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Strategic Behaviour under Regulation Benchmarking

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Abstract

Liberalisation of generation and supply activities in the electricity sectors is often followed by regulatory reform of distribution networks. In order to improve the efficiency of distribution utilities, some regulators have adopted incentive regulation schemes that rely on performance benchmarking. Although regulation benchmarking can influence the "regulation game", the subject has received limited attention. This paper discusses how strategic behaviour can result in inefficient behaviour by firms. We also present a survey of issues encountered by electricity regulators. We then use the Data Envelopment Analysis (DEA) method with US utility data to examine implications of selected cases of strategic behaviour. The results show that gaming can have significant effects on the measured performance and profitability of firms.

Key words: gaming, strategic behaviour, regulation, benchmarking, electricity
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STRATEGIC BEHAVIOUR UNDER REGULATION BENCHMARKING

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1. Introduction

From the early 1990s, many countries throughout the world have liberalised their electricity industries, transforming their structure and changing the rules governing their operation. An important aspect of this development has been the establishment of regulatory agencies or, where a regulator already existed, a shift from overseeing the operation of centralised sectors with vertically integrated utilities operating under rate-of-return (ROR) regulation, to overseeing the operation of decentralised sectors with unbundled activities. In the liberalised sectors, the potentially competitive generation and supply activities operate in a market-oriented environment. Transmission and distribution networks, generally viewed as natural monopolies, have also undergone regulatory reform.

Strategic behaviour of regulated firms, including electric utilities, is extensively discussed within the context of ROR regulation and the existence of asymmetric information between firm and regulator (see e.g. Armstrong and Cowan et al., 1994; and Vickers and Yarrow, 1988). More recently, the strategic behaviour of generating companies in the form of exercising market power in wholesale electricity markets of liberalised sectors, has attracted considerable interest. Market power in wholesale electricity markets can arise from ownership concentrations, lack of access to, and constraints in, transmission networks, tight supply-demand conditions, and flawed trading and regulatory arrangements. This interest has arisen from the failure of reform design to ensure effective competition in some countries, the recent electricity crisis in California, and to some extent the collapse of energy trader Enron (see e.g. Borenstein, Bushnell, and Wolak, 2002; and Joskow and Kahn, 2002).

At the same time, in the post reform era some jurisdictions have moved away from ROR regulation of transmission and distribution utilities and adopted incentive-based models. Some regulators, in particular in Europe and Australia, have adopted benchmarking as a tool in the incentive regulation of network utilities (Jamasb and Pollitt, 2001). This development has effected the nature of the "regulation game" played between regulator and utilities. This emerging aspect of regulation gaming or strategic behaviour has received relatively little attention.

In this paper we focus on strategic behaviour, or gaming, in the context of benchmarking in incentive-based regulation of distribution utilities. We refer to strategic behaviour or gaming as *type of behaviour that aim to increase profits without achieving real efficiency gains, i.e.* they defy the incentive purpose of benchmarking, the regulatory objectives of efficient operation, and protection of public interest. It should be noted that "gaming" behaviour is not necessarily illegal and should be viewed within the regulatory

[*] The views expressed are those of the author and do not necessarily represent the views of REMU NV. Authors would like to thank Liz McIsaac for her contribution to research for the survey and other valuable help throughout this paper.

context, as the optimisation process must remain within general accounting, fiscal, legal, and corporate governance statutes and policies.

In this study we identify and examine the ways in which benchmarking can influence firms' behaviour and we attempt to analyse the possible implications. Then utilising a data set comprising the distribution activities from a sample of US electric utilities from several states, we illustrate some strategic issues that a Public Utility Commission overseeing few electric utilities may encounter when using frontier-based benchmarking in incentive regulation. The purpose of the exercise is to examine the main issues involved and draw lessons from potential gaming that are general and applicable to other regulatory settings.

The following section reviews gaming aspects of incentive regulation and regulatory benchmarking. Section 3 presents a survey of selected electricity regulators on strategic gaming issues. Section 4 describes the Data Envelopment Analysis (DEA) technique as the benchmarking tool. Section 5 describes the data set of US electricity distribution businesses used in the study and our preferred models of analysis. Section 6 describes the main findings of our quantitative analysis of various gaming strategies on the outcome of regulatory benchmarking. Section 7 is a discussion of lessons and conclusions.

2. Gaming in Incentive Regulation Benchmarking

2.1 Incentive regulation

Asymmetric information between the regulator and the regulated firm is a key issue in the regulation of natural monopolies. Baron and Myerson (1982) and Laffont and Tirole (1986) address regulation of monopoly firms in the presence of asymmetric information in the form of unknown costs and unobservable effort to reduce costs.[1] A rather common criticism of the ROR regulation model is that it lacks incentives for efficiency improvements and encourages firms to engage in strategic behaviour. Averch and Johnson (1962) showed that ROR regulation encourages utilities to inflate their regulatory asset base through over-investment and socially inefficient resource allocation. The argument finds some parallels in the US power sector in the 1970s and 1980s where stranded costs of over-investment in generation capacity contributed to electricity price increases and, consequently, the calls for restructuring of the sector in the high-price states (Joskow, 1997).

Regulatory reform of network industries around the world has challenged the traditional ROR regulation, as regulators have adopted a variety of incentive-based models. These models aim to provide monopolies with the incentive to utilise their exclusive information on effort and costs to improve operating efficiency and investment decisions, and to ensure that consumers benefit from the efficiency gains.[2] In the US, incentive-based regulation is generally termed Performance-Based Regulation or Rate-Making (PBR). This interest in incentive regulation is not due to new contributions from economic theory, rather, it reflects the need and desire for new practical approaches to regulation, even

[1] See also Armstrong, Cowan, and Vickers (1994) for a review of these models.

[2] See Joskow and Shmalensee (1986) for a discussion of the main approaches to incentive regulation of electric utilities.

though these may not always be fully in line with theory (Crew and Kleindorfer, 1996, p. 215).

In this paper we focus on price/revenue cap regulation model based on the RPI-X formula.[3] Price cap regulation de-couples profits from costs by setting maximum prices for the duration of a specified regulatory lag or rate period. The utility is then allowed to retain the profits in terms of the difference between the regulated price and its actual costs during the (typically 5-year) rate period. Price cap regulation was first implemented in post-privatisation regulation of British Telecom (Littlechild, 1983). The model has since been adopted in the regulation of other sectors in Britain and in many other countries.[4]

An important feature of incentive regulation is the use of benchmarking, which can be broadly defined as the *comparison of a firm's actual performance against some pre-defined reference or benchmark performance*. A perceived advantage of benchmarking has been that it reduces the information asymmetry problem that occurs in ROR regulation by reducing the regulator's reliance on the firm's own costs, but references the price to an external non-influencable benchmark.

2.2 Regulatory Benchmarking – Methods, Techniques, and Setting of X-factors

The most contentious issue in price cap regulation is the basis for determining efficiency improvements and the translation of these into tariff changes (X-factors). Regulators have adopted a variety of benchmarking methods to arrive at X-factors and it is in the implementation of these that the regulation game may be played. For the purposes of this study, we distinguish between two types of benchmarking methods used in setting the X-factors: (i) frontier-based and (ii) non-frontier techniques.[5] This division also reflects the divide in benchmarking approaches used by, on the one hand, the European and Australian electricity regulators, and the PUCs in the United States on the other hand. The European regulators have generally adopted frontier-based benchmarking methods as the basis on which to calculate the X-factors. The PUCs that have adopted PBR have tended to use measures such as Total Factor Productivity (TFP) to calculate the efficiency requirements.

2.2.1 Frontier-Based Benchmarking Techniques

In frontier-based benchmarking, the relative performance of a firm is measured in the form of efficiency scores on a scale of 0 (lowest) to 1 (highest) against the best practice or efficient frontier of a sample of firms. Regulators then work out procedures for translating the efficiency scores into X-factors and setting initial prices for the rate period in question. The procedures that translate scores into tariffs and X-factors reflect the different objectives of regulators, such as speed of decisions, level of efficiency drive, or detail of output

[3] For the purpose of this study, unless specified, we do not differentiate between a price and a revenue cap regulation based on the RPI-X formula.

[4] See Vickers and Yarrow (1993) for a description of the methodology and implementation in Britain.

[5] The review of the methods in this section is based on Jamasb and Pollitt (2001) and Pollitt (1995). See also Coelli, Rap, and Battese (1998) and DTe (1999).

steering.[6] The most widely used frontier-based benchmarking methods are Data Envelopment Analysis (DEA), Corrected Ordinary Least Square (COLS), and Stochastic Frontier Analysis (SFA). DEA is non-parametric and identifies the efficient frontier using a linear programming technique. In DEA, the relative efficiency of a firm is computed (rather than estimated) on a scale of 0 to 1 relative to best practice or to a sample of efficient firms. The technique is briefly described in the next section.

COLS and SFA are statistical techniques that estimate the efficiency score of a firm relative to an efficient frontier. Both techniques require the specification of a production or cost function. Similar to DEA, the COLS technique assigns all deviation from the frontier to inefficiency. The efficiency scores calculated using COLS are therefore sensitive to the position of the frontier firms. SFA recognises the possibility of stochastic errors in the measurement of the inefficiencies. If there are no inefficiency measurement errors in the sample, the error assumption would result in some inefficiency being regarded as noise. Essentially, a part of the relative inefficiency is attributed to stochastic elements in the data rather than to the inefficient operation of the firm. Consequently, due to the measurement error factor, the SFA scores are likely to be higher than those measured by COLS.

2.2.2 Non-Frontier Methods

The most widely used benchmarking technique in non-frontier approaches is Total Factor Productivity (TFP). The method can, for example, use the Tornqvist index as a measure of historical productivity growth of the individual firm (internal benchmarking), the electricity sector (domestic or international), or the whole economy when setting the factor X in incentive regulation (see e.g. Coelli, Rap, and Battese, 1998). In either case, a simple Tornqvist TFP index can be expressed in terms of:

$$\text{TFP} = (\text{output index}) / (\text{input index}) \qquad (1)$$

The Tornqvist input quantity requires information on quantity and cost share of inputs for the two periods for which productivity change is calculated. Equation (2) shows the Tornqvist input quantity index from the base period *S* to period *t*. The output index is calculated in a similar way.

$$Q_{st}^{T} = \prod_{i=1}^{N} \left[\frac{x_{it}}{x_{is}} \right]^{\frac{\omega_{is}+\omega_{it}}{2}} \qquad (2)$$

where:
ω_{is} cost share of *i*-th input in period *s*
x_{it} quantity of *i*-th input in period *t*

[6] See Jamasb and Pollitt (2001) for some examples.

The implementation of TFP-related X-factors for regulatory purposes is relatively easy, but the information requirement of the approach is non-trivial. Also, a potential weakness of the approach is that less efficient firms may find it easier than efficient firms to outperform the TFP and earn large profits.[7]

A statistical average-based approach to benchmarking is the Ordinary Least Square (OLS) technique. OLS estimates the average production or cost function of a sample of firms. The actual performance of firms can then be compared to the estimated performance by substituting actual input, output, and environmental data measured into the estimated function.

In yardstick regulation, the mean of the costs of a peer group of firms can also serve as the benchmark for individual firms. In this approach, all the firms in the group are subject to the same price cap. A version of this approach has been used by the National Energy Commission (CNE) in Chile to calculate the value added for the distribution services. The value added for a group of comparable firms is derived from a designed efficient model or reference firm (see e.g. Rudnick and Donoso, 2000; Rudnick and Rainari, 1997). In Spain, the regulator has used model firms for specific geographical areas to allocate a portion of the total system revenues among distribution utilities.

Also, the sliding scale method can be viewed as a form of average benchmarking where the target ROR in the dead-band is intended to represent a fair rate of return based on the return earned by comparable industries or firms in similar operating environments. The regulated utility is, therefore, competing with the average performance in the industry or economy.

2.2.3 Other benchmarking methods

The Norwegian Water and Energy Administration (NVE) has used the Value Chain Model (VCM) for one-to-one benchmarking of the state-owned central transmission utility Statkraft against the Swedish national grid company Svenska Kraftnät. The model allows for the adjustment of data to account for operational and environmental factors.[8] There are also partial benchmarking approaches, such as the method applied in the study of electricity distribution utilities in the state of Victoria, Australia (see UMS, 1999). The method assumes separability of different cost categories and involves the comparison of firms of different scales. This drawback is potentially mitigated when the firms have similar technologies and scale. Finally, targeted incentive schemes can use average or frontier performance benchmarks to address specific aspects of operations of firms. These benchmarks may be based on the past or expected performance of the firm or industry.

From a regulatory policy point of view, a major difference between the frontier and average benchmarking is that the former has a stronger focus on performance variations between firms. Frontier methods appear suitable at initial stages of regulatory reform when a primary objective is to reduce the performance gap among the utilities through firm-

[7] The Dutch energy regulator DTe, intends to implement a generic X-factor method in the next regulatory period, starting in 2004. The generic X-factor will be based on the productivity growth of the frontier firms. See DTe (2002) for a detailed description of the proposed methodology for the next period.

[8] See Magnus and Midttun (2000) for a brief description of the method.

specific efficiency requirements. Average benchmarking methods may be used to mimic competition among firms with relatively similar costs, or when there is a lack of sufficient data and comparators for the application of frontier methods.

It should be noted that there is an important methodological difference between frontier and TFP based approaches to efficiency measurement. In the frontier-based approach, a relative efficiency score is measured for each firm relative to the efficient frontier. This results in a direct inter-dependence between a firm's efficiency measure (score) and strategic behaviour involving frontier firms in the sample. In the index number approach to TFP at sector level, each firm's benchmark is the same and can be marginally affected by own or other firms' strategic behaviour.

2.3 The nature of regulation benchmarking game

In principle, the purpose of incentive regulation is to exploit the efficiency improvement potential of the regulated firm. Regulators should recognise that their benchmarking exercise inevitably shapes the efforts, and directs considerable resources, of the firms towards the make up and variables of these models. However, while benchmarking can measure "true" performance improvements, gaming can sometimes produce illusive or "virtual" efficiency improvements by. Therefore, benchmarking models need to strike a balance between reflecting the main performance drivers of the business in question and reducing incentives for engaging in unproductive method or model-induced strategic behaviour.

This type of behaviour is rational from a firm's perspective. Optimising the regulatory process and exploiting the information advantage will maximise profits for shareholders. In cases where customers are, directly or indirectly, shareholders (e.g. co-operatives or mutuals in the strict sense, or municipal-owned), the firm's excess profits might still benefit the local consumer. However, where customers have no relation with the capital of the firm, such regulatory strategies will lead to welfare losses.

Regulated firms may attempt to influence the use of regulation benchmarking at the adoption stage. Although these efforts may not be considered as gaming, utilities may attempt to influence: (i) the use of benchmarking in incentive regulation, (ii) choice of method, model, and variables, (iii) definition of variables adopted during the consultation process, and (iv) translation of efficiency scores into X-factors. At a later stage, firms may use gaming strategies to benefit from the regulator's adopted benchmarking model.

Some regulation games are associated with the periodic aspect of ROR and incentive based regulatory reviews through timing of specific types of actions. Dynamic aspects of strategic behaviour of the firm associated with regulatory lag are known to regulators, and have been addressed by some authors (see e.g. Baumol and Klevoric, 1970; Sappington, 1980). Di Tella and Dyck (2002), in a study of the Chilean electricity distribution utilities under price cap regulation, report evidence of cyclical cost reductions that coincide with the initial years of rate periods, and the reverse prior to the next rate review.

Gaming behaviour is not only limited to private firms. Publicly-owned firms can also be motivated to pursue monetary or other performance measures. Several countries noted for the use of benchmarking, including The Netherlands, Norway, and Australia, have significant municipal or state ownership. Courty and Marschke (2002), in a study of job training agencies, show that public organisations can engage in gaming by timing their performance reports in order to benefit from awards. They show that performance incentives can come at a cost by having a negative effect on efficiency.

Broadly, it is possible to differentiate between two types of strategic behaviour. The first is behaviour that may not have a material effect on the efficient operation of the firm and is intended to present the performance of the firm in a more favourable light. For example, a firm may shift costs from operating to capital costs, or influence the choice of output variables in order to affect measured relative performance. The main undesirable outcome of such virtual efficiencies is that they result in welfare transfer from customers, or even other firms, to the gaming firm through lower efficiency targets than the true underlying efficiency would suggest.

The second type of gaming is in the form of behaviour that distorts the efficient operation and investment decisions of the firm. For example, the firm might increase its cost base or delay efficiency improvements in periods leading to a new rate case. This type of gaming results in socially inefficient resource allocation and dead-weight loss. An important concern with both of these gaming categories in frontier-based approaches is that, due to the inter-dependency between the efficiency scores, a firm's gaming can also affect the measured performance of other firms.

In cost-based DEA models the regulator may use controllable operating expenditure (OPEX) as the input variable and treat capital expenditures (CAPEX) outside of the benchmarking exercise or alternatively use total expenditures (TOTEX). This has implications for the possible strategic behaviour by firms. A firm may appear more efficient by reducing costs, as well as by appearing larger in terms of higher output variables. For example, if the benchmarking model uses OPEX as input and network length or transformer capacity as output, and is given approval for expansion plans for increasing separately treated CAPEX, it can earn a return on its capital expenditures and, at the same time, increase the output variables and hence its relative efficiency.

Alternatively, the regulator may use OPEX and CAPEX as two separate variables. This will allow the possible trade-offs between the two types of costs to be reflected in the model. It has been suggested that where OPEX is used as input variable the chosen outputs should be independent of CAPEX or adjusted to reflect their relative share of total costs (see Coelli, 2000). In general, a complicating factor in benchmarking is a question of which model specification best represents the activity of electric distribution utilities. Jamasb and Pollitt (2001) show that efficiency studies of distribution utilities have used a variety of variables and model specifications and the issue is not yet satisfactorily settled.[9]

It should be noted that the choice of benchmarking model could also serve specific regulatory objectives. For example, the choice of constant or variable returns to scale models can affect the long-term structure of the sector. The Dutch regulator has used a constant returns to scale DEA model and assumes that firms can freely adjust their scale of operations through mergers and acquisitions. Other countries value the maintenance of the number of comparators and use variable returns to scale measures (e.g. the UK). The UK regulator has estimated the cost of information loss due to mergers among electricity

[9] *In extremis* certain variables may be used as inputs in one regulatory model, whereas in other regimes they are used as outputs. For a Dutch discussion see, Nillesen and Telling (2001).

distribution utilities at £32 million and applies a corresponding reduction in regulated revenue of the merged firms over a 5-year period (OFGEM, 2002).

3. Strategic behaviour in action - A survey of electricity regulators

As discussed in the previous section a perceived advantage of incentive regulation in general, and benchmarking in particular, is that they diminish the effect of information asymmetry in regulation by reducing the reliance on the firm's own costs. A number of electricity regulators have now adopted regulation benchmarking. We have surveyed a select number of these electricity regulators on their experience with various aspects of strategic behaviour.

The survey questions are outlined in Table 1 and the returns to the questionnaires are summarised in Table 2. The survey questions are structured against the backdrop of three possible types of gaming strategies. Questions in the first category are aimed at gaming that primarily involves cost issues. These questions explore strategic behaviour through shifting of costs and assets across sectors (e.g. electricity vs. gas or water) and within the electricity sector (e.g. generation, transmission, distribution, and supply), costing rules, definitions, and rate of return by firms. Questions in the second category address issues associated with the use of benchmarking models, output variables, and information disclosure. The two questions in the third category are concerned with mergers, an issue increasingly faced by electricity regulators. We follow a similar classification in the analysis of effects of selected possible strategies.

It should be noted that determining whether certain behaviour by firms constitutes gaming is to some degree a subjective matter and therefore requires judgement. In other words, the perceived motives are often observed indirectly through their effect on the regulatory objectives or outcomes. Further, because of the complex interplay of firms and issues it is virtually impossible to isolate and predict the outcome of a particular strategy of an individual firm, making it difficult to separate cause and effect. All gaming opportunities must be conducted within the prevailing legal, accounting, fiscal and corporate governance regulations, so gaming should be seen as regulatory model optimisation, rather than fraudulent or deceptive behaviour.

3.1 Operating and capital costs

The periodic rate reviews in price cap regulation provide the regulated firm with an incentive to build-up or inflate their regulatory asset or cost base (RAB and RCB) prior to a rate review. In general, by building up the regulatory cost-base of the reference year through creating or accumulating costs, the firm can achieve a net gain by increasing its allowed revenues for the subsequent rate period. In particular, regulators in reforming countries have experienced that at the time of the unbundling of vertically integrated utilities, firms tend to shift costs and assets from potentially competitive activities to regulated businesses. The motivation is that by inflating their cost base, the firms can profit from certain allowed revenues over the rate period, a return that would not be guaranteed under competition.

The ability to influence costs is facilitated by the asymmetric information on the firm's costs and intensity of effort to reduce those costs. In addition, when capital expenditures are excluded from the benchmarking model, there is an incentive to shift assets from competitive to regulated businesses in order to secure a regulated rate of return on these assets.

As revealed in our survey, regulators have experienced a variety of cost and asset shifting strategies. Regulators A, D, and H have reported tendencies toward shifting OPEX and CAPEX to distribution business. It should be noted that Regulators D and H have used a total cost approach to benchmarking while Regulator A has only used OPEX. As shown in the table, the direction of shifting cost and assets in the activity chain to distribution has been both downwards from generation (Regulator H) and upwards from supply businesses (Regulators A and D). In addition, Regulators B and C state that requests by firms to include customer contributions in their regulatory asset base has been a source of disagreement between firms and regulator.

Accounting rules and definitions of variables do not appear to have created major disagreements among the regulators and firms, although several iterations may be required to clarify definitions – which may influence the perception of certain actions. This may partly be due to the fact that accounting procedures are universal for the firms in a given sector and therefore the relative advantage to be gained from changes in the rules is likely to be limited.[10] Indeed, in one surveyed jurisdiction where there is only a single distribution utility the accounting rules concerning the depreciation method has been an issue.

3.2 Output and other model related issues

The survey results also reveal that firms have attempted to influence the definition of outputs used in the regulators' benchmarking exercise. They have raised such issues as which proxy measures of outputs should be included in the benchmarking models and how these variables should be measured.

One frequently used output measure is the length of the network operated by the firms. Regulator D stated that some firms argued that circuit length rather than route length is the appropriate measure to represent network size, and final connections to customer should be included in this. Regulator F received a request that network length should be used as an input rather than an output. Another commonly used cost driver is the number of connections or customers they serve. Firms can also argue that the models or samples used do not accurately reflect the characteristics of their particular network. For example, a utility had argued that it is inherently different from the international comparators used in regulator B's benchmarking sample. Some firms disputed the relative weights given to different output measures in the regulator's models while others argued that DEA is more appropriate as benchmarking method. Resolving the issue of comparability can generally be addressed through the inclusion of additional discretionary or non-discretionary variables in

[10] Some discussions did take place with Regulator D over depreciation periods and the accounting treatment of customer contributions when connecting a new customer.

the model. In DEA-based models increasing the discriminatory power of models generally results in improving efficiency scores of firms.[11]

3.3 Mergers and acquisitions

The result of unbundling vertically integrated utilities, third party access to networks, and incentive-based regulatory reform, is that some distribution utilities may reassess their position in the sector and reposition themselves through mergers. The main motives are to reconfigure assets, achieve cost savings, and benefit from economies of scale. In many countries, there are a limited number of utilities and each merger reduces both the regulators' information base and potential merger partners for other firms. Nevertheless, some countries have a large number of small utilities, and mergers may be desirable.

It is difficult to determine whether, or to what extent, mergers are purely driven by gaming motives. However, it is conceivable that firms take note of the financial implications of benchmarking for the merged entity. An indicative case in our survey is that of a utility formed from the merger of three others who argued that it should be represented as one firm in the Regulator D's benchmarking, just to reconsider and ultimately withdraw the request.

The results of the survey confirm that regulators have experienced a variety of arguments or actions resulting in outcomes similar to those of gaming the regulation benchmarking. In Section 6 we use a simple framework to analyse the possible implications of selected types of strategic behaviour reported in the survey.

[11] Regulator D used two extra output variables in the benchmarking exercise in order to capture the fact that some of the network operators also owned and operated small transmission grids. The additional variables were large customers and transmission peak demand.

Table 1: Overview of survey questions

Within the context of incentive regulation, what have been major disagreements/differences between the utilities and regulator with regards to:

Category 1 – Operating and capital costs

1. Allocation of costs or assets from competitive activities (generation, supply) to regulated activities (transmission, distribution)?
2. Shifting assets between different regulatory regimes by multi-utilities?
3. Level or definition of what constitutes controllable or un-controllable operating expenditures?
4. Level or definition of what constitutes capital investments?
5. Specific aspects of regulatory accounts and rules (e.g. for depreciation and goodwill)?
6. Level of gearing or definition of financial costs as uncontrollable costs?
7. Transfer pricing or outsourcing that inflate operating costs/transfer profits to other firms (e.g. supply business) in the same group?
8. Rate of return and related issues e.g. level, calculation base, and dead-band?

Category 2 – Output related and general issues

9. (Low) levels of inputs or (high) levels of outputs when using relative comparative efficiency analysis?
10. Specific model specifications (method and variables) in relative/comparative efficiency analysis and incentive regulation?
11. Estimates/projections of important variables (e.g. demand, number of customers, investment requirements)?
12. Adverse impacts on service quality (e.g. security, reliability), DSM measures, or T&D losses?
13. Information disclosure - in general or particular types of information?

Category 3 - Mergers and acquisitions

14. Mergers and acquisitions that can affect/influence comparative efficiency analysis?
15. Treatment of goodwill or other measures that inflate prices at mergers?

Table 2: Survey returns

Question		Regulator A	Regulator B	Regulator C	Regulator D
1	**Cost & Asset Reallocation**	Yes: In OPEX reallocation when separating S from D in 2000. No: In CAPEX reallocation.	No	No	Yes: Cost allocation between S and D in power & gas. Data checking, hearings and workshops aimed to clarify definitions.
2	**Shifting Assets Between Regulators**	Issue has not been explicitly up but has potential for OPEX (less so for CAPEX).	No	Yes: Considerable amounts. Regulator states that customers have paid for much of the firms' capital base.	Yes: Between gas and electricity assets. Although data checking, hearings and workshops aim to clarify definitions.
3	**Operating Costs**	Definitions gradually less of an issue. Levels expected to remain issue.	No	No	No
4	**Capital Costs**	Less contentious than CAPEX. Level remains an issue.	No	No	No
5	**Accounting Rules**	Yes	Regulator asked to use straight-line method for depreciation. Also requested inclusion of customer capital contributions in asset base.	No	Yes: One company submitted replacement costs rather then historical costs.
6	**Gearing & Financial Costs**	Yes. Regulator assumes 50-50 debt-equity as basis for calculation of WACC.	No	No	No
7	**Transfer Pricing & Outsourcing**	Was an issue previously but less in future.	No	No	Yes: Audits are performed. Outsourcing is encouraged when improves efficiency.
8	**Rate of Return**		The approved WACC was 1.2% lower than the rate requested by utility.	The ROR is 7%. It is corrected if a firm has equity > 40% and will be lowered by 0.1% for each percentage the equity is higher.	No
9	**Input & Output Levels**	Weights of components of composite variable. Some firms argue for and some against inclusion of quality of service.		No	Yes: On network length e.g. route vs. circuit km or inclusion of final connection to customer.
10	**Model Specification**	Some opposition against COLS and support for DEA	Utility did not accept the benchmarking exercise and argued that firms in the sample were inherently different to them.	To address uncertainty in data accuracy the regulator uses aggregate data in benchmarking e.g. in the construction of a city-country correction factor in benchmarking.	No
11	**Estimate/forecasts of important variables**	Yes: investments	Utility estimate of number of new customers was 40% higher than the regulator's. The regulator then included a revenue adjustment formula for new connections.	With regard to the city vs. country correction factor there has been discussion whether to use the no. of customers or households instead of no. of meters used by the regulator.	No
12	**Adverse Effect on Quality, DSM, T/D Losses**	Gradually less important as firms' asset management tools are better developed.	No	No	Yes: Will be explicitly included in next price review.
13	**Information Disclosure**	Less of a issue now than previously		No.	Yes: Information revelation impact of regulation
14	**Strategic M&A**	Not so far but anticipated to affect future price controls	No	No	Yes: One firm initially requested to be benchmarked as 3 separate units and later wished to be considered as one firm again.
15	**Price Inflation in M&A**	Not so far but possible	No	No: Annual accounts differ form regulatory accounts.	No

Table 2: Survey returns (contd.)

Ques-tion		Regulator E	Regulator F	Regulator G	Regulator H
1	**Cost & Asset Reallocation**	Yes: ca 10% difference.	Yes (Gas) – High marketing costs due to market barriers, climate, and competitors' artificially low costs.	Yes - 10-15% of OPEX subject to potential differences in cost allocation process.	Utilities tended to shift costs and in particular assets to regulated activities (from G to D).
2	**Shifting Assets Between Regulators**	Yes: continuos changes to study basis and methods.	No	No.	Not so far. But possible in the future.
3	**Operating Costs**	Yes: ca 15%	No	Yes: Approved OPEX was 25% lower than amount requested by utilities.	No. Controls are at aggregate level.
4	**Capital Costs**	Yes - Reference firm not representative of concession area.	Yes: Difference in estimates made by the utility and technical experts	Yes – Approved CAPEX was 95% of the amount requested by firms.	No. Controls are at aggregate level.
5	**Accounting Rules**	No	Yes (Gas): Objections to accounting codes for electricity distribution utilities and legal powers of the regulator.	Yes - As in Q1.	No. Utility reports are based on generally accepted accounting principles.
6	**Gearing & Financial Costs**	Yes: ca 10%	No	No.	Financial costs are not part of controls as the focus is on operational results.
7	**Transfer Pricing & Outsourcing**	No	No	Yes - As in Q1.	Not so far. Possible in the future.
8	**Rate of Return**	No	Yes – 1 pp difference between requested and allowed market risk premium. Firms required higher regulatory uncertainty.	Yes - Rural firms requested 1% increment to WACC to reflect higher risk, asset write-off, and natural disasters.	Utilities claim efficiency improvements do not result in higher rate of return.
9	**Input & Output Levels**	Yes: No participation in the study.	No	No.	No. But reported data can be controlled.
10	**Model Specification**	Yes: No participation in the study.	Yes – Use of network length as input or output variable	Yes - Whether building block approach constitutes rate of return rather than price cap as required by law.	Firms: DEA model unfavourable to small firms, climate, and sea cables. Regulator: large firms have little influence on scores and non-delivered energy variable reflects climate.
11	**Estimate/forecasts of important variables**	No	Yes – Difference in projected efficiency gains. Firms requested more CAPEX to reduce future OPEX.	No.	Accuracy of the variable non-delivered energy (introduced in 2001) is questioned.
12	**Adverse Effect on Quality, DSM, T/D Losses**	No	No	No.	Yes: Firms considered the quality targets too stringent. A revenue adjustment formula to achieve or exceed the target was then used.
13	**Information Disclosure**	Yes	Yes (Gas) – Firms argued the info may be misused by some customers.	No.	No
14	**Strategic M&A**	No	No	No.	Merging utilities oppose the use of pre-merger data in benchmarking.
15	**Price Inflation in M&A**	No	No	No.	The regulator uses historical values. Good-will therefore not relevant..

4. Methodology - Data Envelopment Analysis (DEA)

DEA has been a popular benchmarking method with electricity regulators (see Jamasb and Pollitt, 2001). DEA identifies an efficient frontier made up of the best-practice firms and uses this to measure the relative efficiency scores of the less efficient firms. Norway uses the DEA in setting revenue caps for regional electricity transmission and distribution utilities. An advantage of the method is that it does not require specification of a production or cost function. It allows calculation of allocative and technical efficiencies that can be decomposed into scale, congestion, and pure technical efficiencies (Färe et al., 1985).

DEA is a non-parametric method and uses piecewise linear programming to calculate (rather than estimate) the efficient or best-practice frontier of a sample (see Farrell 1957; Färe et al. 1985). The decision-making units (DMUs) or firms that make up the frontier envelop the less efficient firms. The efficiency of the firms is calculated in terms of scores on a scale of 0 to 1, with the frontier firms receiving a score of 1.

DEA models can be output or input oriented and can be specified as constant returns to scale (CRS) or variable returns to scale (VRS). Output-oriented models maximise output for a given amount of input. Conversely, input-oriented models minimise input factors required for a given level of output. An input-oriented specification is generally regarded as the appropriate form for electricity distribution utilities as demand for their services is a derived demand that is beyond the control of utilities and that has to be met.

The linear program calculating the efficiency score of the i-th firm in a sample of N firms in CRS models takes the form specified in Equation (3) where θ is a scalar (equal to the efficiency score) and λ represents an $N\times 1$ vector of constants. Assuming that the firms use K inputs and M outputs, X and Y represent $K\times N$ input and $M\times N$ output matrices respectively. The input and output column vectors for the i-th firm are represented by x_i and y_i respectively. The equation is solved once for each firm. In VRS models a convexity constraint $\Sigma\lambda=1$ is added. This additional constraint ensures that the firm is compared against other firms with similar size.

$$
\begin{aligned}
&\min_{\theta,\lambda}\theta, \\
&s.t. \\
&-y_i + Y\lambda \geq 0, \\
&\theta x_i - X\lambda \geq 0, \\
&\lambda \geq 0
\end{aligned}
\qquad (3)
$$

In equation (3) firm i is compared to a linear combination of sample firms which produce at least as much of each output as it does with the minimum possible amount of inputs. Figure 1 illustrates the main features of an input-oriented model with constant returns to scale. The figure shows three firms (G, H, R) that use two inputs (capital K, labour L) for a given output Y. The vertical and horizontal axis represent the capital and labour costs per unit of output respectively, and the line PP shows the relative price of the two inputs.

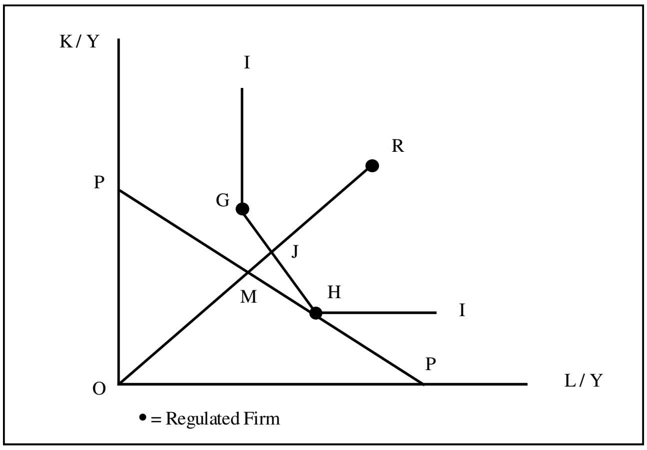

Figure 1: Data envelopment analysis

Firms G and H produce the given output with lower inputs and form the efficient frontier that envelops the less efficient firm R. The technical and allocative efficiencies of firm R relative to the frontier can be calculated from OJ/OR and OM/OJ ratios respectively. Technical efficiency measures the ability of a firm to minimise inputs to produce a given level of output. Allocative efficiency reflects the ability of the firm to optimise the balance of different inputs, given input prices. The overall efficiency of firm R is measured from OM/OR.

An important step in DEA is the choice of appropriate input and output variables. The variables should, to the extent possible, reflect the main aspects of resource-use in the activity concerned. DEA can also control for the effect of environmental variables that are beyond the control of the management of firms but affect their performance. Also, the basic DEA model illustrated above does not impose weights on model input and output variables, but it can be extended to incorporate value judgements in the form of relative weight restrictions imposed on model inputs or outputs (see Thanassoulis, 2001).

An advantage of DEA is that inefficient firms are compared to actual firms rather than to a statistical measure. In addition, DEA does not require specification of a cost or production function. However, efficiency scores tend to be sensitive to the choice of input and output variables. Also, the results (scores) are sensitive to measurement errors in the frontier firms as these comprise the best-practice frontier. In addition, the method does not allow for stochastic factors and measurement errors. Further, as more variables are included in the models, the number of firms on the frontier increases, therefore it is important to examine the sensitivity of the efficiency scores and rank order of the firms to model specification.

5. Data and preferred models

5.1 Data

In order to illustrate numerical examples of the possible effects of strategic behaviour in regulatory benchmarking, we utilise a data set comprising electricity distribution business of 28 utilities operating in the north-east of the United States. The data used is based on annual company returns to Federal Energy Regulation Commission (FERC) and DEPPD (2002) for the financial year 2000. Within our sample we focus on a subset of 5 utilities and examine the effects of gaming on them. These focus firms could be viewed as firms operating under the jurisdiction of a regulatory commission in a federal state being benchmarked against a national sample.

Alternatively, the focus firms may be regarded as utilities operating under a national regulator being benchmarked against an international sample.[12] Individual utilities are not identified here as we wish to address the issues involved at a general level. Table 3 shows the summary statistics for the entire sample and for the focus firms. As shown in the table, the focus firms are relatively far from the extreme ends of the larger sample.

Table 3: Summary statistics for the sample and focus firms.

	Distribution OPEX ('000 $US)[13]	Electricity delivered (MWh)	Customers (#)	Network length (miles)	Meters (#)	Max. Demand (MV)
Focus firms:						
Firm 1	88,033	14,144,052	582,339	16,390	252,622	2,673
Firm 2	219,238	21,261,331	1,000,526	23,391	1,052,369	4,961
Firm 3	43,608	14,607,563	491,142	14,900	524,605	2,342
Firm 4	20,057	7,933,735	134,554	6,121	174,067	926
Firm 5	94,822	21,714,983	680,405	21,735	789,637	3,311
Sample:						
Mean	110,873	13,505,020	553,329	13,095	598,271	2,324
Minimum	2,885	124,425	26,672	120	27,840	101
Maximum	478,345	41,834,169	3,074,592	41,000	3,301,863	9,379

5.2 Preferred models

In order to examine the possible effects of strategic behaviour on the outcome of regulation benchmarking, we use relatively familiar DEA model specifications. An initial model serves as the reference or base model against which we compare the outcomes of strategic behaviour. A financial model is also used to calculate the benefits and losses from changes in relative efficiency.

5.2.1 DEA models

Our preferred model is input-oriented and assumes constant returns to scale (CRS) so that the measured relative efficiency of firms is not affected by their size. This is consistent with

[12] See Jamasb and Pollitt (2003) for an example and discussion of international regulation benchmarking.

[13] The operating expenditures are calculated from reported data and adjusted to allow for an allocation of common administration costs.

the DEA models adopted by the Dutch and Norwegian regulators. Empirical studies in Norway, Canada, New Zealand, and Switzerland find evidence of the presence of economies of scale in electric distribution utilities. However, in some of these studies, the minimum efficient firm size in terms of number of customers is estimated to be around 20,000-30,000.[14] Also, Allas and Leslie (2001) report that about 85 percent of costs vary with the number of customers and the units of energy delivered.

The preferred model uses a single cost input reflecting the OPEX of the distribution business of the utilities. The output variables in our preferred model are: (i) units of electricity delivered, (ii) number of customers, and (iii) length of network. The literature on relative efficiency analysis and benchmarking does not reveal a universally agreed set of input and output variables for modelling of electricity distribution utilities. However, as reported in Jamasb and Pollitt (2001), the input and output variables in our simple model are among the most widely used in studies of relative performance.

5.2.2 Financial model

The financial model calculates the efficient level of costs for individual firms as the product of the efficiency scores and OPEX in the reference year. The model assumes that the efficient cost levels are achieved by the end of a five-year regulatory rate period. This is achieved through annual efficiency improvement requirements or X-factors calculated for individual firms. Figure 2 illustrates a gliding path reflecting combinations of X-factors and reference prices. In this example, a firm's OPEX are benchmarked while it is allowed to recovers its depreciation costs and earn a weighted average cost of capital (WACC) on its regulatory asset base (RAB). Line AC shows the path bringing the allowed revenues of the firm to the efficient frontier level, inclusive of an anticipated frontier shift BC, during the course of a 5-year rate period.

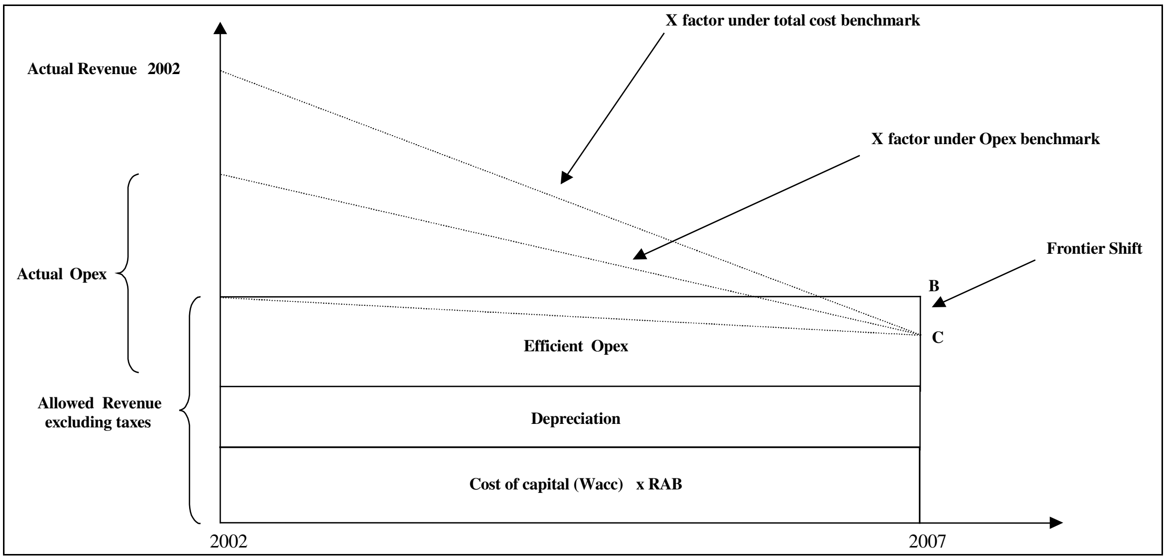

Figure 2: The gliding path of allowed revenue during a rate period

[14] See Filippini (1986, 1987, 1988) and Filippini and Wold (1998) for studies of Switzerland; Salvanes and

However, in reality, the ability of highly inefficient firms to achieve cost savings during a given period may be limited. Recognising this practical limitation, regulators in The Netherlands and Norway have introduced limits on maximum efficiency requirements imposed on least efficient firms. The assigned X-factors in this model are therefore capped at 8 percent per year (as in The Netherlands). In addition, the model assumes that the efficient cost levels can achieve a further 1 percent efficiency gain per year over a 5-year rate period. The total efficiency requirements or effective X-factors are then used to calculate the allowed revenues to cover the firms' operating expenditures. Ordinarily, regulatory models calculate X-factors for total allowed distribution revenues regardless of whether operating or total expenditures (operating plus capital expenditure) are benchmarked. However, for the purposes of simplicity and transparency, we focus solely on the gaming OPEX and its effect on efficiency score and X-factor.

6. Results

As discussed in Section 3, there are various ways in which strategic behaviour can affect the outcome of a regulation benchmarking. In this section, we report benchmarking results using a base model, which we assume to be the regulator's model of choice in the absence of gaming behaviour. We then examine the results of three selected cases of deviation from the base model that can arise from strategic gaming.

6.1 Base case – No gaming

Table 4 shows the calculated efficiency scores for the distribution business of 28 electric utilities in our sample (the base model was described in Section 5). Utilities F1-F5 are the focus firms assumed to be operating under the jurisdiction of a single regulator and being benchmarked within a sample of firms. As shown in the sample, the range of efficiency scores for the sample is rather wide (26-100 percent). Four firms, two of which are among our focus firms (F3 and F4), have an efficiency of 100 percent and constitute the efficient frontier. Utilities F1 and F2 of the focus firms score relatively low, while firm F5 is the most efficient non-frontier firm in our focus group.

Table 5 summarises the results of the base model. As shown in the table, the implied X-factor for firms F1 and F2 exceeds the maximum 8 percent and is therefore capped at that level. The final X-factor is the effective (or total) rate of cost reduction assigned to the firms and includes a 1 percent annual frontier shift in efficient cost level. It is interesting to note that under a capping regime, a lower efficiency score can translate into a lower final X-factor.

The two frontier firms in our focus group are the smallest firms in terms of OPEX in the reference year while the largest firm appears as the least efficient firm among these. The table also shows the allowed OPEX for the firms during the rate period and the required cost reductions that the effective X-factors represent in relation to the OPEX in the reference year.

Tjotta (1994, 1998) for Norway; Giles and Wyatt (1993) for New Zealand; and Yatchew (2000) for Canada.

Table 4: Efficiency scores for the sample - the base case

No.	Efficiency Score	No.	Efficiency Score
F1	57.6%	F15	100.0%
F2	38.1%	F16	72.8%
F3	100.0%	F17	34.9%
F4	100.0%	F18	22.6%
F5	67.6%	F19	58.5%
F6	41.6%	F20	49.3%
F7	29.0%	F21	41.8%
F8	30.4%	F22	34.3%
F9	78.9%	F23	50.8%
F10	32.1%	F24	60.0%
F11	43.2%	F25	76.1%
F12	43.7%	F26	57.3%
F13	61.6%	F27	100.0%
F14	66.8%	F28	43.6%

Table 5: Summary results - Base case

Base Case	Firm 1	Firm 2	Firm 3	Firm 4	Firm 5
Efficiency Score	57.6%	38.1%	100.0%	100.0%	67.6%
X-factor	10.4%	17.5%	0.0%	0.0%	7.5%
Implied X-factor	8.0%	8.0%	0.0%	0.0%	7.5%
Final X-factor	8.8%	8.5%	1.0%	1.0%	8.5%
OPEX - reference year (‘000 US$)	88,033	219,238	43,608	20,057	94,822
Accumulated allowed OPEX - rate period (‘000 US$)	337,629	847,161	211,587	97,316	367,535
Accumulated required cost savings - rate period (‘000 US$)	102,537	249,027	6,455	2,969	106,575

6.2 Gaming OPEX

As discussed previously, one of the perverse incentives associated with price cap regulation is that firms may attempt to inflate their distribution cost base before a price review. As shown here, relatively small changes in X-factors that do not appear significant in relation to the original X-factor, can result in considerable revenue implications.

Table 6 shows the effect of 1, 5, and 10 percent increase in the OPEX of firm F5 in the reference year 2000 on its allowed revenue for the rate period 2001-2005. The table shows that as the firm's cost base increases, its efficiency score declines. This results in higher X-factors and consequently higher cost saving requirements. At the same time, the firm enjoys a higher cost base that gives it a higher level of allowed revenues. The table shows the net increase in allowed cost recovery or revenue after controlling for the effect of higher efficiency requirements through higher X-factor. For example, a 5 percent ***increase*** in the cost base prior to rate review results in a ***reduction*** of the relative efficiency score of 6 percentage points, yet also results in a 3.6 percent net ***increase*** in allowed revenues corresponding to $19.59 per customer during the rate period.

Table 6: Summary results – Gaming OPEX

Firm 5:	**Base case**	**OPEX 1%**	**OPEX 5%**	**OPEX 10%**
Efficiency score	67.6%	66.9%	64.3%	61.4%
X-factor	7.5%	7.7%	8.4%	9.3%
Implied X-factor	7.5%	7.7%	8.0%	8.0%
Final X-factor	8.5%	8.7%	8.9%	8.9%
OPEX in reference year ('000 US$)	94,822	95,770	99,563	104,304
Accumulated required cost savings ('000 US$)	106,575	109,697	116,954	122,072
Δ accumulated required cost savings ('000 US$)	-	3,122	10,379	15,497
Accumulated allowed OPEX in rate period ('000 US$)	367,535	369,154	380,861	399,449
Δ accumulated allowed OPEX in rate period ('000 US$)	-	1,620	13,327	31,914
as % of accumulated allowed revenue (in base case)	-	0.4%	3.6%	8.7%
$ Revenue increase (+)/ decrease (-) per customer	-	2.38	19.59	46.90

Table 7 shows the effect of a 10 percent cost inflation for the other four firms. As shown in the table, the frontier firms F3 and F4 retain the full increase in their cost base. The least efficient firms F1 and F2, despite receiving lower efficiency scores relative to the base case, due to their capped X-factors, benefit fully from higher cost base. They also achieve an additional small gain as the 1 percent frontier shift is applied to a lower efficient cost base.

Table 7: Summary results – Gaming OPEX with 10%

	Firm 1 10%	**Firm 2 10%**	**Firm 3 10%**	**Firm 4 10%**
Efficiency score	52.4%	34.7%	100.0%	100.0%
X-factor	12.1%	19.1%	0.0%	0.0%
Implied X-factor	8.0%	8.0%	0.0%	0.0%
Final X-factor	8.7%	8.5%	1.0%	1.0%
OPEX in reference year ('000 US$)	96,837	241,161	47,969	22,063
Accumulated required cost savings ('000 US$)	112,040	272,694	7,100	3,266
Δ accumulated required cost savings ('000 US$)	9,503	23,668	645	297
Accumulated allowed revenue in rate period ('000 US$)	372,143	933,112	232,746	107,048
Δ accumulated allowed OPEX in rate period ('000 US$)	34,514	85,951	21,159	9,732
as % of accumulated allowed OPEX (in base case)	10.2%	10.1%	10.0%	10.0%
$ Revenue increase (+)/ decrease (-) per customer	59.3	85.9	43.1	72.3

6.3 Influencing output weights

The selection of appropriate output variables for use in benchmarking models can be a source of disagreement between regulator and firm. In principle, the main issue is the extent to which the selected variables are true cost drivers and how accurately they portray the production function. The underlying concern is how the choice and use of variables can affect the relative efficiency measure and, consequently, firms' revenues. We modify our base model by assigning a set of weights to the output variables.

As mentioned in Section 4, DEA can be used with weight restrictions applied to inputs and outputs. In the following example, we examine the effect of output weights similar to those used by the UK regulator OFGEM, namely: (i) number of customers 50 percent, (ii) units of electricity delivered 25 percent, and (iii) length of distribution network 25 percent. The weights on the outputs are introduced by including additional constraints to our basic DEA model (see Thanassoulis, 2001). Table 8 shows the summary results of applying the weights to the output variables in the base model.

Table 8: Summary results - Influencing output weights

Outputs with weights	**Firm 1**	**Firm 2**	**Firm 3**	**Firm 4**	**Firm 5**
Efficiency Score	42.5%	26%	87.4%	100.0%	59.5%
X-factor	15.8%	23.6%	2.7%	0.0%	9.9%
Implied X-factor	8.0%	8.0%	2.7%	0.0%	8.0%
Final X-factor	8.6%	8.4%	3.6%	1.0%	8.8%
OPEX in reference year (‘000 US$)	88,033	219,238	43,608	20,057	94,822
Accumulated Required cost savings (‘000 US$)	100,568	245,074	22,382	2,969	110,708
Δ Accumulated Required cost saving (‘000 US$)					
Accumulated allowed revenue in rate period (‘000 US$)	339,598	851,114	195,659	97,316	363,402
Δ Accumulated allowed revenue in rate period (‘000 US$)	1,969	3,952	-15,928	0	-4,133
as % of accumulated allowed OPEX (in base case)	0.6%	0.5%	-7.5%	0.0%	-1.1%
$ Revenue increase (+)/ decrease (-) per customer	3.4	4.0	-32.4	0.0	-6.1

The table shows that, after introducing the output weights, firm F3 is no longer on the efficient frontier and its allowed revenues decrease with 7.5 percent corresponding to a $32.43 reduction per customer. It is noteworthy, that although firms F1 and F2 have lower efficiency scores than in the base case, they achieve a relatively small net gain from the weights. The observed gain is due to the fact that in the revised model the 1 percent frontier shift is applied to a lower efficient cost base while the firms’ X-factor is, despite a nominal increase, still capped at 8 percent. However, a lower efficiency score for firm F5 means that it faces an increase in effective X-factor up to the cap limit that results in a net loss for the firm.

The results shown here indicate that while there is some potential for moderate gains by the two least efficient firms, the negative effect on more efficient firms outweighs the gain. The results from this example indicate that conflicting interest among the firms may reduce the likelihood of influencing the base model in this direction. It should, however, be pointed out that the magnitude of potential benefits and losses, and the number of gainers and losers, is highly dependent on the composition of the benchmarking sample.

6.4 Changing the firm through mergers and acquisitions

The changing structure of the electricity industry has prompted many utilities to achieve efficiency improvements through mergers and acquisitions (M&A). From a strategic perspective, mergers can also help utilities to reposition themselves in the market by changing their scale of operations and reconfiguring their resources. However, M&A involve two sources of concern for regulators that use benchmarking: (i) transactions intended to influence the relative position of the firm without achieving real efficiency gains and (ii) the shrinking number of firms and reduction in information on which regulators base their analysis (see Nillesn, Pollitt, and Keats, 2001). The first type of merger may be regarded as a special form of collusion to game the regulator's incentive scheme.[15]

In this section we examine a case of "virtual" efficiency improvement achieved by the merger of two firms. Table 9 shows the results when a frontier firm (F3) and a relatively efficient firm (F5) merge to form a new entity.

Table 9: Summary results - Merger effects

Merger between F3 and F5	Firm 1	Firm 2	Firm 4	Firms 3&5
Efficiency score	67.3%	42.7%	100.0%	91.5%
X-factor	7.6%	15.6%	0.0%	1.8%
Implied X-factor	7.6%	8.0%	0.0%	1.8%
Final X-factor	8.5%	8.6%	1.0%	2.7%
OPEX in reference year ('000 US$)	88,033	219,238	20,057	138,430
Accumulated required cost savings ('000 US$)	99,621	250,510	2,969	54,506
Δ Accumulated required cost saving ('000 US$)				
Accumulated allowed revenue in rate period ('000 US$)	340,545	845,678	97,316	637,645
Δ accumulated allowed revenue in rate period ('000 US$)	2,916	-1,483	0	58,523
as % of accumulated allowed OPEX (in base case)	0.9%	-0.2%	0.0%	10.1%
$ Revenue increase (+)/ decrease (-) per customer	5.0	-1.5	0.00	50.0

[15] Collusion can also take the form of collaboration on the pace of cost saving effort among the firms but this is beyond the scope of this study (see e.g. CPB, 2000).

Firms F1 and F2 exhibit higher efficiency scores relative to the base case due to the reduction in the number of frontier firms. A higher score for F1 means that the firm's X-factor falls below the cap threshold and therefore benefits from the new higher efficiency score. However, for firm F2 the higher efficiency score means that the 1 percent annual frontier shift is applied to a higher cost base while the firm's X-factor remains capped despite the higher scores.

The results show that a merger between firms F3 and F5 can result in 10.1 percent increase in allowed revenues corresponding to $50 per customer during the rate period. Although a range of factors can influence a firm's decision to merge or acquire, simple comparative efficiency analysis can reveal the side benefits or loses associated with the decisions.

7. Discussion and Conclusions

A number of regulators have used benchmarking in periodic price controls as part of the incentive-based regulation of natural monopolies. An important motive for the use of benchmarking has been that yardstick regulation encourages efficiency and reduces reliance on the firms' own information. However, as discussed in this paper, the use of benchmarking can lead firms to pursue virtual rather than true performance improvements by gaming the regulator's benchmarking in a number of ways that are contrary to the intentions of the scheme.

We showed how strategic behaviour in the context of benchmarking may lead to (i) foregone efficiency improvements or dead-weight losses, (ii) welfare transfers from customers to firms, and (iii) welfare transfers among firms. We also used numerical examples to illustrate selected aspects of strategic gaming associated with regulatory benchmarking and their effects. We show that the net effect of gaming can depend on the method of translating efficiency scores into X-factors and the caps applied to them (i.e. the extent to which the efficiency gap among the firms can or is to be closed in a given rate period). We also showed the interrelationship between gaming by one firm and its effect on the X-factors for other firms.

The following lessons can be drawn from our review of issues and examples:

- The allocation of costs and assets when distribution is unbundled from other utility activities, and the reliability of this information base for subsequent price controls, are both important. Regulators need to pay particular attention to increasing the reliability of information through audits, technical studies, and comparison of cost patterns in review vs. non-review periods.
- Regulators need to conduct sensitivity analyses of their chosen benchmarking approach and data sets in order to identify the most influential variables and to assess the effects of measurement errors and likely gaming.
- An important strength of DEA is the ability to accommodate multiple inputs and outputs. Using models with a single cost input variable might increase the sensitivity of results to changes in costs.
- Mergers are increasingly a source of concern for regulators and utilities. Both can use benchmarking analyses to determine the effects of possible and actual mergers on the firms in the sector and their implied X-factors. Such analysis can also help regulators to design their policies towards separating virtual from actual efficiency gains in mergers.

• Regulators need to recognise the shortcomings of their chosen benchmarking methods and to apply discretion and judgment in the use of results. For example, in order to reduce reliance on a limited number of variables, regulators can use competing models and average their results. In some instances, it may be preferable to simplify the process by placing the firms in a few categories with similar X-factors.

• Finally, from a theoretical and methodological point of view, regulatory benchmarking leaves considerable scope for improvement. Regulatory benchmarking therefore owes much of its legitimacy to the wider regulatory framework and the implementation process. Transparency of the benchmarking exercise and decision process together with the public availability of underlying data, and combined with consultations and hearings, can provide third party scrutiny and thus increase acceptability and reduce gaming.

Regulatory benchmarking does not eliminate the issue of asymmetric information on firms' costs and efficiency improvement effort as known under rate of return regulation. Rather, it adds new dimensions to this issue and the ways in which firms can behave strategically. Countering strategic behaviour can partly be overcome by increasing data accuracy and improving data collection procedures. The information requirement for reliable regulatory benchmarking therefore appears to be higher than initially expected. The continued efforts made by regulators using benchmarking to improve data quality are testament to this fact.

At the same time, regulated utilities need to conduct their own benchmarking analysis in order to:

• Examine the effect of the regulator's choice of benchmarking method, variables, X-factors.

• Analyse the effects of possible gaming by other firms on their profits and available future partners for M&A.

• Evaluate benefits and losses of mergers involving own firm or competitors and to convey their findings to regulators.

References

Allas, T. and Leslie, K. (2001), Sizing power, The McKinsey Quarterly, No. 1, 138-145.

Armstrong, M., Cowan, S., and Vickers, J. (1994), Regulatory Reform: Economic Analysis and British Experience, London-Cambridge MA, The MIT Press.

Averch, H. and Johnson, L. L. (1962), Behavior of the firm under regulatory constraint, American Economic Review 52 (December), 1052-1069.

Baumol, W. J. and A. K. Klevorick (1970), Input choices and rate of return regulation, Bell Journal of Economics, 1:162-90.

Baron, D. P. and Myerson, R. B. (1982), Regulating a monopolist with unknown costs, Econometrica, 50:911-30.

Borenstein, S., Bushnell, J., and Wolak, F. (2002), Measuring market inefficiencies in California's restructured wholesale electricity market, Working Paper CSEM WP 102, University of California Energy Institute, June 2002 (forthcoming in American Economic Review).

Coelli, T. (2000), Some scattered thoughts on performance measurement for regulation of a natural monopoly network industry, Centre for Efficiency and Productivity Analysis, School of Economic Studies, University of New England.

Coelli, T., Rap, D. S. P. and Battese, G. E. (1998), An Introduction to Efficiency and Productivity Analysis, Kluwer Academic Publishers, London.

Courty, P. and Marschke, G. (2002), An empirical investigation of gaming responses to explicit performance incentives, Center for Economic Policy Research (CEPR), Discussion Paper, No. 3164, January.

CPB (2000), Yardstick competition: Theory, design, and practice, CPB Netherlands Bureau for Economic Policy Analysis, Working Paper, No. 133, December 2000, The Hague.

Crew, M. A. and Kleindorfer, P. R. (1996), Incentive regulation in the United Kingdom and the United States: Some lessons, Journal of Regulatory Economics, Vol. 9, 211-225.

DEPPD (2002), Platts Directory of Electric Power Producers and Distributors 2002, 110th Edition of the Electrical World Directory, The McGraw.Hill Companies.

Di Tella, R. and Dyck, A. (2002), Cost reductions, cost padding and stock market prices: The Chilean experience with price cap regulation, Working Paper, No. 03-050, Harvard Business School.

DTe (1999), Price Cap Regulation in the Electricity Sector, Netherlands Electricity Regulatory Service, Hague.

DTe (2002), Maatstafconcurrentie Regionale Netbedrijven Elektriciteit, Tweede Reguleringsperiode, Informatie- en Consultatiedocument, Netherlands Electricity Regulatory Service, Hague (in Dutch, English version available on www.dte.nl).

Färe, R., Grabowski, R., and Grosskopf, S. (1985), The Measurement of Efficiency of Production, Boston, Kluwer Academic Publishers.

Farrell, M. J. (1957), The measurement of productive efficiency, Journal of Royal Statistical Society, Series A, 120, 253-281.

Filippini, M. (1996), Economies of scale and utilization in the Swiss electric power distribution industry, Applied Economics, 28, 543-550.

Filippini, M. (1997), Elements of the Swiss Market for Electricity, Physica-Verlag. Berlin.

Filippini, M. (1998), Are municipal electricity distribution utilities natural monopolies?, Annals of Public and Cooperative Economics, 2, 157-174.

Filippini, M. and Wild, J. (1998), The estimation of an average cost frontier to calculate benchmark tariffs for electricity distribution, Working Paper No. 9803, September 1998, Socioeconomic Institute, University of Zurich.

Giles, D. and Wyatt, N. S. (1993), Economies of scale in New Zealand electricity distribution industry, in P. C. B. Phillips (ed.) Models, Methods and Applications of Econometrics, Blackwell, Oxford, 370-382.

Jamasb, T. and Pollitt, M. (2003), International benchmarking and regulation: An application to European electricity distribution utilities (forthcoming in Energy Policy).

Jamasb, T. and Pollitt, M. (2001), Benchmarking and regulation: International electricity experience, Utilities Policy, Vol. 9/3, pp. 107-130.

Joskow, P. and Kahn, E. (2002), A quantitative analysis of pricing behaviour in California's wholesale electricity market during summer 2000, The Energy Journal 23(4):1-36.

Joskow, P. (1997), Restructuring, Competition and Regulatory Reform in the US Electricity Sector, Journal of Economic Perspectives, Vol 11, No 3, Summer 1997.

Joskow, P. J. and Schmalensee, R. (1986), Incentive regulation for electric utilities, Yale Journal on Regulation, Vol. 4 (1), 1-49.

Laffont, J.-J. and Tirole, J. (1986), using cost information to regulate firms, Journal of Political Economy, 94:614-41.

Littlechild, S. (1983), Regulation of British Telecommunications' Profitability, Department of Industry, London.

Magnus, E. and Midttun, A., eds. (2000), Electricity market reform in Norway, Basingstoke, Macmillan.

Nillesen, P. H. L. and Telling, J.G. (2001), Benchmarking distribution companies, Energy & Power Risk Management, March, 10-13

Nillesen, P. H.L., Pollitt, M.G., and Keats, K. (2001), Strategic Benchmarking: Identifying and quantifying the Gains from M&A, Energy & Power Risk Management, June, 42-45.

OFGEM (2000), Mergers in the Electricity Distribution Sector - Policy Statement, Office of Gas and Electricity Markets (OFGEM), May 2002, London.

Pollitt, M. (1995), Ownership and Performance in Electric Utilities, Oxford-New York. Oxford University Press.

Rudnick, H. and Donoso, J. (2000), Integration of price cap and yardstick competition schemes in electrical distribution regulation, IEEE Power Engineering Review, August.

Rudnick, H. and Raineri, R. (1997), Chilean Distribution Tariffs: Incentive Regulation, in (De)Regulation and Competition: The Electric Industry in Chile, F. G. Morande and R. Raineri eds., Santiago, ILADES/Georgetown University.

Salvanes, K. and S. Tjotta (1994), Productivity differences in multiple output industries, Journal of Productivity Analysis, 5:23-43.

Salvanes, K. and S. Tjotta (1998), A test for natural monopoly with application to Norwegian electricity distribution, Review of Industrial Organization, 13:669-685.

Sappington, D. (1980), Strategic firm behaviour under a dynamic regulatory adjustment process, Bell Journal of Economics and Management Science, 11:360-72.

Thanassoulis, E. (2001), Introduction to the Theory and Application of Data Envelopment Analysis: A Foundation Text with Integrate Software, Kluwer Academic Publishers, Massachusetts.

UMS (1999), Operating Expenditure Benchmarking: Study Undertaken for the Regulator General of Victoria, UMS Group Australia, Government Strain.

Vickers, J. and Yarrow, G. (1988), Privatization: An Economic Analysis, London-Cambridge MA, The MIT Press.

Yatchew, A. (2000), Scale economies in electricity distribution: A semiparametric analysis, Journal of Applied Econometrics, 15:187-210.