INCENTIVE REGULATION IN THEORY AND PRACTICE: ELECTRICITY DISTRIBUTION AND TRANSMISSION NETWORKS

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ABSTRACT

Modern theoretical principles to govern the design of incentive regulation mechanisms are reviewed and discussed. General issues associated with applying these principles in practice are identified. Examples of the actual application of incentive regulation mechanisms to the regulation of prices and service quality for "unbundled" transmission and distribution networks are presented and discussed. Evidence regarding the performance of incentive regulation in practice for electric distribution and transmission networks is reviewed. Issues for future research are identified.

Keywords: regulation, incentives, networks, electricity, transmission, distribution

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As the industry liberalization initiatives were gaining steam in Europe, Latin America, Australia, New Zealand and North America during the late 1980s and the 1990s, theoretical research on the properties of alternative incentive regulation mechanisms developed quite rapidly as well. However, the relationship between theoretical developments and applications of incentive regulation theory in practice has not been examined extensively. In this paper I provide an overview of the theoretical and conceptual foundations of incentive regulation theory, discuss some practical implementation issues, examine how incentive regulation mechanisms have been structured and applied to electric distribution and transmission networks, primarily in the UK where the application of these mechanisms is most advanced, review the limited available empirical analysis of the performance of incentive regulation mechanisms applied to electric distribution and transmission networks, and draw some conclusions about the relationships between incentive regulation theory and it application in practice.

As I will discuss, the implementation of incentive regulation concepts is more complex and more challenging than may first meet the eye. Even apparently simple mechanisms like price caps (e.g. so-called "RPI – x" regulation) are fairly complicated to implement in practice, are often imbedded in a more extensive portfolio of incentive regulation schemes, and depart in potentially important ways from the assumptions upon which related theoretical analyses have been based. Moreover, the sound implementation of incentive regulation mechanisms depends in part on information gathering, auditing, and accounting institutions that are commonly associated with traditional cost of service or rate of return regulation. These institutions are especially important for developing sound approaches to the treatment of capital expenditures, to develop benchmarks for operating costs, to implement resets ("ratchets") of prices, to take service quality attributes into account, and to deter gaming of incentive regulation mechanisms that have mechanisms for resetting prices or price adjustment formulas of one type or another over time.

The failure to understand the role of this regulatory infrastructure, especially as it relates to data collection, accounting rules, reporting and auditing standards can significantly undermine the effectiveness of incentive regulation in practice. In the UK, for example, the initial failure of regulators to fully understand the need for a uniform system of capital and operating cost accounts as part of the foundation for implementing incentive regulation mechanisms has placed limitations on their effectiveness and led to gaming by regulated firms (e.g. capitalizing operating costs to take advantage of asymmetries in the treatment of operating and capital costs). The lack of a good standard accounting and reporting system made more difficult the UK electricity regulator's efforts to remove distortions caused by the periodicity of regulatory reviews. As a result, the electricity regulator in the UK has now found it necessary to strengthen and standardize cost accounting and reporting protocols to allow for better incentive regulation (OFGEM 2004f).

proceedings to (in theory)[4] assist the regulatory agency in developing better information and reducing its regulatory disadvantage: and appeals court review, and legislative oversight processes. In addition, since regulation is a repeated game, regulators (as well as legislators and appeals courts) can learn about the firm's attributes as they observe its responses to regulatory decisions over time and, as a result, the regulated firm naturally develops a reputation for the credibility of its claims and the information that it uses to support them.

However, although the development of U.S. regulatory practice focused on improving the information available to regulators, the regulatory mechanisms adopted typically did not utilize this information nearly as effectively as they could have. While U.S. regulatory practice differs significantly from the way it is often characterized, and during long periods of time provided incentives to control costs (Joskow 1974, 1989), formal incentive regulation mechanism where historically used infrequently in the U.S., Canada, Spain, Germany and other countries with private rather than state owned regulated network industries. Perhaps regulatory practice evolved this way due to the absence of a sound theoretical incentive regulation framework to apply in practice.

Beginning in the 1980s, theoretical research on incentive regulation rapidly evolved to confront directly imperfect and asymmetric information problems and related contracting constraints, regulatory credibility issues, dynamic considerations, regulatory capture, and other issues that regulators have been trying to respond to for decades but in the absence of a comprehensive theoretical framework to guide them. This theoretical framework is reasonably mature and can help regulators deal with these challenges much more directly and effectively (Laffont and Tirole 1993; Armstrong, Cowan and Vickers 1994; Armstrong and Sappington 2003).

Consider the simplest characterization of the nature of the regulator's information disadvantages and its potential implications. A firm's cost opportunities may be high or low based on inherent attributes of its technical production opportunities, exogenous input cost variations over time and space, inherent differences in the costs of serving locations with different attributes (e.g. urban or rural), etc. While the regulator may not know the firm's true cost opportunities she will typically have some information about their probability distribution. The regulator's imperfect information can be summarized by a probability distribution defined over a range of possible cost opportunities between some upper and lower bound within which the regulated firm's actual cost opportunities lie. Second, the firm's actual realized costs or expenditures will not only depend on its underlying cost opportunities but also on the behavioral decisions made by managers to exploit these cost opportunities. Managers may exert varying levels of effort to get more (or less) out of the cost opportunities that the firm has available to it. The greater the managerial effort the lower will be the firm's costs, other things equal. However, exerting more managerial effort imposes costs on managers and on society. Other things equal, managers will prefer to exert less effort than more to increase their own satisfaction, but less effort will lead to higher costs and more "x-inefficiency."

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[4] Of course, third parties may have an incentive to inject inaccurate information into the regulatory process as well.

monopoly firm producing a single product. The first regulatory mechanism involves setting a fixed price ex ante that the regulated firm will be permitted to charge going forward (i.e. effectively forever). Alternatively, we can think of this as a pricing *formula* that starts with a particular price and then adjusts this price for *exogenous* changes in input price indices and other exogenous indices of cost drivers (forever). This regulatory mechanism can be characterized as a *fixed price* regulatory contract or, in a dynamic setting, a *price cap* regulatory mechanism where prices adjust based on exogenous input price and performance benchmarks. There are two important attributes of this type of regulatory mechanism. Because prices are fixed (or vary based only on exogenous indices of cost drivers) and do not respond to changes in managerial effort or ex post cost realization, the firm and its managers are the residual claimants on production cost reductions and the costs of increases in managerial effort (and vice versa). That is, the firm and its managers have the highest powered incentives fully to exploit their cost opportunities by exerting the optimal amount of effort (Brennan 1989; Cabral and Riordan 1989; Isaac 1989; Sibley 1989; Kwoka 1993). Accordingly, this mechanism provides optimal incentives for inducing managerial effort and eliminates the costs associated with managerial managerial moral hazard. However, because the regulator must adhere to a firm participation or financial viability constraint, when there is uncertainty about the regulated firm's cost opportunities the regulator will have to set a relatively high fixed price (or dynamic price cap) to ensure that *if* the firm is indeed inherently high cost, the prices under the fixed price contract or price cap will be high enough to cover the firm's (efficient) realized costs. Accordingly, while a fixed price mechanism may deal well with the potential moral hazard problem by providing high powered incentives for cost reduction, it is potentially very poor at "rent extraction" for the benefit of consumers and society, potentially leaving a lot of rent to the firm due to the regulator's uncertainties about the firm's inherent costs and its need to adhere to the firm viability or participation constraint. Thus, while a fixed price type incentive mechanism solves the moral hazard problem it incurs the full costs of adverse selection.

At the other extreme, the regulator could implement a "cost of service" contract or regulatory mechanism where the firm is assured that it will be compensated for all of the costs of production that it actually incurs. Assume for now that this is a credible commitment --- there is no ex post renegotiation --- and that audits of the expenditures the firm has incurred are accurate. When the firm produces it will then reveal whether it is a high cost or a low cost firm to the regulator. Since the regulator compensates the firm for all of its costs, there is no "rent" left to the firm or its managers in the form of excess profits. This solves the adverse selection problem. However, this kind of cost of service recovery mechanism does not provide any incentives for the management to exert optimal (any) effort. If the firm's profitability is not sensitive to managerial effort, the managers will exert the minimum effort that they can get away with. Even though there are no "excess profits" left on the table since revenues are equal to the actual costs the firm incurs, consumers are now paying higher prices than they would have to pay if the firm were better managed and some rent were left with the firm and its managers. Indeed, it is this kind of managerial slack and associated x-inefficiencies that most policymakers have in mind when they discuss the "inefficiencies" associated with

Under pure cost of service regulation where the regulator can observe the firm's expenditures but not evaluate their efficiency:[7]

$a = 0$

$b = 0$

Under profit sharing contract or sliding scale regulation (Performance Based Regulaion)

$0 < b < 1$

$0 < a < C^*$

The challenges then are to find the optimal performance based mechanism given the information structure faced by the regulator and for the regulator to find ways to reduce its information disadvantages vis a vis the regulated firm and to use the additional information effectively. Laffont-Tirole show that it is optimal for the regulator to offer a *menu* of contracts with different combinations of a and b that meet certain conditions driven by the firm's budget constraint and an incentive compatibility constraint that leads firms with low cost opportunities to choose a high powered scheme (b is closer to 1 and a is closer to the efficient cost level for a firm with low cost opportunities) and firms with high cost opportunities to choose a lower powered incentive scheme (a and b are closer to zero). The lower powered scheme is offered to satisfy the firm participation constraint, sacrificing some costs resulting from managerial moral hazard, in order to reduce the rents that must be left to the low cost firm as it is induced to exert the optimal amount of managerial effort while satisfying the firm viability constraint if it turns out to be a high cost opportunity firm. (So far, this discussion has ignored quality issues. Clearly if a regulatory mechanism focuses only on reducing costs and ignores quality it will lead to firm to provide too little quality. This is a classic problem with pure fixed price or price cap mechanisms and will be discussed further below.)

The incentive regulation literature is not a substitute for the older literature on optimal pricing for natural monopolies subject to a budget constraint, but rather a complement to it. This can be seen most clearly in the framework developed by Laffont and Tirole where the availability of government transfers creates a dichotomy or separation between optimal pricing and optimal incentives for controlling costs (Laffont-Tirole 1993, Chapter 2). As a result, all of the basic second-best optimal pricing results for a natural monopoly subject to a budget constraint continue to be applied alongside the application of optimal incentive schemes (given asymmetric information) for controlling production costs. More generally, however, pricing and incentives cannot be so easily separated and their effects are likely to be interdependent. Some mechanisms can provide both good pricing and performance (cost, quality) incentives, but typically, the desire to get prices as well as performance incentives right creates another constraint that

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[7] This is not a particularly accurate characterization of cost of service regulation in practice in the U.S., but it has become the common characterization of it, especially among those who had no experience with it (Joskow and Schmalensee 1986).

payments from the government to the firm which affect the rents earned by the firm. These transfer payments come out of the government's budget and carry a social cost resulting from the inefficiencies of the tax system used to raise these revenues. Thus, for every dollar of transfer payments given to the firm to increase its rent, effectively $(1+\lambda)$ dollars of taxes must be raised, where λ reflects the inefficiency of the tax system. Accordingly, by reducing the transfers to the firm over and above what is required to compensate it for its efficient production costs and the associated managerial disutility of effort, welfare can be increased. As noted above, this set-up also leads to a nice dichotomy between incentive mechanisms and the setting of second-best prices for the services sold by the firm. That is, regulators first establish compensation arrangements (define how the firm's budget constraint or "revenue requirements" will be determined) to deal as effectively as possible with adverse selection and moral hazard problems given the information structure assumed. The regulator separately establishes a second best price structure to deal with allocational efficiency considerations. These prices may not yield enough revenue to cover all of the firm's costs, with the difference coming from net government transfers (or vice versa). In addition, Laffont and Tirole introduce managerial effort (e) as a variable that affects costs. Managers have a disutility of effort (U) and must be compensated for it. Accordingly, the utility of management also appears in the social welfare function.

What does the regulator know about the firm ex ante and ex post? The literature that focuses on adverse selection builds on the fundamental paper by Baron and Myerson (1982). There the regulator does not know the firm's cost opportunities ex ante but has information about the probability distribution over the firm's possible cost opportunities.[8] Nor can the regulator observe or audit the firm's costs ex post. The firm does know its own cost opportunities ex ante and ex post. The firm's demand is known by both the regulator and the regulated firm. There is no managerial effort in these early models of incentive mechanism design. Accordingly, the analysis deals with a pure adverse selection problem with no potential inefficiencies or moral hazard associated with inadequate managerial effort. The regulation in the presence of adverse selection literature then proceeds to consider asymmetric information about the firm's demand function, where the firm knows its demand but either the regulator does not observe demand ex ante or ex post or learns about demand only ex post (Lewis and Sappington 1988a; Riordan 1984).

In light of common U.S. and Canadian regulatory practice, a natural extension of these models is to assume that the regulated firm's actual realized costs are observable ex post, at least with uncertainty. Baron and Besanko (1984) considers cases where a firm's costs are "audited" ex post, but the actual realized costs resulting from the audit are observable by the regulator with a probability less than one. The regulator can use this information to reduce the costs of adverse selection. Laffont and Tirole (1986, 1993) consider cases where the firm's realized costs are fully observable by the regulator. However, absent the simultaneous introduction of an uncertain scope for cost reductions through managerial effort, the regulatory problem then becomes trivial --- just set prices

[8] In models that distinguish between fixed and variable costs, the regulator may know the fixed costs but not the variable costs. See Armstrong and Sappington (2003).

intermediate types' rent defined by the difference in their marginal costs. Similarly, the effort of the lowest cost type is optimal and the effort of the highest cost type is distorted the most, with intermediate types having smaller levels of distortion (and more rents) as β declines toward β_1. In the case of a continuous distribution of types, the optimality conditions are directly analogous to those for the two-type case.

Laffont and Tirole (1993) show that these optimality conditions can be implemented by offering the firm a menu of linear contracts, which in their model are transfer or incentive payments in excess of realized costs (which are also reimbursed), of the form:

$$t(\beta, c) = a(\beta) - b(\beta)c$$

where a is a fixed payment, b is a cost contingent payment, and a and b are decreasing in β.

We can rewrite the transfer payment equation in terms of the gross transfer to the firm including the unit cost reimbursement:

$$R_t = a(\beta) - b(\beta)c + c = a(\beta) + (1-b(\beta))c \qquad (36)$$

where $da/db > 0$

(for a given β a unit increase in the slope of the incentive payment must be compensated by an increase in the fixed payment to cover the increase in production costs)

and $d^2a/db^2 < 0$

(the fixed payment is a concave function of the slope of the incentive scheme.)

(See Figure 1) The lowest cost type chooses a fixed price contract with a transfer net of costs equal to U_1 and the firm is the residual claimant on cost reducing effort ($b = 1$). As β increases, the transfer is less sensitive to the firm's realized costs (b declines), the rent is lower (a declines), and the efficiency distortion from suboptimal effort increases.

efficient regulatory mechanism involves setting the price for each firm based on the costs of the other firms. Each individual firm has no control over the price it will be allowed to charge (unless the firms can collude) since it is based on the realized costs of (n-1) other firms. So, effectively each firm has a fixed price contract and the regulator can be assured that the budget balance constraint will be satisfied since if the firms are identical prices will never fall below their "efficient" realized costs. This mechanism effectively induces each firm to compete against the others. The equilibrium is a price that just covers all of the firm's efficient costs as if they competed directly with one another.

Of course, the regulator is unlikely to be able to find a large set of truly identical firms. However, hedonic regression, frontier cost function estimation and related statistical techniques can be used to normalize cost variations for exogenous differences in firm attributes to develop normalized benchmark costs (Jamasb and Pollitt 2001, 2003; Estache, Rossi, Ruzzier 2004). As we shall see below, these benchmark costs can then be used by the regulator in a yardstick framework or in other ways to reduce its information disadvantage, allowing it to use high powered incentive mechanisms without incurring the cost of excessive rents that would accrue if the regulator had a greater cost disadvantage. However, data to perform this type of benchmarking analysis are not always available, a variety of benchmarking techniques can be utilized, and the failure to integrate cost and quality variables can lead to misleading results (Giannakis, Jamasb and Pollitt 2004; Jamasb and Pollitt 2001).

Of additional practical interest are issues that arise as we consider the dynamic interactions between the regulated firm and the regulator and the availability and utilization of mechanisms that the regulator potentially has available to reduce its information disadvantage. It is inevitable that the regulator will learn more about the regulated firm as they interact over time. So, for example, if the regulator can observe a firm's realized costs ex post it will learn a lot about its true cost opportunities. Should the regulator use that information to reset the prices that the regulated firm receives (commonly known as a "ratchet" --- Weitzman 1980)? Or is it better for the regulator to commit to a particular contract ex ante, which may be contingent on realized costs, but the regulator is then not permitted to use the information gained from observing realized costs to change the terms and conditions of the regulatory contract offered to the firm? Is it credible for the regulator to commit *not* to renegotiate the contract, especially in light of U.S. regulatory legal doctrines that have been interpreted as foreclosing the ability of a regulatory commission to bind future commissions? Clearly, if the regulated firm knows that information about its realized costs can be used to renegotiate the terms of its contract ex post, this will affect its behavior ex ante. It may have incentives to engage in less cost reduction in period 1 or try to fool the regulator into thinking it is a high cost firm so that it can continue to earn rents in period 2. Of if the regulated firm has a choice between technologies that involve sunk cost commitments, will the possibility of ex post opportunism or regulatory expropriation, perhaps driven by the capture of the regulator by other interest groups, affect its willingness to invest in the lowest cost technologies when they involve more significant sunk cost commitments (leading to the opposite of the Averch-Johnson effect --- Averch and Johnson 1962; Baumol and Klevorick 1970).

Capital cost accounting issues have largely been ignored in the theoretical literature on incentive regulation. Although it has been of limited concern to contemporary economists, any well functioning regulatory system needs to adopt good cost accounting rules, reporting requirements for costs, output, prices, and other dimensions of firm performance, and enforce auditing and monitoring protocols to ensure that the regulated firm applies the auditing rules and adheres to its reporting obligations. Much of the development of U.S. regulation during the first half of the 20th century focused on the development of these foundation components required for any good regulatory system that involves cost contingent regulatory mechanisms.

Of course, cost is only one dimension of firm performance. Firm performance may also have various "quality" dimensions and there are likely to be inherent tradeoffs between cost and quality. If incentives are to be extended to the quality dimension as well, as they should be, then these quality dimensions must be defined and associated performance indicia measured by the firm, reported to the regulator, and must be subject to auditing protocols.

Regulators also need information to develop a view about the distribution of cost opportunities, consumer valuations of service quality, and other dimensions of firm performance to implement incentive regulation mechanisms that do not leave too much rent to regulated firms and do not lead to excessive managerial efficiency. Regulators need to have the resources to develop information about industry performance norms and the causes of variations in the performance of regulated firms. Accordingly, they need the resources to commission industry studies that give them this kind of information so that their information disadvantage can be reduced.

b. *Should the regulator offer the regulated firm a menu of contracts or a specific contract with a single set of values for a and b as discussed above?* The Laffont-Tirole framework implies that firms should be offered a menu of cost-contingent contracts from which they can choose. The menu forces the firm to reveal its type ex post and allows for a better balance of efficiency and rent extraction than would a single linear incentive contract designed ex ante based on the same information and subject to the same budget balance constraints. However, it appears that regulators typically offer firms only a single regulatory contract and when the contracts is cost contingent it is typically linear (Schmalensee 1989). I am aware of two situations in which regulated firms were offered a menu of cost contingent or sliding scale contracts. The first relates to the System Operator (SO) incentive schemes that have been offered to the electric transmission system operator in England and Wales discussed below. The second is the menu of sliding scale mechanisms offered to the electric distribution companies in the UK for determining future capital expenditure allowances and associated user charges for capital services pursuant to the most recent price cap review in late 2004. These menus are discussed in more detail below as well. However, there may be more use of a de facto menu of contracts approach than first meets the eye when we take the attributes of the regulatory review process itself into account. The final regulatory mechanism applied to a regulated firm is often the result of formal and informal negotiations involving proposals by the regulator's staff, the regulatory firm and interested third parties (Joskow *e. Should the incentive mechanism be comprehensive or "partial?"* There are multiple dimensions of firm performance defined by cost and quality indicia and the tradeoffs between them. Most regulated firms supply multiple products for which demand and cost attributes vary. There are also multiple dimensions of firm costs with different adjustment lags. Operating costs can be adjusted relatively quickly, while capital costs are often long-lived and can be economically adjusted much more slowly. Moreover, both the level and adjustment opportunities for operating costs depend upon the attributes of the legacy stock of capital and investments in new facilities and can both expand the firm's capacity to supply particular products and affect its operating costs. Capital and operating costs are inherently interdependent with varying adjustment lags. Moreover, as a practical matter, the line between an operating cost and a capital cost may not be well defined except by clear accounting rules. A hammer that lasts for five years may be expensed while software that has a useful life of three years may be capitalized. Under some incentive regulation mechanisms this creates opportunities for gaming by expensing capital costs or capitalizing operating costs.

Ideally, a comprehensive incentive regulation mechanism that consistently integrates all cost and quality relationships at a point of time and over time would be applied. However, as a practical matter this often places very challenging information and implementation burdens on the regulator. Partial mechanisms or a portfolio of only loosely harmonized mechanisms are often used by regulators. Operating and capital cost norms and targets are typically developed separately and the effective power of the incentive scheme applicable to operating and capital costs may vary between them. Separate incentive mechanisms may be applied to measures of quality than to measures of total operating and capital costs. This reality represents perhaps the most significant variation between received incentive regulation theory and incentive regulation in practice.

IMPLEMENTATION IN PRACTICE TO ELECTRICITY AND GAS NETWORKS

a. Early applications

Although the theoretical literature on incentive regulation is fairly recent, we can trace the earliest applications of incentive regulation concepts back to the early regulation of the manufactured gas distribution sector[10] (town gas) in England in the mid-19th century (Joskow and Schmalensee 1986, Hammond, Johnes, and Robinson, 2002). A sliding scale mechanism in which the dividends available to shareholders were linked to increases and decreases in gas prices from some base level was first introduce in England in 1855 (Hammond, Johnes, and Robinson, 2002 p. 255). The mechanism established a base dividend rate of 10%. If gas prices increased above a base level the dividend rate was reduced according to a sharing formula. However, if gas prices fell below the base level the dividend rate did not increase (a "one-way" sliding scale). The mechanism was

[10] This is before the development of natural gas. "City gas" was manufactured from coal by local gas distribution companies. At the time there were both private and municipal gas distribution companies in operation in England.

multiple products or different types of customers) is then adjusted from one year to the next for changes in inflation (rate of input price increase or RPI) and a target productivity change factor "x." Accordingly, the price in period 1 is given by:

$$p_1 = p_0 (1 + RPI - x)$$ [12]

Typically, some form of cost-based regulation is used to set p_0. The price cap mechanism then operates for a pre-established time period (e.g. 5 years). At the end of this period a new starting price p_0 and a new x factor are established after another cost-of-service and prudence or efficiency review of the firm's costs. That is, there is a pre-scheduled regulatory-ratchet built into the system.

As discussed earlier, in theory, a price cap mechanism is a high-powered "fixed price" regulatory contract which provides powerful incentives for the firm to reduce costs. Moreover, if the price cap mechanism is applied to a (properly) weighted average of the revenues the firm earns from each product it supplies, the firm has an incentive to set the second-best prices for each service (Laffont and Tirole 2000; Armstrong and Vickers 1991) given the level of the price cap. It is also fairly clear that pure "forever" price cap mechanisms are not optimal from the perspective of an appropriate tradeoff between efficiency incentives and rent extraction (Schmalensee 1989).

In practice, price cap mechanisms apply elements of cost of service regulation, yardstick competition, high powered "fixed price" incentives, plus a ratchet. Price caps on operating costs or capital plus operating costs are often one component of a larger portfolio of incentive mechanisms. As I will show presently, the details of constructing a price cap mechanism for electric distribution and transmission networks are more complicated than is often thought. Moreover, the regulated electric or gas distribution firm's ability to determine the structure of prices under an overall revenue cap is typically limited. Price caps applied to electricity and gas distribution and transmission are used primarily as incentive mechanism not as a mechanism to induce optimal pricing. In telecommunications, regulated firms are given more pricing freedom so price cap mechanism affect both performance incentives and pricing incentives.

It is worth noting again that in an ongoing regulated firm context, a pure "forever" price cap without any cost-sharing (i.e. without a sliding scale mechanism) is not likely to be optimal given asymmetric information and uncertainty about future productivity opportunities (Schmalensee 1989). Prices would have to be set too high to satisfy the firm participation constraint and too much rent with be left on the table for the firm. The application of a ratchet from time to time that resets prices to reflect observed costs is a form of cost-contingent dynamic regulatory contract. It softens cost-reducing incentives but extracts more rents for consumers in the long run.

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[12] Many implementations of price cap regulation also have "z" factors. Z factors reflect cost elements that cannot be controlled by the regulated firm and are passed through in retail prices. For example, in the UK, the charges distribution companies pay for connections to the transmission network are treated as pass-throughs. Changes in property tax rates are also often treated as pass-throughs.

established through more traditional utility planning and cost-of-service regulatory accounting methods including the specification of a rate base (regulatory asset value or RAV), depreciation rates, debt and equity costs, debt/equity ratios, tax allowances, etc.. Since operating costs for distribution networks are often a smaller fraction of total costs than are capital-related costs, the focus on operating costs (or so-called "controllable costs") is potentially misleading. In addition, it is widely recognized that a pure price cap mechanism provides incentives to reduce both costs <u>and</u> the quality of service (Banerjee 2003). Accordingly, price cap mechanisms are increasingly accompanied either by specific performance standards and the threat of regulatory penalties if they are not met or formal PBR mechanisms that set performance standards and specify penalties and rewards for the firm for falling above or below these performance norms (OFGEM 2004d, 2004f; Sappington 2003; Ai and Sappington 2004; Ai, Martinez and Sappington 2004).

c. <u>The Basic Price Cap Mechanism for Electric Distribution Companies in the UK Today</u>

There are 14 electric distribution companies in the UK, several of which are under common ownership within a holding company structure. These companies, which are referred to as Regional Electricity Companies or RECs, provide delivery services in specific geographic franchise areas to transport electricity from points of interconnection with the high voltage transmission network to points of interconnection with final consumers. Their total revenues and the associated prices for using their networks are regulated by the UK Office of Gas and Electricity Markets (OFGEM). The distribution companies themselves provide only delivery services and do not contract to buy or produce electricity for resale to final customers, a competitive function referred to as "electricity supply" in the UK, though they may have functionally separated or "ring fenced" supply affiliates which do so. The primary mechanism used to determine the total revenues that a regulated electricity distribution firm is permitted to recover from its prices for delivery service (the allowed revenue and associated average price level) is a price cap mechanism that sets an initial starting value for revenues (p_o), specifies an exogenous input price index for adjusting revenues for input price inflation and the associated price levels over time (RPI), and a productivity factor "x" which further adjusts revenues and profits over time. The value for x can be either positive or negative or zero. The regulatory framework establishes values for p_o, x, and the relevant RPI index once every five years.

The p_o and x values are developed based on a review of the relative efficiency of each firm's operating costs, the firm's current capital rate base (adjusted for depreciation and inflation since the previous price review), referred to as the firm's regulatory asset value (RAV), forecasts of future capital additions required to provide target levels of service quality, and the application of depreciation rates, estimates of the cost of the firm's debt and equity capital, assumptions about the firm's dept/equity ratio, tax allowances and other variables. The allowed revenues for the firm over the 5-year period are then the sum of allowed operating costs and allowed capital costs determined in each statistical analyses have been used by OFGEM to arrive at operating cost targets for each of the electric distribution companies (OFGEM 2004c). These methods are now reasonably well developed and understood by the regulated firms and third parties. During the 5-year price control period, the firms are (in principle) the full residual claimants on variations between the target and the actual operating costs.

FIGURE 2

UK ELECTRIC DISTRIBUTON PRICE CAPS 2005-2010
(x = 0)

Final proposals for P0

DNOs	June Initial Proposals	Change	September Update	Change	November Final Proposals
	%	%	%	%	%
CN - Midlands	-6.5%	2.0%	-4.5%	1.6%	-2.9%
CN - East Midlands	-10.8%	3.3%	-7.5%	1.8%	-5.7%
United Utilities	-1.8%	7.4%	5.6%	2.4%	8.0%
CE - NEDL	-11.5%	8.6%	-2.9%	-0.8%	-3.7%
CE - YEDL	-14.7%	1.8%	-12.9%	3.7%	-9.2%
WPD-South West	-0.2%	1.8%	1.6%	-0.1%	1.5%
WPD-South Wales	1.7%	5.6%	7.3%	-1.1%	6.2%
EDF - LPN	-2.5%	-1.7%	-4.2%	1.8%	-2.4%
EDF - SPN (note 2)	-3.7%	6.7%	3.0%	4.2%	7.2%
EDF - EPN	-4.6%	2.5%	-2.1%	2.0%	-0.1%
SP Distribution	8.4%	2.2%	10.6%	1.3%	11.9%
SP Manweb	4.0%	-9.5%	-5.5%	-0.4%	-5.9%
SSE - Hydro	-0.1%	2.8%	2.7%	1.2%	3.9%
SSE - Southern	6.1%	3.1%	9.2%	0.1%	9.3%
Average	**-2.5%**	**2.5%**	**0.0%**	**1.3%**	**1.3%**

Note:
1. The P0 figures for November include allowances for Innovation Funding Incentive (IFI). Those for June and September do not include IFI.
2. For comparability, EDF - SPN is shown on the basis of X = 0. Actual P0 will be 3.1%, with RPI + 2.

Sorce: OFGEM (2004f)

Despite the fact that capital carrying costs are roughly twice operating costs for electric distribution companies, the benchmarking methods for determining allowed capital expenditures are much less well-developed than are those for operating costs. Of course, during any particular review period the future stream of allowed carrying charges associated with the stock of capital investments are heavily influenced by historical investments that have been included in the RAV in the past, just like under rate of return regulation. During a new price review, the carrying charges for the historical components of the RAV are affected only by the choice of the allowed returns on debt

The menu of sliding scale incentives is reproduced as Figure 3 below. The values for the sharing fractions are based on the ratio of the distribution company's (DNO) choice of capital expenditure target and that recommended by OFGEM's consultant (PB Power). These ratios vary between 100 and 140. For example, in Figure 3 if a firm agrees to accept a capital expenditure budget equal to 105% of the consultant's recommendation (PB Power = 100 in Figure 3) it would also be choosing the sliding scale in the first column. It would get a base bonus of 2.5% of its target income. If it's actual expenditures turned out to be 70% of the target (through efficiencies) during the price control period it would get a 16.5% increase in its income as a reward. If it greatly exceeds the target and has realized capital expenditures of 140% of the target than its income is reduced by 11.5% from the target.

This is the most direct and extensive application of Laffont and Tirole's menu of cost-contingent contracts result that I have seen. However, it appears to be the case that the sliding scale scheme for capital expenditures is integrated into the price cap mechanism in a way that appears to make the power of the incentive scheme for capital expenditures appears to be different from the power of the incentive scheme applied to operating costs.

FIGURE 3

SLIDING SCALE MATRIX FOR CAPITAL EXPENDITURE ALLOWANCE

DNO:PB Power Ratio	100	105	110	115	120	125	130	135	140
Efficiency Incentive	40%	38%	35%	33%	30%	28%	25%	23%	20%
Additional Income	2.5	2.1	1.6	1.1	0.6	-0.1	-0.8	-1.6	-2.4
as pre-tax rate of return	0.200%	0.168%	0.130%	0.090%	0.046%	-0.004%	-0.062%	-0.124%	-0.192%
Rewards & Penalties									
Allowed expenditure	105	106.25	107.5	108.75	110	111.25	112.5	113.75	115
Actual Exp									
70	16.5	15.7	14.8	13.7	12.6	11.3	9.9	8.3	6.6
80	12.5	11.9	11.2	10.5	9.6	8.5	7.4	6.0	4.6
90	8.5	8.2	7.8	7.2	6.6	5.8	4.9	3.8	2.6
100	4.5	4.4	4.3	4.0	3.6	3.2	2.4	1.5	0.6
105	2.5	2.5	2.5	2.3	2.1	1.7	1.1	0.4	-0.4
110	0.5	0.7	0.8	0.7	0.6	0.3	-0.1	-0.7	-1.4
115	-1.5	-1.2	-1.0	-0.9	-0.9	-1.1	-1.4	-1.8	-2.4
120	-3.5	-3.1	-2.7	-2.5	-2.4	-2.5	-2.6	-3.0	-3.4
125	-5.5	-4.9	-4.5	-4.2	-3.9	-3.8	-3.9	-4.1	-4.4
130	-7.5	-6.8	-6.3	-5.8	-5.4	-5.2	-5.1	-5.2	-5.4
135	-9.5	-8.7	-8.0	-7.4	-6.9	-6.6	-6.4	-6.3	-6.4
140	-11.5	-10.6	-9.7	-9.0	-8.4	-8.0	-7.6	-7.5	-7.4

where, for example: (top-left corner) 16.5 = (105 – 70) x 40% + 2.5

(bottom-right) -7.4 = (115 – 140) x 20% - 2.4

Source: OFGEM 2004f, p.87

discounted value of allowed costs. As noted earlier, in the most recent price review OFGEM chose to set x to zero which has the effect of "backloading" the revenues toward the end of the price review period. An example of what the various operating and capital cost components look like for one distribution company (United Utilities) is displayed in Table 1.

TABLE 1

ALLOWED 2005 COSTS (YEAR 1) FOR ONE UK DISTRIBUTION COMPANY

£millions

Operating costs:	67.0	Change in p_0 = +8.0%
Capital charges:	103.5	$x = 0$
Tax allowances:	16.0	
Capex incentives:	3.4	
Opex incentives:	1.4	
Pensions:	16.0	
Other:	1.5	
TOTAL	212.3	

Source: OFGEM 2004f, p. 127.

There are a number of issues that have not been fully resolved in this price setting and incentive mechanism specification process. First, as already noted, the 5-year ratchet potentially leads to differential incentives for cost reduction depending on how close the firm is to the next price review. OFGEM has indicated that it is aware of this problem and is committed to allowing firms to keep the benefits of "outperformance" (and presumably the costs of underperformance) for a full five years regardless of when during the 5-year review period the outperformance actually occurs. For capital expenditures, OFGEM has adopted a formula for rolling adjustments in the value of capital assets used for regulatory purposes (regulatory asset value or RAV) so that outperformance or underperformance incentives and penalties are reflected in prices for a five-year period. Although OFGEM has made a commitment to allow operating cost (OPEX) savings to be retained for five years, it did not adopt a formal rolling OPEX adjustment mechanism in the latest price review do to imperfections in the operating cost accounting and reporting protocols that now exist (OFGEM 2004f). OFGEM has started a process to develop a better uniform system of accounts and reporting requirements to facilitate improvements in the incentive regulation mechanisms.

investments. Specifically, at the time of a price review the RAV (original cost of capital investments less depreciation) should be adjusted for inflation that has occurred since the last price review and the allowed rate of return on the RAV during the price review period should be based on the real cost of debt and equity capital net of taxes, with tax allowances then added back in. Since prices are based on both operating and capital costs, the RPI - x formula essentially yields a nominal return equal to the real cost of capital plus the rate of inflation. Capital related charges rise with the rate of inflation in this case and this is consistent with the RAV rising with the rate of inflation, together yielding an approximation to the economic depreciation rate (depending exactly on how the depreciation rates are set; Joskow 2005a, Schmalensee 1989a). Simply bolting a price cap mechanism on to the capital cost accounting formulas used in the U.S. (Joskow 2005a) would lead to the wrong result since regulated prices in the U.S. are based on the nominal cost of capital and a depreciated original cost rate base (RAV) that is not adjusted for inflation.

d. Service Quality Incentives for Electric Distribution Companies in the UK and the U.S. [13]

Any incentive regulation mechanism that provides incentives only for cost reduction also potentially creates incentives to reduce service quality when service quality and costs are positively related to one another. The regulatory mechanisms developed for electric distribution companies in the UK have included an additional set of incentive mechanisms to provide incentives for the regulated firms to maintain or enhance service quality. Adding quality-related incentives to cost-control incentives makes good sense in theory and in practice. However, integrating these incentive mechanisms into a package that gives the correct incentives on all relevant margins remains a considerable challenge for incentive regulation in practice.

OFGEM has developed several incentive mechanisms targeted at various dimensions of performance. These include: (a) two distribution service interruption incentive mechanisms targeted at the number of outages and the number of minutes per outage, (b) storm interruption payment obligations targeted at distribution company response times to outages caused by severe weather events, (c) quality of telephone responses during both ordinary weather conditions and storm conditions, (d) and a discretionary award based on surveys of customer satisfaction. Overall, about 4% of total revenue on the downside and an unlimited fraction of total revenue on the upside are subject to these quality of service incentive mechanisms. See Figure 5. Is this the right allocation of financial risk to variations in service quality? Nobody really knows.

[13] The UK has also applied incentive arrangements for distribution system losses that I will not discuss here.

FIGURE 6

TARGETS FOR AVERAGE NUMBER OF CUSTOMER INTERUPTIONS BY DISTRIBUTION COMPANY AND YEAR

	Actuals				Target				
	2001/02	2002/03	2003/04		2005/06	2006/07	2007/08	2008/09	2009/10
CN - Midlands	120.1	99.8	113.1		109.4	107.8	106.2	104.6	103.0
CN - East Midlands	77.0	74.7	83.4		77.9	77.5	77.1	76.7	76.3
United Utilities	55.5	65.7	50.3		57.2	57.1	57.1	57.1	57.1
CE - NEDL	82.2	76.5	64.9		74.5	74.5	74.5	74.5	74.5
CE - YEDL	77.4	62.8	66.0		68.7	68.6	68.5	68.5	68.4
WPD - South West	100.7	81.8	71.0		84.5	84.5	84.5	84.5	84.5
WPD - South Wales	112.7	96.0	94.7		99.7	98.2	96.8	95.3	93.9
EDF - LPN	38.0	35.8	34.7		36.2	36.2	36.2	36.2	36.2
EDF - SPN	93.0	88.4	96.1		90.5	88.5	86.5	84.5	82.5
EDF - EPN	101.0	84.7	89.6		90.3	88.8	87.2	85.7	84.2
SP Distribution	59.0	63.4	60.2		60.9	60.8	60.8	60.8	60.8
SP Manweb	46.1	41.0	49.2		46.7	46.7	46.7	46.7	46.7
SSE - Hydro	115.4	90.0	84.1		96.2	95.8	95.5	95.2	94.9
SSE - Southern	98.3	91.5	86.1		91.0	90.1	89.2	88.3	87.4
Average	83.1	75.0	75.3		77.1	76.5	75.8	75.1	74.5

Source: OFGEM 2004f, p.17

FIGURE 7

TARGETS FOR AVERAGE CUSTOMER MINUTES LOST BY DISTRIBUTION COMPANY AND YEAR

	Actuals				Target				
	2001/02	2002/03	2003/04		2005/06	2006/07	2007/08	2008/09	2009/10
CN - Midlands	116.9	100.9	100.3		102.3	98.5	94.7	91.0	87.2
CN - East Midlands	87.0	78.5	84.8		80.1	76.7	73.4	70.0	66.7
United Utilities	61.7	65.6	57.4		59.8	58.1	56.4	54.7	53.0
CE - NEDL	83.9	67.7	65.8		71.4	70.4	69.4	68.4	67.4
CE - YEDL	72.6	66.2	71.8		68.5	66.8	65.1	63.4	61.7
WPD - South West	78.6	57.9	50.2		62.2	62.2	62.2	62.2	62.2
WPD - South Wales	83.3	69.5	63.8		72.2	72.2	72.2	72.2	72.2
EDF - LPN	40.8	41.7	38.2		40.2	40.1	40.1	40.1	40.0
EDF - SPN	93.3	77.4	86.7		81.4	77.0	72.6	68.2	63.8
EDF - EPN	77.5	74.6	73.4		73.7	72.2	70.6	69.1	67.6
SP Distribution	61.8	70.3	73.4		64.9	61.2	57.6	54.0	50.4
SP Manweb	50.2	49.9	61.0		51.8	49.9	48.0	46.1	44.2
SSE - Hydro	135.6	79.6	75.6		95.9	94.9	93.9	93.0	92.0
SSE - Southern	95.8	78.8	76.2		82.0	80.5	78.9	77.4	75.8
Average	79.7	70.8	71.1		71.8	69.8	67.8	65.8	63.8

Source: OFGEM 2004f, p. 17

FIGURE 9
INCENTIVE PAYMENTS/PENALTIES FOR INTERRUPTIONS AND MINUTES LOST BY DISTRIBUTION COMPANY AND YEAR

Incentive rates for the number of customers interrupted per 100 customers (£m/CI – 02/03 prices)						
DNO	2005/6	2006/7	2007/8	2008/9	2009/10	2004/5 IIP incentive rate
CN – Midlands	0.10	0.11	0.11	0.11	0.11	0.06
CN – East Midlands	0.15	0.15	0.15	0.15	0.16	0.09
United Utilities	0.18	0.18	0.18	0.19	0.19	0.13
CE – NEDL	0.10	0.10	0.10	0.10	0.10	0.06
CE – YEDL	0.13	0.14	0.14	0.14	0.14	0.08
WPD - South West	0.10	0.10	0.10	0.10	0.11	0.07
WPD - South Wales	0.07	0.07	0.07	0.08	0.08	0.03
EDF – LPN	0.29	0.30	0.30	0.31	0.31	0.24
EDF – SPN	0.09	0.09	0.09	0.10	0.10	0.05
EDF – EPN	0.15	0.15	0.16	0.16	0.17	0.10
SP Distribution	0.23	0.23	0.23	0.23	0.23	0.13
SP Manweb	0.18	0.18	0.18	0.18	0.18	0.11
SSE - Hydro	0.08	0.08	0.08	0.09	0.09	0.04
SSE - Southern	0.18	0.18	0.18	0.19	0.19	0.11
Average	0.15	0.15	0.15	0.15	0.15	0.10

Incentive rate for the number of customer minutes lost per customer (£m/CML)						
DNO	2005/6	2006/7	2007/8	2008/9	2009/10	2004/5 IIP incentive rate
CN – Midlands	0.14	0.15	0.15	0.16	0.17	0.10
CN – East Midlands	0.18	0.19	0.20	0.21	0.23	0.17
United Utilities	0.22	0.23	0.23	0.24	0.25	0.16
CE – NEDL	0.13	0.13	0.14	0.14	0.14	0.08
CE – YEDL	0.17	0.18	0.18	0.19	0.20	0.16
WPD - South West	0.17	0.17	0.17	0.18	0.18	0.13
WPD - South Wales	0.12	0.12	0.12	0.12	0.13	0.05
EDF – LPN	0.33	0.33	0.34	0.35	0.35	0.25
EDF – SPN	0.12	0.13	0.14	0.15	0.16	0.09
EDF – EPN	0.23	0.24	0.25	0.25	0.26	0.17
SP Distribution	0.27	0.28	0.30	0.33	0.35	0.14
SP Manweb	0.20	0.21	0.22	0.23	0.24	0.12
SSE – Hydro	0.10	0.11	0.11	0.11	0.11	0.04
SSE - Southern	0.24	0.25	0.26	0.27	0.28	0.15
Average	0.19	0.19	0.20	0.21	0.22	0.13

Source: OFGEM 2004f, page 19.

FIGURE 10

Mass. DTE's SQ Plans

	Performance Measure	Weight	Penalty or Offset
Operations	Frequency of outages	22.5%	$3.0 M
	Duration of outages	22.5%	3.0 M
Customer Service	On cycle meter reads	10%	1.3 M
	Timely call answering (w/in 20 seconds)	10%	1.7 M
	Service appointments met	10%	1.7 M
	Complaints to regulators	5%	0.7 M
	Billing Adjustments	5%	0.7 M
Safety	Lost Work Time Accidents	10%	1.3 M
	Risk/Reward Potential	100%	$13.4 M *

* Based on 2% of T&D revenues (using Mass Electric as an example)

Source: Massachusetts Electric Company

created to own, maintain, operate and invest in the England and Wales transmission network. It was originally owned by the distribution companies but was spun off as an independent company in 1995. NGC is subject to regulation by OFGEM. Separate but compatible incentive regulation mechanisms are applied to the transmission owner (TO) and system operating functions (SO). These regulatory mechanisms effectively yield values for the target revenues NGC is permitted to earn from charges made to generators, electricity suppliers and distribution companies for transmission service and system operations. These mechanisms define the aggregate revenues that NGC is allowed to earn in each period --- the incentive mechanism defines the average price <u>level</u> for transmission service.

The allowed aggregate revenues determined through the regulatory process are then be recovered through a set of prices for the services provided by NGC. Transmission customers (generators and retail suppliers) pay NGC for the aggregate operating and capital costs allowed for the transmission network defined by the basic incentive mechanism pursuant to a regulated tariff.[15] The tariff has two basic components. The first is a "shallow" connection charge that allows NGC to recover the capital (depreciation, return on investment, taxes, etc) and operating costs associated with the facilities that support each specific interconnection (now using the "Plugs" methodology). The second component of the transmission tariff is composed of the Transmission Network Use of System Charges (TNUoS). (NGC 2004a,b,c). The SO revenues defined by the SO incentive mechanism are then recovered as surcharges on the price of energy delivered to each transmission customer, reflecting variations in these charges at different points in time.

Thus, the general <u>level</u> of charges are set to allow NGC to recover its cost-of-service based "revenue requirement" or "allowed revenues" as adjusted through the incentive regulation mechanism that I will discuss presently. The <u>structure</u> of the TNUoS charges provides for price variation by location on the network based upon (scaled) differences in the incremental costs of injecting or receiving electricity at different locations as specified in the Investment Cost Related Pricing Methodology. The regulator determines the structure of the charges whose level is adjusted each year to yield NGC's allowed aggregate revenues. The objective of this pricing mechanism is stated to be: "... efficient economic signals are provided to Users when services are priced to reflect the incremental costs of supplying them. Therefore charges should reflect the impact that Users of the transmission system at different locations would have on National Grid's costs, if they are to increase or decrease their use of the system. These costs are primarily defined as the investment costs in the transmission system, maintenance of the transmission system and maintaining a system capable of providing a secure bulk supply of energy." (NGC 2004a,b,c). So, for example, generators pay significantly higher transmission service costs in the North of England than in the South (where the prices may be negative) because there is congestion from North to South and "deep" transmission network reinforcements are more likely to be required to accommodate new generation added at various locations in the North but not in the

[15] http://www.nationalgrid.com/uk/ click "charging".

real cost of debt and equity capital and a debt/equity ratio are defined and applied to the RAV to yield the allowed rate of return component of capital charges for each year of the price control period. The values for allowable O&M expenditures during the future price control period are defined and added to each year's capital charges (depreciation, allowed rate of return on investment, and capital related taxes). A target rate of productivity improvement in operating costs --- the "x" factor --- is included in the forecast of allowable real operating costs, or alternatively, the year one allowed operating costs are adjusted by the x factor chosen by OFGEM, in addition to the RPI inflation adjustment over time.

Statistical benchmarking is very difficult for transmission networks. There is only one transmission network in England and Wales. The composition of a particular transmission network depends on many variables, including the distribution of generators and load, population density, geographic topography, the attributes and age of the legacy network's components and various environmental constraints affecting siting of new lines, transformers and substations. Comparable cost and performance data are also not collected across transmission networks. Indeed there is no standardization of where the transmission network ends and the distribution network begins. In the UK, the transmission network includes network elements that operate at 270kv and above. In the U.S. and France transmission includes network elements that operate down 60kv. Thus, "transmission" includes different types of facilities with different costs and different performance attributes in these two sets of countries. Benchmarking one against the other would not be very meaningful. In the U.S. there is no systematic collection of data on transmission network performance measures (U.S. Energy Information Administration 2004). Accordingly, opportunities for relying on statistical benchmarking are not yet available in the U.S. because the necessary data are not collected and the value of x is determined through a regulatory consultation process rather than through statistical benchmarking studies based on NGC's forecasts of O&M requirements, wage escalation, and various engineering studies of the physical needs of the network and the costs of alternative methods to respond to them performed for OFGEM by independent consultants. Transmission service customers participate in this consultation process as well. (I suppose that the phrase "consultation process" sounds better than "rate case," but they are effectively the same animals.)

The allowed operating and capital cost values are expressed at the price levels prevailing at the time the price review is complete and then are escalated automatically during the price control period according to the RPI. Unbudgeted capital expenditures during the price review period can be considered in the next price review, though NGC may be at risk for amortization charges during the period between reviews. Underspending on capital may also be considered in next price review and adjustments made going forward. After a five year (or longer) period another price review is commenced, the starting price is reset to reflect then-prevailing costs, and new adjustment parameters defined for the next review period.[17]

[17] There is also an incentive regulation mechanism that governs network losses that involves annual adjustments in the benchmark.

FIGURE 13

MENU OF SO INCENTIVE CONTRACTS FOR 2005-06

Proposed value[6]	Option 1	Option 2	Option 3
Target	£480 million	£500 million	£515 million
Upside sharing factor	60%	40%	25%
Downside sharing factor	15%	20%	25%
Cap	£50 million	£40 million	£25 million
Floor	-£10 million	-£20 million	-£25 million

Ofgem also outlined a potential revision to the treatment of transmission losses within the SO incentive scheme, which entailed a move from a gross to a net transmission losses scheme. Ofgem considered that the introduction of a net transmission losses scheme should be considered, as it better reflects the true balancing costs to which the market is exposed.

Source: OFGEM 2005, Summary, page 3.

FIGURE 14

FINAL SYSTEM OPERATOR INCENTIVE SCHEME 2005-06

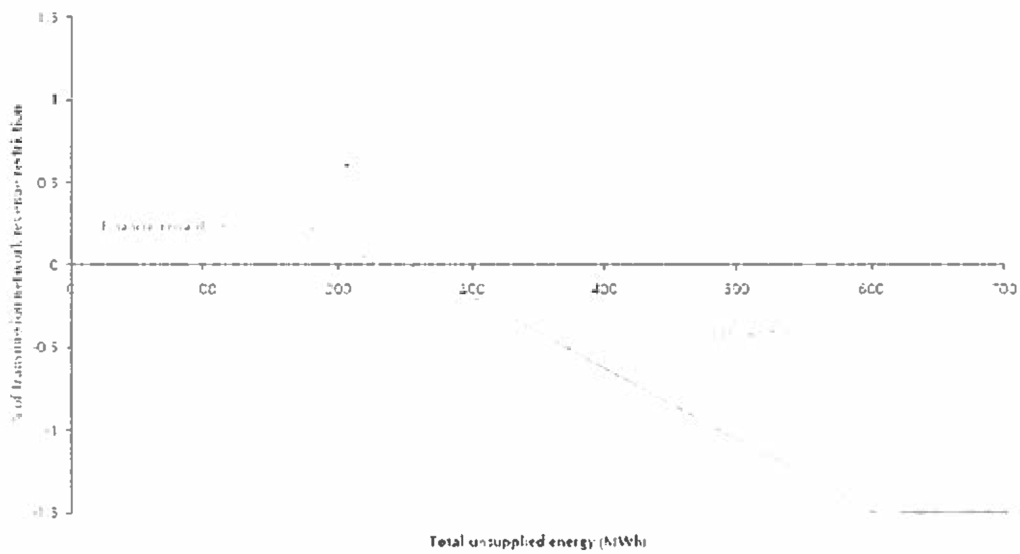
Proposed value	2005/06 Final Proposals
Target	£377.5 million
Upside sharing factor	40%
Downside sharing factor	20%
Cap	£40 million
Floor	-£20 million

Ofgem considers that the Final Proposals for the 2005/06 SO incentive scheme provide NGC with an appropriate balance of risk and reward which is in the interests of customers, who ultimately pay for the costs of system operation.

Source: OFGEM 2005, Summary, page 5.

FIGURE 16

SLIDING SCALE STRUCTURE



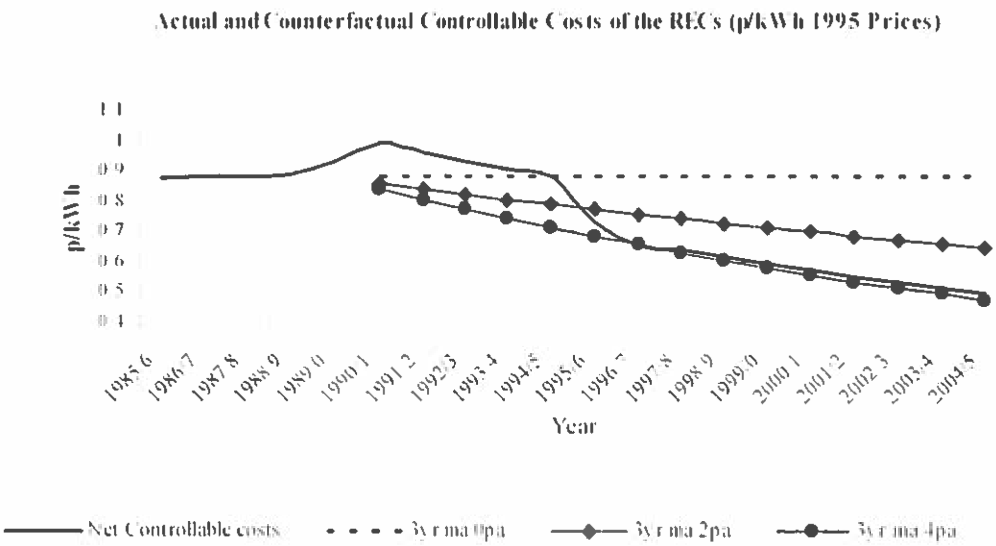
Source: OFGEM 2004h, page 29.

g. Reflections on price cap regulation vs. cost of service regulation in practice

The basic price-cap regulatory mechanism used to regulate electricity, gas and water distribution and transmission companies in the UK, is often contrasted with characterizations of cost-of-service or "cost plus" regulation that developed in the U.S. during the 20th century. However, I believe that there is less difference than may first meet the eye. The UK's implementation of a price cap based regulatory framework is best characterized as a combination of cost-of-service regulation, the application of a high powered incentive scheme for operating costs for a fixed period of time, followed by a cost-contingent price ratchet to establish a new starting value for prices. The inter-review period is similar to "regulatory lag" in the U.S. context (Joskow 1972, 1974, Joskow and Schmalensee 1986) except it is structured around a specific RPI-x formula that employs forward looking productivity assessments, allows for automatic adjustments for inflation and has a fixed duration. A considerable amount of regulatory judgment is still required by OFGEM. The regulator must agree to an appropriate level of the starting value for "allowable" O&M as well as a reasonable target for improvements in O&M productivity during the inter-review period. The regulator must also review and approve investment plans ex ante and make judgments about their reasonableness ex post, though investment programs that fall within budgeted values are unlikely to be subject to ex post review. It does this without statistical benchmarking studies which are unavailable. An allowed rate of return must be determined as well as compatible valuations of the rate

The most comprehensive study of the post reform performance of the regional electricity distribution companies in the UK (distribution and supply functions) has been done by Domah and Pollitt (2001). They find significant overall increases in productivity over the period 1990 to 2000 and lower real "controllable" distribution costs compared to a number of benchmarks. See Figure 17. However, controllable costs and overall prices first rose in the early years of the reforms before falling dramatically after 1995. The first application

FIGURE 17



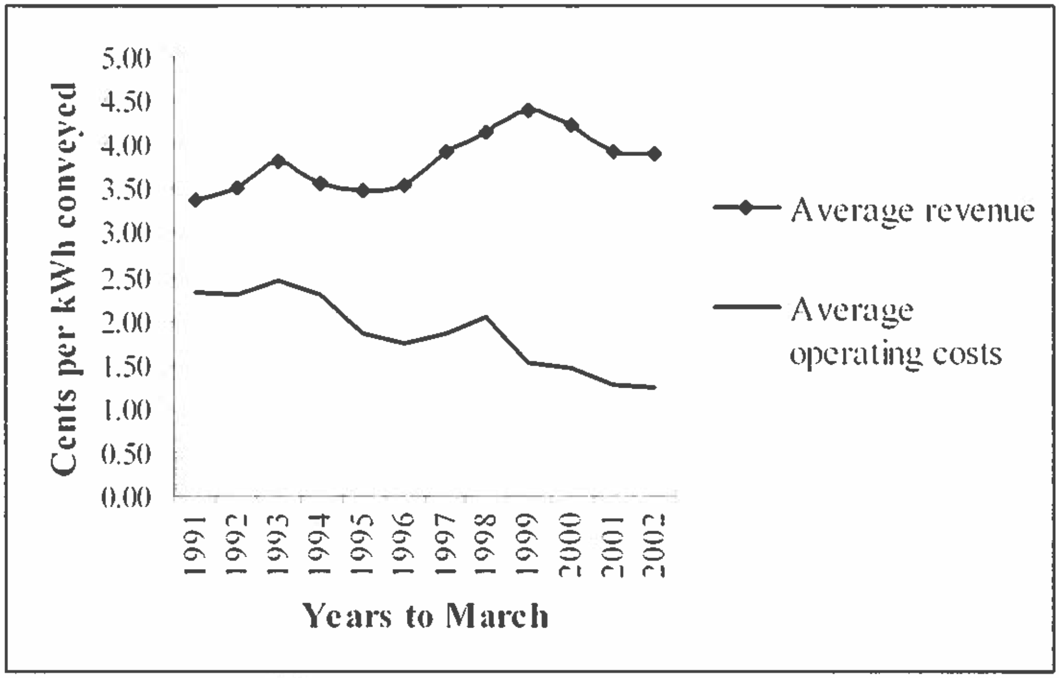
Source: Domah and Pollitt (2001). p. 21

of price cap mechanisms to the RECs in 1990 was too generous (average of RPI+ 2.5%) and a lot of rent was left on the table for the RECs' initial owners (who cleverly soon sold out to foreign buyers). Subsequent price cap mechanisms placed much more cost pressure on the RECs and stimulated large increases in realized productivity and falling distribution charges.

Bertram and Twaddle (2005) provide an interesting analysis of the combined effects on the prices charged for distribution service resulting from capital asset valuation decisions and the impacts of price cap-type regulation on the operating costs of distribution networks. When sector restructuring takes place one decision that must be made is how to value the assets of the distribution and transmission companies that will be used for regulatory purposes going forward: that is, how the rate base or RAV of the capital stock will be valued. The typical approach has been to carry forward the existing depreciated book value of historical investments in transmission and distribution into the new liberalized regime so that the base level of distribution and transmission charges associated with the recovery of capital-related charges does not change as a consequence

FIGURE 18

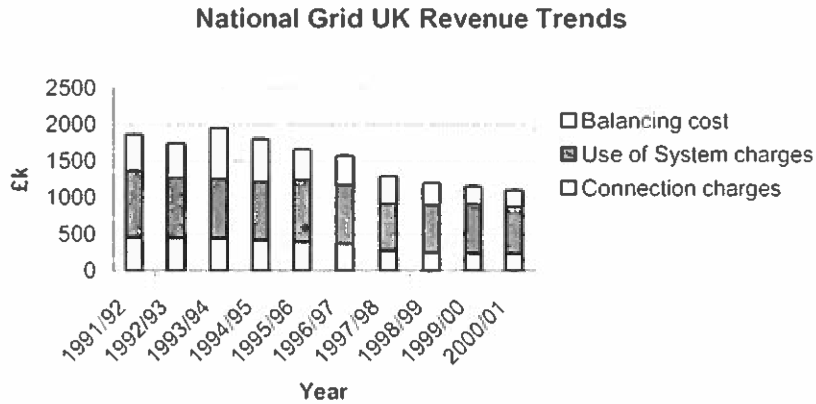
DISTRIBUTION NETWORK PRICES AND COSTS IN NEW ZEALAND



Source: Bertram and Twaddle (2005)

Distribution service quality, at least as measured by supply interruptions per 100 customers and average minutes of service lost per customer, has improved as well in the UK since the restructuring and privatization initiative in 1990. This suggests that incentive regulation has not led, as some had feared, to a degradation in these dimensions of service quality. See Figure 19.

FIGURE 20



Source: National Grid Company

The organizational and regulatory arrangements that characterize the system in England and Wales are generally viewed to have been quite successful in supporting competitive wholesale and retail power markets with a transmission system that has attractive operating and investment results. During the period, demand grew, about 25,000 Mw of new generating capacity entered the system, and almost an equal amount was retired (UK Department of Trade and Industry 2002). Power flows changed significantly on the network. While network investment is cyclical, following cycles of generation additions and retirements, intra-control area investment post-restructuring has increased significantly compared to intra-control area investment pre-restructuring (Figure 21), while congestion costs have declined significantly since 1994. Network losses have declined and system reliability has been maintained. A more formal assessment of performance is difficult because it very challenging to define a counterfactual for comparison purposes.

information burden to implement incentive regulation mechanisms well is similar to that for traditional cost of service regulation.

What distinguishes incentive regulation in practice from traditional cost of service regulation is that this information is used more effectively, looking forward rather than backward, and recognizing that regulators have imperfect and asymmetric information that makes the use of regulatory mechanisms that clearly recognize the associated adverse selection and moral hazard problems and are designed to mitigate them. The proof of the pudding must ultimately lie in analyses of the performance of alternative regulatory mechanisms. More work needs to be done on the performance of incentive regulation mechanisms applied to electric distribution and transmission system.

2. Incentive regulation in practice is clearly an evolutionary process. One set of mechanisms is tried, their performance assessed, additional data and reporting needs identified, and refined mechanisms developed and applied. This type of evolutionary process seems to me to be inevitable. However, to the extent that changes in regulatory mechanisms are contingent on past performance, this kind of evolutionary process raises credibility issues and may lead to strategic behavior of firms that are playing a repeated game with their regulators. Theoretical work that more accurately captures these adaptation properties of incentive regulation in practice would be desirable.

3. Price cap mechanisms are the most popular form of incentive regulation used around the world, in part because this mechanism has been heavily advertised as being simple alternative to cost of service regulation. There is a lot of loose and misleading talk about the application of price caps in practice. From a theoretical perspective the infatuation with price caps as incentive devices is surprising since price caps are almost never the optimal solution to the tradeoff between efficiency and rent extraction when the regulator must respect the regulated firm's budget-balance constraint (Schmalensee 1989) and raise service quality issues. However, price caps in practice are not like "forever" price caps in theory. There are ratchets every few years which reduce the power of the incentive scheme and make it easier to deal with excessive or inadequate rents left to the firm. They are not so simple to implement because defining the relevant capital and operating costs and associated benchmarks is challenging. Price caps are also typically (eventually) accompanied by other incentive mechanisms to respond to concerns about service quality. Evaluating the performance of price cap mechanisms without taking account of the entire portfolio of incentive mechanisms in place can lead to misleading results. Effective implementation of a good price cap mechanism with periodic ratchets requires many of the same types of accounting, auditing, capital service, and cost of capital measurement protocols as does cost of service regulation. Capital cost accounting and investment issues have received embarrassingly little attention in both the theoretical literature and applied work on price caps and related incentive mechanisms, especially the work related to benchmarking applied to the construction of price cap mechanisms. Proceeding with price caps without this regulatory information infrastructure and an understanding of benchmarking and the treatment of capital costs, as has been the case in many developing countries following guidance from World Bank regulatory gurus, can lead to serious performance problems.

uncertain, it is better to use an imperfect estimate of the right number than a highly accurate estimate of the wrong number. Efforts need to be made to harmonize these schemes and to guard against distortions caused by differences in the effective power of the constituent components of the overall incentive mechanisms.

8. Incentive regulation mechanisms often have "deadbands," caps, and floors that place limits on the performance realizations for which the regulated firm is at risk. At first blush, the use of hard caps and floors on the realizations of sliding scale mechanisms that place kinks in the incentive structure are hard to rationalize from a theoretical perspective and appear to have poor incentive properties for realizations near to the kinks in the incentive contract. Caps and floors may be justified as reflecting outcomes that were not contemplated (bounded rationality) in the level and structure of the target performance norms and the distribution of profits around these targets. They effectively trigger renegotiation. However, it is likely that a multipart sliding scale structure that softens incentives as the cap and floor are approaches would have superior efficiency properties. We need to better understand the popular use of hard caps and floors and try to better understand their efficiency properties.

9. Our ability to use incentive regulation mechanisms effectively is dependent on the attributes of the restructuring and liberalization program of which it is part. For example, it is much easier to develop and apply an incentive regulation program to the electric transmission system in England and Wales because there is one integrated transmission owner and system operator. The balkanized ownership structure of transmission assets in the U.S., combined with the separation of system operating functions (to non-profit independent system operators) from transmission ownership, maintenance, physical operation and investment, makes the application of incentive regulation mechanisms (indeed any effective regulation mechanism) a very significant challenge. The difficulties are enhanced by the peculiar mix of federal and state regulation of transmission in the U.S. and the failure of the federal regulator to take an active role in defining performance attributes, collecting performance data and developing performance norms. FERC Order 2000 effectively assigns these responsibilities to RTO/ISO entities, but they have not taken up this challenge to date (Joskow 2005b).

10. It would be worthwhile to pursue more work on the performance of incentive regulation mechanisms on electric and gas distribution and transmission companies in all relevant dimensions. The empirical research on the performance of incentive regulation in the telecommunications sector is much more extensive than is the research on electricity and gas networks. This kind of comparative institutional work is not easy, but it needs to be done, perhaps in conjunction with benchmarking studies that include firms subject to different types of regulation.

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