administrative supervision, it is also possible to file a judicial appeal directly before the Administrative Federal Court of Appeal. The Supreme Court of Justice has established that the judicial authority is broad, which means that the court may review any question regarding law or facts.

Implementation

The final stage is to implement the agreed (or determined) price control. Legal amendments to the company's concession contract, or its license, need to be drafted. (It might be best for these to be included in the decision document, but the pressure of time may not allow this.) The contract may contain formal requirements for a valid amendment, such as publication of the amendment twenty-eight days before it takes effect. The regulator must be careful to comply with any formal requirements of this kind.

Once the new control is in the concession contract, the regulator must enforce it. One significant advantage of price controls is that enforcement can be relatively easy. If the control simply bears on a basket of published prices, the regulator only has to check that the weighted average of these

Table 3-1. A United Kingdom Timetable

Time period	Activity
A – 15 months	Start work on consultation papers, request for information from company
A – 12 months	Issue consultation paper and information request
A – 11 months	Commission consultants to report on efficiency and investment plans
A – 10 months	Deadline for replies to consultation paper
A – 9 months	Deadline for information from company
A – 7 months	Consultants' reports received
A – 6 months	Preliminary analysis of information, requests for clarification
A – 5 months	An interim public paper could be issued at this stage
A – 4 months	Additional information received from company
A – 3 months	Further analysis, clarification (if required)
A – 1 month	Numbers should be finalized by now
A – 2 weeks	Proposals finalized, public statements prepared
A – 1 week	Statements written and sent to secure printers
A – 1 day	Final preparation of announcement
A	Announcement of proposals: at least 9 months before D
A + 1 month	Company decides whether to accept proposals
D – 8 months	If the proposals are rejected, terms of reference for appeal prepared
D – 7 months	Appeal body starts inquiry
D – 1 month	Appeal body's report completed and published
D	Deadline for the company to know how much revenue it can raise, so that it can set and communicate prices: perhaps 2 months before E
Before E	Formal procedures for a license amendment to be completed
E	Price control takes effect

Note: A: announcement; D: deadline; E: effective date.

prices is below the price cap and that the prices are actually those charged to consumers. If a revenue-yield price control is used, under which the company's revenues are divided by the volume of its sales, audited sales and volume figures are required, but it is again a straightforward procedure to check that they are consistent with the formula.

In general, as long as the prices charged by the company are consistent with the price control, the regulator need not be concerned with the level of individual prices. From time to time, the regulator might be involved in discussions about the general principles to be used in setting prices— for example, when prices for gas or electricity transmission should vary across the country. Once the principles have been agreed, the regulator can again take a backseat. The exception is when there is a risk of discrimination or cross-subsidy, and the regulator is required to enforce provisions against this. Even so, the regulator may choose to be reactive, rather than proactive. In that case, the regulator would react to complaints of discrimination by gathering information on the costs and prices of particular products or services and assessing whether they breached the relevant conditions in the license. A full discussion of this issue is beyond the scope of this volume; the main point is that the regulator should not normally be involved in setting individual prices.

Argentina's approach to regulation in most sectors has been one of fixing not only a price cap over a basket of services, but also a cap over each individual price. This poses two kinds of problems. First, there is the

Table 3-2. Gas Tariff Review in Argentina

Date	Activity
March 1995	First meeting called by ENARGAS
August 1995	Cost of capital document by ENARGAS
October 1995	Meeting to discuss cost of capital document
March 1996	Request of data for X and K factors Methodological document by ENARGAS
June 1996	External consultants hired by ENARGAS for X-factor study
July 1996	Cost of capital fixed by ENARGAS
September 1996	Base case data presented by companies
January 1997	Final report presented by external consultants on X-factor Meeting with all companies to discuss X and K projects and methodology
February 1997	Additional data on base case
March 1997	Initial proposal presented by ENARGAS
May 1997	Public hearing
June 1997	X- and K-factor resolution by ENARGAS Eventual appeals to secretary of energy and courts
December 1997	New tariffs enter into effect

problem of getting relative prices right. Evidence from electricity and gas shows that the tariff structure presents some problems that lead to a distortion of consumption patterns. In electricity distribution, for example, the price of medium-voltage service is relatively cheap compared with low-voltage service. Consumers find it profitable to ask for a medium-voltage connection and do their own transformation to low voltage (the transformer will pay for itself in less than two years at the prevailing rates). Because one would expect to find economies of scale and scope in transformation, implying that the distribution company should be able to do it at a lower cost, the existing price differential is too large.

The second problem associated with fixing the price structure is that it reduces flexibility for the firm, and the regulator loses valuable information on relative costs and demand that is only revealed when the firm is allowed to choose the relative prices for its services. The firm might be able to manipulate relative prices to increase its profits at the expense of consumers, but choosing the right set of prices will often improve welfare for both the firm and its consumers. We recommend that the firm be given the flexibility to do this, while reserving the regulator's right to intervene.

Possible Timetables

Two timetables are set out in tables 3-1 and 3-2: one based on typical procedures in the United Kingdom and the other based on the rules laid down in Argentina.

4

The Form of a Price Control

This section discusses the form of price control that should be adopted. There are two major kinds of control: price basket and revenue yield. Each will be discussed in turn, describing the formulae that would have to be included in the company's license to define the control. The price basket can lead to more efficient relative prices, but will only be suitable when the company has a set of prices that is both relatively small and unchanging. When the company's prices are more complicated, the revenue-yield approach will be required, although it may give the company an incentive to expand sales in low-price sectors. If some elements of the company's costs are uncertain and outside the company's control, it may be appropriate to include a pass-through term that reduces the risk faced by the company (while increasing the risk to its customers). We also consider the choice of the price index to be used in the control and the issue of tariff rebalancing.

The control will have to specify which prices are included within the scope of the control. Some activities may be excluded because they are subject to competition—for example, if a gas company also services customers' appliances, in competition with independent companies, this activity should not be subject to the control. The prices paid by particularly large customers may be excluded because they are believed to have enough bargaining power to protect themselves. The definitions of the categories chosen should be unambiguous.

Price Structure

Economists argue that prices should generally be related to marginal costs. If the price of every good is equal to the cost of producing another unit of that good, a consumer who chooses between the goods on the basis of their prices is making the same tradeoff that they would make if they had all the information on how much of each good society could produce.

For some utilities, average costs will be above marginal costs, and prices may thus have to exceed marginal costs if the company is to cover its costs.[1] "Ramsey prices" are designed to collect this revenue as efficiently as possible, minimizing the changes in quantity relative to the quantities that would be bought at prices equal to marginal cost. The general principle is that the products with the least price-sensitive demand should have the highest prices, relative to their marginal cost.

An alternative is to charge a two-part tariff, so that each consumer pays both a connection fee and a price for each unit consumed. The unit price can be set at marginal cost, which is efficient as long as the connection fees can raise sufficient revenue without dissuading some consumers from buying the product at all. If necessary, a lower connection fee could be combined with a unit price slightly above marginal cost. A company may be able to increase both its profits and its consumers' welfare by offering a carefully chosen menu of tariffs and allowing consumers to choose between them. (Small consumers might choose a low fixed fee and a high unit rate, while large consumers pay a larger fixed fee and a lower unit rate).

If it is not possible to measure the consumer's consumption, the company cannot charge a price per unit and must rely on a flat fee, or a fee related to some observable characteristic of the consumer. This will often be the case in the water industry, where relatively few consumers have meters, and payments may be based on the size of their houses. This may act as a proxy for their consumption; it will also act as a proxy for their ability to pay.

Ability to pay is an important consideration in setting utility prices, and it has often caused governments to set prices that differ from those

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1. If the company was privatized with a sale price below its asset value, this would reduce its regulatory cost base, so that the appropriate regulated price could be less than its marginal cost.

suggested by strict efficiency principles. As well as helping low-income consumers, governments may have favored selected groups for political reasons. Ramsey prices imply high charges for essential products, because their demand does not respond to price, but lower prices (relative to cost) for price-sensitive luxuries. The government may prefer low prices for necessities, and higher prices for luxuries. With two-part tariffs, the fixed fee will be lower, and the unit rate higher, in order to reduce the bill paid by small consumers. For telephone services, this has typically meant low line-rental charges (which are of most concern to domestic customers), which are paid for by high charges for long-distance calls (of most concern to businesses).

This means that existing price structures may be inefficient and incompatible with competition (if that is being considered as an option). For example, if the incumbent telephone company is required to set prices to business customers that are significantly above the costs of serving them in order to subsidize domestic customers, it will be vulnerable to "cream-skimming" entry. A new company that does not have to serve domestic customers could undercut the incumbent's prices for business customers, even if it is less efficient than the incumbent, because it does not have to pay the cross-subsidy.

It will often be best to give the regulated company the right to rebalance its tariffs, moving prices toward costs. A price control that simply requires the company to change each of its existing prices by $RPI - X$ percent each year will lock in any existing inefficiencies, and may create new ones in time. The controls described below allow the company to increase some prices by more than the average, as long as others are increased by a lesser amount.

It may be appropriate to place some limits on this rebalancing. A subsidiary price control on particularly sensitive prices might slow down the process—while the average price of telephone services in the United Kingdom was required to fall by 3 percent a year in real terms between 1984 and 1989, the charge for a line rental was allowed to rise by up to 2 percent a year in real terms. The regulator may also be given powers to investigate the company's price structure, *in response to complaints,* if the company is forbidden to discriminate among customers or to impose cross-subsidies. It may be necessary to exempt inherited discrimination from this requirement, but it can ensure that rebalancing does not go too far, subsidizing competitive activities at the expense of captive customers.

Price-Basket Controls

The first *RPI − X* price control, set for British Telecommunications in 1984, was based on a basket of prices. The company was required to increase the weighted average of these prices by less than the increase in the retail price index, less 3 percent. The weights used were the previous year's revenue shares. The formula can be written as:

$$\sum \text{weight}_i \times \text{price}_{it} \le \sum \text{weight}_i \times \text{price}_{it-1}\left[1 + \frac{RPI_t - X}{100}\right]$$

where RPI_t is the percentage increase in the retail price index over the "reference period" of twelve months, and X is the amount of tightening desired in the price control (set to 3 for British Telecommunications). It is best if the reference period ends before the firm's prices have to be set, so that each element of the formula is known by the start of the year to which it applies. In that case, the company simply has to send the regulator a statement demonstrating that its proposed price increases are below the limit set by the formula. This simplicity of operation is one of the greatest advantages of the price-basket approach; the main problem is that the tariff structure may become too rigid unless the formula can be adjusted to allow the company to introduce new prices. (For example, the company could not move from a single to a two-part tariff without negotiating changes to the price-basket control.)

The regulator must also determine the weights to be used in the formula. If the company believes that the weights are fixed, and the right values are chosen, it can be given an incentive to choose an efficient set of relative prices. If the weights are out of line with the quantities sold by the company, however, it may be able to increase its revenue by more than the regulator had intended by concentrating price increases on products that are underrepresented in the index. Economic theorists have shown that the efficient set of weights should be proportional to the quantities that would be sold at the efficient level of prices, although the regulator is unlikely to have the information on costs and demand patterns that would allow these to be calculated. In practice, the price control for British Telecommunications used weights equal to the revenue share for each service in the previous year. These weights are not really fixed, and a farsighted company might try to adjust prices in one year in order to affect the revenue shares of different products, and hence its future price control, but this seems unlikely to be a significant problem in practice. Most

subsequent price controls in the United Kingdom have gone further down this route, relating prices not to the revenue shares of the previous year, but to those of the current year.

Revenue-Yield Controls

The advantage of the revenue-yield control is that the regulator does not need to specify a list of prices. The company is free to bring in new tariffs, as long as its overall revenue stays within the level specified by the control. There are two main disadvantages to this approach. First, the company will have to set its prices in advance, but can only check the revenue that they yield afterward. This means that the company may, quite innocently, earn more than the price control allows.[2] The control must therefore include a correction factor to reduce the company's allowable revenues in one year if it over-recovers in the previous year. (The correction factor also allows the company to recover the revenue forgone if its prices turn out to be lower than the control would have allowed.)

Second, the cap is likely to be complicated to specify. If the cap simply specifies the revenue for each unit of sales, the company can effectively ease the cap by expanding sales to low-price customers, because this will increase its volume by a greater proportion than its revenue.[3] To reduce the scope for such manipulation, the control would have to include a number of "revenue drivers" in the formula, which would tie the company's total revenue to factors such as the number of customers and the sales to each customer group. If these are chosen appropriately, the company's total revenue can move into line with to its costs, whatever the pattern of output.

The basic form of a revenue-yield control is:

(1) $$\frac{\text{Total Regulated Revenue}_t}{\text{Unit sales}_t} \leq \text{Maximum Average Charge}_t$$

$$= 1 + \frac{RPI_t - X}{100} P_{t-1} - K_t$$

2. For example, if the company has a fixed charge for each consumer and a unit rate, the average revenue for each unit falls as demand increases. If demand is lower than expected, then the company's average revenue for each unit will be higher, leading it to breach the price control.

3. It might seem that this kind of control has to be related to a common unit of sales—for example, controlling the average revenue for each kWh sold. It is shown below, however, that the control could be respecified in terms of total revenue rather than an average, and this could be linked to several different measures of sales.

where RPI_t is the percentage change in the retail price index (or other "control index") over the reference period of twelve months, P_{t-1} was the maximum average charge (net of the correction factor) in the previous year, and K_t is the correction factor. The formula will need to define total regulated revenue and the unit of sales that serves as the divisor. Separate formulae are used to define P_{t-1} and K_t.

The formula for P_{t-1} relates it to the value of P_{t-1} in the previous year, now known as P_{t-2}. In the first years of a control, however, a number, P_0, is used in place of the formulae:

$$P_{t-1} = \left[1 + \frac{RPI_t - X}{100}\right]P_{t-2}.$$

The correction factor is given by:

$$K_t = \frac{\text{Revenue}_{t-1} - \text{Maximum Average Charge}_{t-1} \times \text{Unit sales}_{t-1}}{\text{Unit sales}_t}\left[1 + \frac{I_t}{100}\right]$$

where I_t is an interest rate, equal to a specified bank's base rate when K_t is negative, but that same rate plus a premium when K_t is positive. This implies that the company has to pay a higher interest rate when it is borrowing from its customers than it receives when it is lending to them, and it ensures that the company does not have any incentive to over-recover. We can combine the formulae above:

$$\text{Maximum Average Charge}_T = \prod_{t=1}^{T}\left(1 + \frac{RPI_t - X}{100}\right)P_0 - K_T$$

where the expression $\displaystyle\prod_{t=1}^{T} Y_t$ represents the product: $Y_1 \times Y_2 \times \ldots \times Y_T$.

Note that this control could be rewritten in terms of the company's total revenue, which indicates that it could be amended if it were impossible to calculate a sensible measure of average revenue:

$$\text{Total Regulated Revenue}_T \leq \prod_{t=1}^{T} \left[1 + \frac{RPI_t - X}{100} \right] P_0 \text{Unit sales}_T - K_T \text{Unit sales}_T.$$

This control only relates the company's revenue to its total sales, which is likely to be inappropriate when sales to different categories of customers (for example, industrial and residential) are made at very different prices. The revenue can be related to sales to these different classes by disaggregating the term P_{t-1} in equation 1:

$$P_{t-1} = \sum_i P_{it-1} \frac{\text{Unit sales in category } i_t}{\text{Unit sales}_t}.$$

The individual prices, P_{it-1}, are updated in exactly the same way as the aggregated price above, starting with a set of prices P_{i0}, which embody the price weights desired in the price control. For example, the regulation of electricity distribution in the United Kingdom uses four regulated categories, and the price control for Hydro Electric adopted in 1995 used the values listed in table 4-1.

Note that these figures are relative allocations, rather than direct instructions to the company about the prices to charge. The figures can be used to send cost messages, but the company is not required to charge prices that produce this exact level of revenue from each group. Note that the allocation is lowest for the off-peak units distributed to customers facing day/night tariffs, although if the high-voltage allocation had been divided in this way, its off-peak allocation would have been even lower.

Table 4-1. Revenue Categories Used in the Price Regulation of Hydro Electric, 1995

Category	Description	P_{i0}
HV	Units distributed at between 1 kV and 22 kV	0.860
	Units distributed at less than 1 kV	
LV1	Peak units of day/night tariffs	1.521
LV2	Off-peak units of day/night tariffs	0.801
LV3	Other units distributed at less than 1 kV	1.605

Such a division may have been rejected as involving too much micromanagement of the company's tariffs. The peak units distributed to customers on day/night tariffs have an allocation nearly twice as high as their off-peak units. The highest allocation is to customers on unrestricted tariffs: these customers tend to consume the least electricity, and thus the cost incurred for each unit distributed is greatest. Note that there is no category for electricity distributed at extra-high voltages, above 22 kV. The revenue from those sales is not regulated, although consumers may appeal to the regulator if they cannot agree on an acceptable contract with the distribution company. Predictions of the value of these sales were subtracted from the company's revenue requirements when the level of the price control was determined.

In practice, the company's costs may not vary in proportion to the number of units it sells, so that a price control that simply covers the revenue for each unit may expose the company to some risk. It may also give the company an incentive to expand its sales (if the marginal revenue would exceed the marginal cost of doing so), which may not always be appropriate. A slightly more elaborate control can weaken the link between units sold and allowable revenues, so that they reflect the company's costs more closely. For example, the increase in the company's costs might depend on the average of the increase in its unit sales and the increase in the number of customers it serves. To relate the allowable revenues to these two factors, the following formula could be used:

$$\text{Maximum Average Charge}_t = \frac{\text{Base Revenue}}{\text{Unit Sales}_t} \times \text{Growth}_t$$

$$\times \left[1 + \frac{RPI_t - X}{100}\right] \text{Price Index}_{t-1} - K_t$$

where Base Revenue is an amount of money, divided by Unit Sales$_t$ so that the formula refers to the average charge per unit, Price Index$_{t-1}$ is updated in the same way as P_{t-1} above (with Price Index$_0$ = 1), and Growth$_t$ is given by the following formula:

$$\text{Growth}_t = 0.5 \left(\frac{\sum_i P_{0i} \times \text{Unit sales in category } i_t}{\sum_i P_{0i} \times \text{Unit sales in category } i_{t-1}} + \frac{\text{Customer numbers}_t}{\text{Customer numbers}_{t-1}} \right) \times \text{Growth}_{t-1}$$

where Growth$_0$ = 1, and P_{0i} is the weight given to each unit of sales in category i, equivalent to the P_{i0} from table 4-1.[4] The relative weights of units sold and customer numbers could be changed if we inserted extra terms into this formula:

$$\text{Growth}_t = \frac{1}{w_u + w_c}\left(w_u \frac{\sum_i P_{0i} \times \text{Unit sales}_{it}}{\sum_i P_{0i} \times \text{Unit sales}_{it-1}} + w_c \frac{\text{Customer numbers}_t}{\text{Customer numbers}_{t-1}}\right) \times \text{Growth}_{t-1}$$

where w_u and w_c are the weights placed on unit sales and customer numbers, respectively. Returning to the 50:50 weights we used at first, we can combine the formulae above to give:

$$\text{Max Revenue}_T = \text{Base Rev} \times \prod_{t=1}^T 0.5 \left[\frac{\sum_i P_{0i}\text{Sales}_{it}}{\sum_i P_{0i}\text{Sales}_{it-1}} + \frac{\text{Customer}_t}{\text{Customer}_{t-1}}\right]$$

$$\times \prod_{t=1}^T \left[1 + \frac{RPI_t - X}{100}\right] - K_T.$$

Note that this formula has been written in terms of the company's total revenue, rather than its charge for each unit, although the price control may still be written in terms of the maximum average charge for each unit. In practice, an agreed forecast of customer numbers is often used instead of the out-turn figures to ensure that there are no subsequent disputes about the definition of a customer (for example, how to treat a building with several occupants).

If a formula of this kind is adopted, the regulator will need to decide on the overall weights to be placed on sales and customer numbers (or any other revenue drivers). For any formula that breaks unit sales into several categories, the identity of those categories and the weights to be placed on each category will have to be determined. The categories will need to have clear boundaries, or the company might attempt to shift sales into categories with higher weights. To reduce the burden of regulation, it may be preferable to use existing statistical categories, but the choice of category should be reviewed from time to time. As far as possible, the

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4. In practice, the figures in the table were actually the P_{0i} used in a control of this kind.

customers within a category should impose similar costs on the company (so that they form a coherent group), costs that differ from those of customers in other categories (otherwise, it might make sense to combine two groups). The size of the customer's consumption and the level of their connection to the system (for example, in electricity, their voltage level) is likely to be more important than their economic category (industrial or commercial customer). For the weights on individual categories, it may be best to take the existing unit prices, unless these are believed to be significantly out of line with costs. If the weight used for one kind of sale is significantly different from the marginal costs of that sale, then the company is likely to face an artificial incentive to expand (if P_{0i} exceeds the cost) or contract those sales.

Pass-through Terms

A regulated company may face significant costs that are both uncertain and largely outside its control. An example would be purchases of gas by a gas distribution utility that are indexed to local oil prices, and therefore effectively tied to the world oil markets. The cost of this gas could easily change by 10 percent or more from one year to the next, judging from past experience. If the utility were forced to charge prices indexed only to a general price index, it would be exposed to a significant risk, raising its cost of capital, and hence the expected price paid by its consumers. These consumers, however, are almost certainly less risk-averse, with respect to the price of gas, than the utility, because they only spend a small part of their income on gas. The general principle—that risk should be passed on to those best placed to bear it—implies, in this case, that the price of gas to consumers should reflect the actual cost of gas to the utility, rather than the prediction that would be needed for a fixed price control. Note that this only applies to significant costs. A regulated telephone company may also be exposed to changes in the price of gas, which it uses to heat its offices, but this will be trivial in the context of the business as a whole.

Another case where a pass-through may be used is when a utility has been broken down into several stages, and more than one stage is regulated. An example would be an electricity industry, where the use of the distribution network and sales to small customers have been identified as separate activities, and regulated. (One benefit of separation is that it provides the possibility of competition to sell to larger customers, with rival sellers using the distribution network as a common carrier, at regulated prices.) The incumbent company would be divided into a distribution

business and a supply (retailing) business, and the supply business would have to pay the same distribution charges as a rival seller. If the distribution price control is reset at a different time from the supply control (to reduce the burden on the regulator), it will be difficult to predict the distribution prices for the final part of the supply control period.[5] Because these charges are regulated, however, it should be acceptable to pass them straight through to the company's customers.

The basic formula for a price control with a pass-through term (which will almost certainly be of the revenue-yield type) is:

$$\text{Maximum Average Charge}_t = \left[1 + \frac{RPI_t - X}{100}\right] P_{t-1} + \text{Pass-through cost per unit}_t - K_t.$$

The pass-through cost for each unit is given by the total cost of the items subject to the pass-through, divided by the number of units sold. Note that auditing this part of the control is likely to increase the burden on the regulator (or the auditor employed by the regulator), because the actual costs of the purchases subject to pass-through will have to be checked each year.[6] If the company buys the same input for regulated and unregulated sales, the purchase costs must be allocated between the two sectors, but the company will generally have an incentive to load the more expensive purchases onto its regulated customers. The regulator will need to establish rules governing the allocation of purchases to ensure that discrimination of this kind is prevented. It is likely that the out-turn costs of particular contracts will vary, even if their expected costs are similar, and contracts should be allocated to regulated or unregulated purchases before those purchases take place to prevent the finer discrimination that allocating contracts after the event would allow.

In some cases, a straight cost pass-through may be inappropriate, particularly if the company is purchasing from itself at unregulated prices. If it is allowed to pass the cost straight through to its customers, with no further restraint, it has an incentive to inflate that cost. The regulator might be given powers to examine and potentially disallow such pur-

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5. Creating a detailed forecast would defeat the purpose of having a separate review of distribution charges.

6. One (British) company actually refused to show its purchase contracts to its regulator, asserting that its own certificate would be adequate proof that it was complying with the price control. The regulator had to go to court to win the right to check the company's calculations!

chases, but this could be an intrusive form of regulation. An alternative would be to use a price index that acts as a proxy for the costs of these purchases, thereby insulating the company from the risk associated with its past purchases, but giving it an incentive to beat the index—in future purchases. The formula would be:

$$\text{Maximum Average Charge}_t = \left[1 + \frac{RPI_t - X}{100}\right]P_{t-1} + \left[1 + \frac{PCI_t}{100}\right]\text{Pass-through term}_{t-1} - K_t$$

where PCI_t represents the change in the pass-through cost index between the previous year and the current year. The initial value of the pass-through term is a number, based on the pass-through cost for each unit in the year before the price control takes effect. The pass-through term is updated in the same way as the price term for controllable costs:

$$\text{Pass-through term}_{t-1} = \left[1 + \frac{PCI_{t-1}}{100}\right]\text{Pass-through term}_{t-2}$$

Note that this formula is equivalent to:

$$\text{Pass-through term}_{t-1} = \frac{PCI_{t-1}}{PCI_0}\text{Pass-through term}_0.$$

Using the formula that updates the pass-through term each year means that the regulator could include an X_p term, forcing the company to "beat the index" if it is to maintain its profitability:

$$\text{Pass-through term}_{t-1} = \left[1 + \frac{PCI_{t-1} - X_p}{100}\right]\text{Pass-through term}_{t-2}.$$

The cost index must be chosen to reflect the costs incurred by the company, while at the same time being based on published information. This mechanism has been used for British Gas, which had gas purchase contracts indexed to general inflation, measured by the producer price index, and to various energy prices. The regulator constructed a gas cost index, which contained elements listed in table 4-2.

Note that the weights do not sum to one, because the company still had some nonindexed contracts (signed before the 1973 increase in the price

Table 4-2. British Gas, Gas Cost Index

Component	Weight
Producer price index	0.45
Electricity component of the RPI	0.06
Market price of gas-oil	0.17
Market price of heavy fuel oil	0.20

of fuel) when the index was first adopted. In practice, the weights cited here are a simplification, because the gas cost index used a mixture of monthly, quarterly, and annual values of its components, with different weights. In this table, only their sum is given. Argentina uses a similar rule (only allowing a market price to be passed through on new contracts) in its regulation of electricity distribution companies (see box 4-1).

Box 4-1. Argentina's Pass-through Rules for Electricity

In Argentina, electricity distribution companies under federal regulation have a complete pass-through of their energy purchases in the wholesale market. The tariff to final customers has the form:

$$Td = Pw (1 + d) + CPD$$

where:

Td:	Tariff to final customers
Pw:	Wholesale price of energy
d:	Allowed distribution losses (in percent)
CPD:	Distribution costs subject to price cap.

The wholesale energy price that may be passed through to final users is a weighted average of seasonal prices (*SP*), transferred contracts (*TC*), and new contracts (NC). Formally:

$$Pw = a1\ SP + a2\ TC + a3\ NC$$

where

$a1$: Share of energy bought at the seasonal price, *SP*
$a2$: Share of energy bought through transferred contracts at price *TC*
$a3$: Share of energy bought through new contracts at price *NC*.

(Box continues on the following page.)

Box 4-1 *(continued)*

The seasonal price is a three-month average of expected spot prices calculated by the market administrator (CAMMESA). According to the law, distribution companies have the right to buy at this stabilized seasonal price, while generators get the spot price. A stabilization fund, managed by CAMMESA, covers the temporal differences between the ex-ante average and the observed spot prices. Seasonal prices, which reflect competitive conditions in the wholesale market, are passed directly to final users.

At the moment of divestiture, the government signed eight-year contracts between the newly created generation and distribution companies that covered approximately 50 percent of the demand. These contracts were transferred as part of the privatization package, and their price, which is now substantially above the spot price, is transferred directly to users.

Distribution companies are free to sign any new contracts they want with any generator in the system. Nevertheless, because this price need not be the result of any competitive mechanism, there is a need for regulation. According to existing regulations, the price for these new contracts that can be passed on to final users has a cap equal to the seasonal price of energy. Therefore, the pass-through price is:

$$Pw = (a1 + a3)\ SP + a2\ TC.$$

The increase in total demand implies that $a2$ decreases over time, so the limit on Pw moves toward SP, which will be the final cap after the transferred contracts expire in the eighth year.

Given that SP is the expected revenue for any generator (the average of spot prices), there has been little interest by distribution and generation companies in signing new contracts. Generators are not willing to accept a price below SP and distribution companies are not allowed to pass a price above SP through to users, leaving little room for trade.

An alternative would be to require the company to hold a competitive tender for any major contract, and then allow it to pass through the cheapest bid. Note that this approach becomes difficult to implement when the tender depends on more than price alone, and the company (and its regulator) must compare bids that differ in areas such as quality, length of contract, and indexation clauses. The United Kingdom has used an economic purchasing obligation (see box 4-2), which can be reviewed by the regulator, to encourage companies to keep their costs down,

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**Box 4-2. The Economic Purchasing Obligation
in the United Kingdom**

In the United Kingdom, the regional electricity companies (RECs) faced a potential conflict of interest: their price control allowed them to pass through the cost of electricity purchases, including purchases from their own affiliated generating companies. This conflict was recognized by including a license condition that required the purchase of electricity "at the best effective price reasonably available, having regard to the sources available." The regulator produced two reports (interim and final) on this condition in 1992/93, shortly before resetting the companies' supply price controls. The reports concentrated on the companies' purchases from new power stations in which they held shares (at the time, the only significant purchases they had made since privatization). They reviewed the procedures used by the companies to evaluate projects, concluding that each company had considered a range of alternatives, although none had held a formal tender. The reports also considered the prices in the contracts compared with those on offer from incumbent generators and concluded that the contracts signed appeared likely to cost less than the alternatives. The comparison did depend upon projections of fuel prices, and some projections implied that the RECs' projects would be more expensive than the alternatives.

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although the regulator's powers are unclear in the event that a company is found to be in breach of this obligation. In the gas industry in Argentina, the regulator can limit the pass-through of an expensive contract to the (lower) amount paid in comparable contracts (see box 4-3).

The Choice of Price Index

The regulator may need to choose the price index that will be linked to the company's prices. In the United Kingdom, the standard general measure of consumer price inflation, the retail price index, has always been used because it was familiar to most analysts and its behavior was reasonably well understood. When it was first adopted for regulation, in the price control for British Telecommunications, this familiarity was felt to outweigh the disadvantage that it might not act as a good proxy for the

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Box 4-3. Pass-through of Gas Costs in Argentina

Gas distribution companies have a complete pass-through of the cost of gas purchases established in the gas law. For each seasonal period (from May to September and from October to April), the tariff is calculated as:

$$T1 = T0 - G0 + G1$$

where:
- $T1$:   Adjusted tariff
- $T0$:   Previous tariff
- $G0$:   Price of gas established in the previous adjustment
- $G1$:   New gas price.

This pass-through is limited by a form of yardstick regulation. Article 38 in the law states that:

> The price of sale to final users will include the cost of gas purchases. When such prices are the result of freely negotiated contracts, the regulator can limit the pass-through to final users in those cases in which the negotiated price exceeds the ones negotiated by other distributors in situations considered equivalent by the Regulator.

The regimentation of the law (Decree 1738/92) establishes that this comparison has to take into account all the circumstances of each case, including the prices prevalent in the market for similar volumes, and avoid a mechanistic application of a minimum cost rule. When a contract is signed by independent parties, the agreement is presumed to be fair and reasonable, and the burden of proof falls on the regulator. The regulator has powers to determine when two parties should not be considered to be independent.

To enforce these rules, a register of contracts is created and the regulator is allowed to publish a list of indicative prices without violating the confidentiality of any particular contract.

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input prices that faced the company. In Argentina, the producer price index for the United States is used, and is translated into the national currency at the prevailing exchange rate.[7] This choice was designed to reas-

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7. Gas and electricity companies use the legal exchange rate of 1 peso per dollar, while the telephone companies use the market exchange rate, which never differs from the legal rate by more than a few cents.

sure investors (particularly foreign investors) by relating their revenues to a "harder" currency than the peso.[8]

An alternative is to link the company's output prices to an index of input prices. This is likely to reduce risks for the company, but would be most appropriate when the company is a price-taker. If the company is the major purchaser of some inputs and can negotiate its own prices, using an input price index might take on some of the characteristics of cost pass-through regulation.

In general, the regulator will have to assess the likely trend of the company's input prices relative to the price index used in the regulatory formula when setting the value of X. The prices of telecommunications equipment, for example, have typically risen less than general measures of inflation, while wages generally rise more quickly. The calculations described in section 5 must be carried out in real terms, where these are defined relative to the price index used in the regulatory formula.

The formulae include the term RPI_t, which refers to the rise in the price index over a reference period. It is probably best if this part of the formula is backward-looking, so that the reference period would end before the company needs to set its prices. This means that prices for the calendar year 1997 might be based on the level of the price index in June 1996. (The increase in prices between 1996 and 1997 would be based on the increase in the price index between June 1995 and June 1996.) If the figure for one month might be too volatile, the average of several months could be used instead. This means that the company does not need to make forecasts of the inflation rate, and it reduces the size of the correction term that carries forward the effects of forecasting mistakes. It has the disadvantage that the company may turn out to be short of revenue if inflation suddenly accelerates, because its prices will not be able to increase until later. (The company will gain from falls in the inflation rate, however.)

One solution to this problem may be to reduce the length of the subperiods used within the price control period. The control could relate to the

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8. In 1991 the Argentine Congress passed a convertibility law (ley de convertibilidad) that pegged the peso to the U.S. dollar with an exchange rate of 1. This law was the cornerstone of a stabilization plan aimed at eliminating inflation, which had been running at over 100 percent a year for almost 20 years, and ended in hyperinflation with a peak rate of 200 percent a month in July 1989. The law also prohibited contracts indexed in local currency, which had been a common practice and one of the main transmission mechanisms for price increases. This prohibition also meant that no local index could be used in the concessions contracts.

company's revenues over a period of three or six months (and would be updated relative to the change in the price index over a period of the same length), so that any change in inflation would feed through to the company's prices more rapidly. The weights would have to be designed so that any seasonal change in consumption patterns (and hence average revenues) was control-neutral. In other words, if household gas consumption increases during the winter, reducing the total payment per kWh consumed (since the tariff includes a fixed charge, spread across a greater number of kWh), this might appear to allow an increase in prices unless the price control formula is carefully designed. A price-basket control would include both the fixed charge and the unit rate, while a revenue yield control would be linked to both customer numbers and consumption.

In Argentina the indexation clauses for electricity and gas distribution and transport are based on past inflation, and prices are updated every six months by a weighted average of the U.S. producer and consumer price indices. In electricity, for example, the mechanism uses a two-month lag to make sure information is available for the May price update, so the inflation in the United States between October of the previous year and March is used. Because past inflation is used, there is no need for a correction factor for forecast errors, and the relatively short length of the period between updates minimizes the impact that an acceleration or deceleration of inflation can have on the companies' finances, although it does impose the administrative cost of publishing new tariffs every six months.

It is also important to note that the choice of price index will have a direct impact on the manner of calculating the real change in the company's prices (X), because efficiency gains in the rest of the economy affect the company through this index. A telephone company, for example, might expect to benefit from cheaper and better equipment provided by technical progress among its suppliers, and innovations might hold its cost increases below those of prices in the economy as a whole. If an economywide price index is used, the regulator should take this relative price effect into account, and is likely to call for a decline in the telephone company's prices in relation to the economy. If the regulator uses a price index for the company's main inputs, the relative price change may well be smaller, reflecting only the efficiency gains made in the company or sector itself, because the gains made by the input suppliers should be reflected in lower input prices.

Duration of the Control

The regulator must also specify the duration of the price control, unless this is laid down by law. Once again, there is a tradeoff between productive and allocative efficiency. If the price control lasts for a long time, the company will have a strong incentive to reduce its costs, since it will keep the benefits for many years. By the end of the period, however, prices may be significantly above the company's costs, leading to allocative inefficiency and possible distributive concerns. The company's sustainability could be endangered if the price control turns out to be too demanding. If the price control period is short, the regulator can ensure that prices are always close to the company's costs, protecting sustainability and allocative efficiency. The drawback is that the incentives to productive efficiency are weakened as the regulation draws closer to a pure rate of return system. The worst scenario would be to announce a long price control period, but then to "reopen" it unexpectedly in response to high profit levels. The resulting uncertainty will greatly reduce the company's incentives in the future.

Regulators in the United Kingdom have generally chosen control periods of four or five years, which strikes a balance between incentives and the risk that prices will get out of line with costs. In Argentina, however, the first price control period for electricity distribution companies was fixed at ten years, with five yearly reviews to follow. The reason for this was that the companies were expected to make losses in the early years of the concession, which could be recouped with profits earned during the second five years. It would have been difficult for the regulator to make a commitment to allow the company to earn these profits if the price control had been reopened in the middle of the period, and thus the longer period was chosen. There is a general principle here: at the time of restructuring or privatization, there may be considerable scope for efficiency gains. A "high-powered" incentive scheme is appropriate in such circumstances, implying predetermined prices for a long period. This is particularly important in cases such as Argentina, where the companies have to carry out a great deal of investment during the early years in order to bring the service up to an acceptable level of quality. Once the restructuring has been completed, there will be less scope for dramatic efficiency gains, and the regulator should pay more attention to allocative efficiency, with shorter intervals between price control reviews.

It may be possible to combine the incentive provided by a longer period of preset prices with some reassurance to the company if the price control includes a *reopener.* Such a provision would include a list of specified events that would lead the regulator to review the price control before the due date. In the U.K. water industry, the companies and the regulator were allowed to ask for a revised price control in the event of significant changes in the cost of construction relative to the retail price index, since a high proportion of the companies' expenditures were for improvements to their infrastructure. An alternative, which could maintain the company's incentives in good conditions, but insure them against poor conditions, would be to allow the company, but not the regulator, to ask for a review after half the period was completed. The company would ask for the review if it needed higher prices, but not if its profits were already high.

5

Present Value Calculations

One aim of the price control is to ensure that the regulated company can finance its activities over the review period. Present value calculations are used to determine the amount of revenue required to cover the company's predicted costs and to yield a set return on its assets. As discussed above, this does not mean that the price control will inevitably be set to produce this level of revenue, but the present value calculation should always be an important consideration. If the company can demonstrate that the present value calculation shows that it would have an inadequate level of revenue, it would be in a strong position to appeal the proposed price control.

In this section, we set out two ways of looking at the present value calculations. The first is *cost-based*: it examines the costs incurred by the company and sets revenues to equal these costs. The second approach is *value-based*: it calculates the revenue required to maintain the value of the business. The two approaches yield exactly the same final formula, but both are included to help the reader.

Looking at present values is an *economic* approach, but we should also consider the financial approach of cash flow analysis. If the company is spending heavily on new investment, it may need a higher level of revenue than present value calculations alone would suggest to avoid excessive borrowing. The regulator should check the company's predicted gearing and interest cover to ensure that these remain acceptable through the review period and its immediate aftermath.

The Cost-Based Approach

In this subsection, we will start with an intuitive formula in which the required revenue is equal to the company's operating costs, including deprecation, plus a return on its capital. (The components of this formula are discussed later in the report.) We will then show that this formula can be converted to one based on cash flows, in which the required revenue is equal to the company's cash spending on operating costs and investment, plus the change in the present value of its assets. This cash-flow-based formula is then slightly modified to take account of the timing of payments and receipts. This modified formula has become the standard used by regulators to reset price controls in the United Kingdom, and it is the formula recommended in this report. This is because it is the most accurate measure of the amount of revenue needed to allow a company to finance its activities. Nevertheless, we introduce the earlier formulae to help the reader understand how the recommended formula is derived.

Consider the simplest case: prices must be set for a single year. The company has expected cash operating costs of 50, a depreciation charge of 10, and a regulatory asset base of 100. The discount rate is 10 percent, so the return on capital should equal 10. For a single year, we can simply add the three elements (operating costs, depreciation, and return) to yield a required revenue of 70. Moving toward the multiyear case, however, we

Table 5-1. Price Control Calculation for a Single Year: Cost-Based Approach

Value	*Item*	*Start*	*End-year 1*	*Key to columns*	
	Interest rate	10%		r	
Actual values	Operating costs		50		OC
	Depreciation		10		D
	Assets	100		A	
	Return on assets		10		$Ret = r^*A$
	Discount factor		0.90909		$d = 1/(1 + r)$
Discounted values	Operating costs		45.455		$oc = OC^*d$
	Depreciation		9.091		$dep = D^*d$
	Return		9.091		$ret = Ret^*d$
	Revenue		63.636		$oc + dep + ret$
Actual value	Revenue		70		$revenue/d$

Note: In the formulae on the right-hand side of the table, capitals are used for actual values and lower-case letters for discounted values.

can start to build up a spreadsheet that discounts each year's costs and revenues to a common date.

For the time being, we assumed that all the costs and revenues for a year accrue at the end of that year, and discount the first year's costs and revenues by 10 percent (multiplying by the discount factor $1/(1 + r)$). In the single-year case, this discounting has no impact, but it becomes important when we consider more than one year. We now have to update the asset base to take account of depreciation and investment during the earlier years. We will assume that the company spent 20 on investment during the first year, so that its net assets rose to 110. The required return on these assets therefore rises to 11. We will assume that the depreciation charge is unchanged at 10, and that operating costs could be reduced to 48 in the second year. The company's total costs could be met by revenue of 69 (48 + 11 + 10) received at the end of the second year (table 5-2).

The regulator could set a price control that produced expected revenues of 70, followed by 69, but it is also possible to redistribute the revenue over time, while maintaining its present value. If the current price is just under 70, the regulator might not wish to raise the price to recover 70 in the first year, when lower prices are indicated for the future. In that case, lower revenues in the first year, and higher revenues in the second year, could yield the same present value (table 5-3).

We can convert this approach, based on accounting costs, into one based on cash flows. Within each year, the required revenue is given by:

Revenue = Operating Cost + rate of return*Opening Assets + Depreciation

If we multiply both sides by the discount factor d (which equals $1/(1 + r)$), we get:[1]

d Revenue = d Op Cost + (1 - d) Opening Assets + d Depreciation
$\qquad$ = d Op Cost + Opening Assets + d Investment
$\qquad$ − d (Opening Assets + Investment − Depreciation)
$\qquad$ = d Op Cost + Opening Assets + d Investment − d Closing Assets.

Following this approach, the required revenue is equal to the cash spent by the regulated company during the year (cash operating costs, plus investment), together with the change in the present value of its assets. The latter can be seen "as if" the company had to buy its assets at the start of the period and would sell them again at the end of the year—it is

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1. Note that $r*d = r / (1 + r) = 1 - 1/(1 + r) = (1 - d)$.

Table 5-2. Price Control Calculation for Two Years: Cost-Based Approach

Value	Item	Start	End-year 1	End-year 2		Key to columns	
	Interest rate	10%			r		
Actual	Operating costs		50	48		OC_1	OC_2
	Depreciation		10	10		D_1	D_2
	Investment		20			I_1	
	Assets	100	110		A_0	$A_1 = A_0 + I_1 - D_1$	
	Return on assets		10	11		$r{*}A_0$	$r{*}A_1$
	Discount factor		0.90909	0.82645		$d = 1/(1 + r)$	d^2
Discounted	Operating costs		45.455	39.669		$OC_1{*}d$	$OC_2{*}d^2$
	Depreciation		9.091	8.264		$D_1{*}d$	$D_2{*}d^2$
	Return		9.091	9.091		$\text{Ret}_1{*}d$	$\text{Ret}_2{*}d^2$
	Revenue		63.636	57.025		$\text{rev}_i = oc_i + \text{dep}_i + \text{ret}_i$	
Actual	Revenue		70	69		rev_1/d	rev_2/d^2

Table 5-3. Alternative Revenue Patterns

Value	Item	Total	End-year 1	End-year 2
	Discount factor		0.90909	0.82645
Discounted	Revenue required	120.661	63.636	57.025
	Alternative 1	120.661	63.409	57.252
	Alternative 2	120.661	63.203	57.458
Actual	Alternative 1		69.75	69.28
	Alternative 2		69.52	69.52

almost a "hire charge" for the assets. Table 5-4 shows the approach for the one-year example studied above.

Note that the level of investment that takes effect at the end of the period has no impact on the amount of revenue required in that year, although it will obviously affect the assets at the start of the next period, and hence the revenue required later. To confirm this point, consider an example with no net investment during the first year. The company spends less during the year, but also ends the year with assets that are worth less, and the two effects exactly cancel out, as shown in table 5-5.

We can also use this method with the two-period example, once again producing the same revenue requirement, as in table 5-6.

Table 5-4. Price Control Calculation for a Single Year: Cash-Flow-Based Approach

Value	Item	Start	End-year 1	Key to columns	
	Interest rate	10%		r	
Actual	Operating costs		50		OC
	Investment		20		I
	Assets	100	110	A_0	$A_1 = A_0 + I - D$
	Depreciation		10		D
	Discount factor		0.90909		$d = 1/(1 + r)$
Discounted	Operating costs		45.455		$oc = OC^*d$
	Investment		18.182		$i = I^*d$
	Assets	100	100.000	$a_0 = A_0$	$a_1 = A_1{}^*d$
	Revenue		63.636		$oc + i + a_1 - a_0$
Actual	Revenue		70		revenue$/d$

Table 5-5. Price Control Calculation for a Single Year: Cash-Flow-Based Approach

Value	Item	Start	End-year 1	Key to columns	
	Interest rate	10%		r	
Actual	Operating costs		50	OC	
	Investment		10	I	
	Assets	100	100	A_0	$A_1 = A_0 + I - D$
	Depreciation		10	D	
	Discount factor		0.90909	$d = 1/(1 + r)$	
Discounted	Operating costs		45.455	$oc = OC^*d$	
	Investment		9.091	$i = I^*d$	
	Assets	100	90.909	$a_0 = A_0$	$a_1 = A_1{}^*d$
	Revenue		63.636	$oc + i + a_1 - a_0$	
Actual	Revenue		70	revenue$/d$	

Table 5-6. Price Control Calculation for Two Years: Cash-Flow-Based Approach

Value	Item	Start	End-year 1	End-year 2	Key
	Interest rate	10%			r
Actual	Operating costs		50	48	OC_t
	Investment		20	20	I_t
	Assets	100	110	120	$A_t = A_{t-1} + I_t - D_t$
	Depreciation		10	10	D_t
	Discount factor		0.90909	0.82645	$d^t = 1/(1 + r)^t$
Discounted	Operating costs		45.455	39.669	$oc_t = OC_t{}^*d^t$
	Investment		18.182	16.529	$i_t = I_t{}^*d^t$
	Assets	100	100.000	99.174	$a_t = A_t{}^*d^t$
	Revenue		63.636	57.025	$oc_t + i_t + a_t - a_{t-1}$
Actual	Revenue		70	69	revenue$_t/d^t$

To save space, a single key has been provided for the two end-year columns, using the subscript t to identify the applicable year. The discount factor is raised to the power t when discounting the cash flows for year t. Note that the discounted revenue over the whole period is given by:

$\text{Assets}_0 + d\ OC_1 + d\ I_1 - d\ \text{Assets}_1 + d\ \text{Assets}_1 + d^2\ OC_2 + d^2\ I_2 - d^2\ \text{Assets}_2 =$
$\text{Assets}_0 + d\ OC_1 + d\ I_1 + d^2\ OC_2 + d^2\ I_2 - d^2\ \text{Assets}_2 .$

where OC stands for operating costs, I for investment, and the subscripts denote the period. This means that the level of assets in the middle of the period does not affect the overall revenue requirement. The pattern of investment obviously does, but the distribution of a given level of depreciation between the two periods will not affect the discounted revenue required. It will, of course, affect the level of revenue that might be sought in each of the two years. The example in table 5-7 shows that the discounted revenue required remains at 120.661, even if almost all the depreciation is charged in the first period.

There is one further complication. In practice, costs and revenues are registered throughout the year, rather than as a single event at year-end. This means that the true present value of a revenue stream is greater than the value if an end-year discount factor is used. In the United Kingdom, regulators have therefore used a mid-year discount factor to revalue costs and revenues, while the end-year factor is still used for the closing asset value. While the end-year factor for year t is equal to $1/(1 + r)^t$, the mid-year factor is equal to $1/(1 + r)^{t - 0.5}$. This adjustment has two effects. First, slightly less revenue is required to cover the change in the present value of the existing capital. Second, the company will require six months worth of return on the investment made during the year, raising its revenue requirements. The formula for the required revenue in a single year

Table 5-7. Price Control Calculation with Alternative Depreciation Pattern

Value	*Item*	*Start*	*End-year 1*	*End-year 2*
	Interest rate	10%		
Actual	Operating costs		50	48
	Investment		20	10
	Assets	100	100.8	110
	Depreciation		19.2	0.8
	Discount factor		0.90909	0.82645
Discounted	Operating costs		45.455	39.669
	Investment		18.182	8.264
	Assets	100	91.636	90.909
	Revenue		72.000	48.661
Actual	Revenue		79.2	58.88

(in which the mid-year discount factor is the square root of the end-year factor) is:

$$d^{0.5} \text{ Revenue}_1 = \text{Assets}_0 + d^{0.5} OC_1 + d^{0.5} \text{ Investment}_1 - d \text{ Assets}_1$$
$$= \text{Assets}_0 + d^{0.5} OC_1 + d^{0.5} \text{ Investment}_1$$
$$- d (\text{Assets}_0 + \text{Investment}_1 - \text{Depreciation}_1)$$
$$= (1 - d) \text{ Assets}_0 + d^{0.5} OC_1 + (d^{0.5} - d) \text{ Investment}_1$$
$$+ d \text{ Depreciation}_1 .$$

This gives us:

$$\text{Revenue}_1 = d^{0.5} r \text{ Assets}_0 + \text{Op Cost}_1 + d^{0.5} \text{ Depreciation}_1 + (1 - d^{0.5}) \text{ Investment}_1$$
$$= d^{0.5} r \text{ Assets}_0 + \text{Op Cost}_1 + \text{Depr}_1 + (1 - d^{0.5}) (\text{Investment}_1 - \text{Depr}_1).$$

We can compare this with the formula for the required revenue using end-year discount factors:

$$\text{Revenue}_1 = r \text{ Assets}_0 + \text{Op Cost}_1 + \text{Depreciation}_1 .$$

Since d (and hence $d^{0.5}$) is less than one, the required return on the existing assets is lower, while the return now required on net investment during the period raises the revenue requirement. In the example in table 5-8, these effects exactly cancel each other, yielding the same required revenue.

We can also construct an example with less investment. In the example given in table 5-9, this formula implies that less revenue is required than with year-end discounting.

Finally, two years can be considered together, as in table 5-10. From this table, we can see that the company is predicted to need revenues of 70 in the first year and 68.5 in the second year. Considering the two years together, the revenue requirement has a present value of 126.106.

The Value-Based Approach

The alternative approach to calculating the company's required revenues is based on the need to maintain the value of the business: investors should expect to get back what they have spent. This return comes in two ways: cash received during the period and the value of the company at the end of the period. Both should be discounted to the start of the period, giving:

Table 5-8. Price Control Calculation for a Single Year with Mid-Year Discounting

Value	Item	Start	During	End		Key to columns	
	Interest rate	10%			r		
Actual	Operating costs		50			OC_1	
	Investment		20			I_1	
	Assets	100		110	A_0		$A_1 = A_0 + I_1 - D_1$
	Depreciation		10			D_1	
	Discount factor		0.95346	0.90909		$d^{0.5} = 1/(1+r)^{0.5}$	$d = 1/(1+r)$
Discounted	Operating costs		47.673			$oc_1 = OC_1 * d^{0.5}$	
	Investment		19.069			$i_1 = I_1 * d^{0.5}$	
	Assets	100		100.0	$a_0 = A_0$		$a_1 = A_1 * d$
	Revenue		66.742			$oc_1 + i_1 + a_1 - a_0$	
Actual	Revenue		70.0			$revenue_t / d^{0.5}$	

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Table 5-9. Price Control Calculation for a Single Year with Less Investment

Value	Item	Start	During year 1	End-year 1
	Interest rate	10%		
Actual	Operating costs		50	
	Investment		10	
	Assets	100		100
	Depreciation		10	
	Discount factor		0.95346	0.90909
Discounted	Operating costs		47.673	
	Investment		9.535	
	Assets	100		90.909
	Revenue		66.299	
Actual	Revenue		69.535	

Table 5-10. Price Control Calculation for Two Years with Mid-Year Discounting

Value	Item	Start	Year 1 During	Year 1 End	Year 2 During	Year 2 End
	Interest rate	10%				
Actual	Operating costs		50		48	
	Investment		20		10	
	Assets	100		110		110
	Depreciation		10		10	
	Discount factor		0.95346	0.90909	0.86678	0.826446
Discounted	Operating costs		47.673		41.606	
	Investment		19.069		8.668	
	Assets	100		100.000		90.909
	Revenue		66.742		59.364	
Actual	Revenue		70.000		68.488	

$$\text{Value}_{after} = d^{0.5} \, \text{Cash}_{during} + d \, \text{Value}_{end}$$
$$= d^{0.5} \, (\text{Revenue}_{during} - \text{Op Cost}_{during} - \text{Investment}_{during}) + d \, \text{Value}_{end}.$$

The value at the end of the period will be equal to the value at the start, plus investment, less depreciation:

$\text{Value}_{end} = \text{Value}_{start} + \text{Investment}_{during} - \text{Depreciation}_{during}.$

We therefore get:

$$\text{Value}_{after} = d^{0.5} (\text{Revenue}_{during} - \text{Op Cost}_{during}) - (d^{0.5} - d) \text{Investment}_{during}$$
$$+ d (\text{Value}_{start} - \text{Depreciation}_{during}).$$

If investors are to get their money back, we require:

$$\text{Value}_{start} = \text{Value}_{after}$$
$$= d^{0.5} (\text{Revenue}_{during} - \text{Op Cost}_{during}) - (d^{0.5} - d) \text{Investment}_{during}$$
$$+ d (\text{Value}_{start} - \text{Depreciation}_{during}).$$

The value at the start of the period is equal to the regulatory asset base. If we change notation, using the subscripts 0 for start and 1 for during, and replacing Value_{start} with Assets_0, we get:

$$(1 - d)\text{Assets}_0 = d^{0.5}(\text{Revenue}_1 - \text{Op Cost}_1) - (d^{0.5} - d)\text{Investment}_1 - d \, \text{Depreciation}_1.$$

This is exactly equivalent to the preferred formula from the previous section:

$$\text{Revenue}_1 = d^{0.5} r \, \text{Assets}_0 + \text{Op Cost}_1 + d^{0.5} \text{Depr}_1 + (1 - d^{0.5}) \text{Investment}_1.$$

We can write a spreadsheet that emphasizes this aspect of the regulator's problem, as in table 5-11.

Note that although the value of revenue is presented as an exogenous variable in this spreadsheet, implying that it might have to be found by trial and error, it can actually be obtained from the formulae given in the previous section; only the presentation is different.

The Path of a Price Control

We can set out three principles for translating the revenue requirement into a price control. First, we should aim to avoid fluctuations in prices. If prices are changing rapidly and in a seemingly unpredictable manner, customers will not be able to react to the signals that prices are meant to send. It is better to set a smooth path of prices based on the company's revenue requirements over the whole period than to match revenues and prices in each subperiod, at the cost of significant variations in

Table 5-11. Price Control Calculation for a Single Year: Value-Based Approach

Value	Item	Start	During	End		Key to columns	
	Interest rate	10%			r		
Actual	Initial value	100			A_0		
	Investment		10		I_1		
	Depreciation		10		D_1		
	Closing value			100		$A_1 = A_0 + I_1 - D_1$	
	Operating costs		50		OC_1		
	Revenue		69.5		R_1		
	Cash flow		9.5		$C_1 = R_1 - OC_1 - I_1$		
	Discount factor		0.95346	0.90909	$d^{0.5} = 1/(1+r)^{0.5}$		$d = 1/(1+r)$
Discounted	Cash flow		9.1		$c_1 = C_1 * d^{0.5}$		
	Closing value			90.9			$a_1 = A_1 * d$
	Value after	100.0			$a_1 + c_1$	These two cells	
	Initial value	100.0			$a_0 = A_0$	should be equal	

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prices. This indicates that in the final year of the review period, the price control should aim to produce revenues that are close to the revenue required in that year. If this is not the case, prices are likely to be out of line with costs, and an adjustment may be required at the start of the next review period.

Second, incentives will be stronger if the price control moves smoothly between the present level of prices and the level desired in the final year, as shown by the dotted line in figure 5-1. This ensures that the firm will retain some of the gains from out-performance in the previous review period in this review period, raising its return to cost-cutting.

Third, if this style of price control is likely to produce seriously excessive (or inadequate) revenues, the control could start with a one-off change in prices, designed to ensure that the firm receives its revenue requirement over the control period as a whole. The excess revenues are shown by the gap between the dotted line and the dashed line in figure 5-1; in figure 5-2, these revenues are largely eliminated.

The style of control selected for adoption may depend on whether prices are currently above or below costs, and on the reason for this divergence. In general, if prices are below costs, the need to ensure that the company can finance its activities may come before the need for incentives, implying that a one-off increase in prices, up to the level of costs, is required. This will not always be the case, however, for if the high costs are clearly the result of bad management by the company, it may not be

Figure 5-1. Projected Costs and Prices: Smoothed Revenue Path
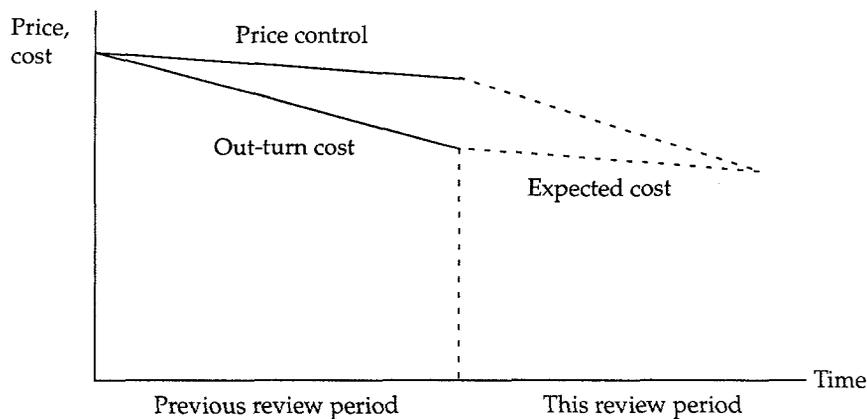
Figure 5-2. Projected Costs and Prices: One-off Price Adjustment
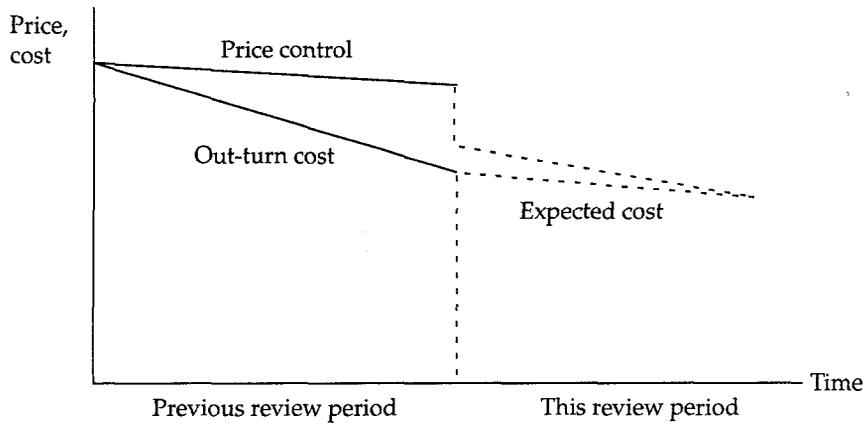
appropriate to require customers to pay more. If the company's costs rose for reasons that were clearly beyond its control, or the assumptions behind the previous price control turned out to be unrealistic, it is appropriate to ensure that the company does not continue to lose money.

6

Operating Costs

To determine the level of costs to include when calculating revenue needs, the regulator needs to assess the company's operating costs. The starting point for this calculation should be the business plan submitted by the company, including its cost history and its projections for the future. These projections should be adjusted in the light of comparisons with other comparable companies. If several companies are being regulated together, a formal system of yardstick competition may be adopted.

Cost Projections

The company should be asked to give details of its current operating costs and its projections for the future. As far as possible, these should be broken down by customer group (industrial, commercial, domestic, and the like), activity (infrastructure maintenance, customer service, and so forth) and category (labor, materials, rent, and the like). The regulator should select a base year (probably the most recent, unless it has been atypical, perhaps because of a restructuring within the company) and identify three types of cost: ongoing controllable costs, ongoing uncontrollable costs, and one-off costs. Most of the company's ongoing costs are likely to be controllable, but fixed payments for property taxes and wayleaves (payments to landowners for the right to have pipelines or cables running across their land) will be uncontrollable. One-off costs include items such as redundancy payments and the costs of restructuring. Each category of costs should be treated slightly differently.

The best available forecast of the company's uncontrollable costs should be included in the projected cost. If the company cannot influence these costs, there is no point in trying to create incentives to do so. The forecast may be that these costs will remain constant in real terms, but if there are good reasons for predicting a rise (or fall), they should be taken into account.

The company's controllable costs need more attention. If prices are based solely on the actual level of these costs, the company may see little reason to operate efficiently. If the regulator defines an arbitrary cost target, however, the company faces the risk that this will not be achievable. This implies that the projections for controllable costs should be designed to set a target that an efficient company could meet, given its present starting point. This should give the company a demanding, but not punitive, target.

The question is, what could an efficient company achieve? One starting point would be productivity growth equal to the average for the economy, but this could be inappropriate for companies that are already performing particularly well (or badly). It will likely be preferable to make comparisons with actual companies, so that investors can have confidence that the target is achievable. The comparator companies should be in similar industries and economies. If several companies in the same industry are regulated together, formal *yardstick competition* may be possible, as discussed below. The regulator will probably need to employ consultants to assess the relative efficiency of the regulated company and its comparators. At a macro level, the companies' overall costs can be compared, remembering that wage levels (and other prices) may well differ between regions and countries. More detailed benchmarking, which compares the costs of undertaking particular tasks (such as repairing a pipeline, dealing with a customer's billing query, or arranging a new connection), gives more specific information. If a company performs well at the benchmarked activities but seems to have a high cost level overall, for example, it may face a poor operating environment (such as a low population density). A company with a low overall cost level, which nevertheless performs poorly in the benchmarking exercise, probably has a better operating environment (for example, a high density of large customers). The aim of these comparisons is to set a target path for the company's costs that envisions it moving toward best practice at a demanding, but achievable, rate.

"One-off" costs pose a problem. Any particular item will not be repeated, and should therefore not be included in the company's ongoing

revenue requirements. Many of these costs have a short payback period; costs incurred in the base year (probably two years before the first year of the new price control period) may well have paid for themselves by the time the new control takes effect.[1] It is likely that the company will need to undertake other one-off projects during the life of the new control, however, and some revenue should be allowed for this. The case for such a provision will be particularly strong if demanding targets have been set for ongoing costs. These may well imply significant restructuring costs, but if the company's revenues are projected to fall as rapidly as its ongoing costs, it will be unable to recoup the one-off costs. In general, the company's business plan will be a guide to the one-off costs that are likely to be incurred, particularly if it can be updated to take account of the regulator's suggested cost targets.

One potentially controversial issue is the treatment of penalty payments. The company may be required to compensate customers who receive an inadequate level of service, and possibly to pay a fine to the government (or other suitable body) if overall standards are not met. Price controls give the company an incentive to reduce its costs, while the aim of penalty payments is to ensure that this is not done at the expense of quality. It is likely to be optimal for the company to make some payments, however: an electricity company may have to make a payment each time a customer suffers a power cut, but it will be cheaper to make a few payments than to carry so much spare capacity that power cuts never occur. The regulator will have to estimate a "reasonable level of failure" and allow for the associated payments in the company's operating costs.

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1. This could be particularly true of redundancy costs incurred toward the end of a financial year. Imagine that a company spends $90 paying workers who will continue to be employed, and $10 paying a worker who is made redundant, at a further one-off cost of $20. The following year, the company's cost is only $90, so that the redundancy will pay for itself in two years. If the previous year's ongoing costs are taken as a base for the next price control, the company's allowable revenue would remain at $100 for four or five years, producing a healthy return. Including the one-off payment in the cost base would certainly make the return excessive. Note that if the regulator cut the company's revenues to $90 in the following year, however (the second year after the redundancy), it would not have recouped the cost of the one-off payment.

Yardstick Regulation

If several companies are regulated together, the regulator may be able to make "yardstick" comparisons among them. If all the companies face the same operating conditions, so that they could, in theory, achieve the same level of costs, the regulator should calculate the average cost that they achieve (either over the whole group or among the more efficient companies) and set prices based on this level. Each company then has an incentive to reduce its costs, since this will have little impact on its allowed revenues. In addition, doing so puts pressure on the other companies' revenues.

In practice, the companies will face different operating conditions, and these must be taken into account. The solution is to estimate a regression equation that shows how the companies' costs vary with exogenous variables, such as population density, and then to calculate the difference between each company's actual costs and the level the equation predicts, given its operating conditions. Figure 6-1 shows how the average cost for each unit might vary with population density: the points represent individual companies, and the line shows the average relationship from the sample as a whole.

Note that the most efficient company, relative to the regression line, is A, even though several other companies, with higher population densities, have lower average costs. Similarly, company B, with a high popula-

Figure 6-1. Unit Cost and Population Density, Sample Companies

Population density
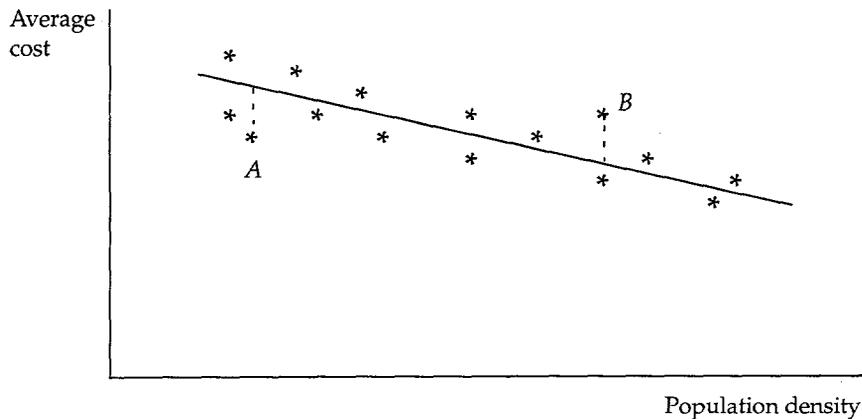
Figure 6-2. Yardstick Regulation: Alternative Cost Targets
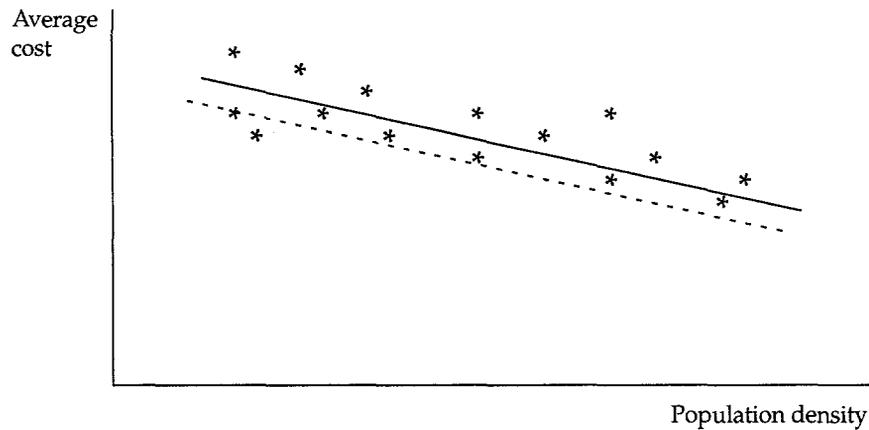
tion density, is the least efficient relative to the regression line, despite having lower unadjusted costs than some of the other companies. It is important to recognize that these differences may not result solely from company efficiency because there will always be factors that cannot be controlled for in the regression. In practice, this has implications for the target that the regulator should set and the speed with which the companies are expected to move toward that goal

One approach, illustrated in figure 6-2, is to set the target for each company equal to the predicted average cost (given its population density), calculated from the whole sample (the solid line). This implies that the more efficient companies will be rewarded with super-normal profits, and it limits the losses faced by the less efficient. An alternative is to set the target so that only the more efficient companies can make normal profits, increasing the losses of the less efficient companies. The dotted line, which has been shifted down to pass through the average cost of the seven most efficient companies, exemplifies this more demanding target. Note that the regulator may wish to set a moving target, on the assumption that even the more efficient companies will be able to raise their productivity over time.

This scenario recognizes that there are two sources of productivity gains: improvements in best practice that shift out the efficient frontier and movements toward the frontier, as firms apply existing techniques more effectively. The scope for movement in the frontier is likely to be

much more difficult to predict than that for movement toward the frontier.[2] To the extent that even the best companies in the sample are behind international best practice, there may be a known target, but this may not take account of country-specific factors that affect costs. An industry that is growing rapidly will probably be able to achieve a better rate of productivity growth than one with constant output. The average growth in total factor productivity in the economy may serve as a starting point for estimates, but it should be used with care and compared with the industry's recent achievements.

Looking at movement toward the frontier, if the regulator has set a target based on the average of the entire sample, it is probably reasonable to expect companies to be able to achieve this target, and quite quickly. In the price control calculations, the regulator might use the companies' actual operating costs in the first year of a control, but use the target operating costs in the final year. In the intermediate years, a weighted average (with changing weights) is used to move smoothly from one to the other. If the target cost level is based on the more efficient companies, it is more likely that some companies will not be able to achieve this goal because of local circumstances beyond their control. In that case, it might be more reasonable to calculate their allowable revenues on the assumption that they can achieve a 50:50 mix of their present costs and the target level by the end of the period. The U.K. water regulator made this assumption in a 1994 review of price controls, assuming that "the less efficient companies can close half of the gap with the more efficient companies by the end of the period."

Formally, the relationship to be estimated is:

$$\text{Cost}_i = \alpha + \sum_j \beta_j z_{ji} + u_i$$

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2. The relative importance of each kind of efficiency gain will vary across industries and over time. In industries characterized by very fast technological change, such as telecommunications, the movement of the production frontier is probably much more important than the distance of any one company to that frontier. In industries with little technological change, such as water, the frontier is almost fixed, so the relevant issue is how far each company is from that frontier. The weights might also vary over time. It is possible that companies will be far from the frontier at the moment of privatization, but that the initial gap will be closed by the new management, and with time the movement of the frontier will become more important.

where the parameters β_j measure the influence of the exogenous variables (such as population density), z_{ji} gives the value taken by variable j for company i, and u_i represents the influence of unobservable and excluded factors, and the company's own efficiency level, on the costs of that company. The best estimate of the relationship is:

$$\text{Cost}_i = \hat{\alpha} + \sum_j \hat{\beta}_j z_{ji} + \hat{u}_i$$

where $\hat{\alpha}$ and $\hat{\beta}$ are obtained by regression techniques, and $\hat{u}_i$ is a residual, representing a mix of relative efficiency and unobservable factors.[3] The best prediction of the company's costs, were it to be of average efficiency, is:

$$\text{Predicted Cost}_i = \hat{\alpha} + \sum_j \hat{\beta}_j z_{ji}$$

This is also the formula for a cost target based on average efficiency: higher efficiency levels can be required by substituting a smaller number for the constant term, $\hat{\alpha}$. In practice, the regulator should probably use a weighted average of the company's actual costs and its cost target (with the weight placed on the target increasing over time) when calculating its revenue needs.

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3. A discussion of those techniques is beyond the scope of this paper. Regulators in the United Kingdom have generally used a technique known as ordinary least squares, which assumes that the residual term u_i is normally distributed around zero, and does not attempt to break it down into relative efficiency and unobserved exogenous factors. A regulator who sets a target based on a 50:50 mix of the company's own costs and its predicted costs might be (implicitly) assuming that unobserved exogenous factors account for half of u_i. Another technique, known as stochastic frontier regression, does attempt to break down the residual, but requires the operator to specify the pattern that efficiency is expected to follow. An alternative to using regressions to estimate the relative efficiency of companies is data envelopment analysis, based on linear programming.

7

Investment and the Regulatory Asset Base

This section discusses the treatment of investment, depreciation, and the asset base. As discussed above, there are significant differences between the spirit of price control regulation and rate of return regulation, but we nevertheless need to take account of the firm's assets when resetting a price control. The required level of future investment is likely to be the most controversial part of the control, since it involves preparing for an uncertain future. The more investment that is included in the price control calculations, the greater the company's revenues, and the company is likely to face an incentive to overstate its investment needs. The regulator may need to employ consultants to assess the investment plans, although there is a danger that this process could become overly intrusive. The amount of depreciation also affects the revenue received in each period, but should not be as controversial as investment. As long as the amount of depreciation allowed in the price control calculations is deducted from the company's asset base for the next review period, the level of depreciation allowed does not affect the present value of the company's revenues. It does, however, affect the balance of payments between present and future customers, and the regulator should check that the company is following reasonable depreciation rules. Finally, the asset base should be updated at each review to take account of actual investment and the depreciation allowed in the previous price control. This should be uncontroversial (although there have been debates about it in the United King-

dom), but the level of the initial asset base may prove more difficult to determine.

Investment

As shown in section 5, the expected level of investment is one of the key elements of the formulae used to suggest the amount of revenue that the company should be allowed to receive under the cash flow approach to price controls. This is perhaps the area where the company's information advantage over the regulator will be greatest. The company will have far more information than the regulator on the state of its infrastructure and expected changes in demand patterns, and hence on the amount of investment required. The best that the regulator can do is probably to assess some of the company's proposals on a *trial audit* basis. This will involve specialized engineering advice, and while the regulatory body may have some in-house engineers, much of the expertise may have to come from consultants. The assessment should involve the amount of investment required and the estimated costs. The company may be planning to add too much capacity, although having some excess capacity in the short term may turn out to be cheapest over the long term. The company may not have considered demand-side alternatives to engineering projects, such as promoting more efficient appliances to reduce demand rather than increasing network capacity. The company's cost estimates should be compared with out-turn figures, both for its own completed projects and for similar projects undertaken by other companies.

If the assessments suggest that the company has overestimated the amount and cost of needed investment, the regulator should consider reducing the amount of investment in the figures used to calculate the company's revenue requirements. Some caution will be needed here, because it is important that the company remain able to finance required investment. Even so, if the company's estimates of investment are clearly excessive, the regulator should substitute more plausible figures.

Sometimes a large investment project may clearly be required, but its cost will not be known when the control is set. Setting a fixed price could expose the company to a significant amount of risk, but if the regulator compensates by adding a margin to reflect this, consumers are likely to pay more than the cost of the project. In these circumstances, it may be advisable to require the company to conduct a tender, to accept the bid that promises the best value, and then to accept this cost as a pass-through item in its price control. This will not be appropriate, however, unless the tender is sufficiently competitive to produce a good price. If

there was collusion between bidders and the firm, an excessive price might be passed through to consumers. It should be stressed that this only applies to large projects: if cost pass-throughs were applied to every investment project, the additional complexity would outweigh the gains from a better balance between risk and incentives. Most investment spending should be predicted in advance, and then treated as a fixed component of the price control.

The Regulatory Asset Base

Section 5 demonstrates that the regulator will need to determine an opening and a closing value for the regulatory asset base when calculating the amount of revenue required by the company. Once the system of price controls is established, the opening value in each review period can be derived from the previous opening value, but an initial value will be required to start the sequence. If possible, this initial value should be "entrenched" in some way to protect the company from subsequent attempts to reduce the base for calculation of future prices. Making the value public, and ensuring that the appeal body would take it into account if the company and the regulator are in disagreement, might be one way of achieving this. Similarly, the rule used to update the asset base should give appropriate consideration to investment and depreciation. In particular, if the depreciation charge used by the regulator in one period is deducted from the asset base for the next period, for example, the company's depreciation policies should not affect its present value.

One possibility for the initial asset base is the net asset value of the company (or its regulated business) at the time of privatization. In general, this should be measured at replacement cost (rather than historic cost), and subsequently increased to take account of inflation. This has the advantage of reflecting the economic cost of the assets involved in the business. Prices that are based on this asset value and the company's cost of capital are likely to be close to their efficient level.

The disadvantage of this approach is that it may lead to prices that are significantly above present levels if the company has been earning a low rate of return. The first price control is generally set as part of the privatization process (if applicable), and is therefore bound to the price that can be obtained for the company. Prices could be increased to the level implied by the net asset value of the company, and this should allow a sale price based on that value, as long as the government and the regulator are committed to maintaining the higher prices until (or perhaps, if) the company's costs fall. The price increases may not be politically accept-

able, however. In this case, the principles of current cost accounting indicate that the value of the company is the net recoverable value: the amount that can be earned, given a feasible level of prices. This amount can be obtained from the price control spreadsheets set out in section 5. Rather than taking the asset value as an input, and calculating the allowable prices, however, the prices are taken as an input, and the asset value must be chosen so that the required revenue (a function of that asset value) is equal to the revenue those prices will produce. This asset base could then be rolled forward in succeeding reviews.

This illustrates one of the fundamental tradeoffs involved at the time of privatization: a government can often obtain a higher price for a company if it is willing to let prices to consumers rise (and investors believe they will stay high). *Stranded assets* are equal to the difference between the net book value of the company's assets and the asset base (given the rate of return) that is consistent with the price level the government is prepared to allow. The government may be willing to absorb such stranded assets as part of the privatization process, but it must ensure that assets are not stranded in the future (this would risk the sustainability of the company). Some state-owned companies have minority private shareholders, and their interests should also be taken into account.[1]

An alternative method—which could be used once (or if) the company has been privatized—is to use the amount paid by investors. There is a danger that this practice could lead to a circular valuation if the investors know that their valuation will be used to determine the asset base, and hence their subsequent returns. A high valuation would produce (and be supported by) high prices, while a lower valuation would lead to lower prices. In general, however, the initial retail prices will be determined before the price to be paid for the company. Those retail prices will thus imply a valuation, which should also be close to the amount investors are willing to pay for the company.[2]

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1. In practice, the price at which their shares are traded should reflect the present regulatory arrangements and profitability of the company, and if stranded assets are a problem, the shares are already likely to be trading at a discount to the asset value.

2. This assumes that the investors will know, and have confidence in, the regulatory asset base chosen and the method to be used to reset the price control. If the price paid for the company is significantly different from the initial asset base, this probably implies that the investors have a different discount rate (and hence cost of capital) from that assumed when the asset base was set.

The amount paid by investors may have to be adjusted to take account of unregulated businesses and the potential to develop them. For example, an electricity distribution company may own a contracting business, and it may have the potential to use its network to create a telecommunications business. The contracting business might be valued on the basis of similar independent firms, but it is difficult to put a value on a potential business. It may be simplest to ignore it; in practice, regulators have tended to do so.[3]

The revenue required during a price control period is linked to the difference between the discounted opening value and closing value of the asset base. The closing value is obtained by adding the expected investment (which is also included in the revenue requirements) and deducting depreciation. Because the expected investment is added to the closing value of the asset base, and the discounted value is subtracted from the company's revenue needs, the net addition to the company's revenue during the first review period is only the annual return on its investment, not the entire investment. This greatly reduces the cost of overestimating the amount of investment the company will need. Only a small part of the excess is kept by the company if the opening asset base for the next price control is calculated appropriately.

The opening asset base should be equal to the opening value of the asset base from the previous control period, plus the actual level of investment during that period, less the amount of depreciation allowed for in that period. This minimizes the gain to the company of exaggerating its investment needs, without actually clawing back any revenue. It is best to avoid clawback, because the company will sometimes be able to reduce its investment costs without sacrificing the quantity or quality of its investment, and it should be given an incentive to do so. Clawing back the savings could eliminate this incentive. This procedure also ensures that the depreciation allowed for in price controls is consistent with the

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3. This could be justified if the telecommunications business is required to pay a market rent to the regulated business for the use of its facilities, and this rent is then subtracted from the regulated business' revenue needs, because the telecommunications business is then unlikely to be a source of super-normal profits. If the telecommunications business could use the distribution network rent-free, this would amount to transferring profits from the regulated business to the unregulated telecommunications business. In that case, the value of the (potential) telecommunications business ought to be taken away from the value of the company to derive the value of the regulated business.

depreciation of the asset base, so that the company should eventually recover neither more nor less than that asset base.

Depreciation

As long as the allowance for depreciation in one period is deducted from the opening value of the regulatory asset base for the next period, the level of the depreciation charge will not affect the present value of the company. If the charge is high, the regulatory asset base in the following period, and hence the revenue that is eventually recovered, will be lower than with a low depreciation charge. The depreciation charge does not affect the distribution of welfare between shareholders and consumers, but it does affect its distribution between present and future consumers. A high depreciation charge will tend to imply high prices now, and lower prices in the future. The company may favor this approach if it lacks confidence in the regulatory system, because it rapidly reduces the amount of its outstanding investment, but there are arguments for reducing depreciation in the early years of a project. First, there is likely to be excess capacity at the beginning of the project, and excess demand later. This implies that low prices in the early years, followed by higher prices, would help match demand to capacity. A low depreciation charge at first, followed by a higher charge later, would support such an arrangement. Second, if real incomes are rising, future consumers would be better able to afford high prices than present consumers, which may provide an equity argument for shifting more of the burden of payment into the future.

In practice, it is unlikely to be sensible to aim for a charge on capital (depreciation and interest combined) that increases over time, because this leaves the company very exposed to future changes in regulation, but it might be worth considering a charge that remains constant. It is possible to calculate the annuity that pays off a capital sum (plus interest) exactly over a given time period, and then to split this into repayment and interest. The repayment element is the equivalent of the depreciation charge, and the interest element, the return on capital. Table 7-1 shows how this method would be used to depreciate a payment of 100 over 7 years at an interest rate of 10 percent. The total payment is constant, but the repayment element (depreciation) nearly doubles over the period.

We can contrast this method with straight-line depreciation (see table 7-2), in which the repayment element is constant, and the annual charge falls by more than one-third, as the interest on the outstanding capital sum is reduced:

Table 7-1. The Annuity Method of Depreciation

Item	Year						
	1	2	3	4	5	6	7
Amount outstanding	100	89.46	77.86	65.11	51.08	35.65	18.67
Repayment	10.54	11.59	12.75	14.03	15.43	16.98	18.67
Interest	10.00	8.95	7.79	6.51	5.11	3.56	1.87
Total charge	20.54	20.54	20.54	20.54	20.54	20.54	20.54

In each case (table 7-3), the present value of the stream of payments is identical, and exactly recovers the initial sum of 100.

This example implies that any other pattern of depreciation would produce the same present value, as long as the depreciation charge (equal to the total payment, less the interest on the amount outstanding) is subtracted from the amount outstanding each period. A shorter depreciation period (with all charges ceasing once the amount outstanding had fallen to zero) would not affect the present value of the total repayments.

This means that it is not essential for the regulator to become involved in the details of the company's depreciation policies. Asset lives can safely be left to the company and its accountants, because they will not affect the total amount paid by consumers. The one exception is that the regulator may want to avoid accelerated depreciation charges, which may distort prices over time, as discussed above.

An accelerated depreciation policy can also affect the company's tax bill, because depreciation is an allowable expense under most corporate tax systems. Accelerated depreciation policies will reduce the company's tax bill in the early years of an asset's life, at the cost of increasing it later,

Table 7-2. The Straight-Line Method of Depreciation

Item	Year						
	1	2	3	4	5	6	7
Amount outstanding	100	85.71	71.43	57.14	42.86	28.57	14.29
Repayment	14.29	14.29	14.29	14.29	14.29	14.29	14.29
Interest	10.00	8.57	7.14	5.71	4.29	2.86	1.43
Total charge	24.29	22.86	21.43	20.00	18.57	17.14	15.71

Table 7-3. Depreciation Methods Compared

Item	Year						
	1	2	3	4	5	6	7
Discount factor	0.9091	0.8264	0.7513	0.6830	0.6209	0.5645	0.5132
Charge, annuity	20.54	20.54	20.54	20.54	20.54	20.54	20.54
Present value	18.67	16.98	15.43	14.03	12.75	11.59	10.54
Total	100						
Charge, straight line	24.29	22.86	21.43	20.00	18.57	17.14	15.71
Present value	22.08	18.89	16.10	13.66	11.53	9.68	8.06
Total	100						

once the asset has been written off. A regulator who is using a post-tax cost of capital, and including the company's taxes as an allowable expense, must decide how to treat accelerated depreciation when setting prices.[4] The regulator could choose to pass tax savings from accelerated depreciation to users as they occur, following a flow-through approach to distributing these benefits. Accelerated depreciation will reduce prices at first, but raise them later. Alternatively, regulators can normalize the savings, passing them on over a number of years. This normalization is equivalent to the utility obtaining an interest-free loan from the government.[5]

In general, however, the regulator should base the depreciation of the regulatory asset base on the company's depreciation policies. The regulatory depreciation charge for assets acquired after privatization (or regulatory reform) could be identical to the company's normal charge for those assets. If the regulatory asset base at privatization was below the net asset value at that time, the regulatory depreciation charge should probably be the same fraction of the company's charge. This would ensure that the regulatory value of an asset was written down to zero at about the same time as the company's accounting value, in the absence of extraordinary charges.

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4. The appendix to this volume includes a detailed description of the construction of a cash flow and the role of depreciation.

5. See Sanford V. Berg and John Tschirhart, 1988, *Natural Monopoly Regulation* (New York: Cambridge University Press), for a discussion of this topic in the American context.

8

Revenues

The present value calculations described above imply the level of revenue that a company should receive. This section describes how the regulator should check the amount of revenue that a proposed price control is likely to produce before adopting a control that promises to yield an appropriate amount of revenue. If the company's sales were fixed (in volume), this would be a simple task—a reduction in revenue of 1 percent a year would imply a price control of $RPI - 1$. In practice, the volume of sales is not fixed, and a more complicated calculation is required. The regulator may also need to take account of unregulated sales if the regulated business is also involved in unregulated activities.

Revenue Forecasting

The regulator will need to create a model that predicts the company's revenues, given the chosen price control. This will essentially be a spreadsheet that contains each element of the price control formula, whether set by the regulator (the price terms, any constant weights, and the level of X) or not (the sales in each category). The predicted sales should be consistent with the company's business plan and cost forecasts, possibly amended by the regulator. If the regulator is contemplating significant price changes, their effect should be included when forecasting demand: lower prices are likely to increase the demand for a product. The extent of the increase is measured by its elasticity of demand; in general, necessities will have a lower elasticity than luxuries, which makes the demand

for necessities less responsive to a given change in prices. The long-term response to a price change may be greater than the short-term response. For example, people may switch between gas and electric heating once the prices have changed, but only when it is time to renew their heating systems. If the company is rebalancing its prices, raising some while reducing others, this may also lead to changes in output.

The regulator should be aware that the company may have an incentive to manipulate its sales predictions, but that this manipulation could be upward or downward. A company that wants to persuade the regulator of the need for an ambitious investment program might argue that it faces a high growth rate. A company that wants to support its prices might argue that there will be little or no increase in its sales, so that any revenue growth will have to come from higher prices. This strategy could be successful if the allowed revenue was proportional to sales (as with the first formula below), but it will not succeed if the allowed revenue is made less sensitive to sales (as with the second formula), so that the marginal revenue from an extra unit is kept close to its marginal cost.

Assume that the company has a *revenue weight* price control, with two classes of sales, to small and to large customers:

$$\text{Maximum Average Charge}_T = \left(P_{0\,\text{large}} \frac{\text{Sales}_{\text{large}\,t}}{\text{Total sales}_t} + P_{0\,\text{small}} \frac{\text{Sales}_{\text{small}\,t}}{\text{Total sales}_t} \right)$$

$$\times \prod_{t=1}^{T} \left[1 + \frac{RPI_t - X}{100} \right]$$

$P_{0\,\text{large}}$ is set at 1¢ for each unit, while $P_{0\,\text{small}}$ is set at 3¢ per unit. At first, an equal amount is sold to each class of customers, but sales to large customers are expected to double over the price control period.[1] The spreadsheet in table 8-1 shows the revenue that would be produced by an X of 3.

This example shows the importance of a price control that sets the maximum average charge in terms of the relative sales to different customer groups. There is a 50 percent increase in overall sales, because sales to large customers have doubled, and the revenue for each unit thus falls by 20 percent, although the prices have only fallen by just over 10 percent.

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1. This might seem an extreme example, but the move toward gas-fired electricity generation in many countries has led to very large increases in the amount of gas transported to large users, at prices far below those offered to small customers.

Table 8-1. Revenue Projection with Two Customer Classes

Item	Year 0	Year 1	Year 2	Year 3	Year 4
X		3	3	3	3
$P_{small\ t}$	3.00	2.91	2.82	2.74	2.66
$P_{large\ t}$	1.00	0.97	0.94	0.91	0.89
Sales to small customers	100	100	100	100	100
Sales to large customers	100	125	150	175	200
Total sales	200	225	250	275	300
Allowable revenue	400	412	423	434	443
Max average charge	2.00	1.83	1.69	1.58	1.48

The spreadsheet in table 8-2 shows that the company's revenues could have risen by 33 percent (rather than 10 percent) if the price control had not differentiated between large and small consumers.

Much higher values of X would have been needed to produce a similar amount of revenue with the simpler formula (table 8-3).

As discussed in section 4, the regulator can weaken the link between sales and revenues by including customer numbers in the formula:

$$\text{Max Revenue}_T = \prod_{t=1}^{T} 0.5 \left[\frac{\sum_i P_{0i} \text{Sales}_{it}}{\sum_i P_{0i} \text{Sales}_{it-1}} + \frac{\text{Customer}_t}{\text{Customer}_{t-1}} \right] \times \prod_{t=1}^{T} \left[1 + \frac{RPI_t - X}{100} \right].$$

The spreadsheet in table 8-4 calculates the revenue that would be produced, given a set of assumptions on demand growth, and an X of 2.

The elements the regulator must choose (the value of X, the weights on each class of sales, and the initial revenue) are underlined in table 8-4. The

Table 8-2. Revenue Projection with One Customer Class

Item	Year 0	Year 1	Year 2	Year 3	Year 4
X		3	3	3	3
P_t	2.00	1.94	1.88	1.83	1.77
Total sales	200	225	250	275	300
Allowable revenue	400	437	470	502	531
Max average charge	2.00	1.94	1.88	1.83	1.77

Table 8-3.   Revenue Projection with One Customer Class

Item	Year 0	Year 1	Year 2	Year 3	Year 4
X		8	8	7	6
P_t	2.00	1.84	1.69	1.57	1.48
Total sales	200	225	250	275	300
Allowable revenue	400	414	423	433	444
Max average charge	2.00	1.84	1.69	1.57	1.48

value of X determines the real decline in the price index (the second geometric sum in the formula). The growth index is the first geometric sum in the formula. Each year, the increase in the growth index is the average of the increase in customer numbers and weighted sales. Sales are increasing by about 6 percent a year. (Sales to large consumers are rising at 10 percent, but this has a much smaller weight than the 5 percent increase in sales to small consumers.) Customer numbers are increasing by 2 percent, and so the growth index rises by about 4 percent. With an X value of 2, revenues would rise by around 2 percent a year. If this is sufficient for the company's needs, the regulator can adopt this formula. If it is insufficient, the regulator must consider different values for X and the initial revenue. In general, the revenue weight on each class of sales should reflect the marginal costs of selling those units, and should not be adjusted to produce a desired level of revenue.

Table 8-4.   Revenue Projection with Unit Sales and Customer Numbers

Item	Year 0	Year 1	Year 2	Year 3	Year 4
X		2	2	2	2
Price index	100	98.00	96.04	94.12	92.24
$P_{0\ small}$	3.00	3.00	3.00	3.00	3.00
$P_{0\ large}$	1.00	1.00	1.00	1.00	1.00
Sales to small	100	105	110	115	120
Sales to large	100	110	120	130	140
Weighted sales	400	425	450	475	500
Customer numbers	100	102	104	106	108
Growth index	100	104	108	112	117
Allowable revenue	400	408	416	423	430

Unregulated Sales

The company may well have some sales at unregulated prices. It may have sales to large customers, at individually negotiated prices, that are not regulated because these customers are thought to have enough bargaining power to get an acceptable deal. Alternatively, some services provided by the company could be open to competition, such as making new connections to its network, if independent contractors are authorized to make these. Where possible, these activities should be in a separate business, with separate accounts. In that case, their costs need not be considered when calculating the company's revenue needs, and the revenues from these sales can also be excluded from the calculations. The regulator should note, however, that the company may have an incentive to shift costs from the unregulated business to the regulated business in order to obtain higher prices (while prices in the unregulated sector presumably depend on market forces, and not the company's costs). The company will often have some central costs that must be allocated among its businesses and some activities that are carried out by one business for another, and charged to its account. The regulator may wish to audit some of these allocations and recharges (on a sample basis) to check that they are not unreasonably favoring the unregulated business at the expense of the regulated business and its customers.

When it is not possible to produce separate accounts for regulated and unregulated sales, so that the regulator will have to consider the costs of both types of sales together, their revenues will also have to be considered together. The regulator will have to forecast the revenues the company will obtain from unregulated sales and add this to the predicted revenues from a price control when deciding if that control will be adequate for the company's needs.

The company should be asked for a prediction of its volumes and revenues from unregulated sales. The volume of sales should be consistent with the cost forecasts in the company's business plan. The company may have an incentive to underestimate its predicted sales, raising the amount of revenue needed from regulated sales, but the importance of this depends on the relationship between prices and costs. If the company's prices are reasonably close to the marginal costs of these sales, then a change in volume should not have much impact on its overall profitability—costs and revenues should change by a similar amount.

If prices are well above marginal costs, however, the company will be able to increase its apparent revenue requirements by predicting low lev-

els of unregulated sales.[2] The margin between prices and costs produces another dilemma for the regulator: what should be assumed about the price of future unregulated sales? If prices had been at marginal cost, there would be little room for further reductions. It would be acceptable to predict constant real prices, or prices that decline at the company's predicted rate of productivity growth. This would be appropriate for unregulated sales because there was sufficient competition. (If there *is* sufficient competition, prices are likely to be forced down to the level of costs.) It may not be appropriate for sales to large customers, who are expected to be able to negotiate a price reduction if the industry's other prices are falling. In that case, it might be better to assume that the unregulated prices follow the same path as the regulated prices, so that large customers get as good an outcome as regulated customers. Note that the company may then be overcompensated if it fails to pass on these price reductions.[3] Assuming constant prices, which carries less risk of overcompensating the company, implies that the large customers should not share in the company's efficiency gains. The regulator should check the terms of some of these contracts to see how prices are renegotiated (and whether there is a right of appeal to the regulator) before deciding what level of price reductions (if any) to assume.

Quality Standards

Price controls reward the company for cutting costs. In many cases, reducing the quality of service is an easy way to cut costs, and a lower quality of service can often be a by-product of cost savings, even if it was not intended. There could be an increased risk of interruptions in supply or fluctuations in pressure (for gas and water; voltage for electricity), while standards of customer service, such as the response to complaints, could fall. A reduction in quality is a hidden price increase, and the regu-

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2. The "textbook" utility is expected to have average costs above its marginal costs, but if a company is sold at a discount to its asset value, this will reduce its regulatory average costs.

3. Electricity distribution prices in the United Kingdom were reset on the assumption that the companies would make the same reductions for their (unregulated) extra-high-voltage (EHV) customers as for their regulated customers, but some EHV customers later complained that their prices had not fallen in line with the average.

lator should put pressure on the company to achieve an appropriate level of service standards.

There are three ways to exert such pressure. The first is to collect and publish data on the company's overall performance against a range of indicators. In the United Kingdom, these include the speed of customer reconnection after faults, the delay before new customers are connected, the proportion of meters read (rather than estimated) each year, and the proportion of customer letters that are answered within 10 working days. This allows the regulator to monitor trends in the quality of service and exposes the company to public criticism if standards fall. This might be most effective if there are several companies in the industry, so that a "league table" could be published, highlighting the laggards. Some companies might respond to this; those impervious to criticism could be threatened with the prospect of a tougher price control after the next review unless standards improve.

A second method is to compensate consumers who are the victims of bad service. This gives the company a direct incentive to avoid triggering such payments, and it offers the customer some redress if the company fails. The standards used in the U.K. electricity industry include payments of $32 for failing to respond to a query about charges within five working days, for failing to keep an appointment with the customer, or for failing to give two-days notice of a planned supply interruption, and require a payment of $64 for failing to restore electricity supplies within 24 hours of a fault. Some companies have voluntarily accepted tougher standards and higher compensation payments as a goodwill gesture.

A third method of exerting pressure would be to include a direct link between the company's allowable revenue and its quality of service in the price control formula. This would provide a stronger incentive to maintain standards in areas unsuited to individual compensation payments, such as fluctuations in voltage. The costs of any one incident will be trivial for each consumer, but the overall cost for a period could be quite substantial, and including a penalty in the price control would ensure that some form of compensation is paid. The main problem with this mechanism might be recording and auditing the company's performance with sufficient accuracy.

In Argentina, electricity distribution companies must meet minimum standards in the quality of the technical product (voltage variation), quality of the technical service (frequency and duration of interruptions), and quality of the commercial service (including the time taken to answer a complaint, the maximum number of estimated bills yearly, and the time

required to connect a new user). Failures to meet the prescribed standards result in fines in the form of rebates to affected consumers. The amount of the fine is related to the value of unserved energy (US$1,500/MWh), a relationship that is intended to provide the right incentive to the firm. It serves to guide the company in how much to invest in improving quality, and at the same time leaves the consumer indifferent (at least in theory) between having and not having good service (since the fine should cover the consumer's reserve price).

9

The Rate of Return

The rate of return, or discount rate, is one of the key variables in the present value analysis. It determines the amount that must be paid to reward investors for the use of their capital. Even in an economy with a liquid stock market, estimation of the rate of return required by a regulated company is a complicated and controversial task. In an economy with an underdeveloped stock market, the regulator may have to use estimates based on the returns achieved by other firms in similar industries (at home or abroad). Alternatively, the regulated rate of return may have been implied by, or even be part of, the bids made when the regulated company was set up.

We can show the importance of the discount rate with the spreadsheet in table 9-1, using figures for the gas transmission and distribution system owned by British Gas. In the top section, a rate of return of 7 percent is used. In the bottom panel, the rate has been increased to 10.8 percent. British regulators have generally used the lower rate, while British Gas previously produced calculations backing the higher rate. The revenue requirements increase by 400 million pounds a year, or one-seventh, when the higher rate is used.

Taxation

Before we calculate the rate of return, we must know whether to use a pre-tax or post-tax return. Regulators in the United Kingdom use pre-tax returns, while regulators in Argentina use post-tax returns. The important

Table 9-1. Price Control Calculations for British Gas

Value	Item	Start	Year 1	Year 2	Year 3	Year 4	Year 5
	Interest rate	7%					
Actual	Operating cost		1,525	1,426	1,383	1,371	1,346
	Investment		779	765	679	682	699
	Assets	11,643	11,842	12,024	12,100	12,166	12,239
	Depreciation		580	583	603	616	626
	Discount factor		0.967	0.903	0.844	0.789	0.738
Discounted	Operating cost		1,474	1,288	1,168	1,082	993
	Investment		753	691	573	538	516
	Assets	11,643	11,067	10,502	9,877	9,281	8,726
	Revenue		2,803	2,545	2,366	2,216	2,063
Actual	Revenue		2,900	2,816	2,802	2,808	2,798
	Interest rate	10.8%					
Actual	Operating cost		1,525	1,426	1,383	1,371	1,346
	Investment		779	765	679	682	699
	Assets	11,643	11,842	12,024	12,100	12,166	12,239
	Depreciation		580	583	603	616	626
	Discount factor		0.950	0.857	0.774	0.698	0.630
Discounted	Operating cost		1,449	1,223	1,070	958	848
	Investment		740	656	525	476	441
	Assets	11,643	10,688	9,794	8,895	8,072	7,329
	Revenue		3,144	2,772	2,494	2,257	2,032
Actual	Revenue		3,310	3,233	3,223	3,232	3,224

Note: Assets are discounted using an end-year discount factor, rather than the mid-year factor given in the table. (More details are given in section 5.)

thing is to be consistent when performing the calculations to determine the company's revenue requirements. If a post-tax rate of return is used, the tax payments the company is expected to make must be included as part of the costs it is allowed to recover. The combination of the lower post-tax rate of return and the higher costs should yield the same result as the higher pre-tax rate of return, excluding tax payments from the company's costs.

In the spreadsheet in table 9-2, the first example is copied from table 5-8, in which a pre-tax return of 10 percent is used. Revenues of 70 are sufficient to cover operating costs of 50 and depreciation of 10, and to provide a return on the company's initial assets (100) and its net investment (10). The second panel uses the post-tax approach, assuming a tax rate of 30 percent. A return of 10 percent before tax is reduced to 7 percent after tax, changing the discount factor. With revenues of 70, the company would have taxable profits (after operating costs and depreciation) of 10, and the tax charge would then be 3. This is paid at the end of the period, and the present value is added to the company's revenue requirements. The combination of higher costs and a lower discount rate produce the same revenue—70—as in the first panel.

This example has implicitly assumed that the firm is entirely financed by equity, and that taxes were paid on the whole of the firm's profit. In practice, most firms also have debt finance, and most tax systems deduct the cost of interest payments from the firm's profits before its tax is calculated. In that case, the post-tax cost of debt will be lower than the pre-tax cost, since an increase in the firm's debt leads to a reduction in its tax bill. With a pre-tax interest rate of r, and a tax rate of t, the post-tax cost of debt is $r(1 - t)$. Note that opportunities for accelerated depreciation and capital allowances may well affect the company's tax bill, and local experts should be consulted when attempting to predict this.

Stock Market Measures of the Cost of Capital

If there is a well-functioning local stock market, and the regulated company, or comparable companies, are quoted there, it may be possible to estimate the company's cost of capital from market information. This will measure the cost of capital for the quoted company as a whole: it is quite possible that the quoted company will include unregulated businesses that are likely to face more risk and have a higher cost of capital than its regulated business. The regulator should also be aware that market-based measures of the cost of capital may be sensitive to seemingly minor

Table 9-2. Price Control Calculations, Pre-Tax and Post-Tax

	Item	Pre-tax approach			Post-tax approach		
Tax rate, 30%	Interest rate	10%			7%		
		Start	During	End	Start	During	End
Actual	Operating cost		50			50	
	Investment		20			20	
	Assets	100		110	100		110
	Depreciation		10			10	
	Taxation						3
	Discount factor		0.95346	0.90909		0.96674	0.93458
Discounted	Operating cost		47.673			48.337	
	Investment		19.069			19.335	
	Assets	100		100.0	100		102.8
	Taxation						2.804
	Revenue		66.742			67.672	
Actual	Revenue		70.0			70.0	

assumptions about the way component parts are measured. The best approach may be to produce several estimates using different assumptions, and then to use a figure from within the range of estimates.

The standard market-based measure of the cost of capital uses the capital asset pricing model (CAPM). This assumes that the return on any asset is equal to the risk-free rate of return for that economy—the amount that investors could receive on the safest asset available, plus a risk premium to reflect that most assets are riskier. In the United Kingdom, the safest asset is taken as an index-linked government bond, since the risk of default is negligible, and the amount repaid is linked to inflation, and therefore fixed in real terms. The real rate of return on these securities has been between 3.5 and 3.8 percent a year. In other economies, a different asset will have to be chosen, but it is likely that there is a local convention regarding the asset to use. The real return on this asset should be measured over a period of several years to avoid the impact of short-term fluctuations in prices or interest rates. In general, securities with a fairly long life should be chosen that will reflect the lifespan of the regulated company's assets. The risk premium on the company's debt can be deduced as the difference between the nominal rate of interest paid on that debt and the nominal rate paid on the riskless asset. Credit rating agencies will also assign a rating to the company, and they can probably provide information on the risk premia faced by companies with the same rating. British Gas was believed to face a risk premium on debt of between 0.3 percent and 0.65 percent a year.

The cost of equity is slightly more complex. For equities as a whole, the market risk premium can be observed as the long-run difference between the return on equities and the return on the risk-free asset. In the United Kingdom, equities have outperformed government bonds by 3.5–5 percent a year, measured over long periods. Once again, the choice of period and details of measurement can produce a wide range of estimates. Some equities are less risky than others, however, and need less of a risk premium. The CAPM assumes that the risk premium required by a share is proportional to its *beta* coefficient, which measures its volatility relative to the market:

$$\text{Return on share}_i = \text{Risk-free rate} + \text{beta}_i * \text{equity risk premium}$$

where

$$\text{beta}_i = \frac{\text{Covariance}(\text{Return on share } i, \text{Return on market portfolio})}{\text{Variance}(\text{Return on market portfolio})}$$

$$= \frac{\displaystyle\sum_{t=1}^{T} (r_{it} - \bar{r}_i)(r_{mt} - \bar{r}_m)}{\displaystyle\sum_{t=1}^{T} (r_{mt} - \bar{r}_m)^2}$$

where r_{it} is the return on asset i in period t, $\bar{r}_i$ is the average return on asset i, r_{mt} is the return on the market portfolio in period t, and $\bar{r}_m$ is the average return on the market portfolio, all measured over T periods. It should be noted that the value of beta reflects investors' perceptions of the quoted company, and not just the underlying risk of the regulated business. If the regulated company is only a small part of a larger group, and most of that group's activities involve more risk than the regulated business, its beta will imply a higher cost of capital than is appropriate for the regulated business. If the share price fluctuates because of takeover speculation, this will increase beta, but it should not affect the cost of capital for the business.[1] Similarly, uncertainty about regulatory decisions may affect the share price, but should not affect the company's future cost of capital once the uncertainty is resolved, unless investors believe that regulation is likely to remain unstable.

We can put these components together to get an estimate of the post-tax cost of equity, illustrated in table 9-3.

Cases 1 and 2 were suggested by a regulated company (British Gas), while its regulator suggested cases 3 and 4. Case 5 shows that even the highest assumed risk-free rate and risk premium can still produce a relatively low rate of return if beta is low. It is likely that the company based its values of beta on observed share prices for the company as a whole,

Table 9-3. Post-Tax Cost of Equity

	Case 1	Case 2	Case 3	Case 4	Case 5
Risk-free rate	3.8	3.5	3.8	3.5	3.8
Risk premium	5.0	4.0	4.5	3.5	5.0
Beta	0.96	0.86	0.73	0.55	0.55
Cost of equity	8.60	6.94	7.09	5.43	6.55

---

1. In practice, the increase will only have a significant impact if beta has been measured over a short period, which is probably undesirable in any case.

while the regulator's values may have been based on attempts to remove the impact of the company's other (riskier) businesses (in gas exploration and production).

The capital asset pricing model gives us a post-tax rate of return on equity. In Argentina, this would be combined with the post-tax cost of debt to yield the post-tax weighted average cost of capital. The weights refer to the shares of debt and equity used by the company:

Weighted average cost of capital = Share of equity*Cost of equity
+ Share of debt*Cost of debt.

For a company with a debt:equity ratio of 40:60, a cost of debt of 4 percent (a risk premium of 0.5 percent on top of a risk-free rate of 3.5 percent), and a cost of equity of 8 percent, we get a weighted average cost of capital of 6.4 percent (since 0.4*4 + 0.6*8 = 1.6 + 4.8 = 6.4). It might appear that the company could significantly reduce its cost of capital by increasing its debt-equity ratio. In practice, however, this would make the returns to its equity more volatile, increasing beta and the cost of the equity, while the risk premium on the company's debt might also rise. These adjustments are likely to absorb most of the apparent benefits of increasing the amount of debt.[2]

The alternative used in the United Kingdom is to calculate a pre-tax rate of return. The unadjusted cost of debt is used, but a tax adjustment has to be made to reflect the difference between pre-tax and post-tax returns to equity. In the United Kingdom, many institutional investors are tax-exempt pension funds, and their needs are assumed to drive share prices. In the early 1990s, they could reclaim a tax credit (for advance corporation tax) that was assumed to be levied on dividends at the main income tax rate of 25 percent. For these investors to receive a 10 percent return, therefore, a company only needed to make a payment of 7.5 percent. The company had to pay corporation tax at a rate of 33 percent, however, and would thus need to earn profits at a rate of 11.25 percent if it was to pay out its post-tax profits at a rate of 7.5 percent. The pre-tax rate of return needed by the company was therefore 1.125 times the post-tax rate observed in the market. The tax systems of other countries will

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2. The Modigliani Miller theorem predicts that the cost of capital would be independent of the debt-equity ratio, but empirical evidence suggests that this theorem does not hold in real-world cases.

require different adjustments, and local accountants will have to be consulted about these.

Note that the figures quoted in this section are for a real rate of return, because they are based on an index-linked risk-free rate. This rate should be used in a spreadsheet (described in chapter 5) that lists all the other variables in real terms. It is also possible to obtain a nominal rate of return, and this is done in the Argentine example below. With a nominal rate of return, the spreadsheet variables (and particularly the asset base) should also be included in nominal terms for consistency.

Other Methods

If the regulated company is not quoted on a liquid stock market, or is only quoted as part of a much larger group, CAPM cannot be used. Even when it is applicable, calculations based on CAPM should still be supplemented with other information, given the range of outcomes it can produce. If possible, the regulator should attempt to determine the cost of capital for similar companies. Useful information may be obtained from other companies in the same part of the industry, in the home country and in similar economies abroad, and from regulated companies in other industries. Note the proviso "in the same part of the industry": a competitive generating company will have a much higher cost of capital than a regulated distribution company that is allowed to pass on the cost of purchasing electricity, and therefore faces very few risks. If these other companies are quoted on a stock market, their cost of capital may be estimated directly. Otherwise, it may be possible to estimate their cost of capital by comparing their profits and assets.

Even under price caps, the regulated variable continues to be the rate of return the company earns; this is the determinant of capital flows into and out of the sector. If the rate of return allowed to investors is below the returns they can get from investments in sectors and/or countries with similar levels of risk, the capital will flow out of the sector into other, more profitable, activities.

In Argentina, the regulatory framework laws take account of this principle and clearly establish that tariffs should be set to ensure efficient companies a fair and reasonable rate of return on their investment.

According to this framework, the return must be related to the degree of efficiency of each company; on average, it must be similar to that of other sectors of similar risk in the country and abroad. The rate of return

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Box 9-1. Electricity Tariff Principles in Argentina

ARTICLE 40. Transmission and Distribution services shall be supplied at fair, reasonable tariffs, ensuring that:

(a) Economically and efficiently operated services obtain sufficient revenues covering reasonable operating costs, taxes, and amortization costs and a rate of return to be determined pursuant to the provisions of Article 41 hereof;

(b) Any reasonable cost differential between the different types of service shall be accounted for on the basis of the service provided, geographical location, and any other characteristic which the ENRE [the regulator] may deem relevant;

(c) In the case of distribution tariffs, the sale price of electricity to users shall include a term to represent purchase costs of electricity in the MEM [wholesale market];

(d) A minimum reasonable cost for users consistent with security of supply, subject to compliance with the requirements established in the above sub-paragraphs.

ARTICLE 41. The tariffs applicable to transmitters and distributors shall provide a reasonable rate of return to efficiently operated companies. In addition, the rate shall:

(a) Bear relation with the company's degree of operating efficiency and efficacy;

(b) Be similar, in average for the industry, to that of other activities having similar or comparable risk at the local and international level.

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to be used in the present value calculations must be based on an average cost of capital for the industry rather than for each individual company. This preserves incentives for productive efficiency, given that companies with a lower cost of capital will receive supra-normal benefits, and at the same time all companies perceive an incentive to lower the cost of capital.

A modified version of CAPM is used to calculate the rate of return, which requires additional information. This is because most companies are not publicly quoted on the stock market, which is relatively small and easily manipulated by large companies.

The Cost of Capital for the Gas Industry in Argentina[3]

As discussed, the cost of capital for the firm is the weighted average of the cost of debt and equity. The gas regulator (ENARGAS) adopted this method to calculate the cost of capital for distribution and transport companies to be used in the tariff review. In this section we will discuss the assumptions adopted by ENARGAS in its calculations.

Cost of Debt

The cost of debt adopted was calculated as the risk-free rate (that of Treasury bonds in the United States) plus the country risk (the relation between Argentine government bonds and the U.S. bonds). This rate is in nominal terms, and so the real rate of return (which is required for the calculations) depends on the assumed rate of inflation. ENERGAS assumed an inflation rate of 1.9 percent a year. All the figures in this section are for nominal rates, but the real rate of return may be obtained from the following formula:

$$\text{Real interest rate} = \frac{1 + \text{Nominal interest rate}}{1 + \text{Inflation rate}} - 1 \, .$$

The alternative of using the rate paid by the firms for their debt was discarded for two reasons. First, except for one or two of the companies, the debt was short term, and therefore unsuitable for the proper evaluation of the 35-year cash flow associated with the duration of the license. Second, using the companies' own rate would have reduced their incentives to reduce the cost of debt because any reductions would have lowered the cost of capital.

ENARGAS adopted as the risk-free rate the rate of U.S. Treasury bonds with an average life equal to the average life of the companies.[4] Theoretically, the risk-free rate is the return on a security that has no default risk

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3. This section is based on "El Costo del Capital en la Revisión Quinquenal de Tarifas," prepared by Alfredo Visintini for the Gerencia de Desempeño y Economía, ENARGAS, July 1996.

4. One important factor to be considered when deciding which risk-free and country-risk rates to use for the analysis is the duration, average life, and maturity of the bonds, which should be the same as the duration of the license or concession. The treatment of this topic is beyond the scope of this work.

and is not correlated with returns on anything else in the economy. The reasonable alternative is to use government securities. In the case of Argentina, government securities carry a high risk, because default on sovereign debt is not unknown in the region. Using U.S. Treasury bonds is the best alternative, because there is almost no default risk associated with U.S. bonds.

The use of U.S. bonds is also justifiable from the point of view of the investors involved in these companies. As long as the country is interested in attracting foreign capital into the sector, the opportunity cost is given by the best alternative available. For small economies such as Argentina, U.S. bonds offer the best proxy for the risk-free rate.

Country or sovereign risk represents the uncertainty investors face over the future prospects of a given economy. Country risk is generally measured as the risk that a given country will default in its public or private external debt as a result of changes in economic policies or political instability.

An estimate of country risk can be found in the difference between the yield or internal rate of return of a domestic bond or basket of bonds in dollars (or other hard currency) and the risk-free rate with the same average life. For bonds in domestic currency, the country risk is given by the sum of the risk of default plus the devaluation risk. Using dollar- or hard-currency-denominated paper has the advantage of avoiding the devaluation risk, which would otherwise have to be included in the analysis.

The choice of the basket of domestic bonds to be used has been one of the more controversial issues in the determination of the cost of capital. Argentina has a wide array of debt instruments in dollars. Some were issued in European markets, some in the United States, and others in the domestic market. Some of these instruments have to be excluded because they were imposed on investors as a compulsory part of debt restructuring (BOCON), others because of their short-term nature (BONEX).

Ideally, the choice should be based on economic criteria, which in this case means estimating the marginal cost of debt for the Argentine economy. According to ENARGAS, the best alternative available was the use of "Euronotas" denominated in dollars and deutsche marks, which reflect the long-run marginal cost of debt for the government and large Argentine firms.

Cost of Equity

According to the CAPM adopted by ENARGAS, the cost of equity is composed of the risk-free rate, plus market risk, plus company risk, plus

country risk. The risk-free and country-risk rates were discussed in the previous section. We shall now concentrate on the estimates for the market risk associated with the companies. This risk has two components: the risk of the market as compared with the risk-free rate on the one hand, and the risk of the company in relation to the market on the other hand.

The long-run relationship between the yields of a basket of market shares and the risk-free rate represents the estimate of the market risk. Assuming that U.S. Treasury bonds represent the risk-free rate, the basket of shares must be a basket of U.S. shares, and ENARGAS adopted the Standard and Poor's 500 Index (S&P Index). Geometric averages of the difference between the risk-free rate and the S&P Index were computed for a selection of time periods (table 9-4).[5]

Table 9-4. Market Risk Estimates
(percent)

Time period	Market risk
1990–94	1.16
1985–94	6.08
1980–94	5.10
1926–94	6.45
1946–94	5.33
1960–94	2.65
1970–94	3.03

The values computed vary between a lower bound of 1.16 percent (the 1990–94 period) and a higher bound of 6.45 percent (considering all the available data). Considering short periods such as 1990–94 does not represent the risk associated with long-run investments, such as those involved in utilities. Therefore, longer periods, of at least 10 to 15 years, should be considered. The lower bound increases to 3.03 percent (1970–94). An intermediate value of 6.08 percent (1985–94) was the one considered by ENARGAS in the calculations.

The measure of market risk represents the difference between the risk-free rate and a basket of shares. The next step is to measure the relation between the company under consideration and the share basket. As we discussed, the CAPM assumes that the risk premium required by a share

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5. Geometric rather than arithmetic averages are the proper measure. See T. Copeland, T. Koller, and J. Murrin, 1994, *Valuation: Measuring and Managing the Value of Companies,* 2d ed. (New York: McKinsey & Company-Wiley).

is proportional to its *beta* (β) coefficient, which measures its volatility relative to the market.

In well-developed capital markets, the βs of all companies are regularly quoted by specialized reports such Value Line or the LBS Risk Measurement Service. When companies are not quoted in the stock market, as is the case for gas distribution and transport companies in Argentina, the value of β has to be estimated by some indirect method.

For these indirect approaches, Copeland and others[6] suggest four alternatives: management comparisons, comparison companies, the multiple regression approach, and covariance of earnings before interest and taxes. For the β of distribution companies, ENARGAS adopted the comparison companies approach, taking the βs of gas distribution companies in the United States.

The βs reported in Value Line for these companies include two kinds of risk: risk associated with the industry and financial risk associated with the debt-capital ratio (leverage) of the company. To get around this problem, ENARGAS unlevers the βs of the comparison companies to obtain their business risk, then relevers, using the target capital structure of the gas companies in Argentina.[7]

The average of the unlevered βs of the U.S. companies is 0.4. Regulation in the United States is generally accomplished with the rate of return model, and therefore the risk of the gas business should be lower than under a price cap system such as that used in Argentina.[8] For this reason, a β of 0.6 was adopted, assuming a 0.2 difference related to the regulatory risk. Using balance sheet data, this value was relevered to obtain a final value of 0.78 for the distribution companies.

For transport companies there are no companies comparable to those in Argentina: transport capacity is sold through long-term firm contracts and

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6. T. Copeland, T. Koller, and J. Murrin, 1994, *Valuation: Measuring and Managing the Value of Companies*, 2d ed. (New York: McKinsey & Company-Wiley).

7. For the methodology to unlever and relever the βs, see Copeland and others 1994, p. 331.

8. A company regulated under a price cap faces more risk than one under cost-plus regulation, and should thus have a higher beta. When information on a firm under cost-plus regulation is used to calculate the cost of capital for a price control, an adjustment must be made to take account of the difference in regulatory regime. For an analysis of this topic see I. Alexander, C. Mayer, and H. Weeds, 1996, "Regulatory Structure and Risk and Infrastructure Firms," World Bank Policy Research Working Paper 1698 (Washington, D.C.).

Table 9-5. Cost of Capital for the Gas Distribution Industry, Argentina, 1996

Item	Cost	
Risk-free rate (*RF*)	6.39%	
Market risk in United States (*MR*)	6.08%	
Country risk (*CR*)	6.17%	
Beta coefficient (β)	0.78	
Cost of equity (*CE*)	17.75%	+ *RF* + β *MR* + *CR*
Cost of debt (*CD*)	13.02%	+ *CR* + *RF*
WACC	15.17%	+ *CE**E/*K* + *CD**D/*K**(1 − *T*)
Debt/*K* (*D*/*K*)	30.0%	
Equity/*K* (*E*/*K*)	70.0%	
Tax rate (*T*)	30.0%	

Table 9-6. Cost of Capital for the Gas Transport Industry, Argentina, 1996

Item	Cost	
Risk-free rate (*RF*)	6.39%	
Market risk in United States (*MR*)	6.08%	
Country risk (*CR*)	6.17%	
Beta coefficient (β)	0.57	
Cost of equity (*CE*)	16.04%	+ *RF* + β *MR* + *CR*
Cost of debt (*CD*)	12.56%	+ *CR* + *RF*
WACC	13.32%	+ *CE**E/*K* + *CD**D/*K**(1 − *T*)
Debt/*K* (*D*/*K*)	37.6%	
Equity/*K* (*E*/*K*)	62.4%	
Tax rate (*T*)	30.0%	

the activity is much less competitive than in the United States. For this reason, ENARGAS adopted a different methodology. Starting from the βs of the distribution companies, the value for transport companies was computed, correcting for the risk differential between these two activities.

As a measure of risk, the standard deviation of the operating profit-capital ratio was computed for the four years for which data was available. The relation between the two activities was 0.68, which resulted in an unlevered β for transport of 0.408. Using the debt-capital ratio of 37.6 percent, the levered β for transport is 0.57 (table 9-6).

Appendix: Taxes

Corporate taxes have two effects on the determination of tariffs of regulated companies. First, they directly affect the cash flow of the company. Second, the tax deductibility of interest payments means that the after-tax cost of debt (and consequently, WACC) is lower than the pre-tax cost of debt.

Tax Effect on Cash Flow

The cash flow to a firm is given by:

Revenues
- Operating expenses (*OPEX*)
= Earnings before interest, taxes, depreciation, and amortization (*EBITDA*)
- Deprecation and amortization (*D&A*)
= Earnings before interest and taxes (*EBIT*)
- Interest expenses ($rd\ D$)
= Earnings before taxes
- Taxes
= Net income
+ Deprecation and amortization
= Cash flow from operations
- Capital expenditures
- Working capital change
- Principal repayments
+ Proceeds from new debt issues

= **Free cash flow to equity**
   + Interest expenses (1 − Tax rate)
   + Principal repayments
   − New debt issues
= **Free cash flow to the firm.**

Tax
= Tax rate (Earnings before taxes)
= Tax rate (Revenue − *OPEX* − *rd D* − *D&A*).

It is important to note that under most tax regimes, for corporate tax purposes, interest payments (*rd D*) and depreciation and amortization (*D&A*) are deductible expenses. This has two implications. On the one hand, the cost of debt is affected by taxes (see below). On the other hand, depreciation and amortization policies have an indirect effect on the cash flow to the firm.

Depreciation and amortization are not expenditures of the firm in the sense that they do not involve cash payments of any kind. Consequently, depreciation and amortization policies, such as the choice between accelerated or linear depreciation, have no direct effect on the cash flow to the firm. Note in the definition above that *D&A* is subtracted from *EBITDA* to obtain *EBIT*; afterward, *D&A* is added to net income to get the free cash flow.

After-Tax Cost of Debt

Since in most countries interest paid on the firm's debt is tax deductible, the after-tax cost of debt is a function of the tax rate. The tax benefit that accrues from paying interest makes the after-tax cost of debt lower than the pre-tax cost. This benefit is directly related to the tax rate. Formally:

After-tax cost of debt = Pre-tax cost of debt (1 − Tax rate).

Pretax cost of debt = *rd D*.

But from the tax formula we know that the interest payments on the debt are tax deductible, therefore the company saves an amount equal to the interest payment multiplied by the tax rate:

Tax = Tax rate (Revenue $-$ *OPEX* $-$ *rd D* $-$ *D&A*)
  = Tax rate revenue $-$ Tax rate *OPEX* $-$ Tax rate *rd D* $-$ Tax rate *D&A*

Therefore, the reduction in total tax paid by the company as a result of the debt is

<div align="center">Tax savings: Tax rate *rd D*.</div>

The after-tax cost of debt can be obtained as the pretax cost minus the tax savings

After-tax cost of debt = Pretax cost of debt $-$ Tax savings
  = *rd D* $-$ Tax rate *rd D*
  = *rd D* $(1 -$ Tax rate).

The weighted average cost of capital results in

$$WACC = rd\ (1 - T)\ D/(K + D) + rk\ K/(K + D).$$

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