

REGULATION OF THE ELECTRICITY MARKET

INCENTIVE REGULATION FOR ELECTRICITY NETWORKS*

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Effective regulation of the terms and conditions of network access, network interconnection and delivery prices, network investment and network service quality have been important components of all successful electricity sector liberalization programs around the world. The benefits of a good regulatory framework include lower network service costs, improvements in service quality, investment to expand the infrastructure to support changes in the level and geographic configuration of demand and generation and the development of good network platforms to support robust competitive wholesale and retail markets.

In what follows I will assume that effective electricity sector restructuring and unbundling mechanisms have been put in place so that there are clearly defined distribution and transmission network entities offering unbundled delivery and network support services to market participants. I will also assume that electricity networks are regulated monopolies¹ and that an independent regulator with adequate staff resources has been created to oversee the regulation of the distribution and transmission networks. The paper then focuses on the attributes of alternative types of “incentive” or “performance-based” regulation of distribution and transmission network price levels and service quality.

Theoretical considerations

The primary goal of regulation in the public interest is to stimulate the regulated firm to produce output

efficiently in the cost and service quality dimensions, to price the associated services efficiently, to produce output to meet demand with adequate levels of reliability and to achieve these goals consistent with satisfying a break-even or budget-balance constraint for the regulated firm. Much of the traditional literature on natural monopoly regulation assumes implicitly that regulators are perfectly informed about the regulated firm’s cost opportunities and demand patterns and can effectively enforce cost minimization on the regulated firm.² The literature then focuses on second-best pricing of the services provided by the regulated firm given defined cost functions, demand attributes and budget balance constraints (e.g. Ramsey-Boiteux pricing, non-linear pricing, etc.).³ The traditional literature has not focused on incentives to minimize costs or improve other dimensions of firm performance (e.g. service quality attributes).

In reality regulators also care about the production efficiency and service quality implications of the regulatory mechanisms they choose, and they are neither completely informed nor completely uninformed about relevant cost, quality and demand attributes faced by the regulated firm. Regulators have *imperfect* information about these firm and market attributes. Moreover, the regulated firm generally has more information about these attributes than does the regulator. Furthermore, managers have the discretion to make choices not only about input proportions but also about how hard they will work to minimize the firm’s costs or with respect to the levels of service quality. Accordingly, the regulated firm may use its information advantage (*asymmetric information*) strategically to exploit the regulatory process to increase its profits or to pursue other managerial goals, to the disadvantage of consumers (Laffont and Tirole 1993, Chapter 1.) This creates potential moral hazard (e.g. too little man-



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¹ The economic attributes of unregulated “merchant” transmission network investment are discussed in Joskow and Tirole (2005).

² An exception is the extensive theoretical and limited empirical literature following Averch and Johnson (1962), and especially after Baumol and Klevorick (1970), which examines potential distortions in input proportions caused by rate-of-return constraints emerged. The empirical foundations for these theories are discussed in Joskow and Rose (1989).

³ Braeutigam (1989).

agerial effort resulting in excessive costs) and adverse selection (e.g. prices that are too high relative to production costs), problems that effective regulatory mechanism design must address. The recent theoretical literature on incentive regulation focuses on devising regulatory mechanisms to respond to these moral hazard and adverse selection problems (Laffont and Tirole 1993; Armstrong and Sappington 2005).

Consider a situation in which the regulator is uncertain about the firm's true underlying cost and cost reduction opportunities. The regulator cannot observe the level of managerial effort expended by the firm, but the regulator can monitor accurately the firm's realized costs *ex post*. The regulated firm knows its true cost opportunities, its managerial effort and the effects of managerial effort on costs. Following Laffont and Tirole (1993, 10–19), under these assumptions we can think of two polar case regulatory mechanisms that might be applied to a monopoly firm producing a single product with a fixed quality. 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). In a dynamic setting this is equivalent to 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 (again, effectively forever). This type of regulatory mechanism can be characterized as a *fixed price* regulatory contract or, in a dynamic setting, a *price cap* regulatory mechanism.

Because prices are fixed with this mechanism (or vary based only on exogenous indices of cost drivers) and do not respond to changes in managerial effort or *ex post* cost realizations, the firm and its managers keep 100 percent of any cost reductions they realize by increasing effort. Accordingly, and ignoring service quality and investment considerations for now, this mechanism provides incentives to induce efficient levels of managerial effort and cost reduction. However, because the regulator must ensure that any regulatory mechanism it imposes on the regulated firm meets a budget balance constraint, when the regulator is uncertain about the regulated firm's true cost opportunities she 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 but high) realized costs. Accordingly, while a fixed price mechanism does well from the perspective of providing incentives to reduce costs, it is potentially very poor at "rent extraction" for the benefit of consumers and society because prices may be too high relative to the firm's true cost opportunities.

At the other extreme, the regulator could implement a "cost of service" regulatory contract where the firm is assured that it will be compensated for all of the costs of production that it actually incurs and no more. After the firm produces, the regulator's uncertainty about whether the firm is a relatively high or a low cost opportunity firm will be resolved. And since the regulator compensates the firm only for its realized costs, there is no "rent" left to the firm or its managers in the form of excess profits. This solves the "rent extraction" or "adverse selection" problem that would arise under a fixed price contract. However, this kind of cost of service regulatory mechanism does not provide any incentives for the management to exert optimal (indeed any) effort. Even though there are no "excess profits" left to the firm, the actual costs incurred by the firm may be inefficiently high as a result of too little managerial effort. Managers now retain 0 percent of any cost savings they achieve and have no incentive to exert cost-reducing effort. Accordingly, consumers may now be paying higher prices than they would have to pay if the management could be induced to exert more effort to reduce costs. 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 regulated firms.

Fixed-price contracts (or price caps) are good at providing incentives for managerial efficiency and cost minimization but bad at extracting the benefits of the lower costs for consumers. Cost of service contracts are good at aligning prices and costs but the costs will be excessive due to suboptimal managerial effort. Perhaps not surprisingly, the optimal regulatory mechanism in the presence of imperfect and asymmetric information will lie somewhere between these two extremes. It will have a form similar to a *profit sharing* contract or a *sliding scale* regulatory mechanism where the price that the regulated firm can charge is *partially* responsive to or contingent on changes in realized costs and *partially* fixed *ex ante* (Schmalensee 1989; Lyon 1996). More generally, by offering the regulated firm a *menu* of cost-contin-

gent regulatory contracts with different cost sharing provisions, the regulator can do even better than if it offers only a single profit sharing contract (Laffont and Tirole 1993).

Price cap mechanisms in practice

While the theoretical literature on incentive regulation is quite rich, it still provides relatively little direct guidance for practical application in real-world circumstances. In practice, well-designed incentive regulation programs have adopted fairly simple mechanisms that reflect the basic theoretical issues discussed above.

A particular form of incentive regulation was introduced for the regulated segments of the privatized electric gas, telephone and water utilities in the UK, New Zealand, Australia and portions of Latin American as well as in the regulated segments of the telecommunications industry in the US.⁴ This mechanism chosen is the “price cap” (Beesley and Littlechild 1989; Brennan 1989; Armstrong, Cowan and Vickers 1994; Isaac (1991)). Under price cap regulation the regulator sets an initial price p_0 (or a vector of prices for multiple products). This price (or a weighted average of the prices allowed for firms supplying 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 ”.⁵ Accordingly, the price in period 1 is given by:

$$p_1 = p_0 (1 + \text{RPI} - x)$$

In theory, a “forever” price cap mechanism is a high-powered “fixed price” regulatory contract that 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) given the level of the price cap. As already noted, however, when the regulator has imperfect informa-

tion about the firm’s cost opportunities and must meet a budget balance constraint, pure “forever” price cap mechanisms are not optimal from the perspective of an appropriate tradeoff between efficiency incentives and rent extraction (Schmalensee 1989) and would leave too much rent to the firm with “average” cost characteristics. Finally, any incentive regulation mechanism that provides incentives only for cost reduction also potentially creates incentives inefficiently to reduce service quality when service quality and costs are positively related to one another.

In practice, “forever” price caps are not typically used in the regulation of distribution and transmission network price levels. Some form of cost-based regulation is used to set an initial value for 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 process to reset or “ratchet” prices based partially on costs realized during the previous period. In addition, price caps are often only one component of a larger portfolio of incentive mechanisms that include quality of service incentives, as discussed in the next section. Finally, regulated electric distribution and transmission network firms’ ability to determine the structure of prices for different types of customers or for services provided at different locations on the network under an overall revenue cap is typically limited. As a result, price caps are properly thought of as cost and quality incentive mechanism not as a mechanism to induce optimal second-best pricing of various network services.

A natural question to ask about price cap mechanisms is where does “ x ” (and perhaps p_0) come from? In England and Wales and some other countries, statistical benchmarking methods have come to be used to help to determine the relative efficiency of individual firms’ operating costs and service quality compared to their peers. This information can then be used as an input to setting values for both p_0 and x (Jamansb and Pollitt 2001 and 2003; OFGEM 2004a) to provide incentives for those far from the efficiency frontier to move toward it and to reward the most efficient firms in order to induce them to stay on the efficiency frontier. In effect this is an application of yardstick regulation (Shleifer 1985).

⁴ The US is behind many other countries in the application of incentive regulation principles to electric distribution and transmission, though their use is slowly spreading beyond telecommunications.

⁵ 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.

Although it is not discussed too much in the theoretical or empirical literature on price caps, capital-related costs are handled quite differently from operating costs in the establishment and resetting of p_0 and x . The limited attention paid to capital-related costs in the academic literature provides a potentially misleading picture of the challenges associated with implementing a price-cap mechanism effectively. This is the case for several reasons. First, in practice, the p_0 and x values must be developed based not only on a review of the relative efficiency of each firm's operating costs, but also based on the value of the firm's current capital stock or rate base, 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 debt/equity ratio, tax allowances and other variables to turn capital stocks into prices for capital services over time. The capital cost related allowances represent a large fraction of the total price (p_0) of supplying unbundled electricity network services so the choices of these parameters for defining capital user charges are very important. Second, allowances for capital-related costs are established through more traditional utility planning and cost-of-service regulatory accounting methods including the specification of a rate base (or regulatory asset value), depreciation rates, debt and equity costs, debt/equity ratios, tax allowances, etc. This is the case because the kinds of statistical benchmarking techniques that have been applied to operating costs have not been developed for capital-related costs, due to significant heterogeneity between firms in terms of the age of assets, geography, service quality, lumpiness of capital investments and other considerations. Third, the efficiency properties of a regulatory mechanism that mixes competitive benchmarking with more traditional forward-looking rate of return regulation are more complex than first meets the eye (Acemoglu and Finkelstein 2006). Thus, the implementation of price cap mechanisms is more complicated than is often implied and places a significant burden of information collection, auditing and analysis on regulators. It involves the application of elements of traditional cost of service regulation, yardstick regulation and high-powered "fixed price" incentives.

The challenge of forecasting future investment needs and costs for electricity network firms has historically been a rather contentious process, sometimes yielding significant differences between what the regulated firms claim they need and what the regulator

claims they need to meet their legal responsibilities to provide safe and reliable service efficiently. In the most recent price review in the UK, the regulator adopted an innovative approach involving a "menu" of sliding scale mechanisms to resolve the asymmetric information problem faced by the regulator as she tries to deal with differences between the firms' claims and the consultants' claims (OFGEM 2004b) about future capital investment requirements to meet reliability targets. The sliding scale menu allows firms to choose between getting a lower capital expenditure allowance but a higher powered incentive (and a higher expected return on investment) that allows them to retain more of the cost reduction if they can beat the target expenditure levels or a higher capital expenditure allowance combined with a lower powered sliding scale mechanism and lower expected return (OFGEM 2004b). This is an application of Laffont and Tirole's menu of cost-contingent contracts mechanism and provides a more effective way to deal with the imperfect and asymmetric information conditions and associated adverse selection problems than the traditional approach of offering a single regulatory contract.

An example of the use of profit-sharing or cost-contingent form of incentive regulatory mechanisms can be found in the incentive mechanism that has been applied to the costs of the transmission system operator (SO) in England and Wales, which is also the transmission owner (TO), though there are separate regulatory mechanisms for SO and TO functions. Each year forward targets are established for the costs of system balancing services and system losses (OFGEM 2005). A sharing or sliding scale formula is specified which places the TO at risk for a fraction (e.g. 30 percent) of deviations from this benchmark (up or down) with caps on profits and losses. There is also a cap and a floor. In recent years the SO was given a menu of three alternative incentive arrangements with different sharing fractions and different caps and floors (with costs of service as a default) from which to choose. If the SO were to choose the cost-of-service default, it would suggest that in constructing the menu, the regulator had underestimated the range of the SO's future cost realizations.

Service quality incentives

As noted earlier, 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. Accordingly, price cap mechanisms are increasingly accompanied by a set performance standards and associated penalties and rewards for the firm for falling above or below these performance norms. Similar mechanisms are used by several US states and in other countries that have liberalized their electricity sectors (e.g. New Zealand, Netherlands, and Argentina).

In the UK, the regulator (OFGEM) has developed several incentive mechanisms targeted at various dimensions of distribution network service quality (OFGEM 2004b; 2004c). 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. OFGEM uses statistical and engineering benchmarking studies and forecasts of planned maintenance outages to develop targets for the number of customer outages and the average number of minutes per outage for each distribution company.

Until recently in the UK there was no formal incentive mechanism that applied to transmission system reliability – network failures that lead to administrative customer outages or “unsupplied energy.” In 2005, a new incentive mechanism that focuses on the reliability of the transmission network as measured by the quantity of “unsupplied energy” resulting from transmission network outages went into effect (OFGEM 2004d). NGC is assessed penalties or receives rewards when outages fall outside of a “dead-band” of ± 5 percent defined by the distribution of historical outage experience (and with potential adjustments for extreme weather events), using a sliding scale with a cap and a floor on the revenue impact.

Performance attributes

Incentive regulation has been promoted as a straightforward and superior alternative to traditional cost of service or rate of return regulation. In practice, incentive regulation is more a complement to than a substitute for traditional approaches to regu-

lating network monopolies. In some ways it is more challenging. Incentive regulation in practice requires a good accounting system for capital and operating costs, cost reporting protocols, data collection and reporting requirements for dimensions of performance other than costs. Capital cost accounting rules are necessary, a rate base for capital must still be defined, depreciation rates specified and an allowed rate of return on capital determined. Comprehensive “rate cases” or “price reviews” are still required to implement “simple” price cap mechanisms. Planning processes for determining needed capital additions are an important part of the process of setting total allowed revenues going forward. Performance benchmarks must be defined and the power of the relevant incentive mechanisms determined.

The information burden to implement incentive regulation mechanisms well is certainly no less than for traditional costs of service regulation. What distinguishes incentive regulation in practice from traditional costs of service regulation is that this information is used more effectively. Whether the extra effort is worth it depends on whether the performance improvements justify the additional effort.

Unfortunately, there has been relatively little systematic analysis of the effects of the application of incentive regulation mechanisms on the performance of electric distribution and transmission companies.⁶ Improvements in labor productivity and service quality have been documented for electric distribution systems in England and Wales, Argentina, Chile, Brazil, Peru, New Zealand and other countries (Newbery and Pollitt 1997; Rudnick and Zolezzi 2001; Bacon and Besant-Jones 2001; Estache and Rodriguez-Pardina 1998; Pollitt 2004). However, most of these studies have focused on developing countries where the pre-reform levels of performance were especially poor prior to restructuring. Moreover, it is difficult to disentangle the effects of privatization, restructuring and incentive regulation from one another.

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 found significant overall increases in productivity over the period 1990 to 2000 and lower real

⁶ There is a much more extensive body of empirical work that examines the effects of incentive regulation mechanisms, primarily price caps, on the performance of telecommunications firms.

“controllable” distribution costs compared to a number of benchmarks. However, controllable costs and overall prices first rose in the early years of the reforms before falling dramatically after 1995 and the first application of price cap mechanisms to the distribution networks in 1990 was too generous (average of RPI + 2.5 percent) and a lot of rent was initially left on the table for the RECs’ initial owners (who cleverly soon sold out to foreign buyers). Distribution service quality in the UK, 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 deterioration in these dimensions of service quality.

The experience with the transmission system operator (SO) incentive mechanism in England and Wales also provides a good example of how incentive regulation can improve performance. During the first few years following the restructuring of the electricity sector in England and Wales in 1990, the SO recovered the costs of system balancing, including managing congestion and other network constraints through a simple cost pass-through mechanism. The SO’s costs escalated rapidly, growing from about \$75 million per year in 1990/91 to almost \$400 million per year in 1993/94. After the introduction of the SO incentive scheme in 1994, these costs fell to about \$25 million in 1999/2000. OFGEM estimates that NGC’s system operating costs fell by about £400 million between 1994 and 2001. A new SO incentive scheme was introduced when NETA went into operation in early 2001. The SO’s costs have fallen by nearly 20 percent over the three year period since the new scheme was introduced (OFGEM 2003).

While more work needs to be done on the performance of incentive regulation mechanisms applied to electric distribution and transmission systems, the experience so far is very encouraging.

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