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International Benchmarking for Monopoly Price Regulation: The Case of Australian Gas Distribution*

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Abstract
Price-cap regulation is widely applied to network industries. However, regulators often encounter the problem of asymmetric information on efficient costs. Benchmarking can help reduce this problem. We present a benchmarking analysis, conducted for an Australian regulator, that derives measures of efficiency for Australian gas distributors relative to U.S. counterparts. Several techniques, such as data envelopment analysis and stochastic frontier analysis, are used to ensure that our measures are robust to methodology choice. We conclude with a discussion of how the regulator used the benchmarking results, along with other information, to help it determine appropriate price caps.

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1. Introduction

It is widely recognized that network industries, such as gas and electricity, have natural monopoly characteristics. Monopolies can exploit their market power and set prices above minimum costs, so as to achieve above-normal profits. For much of this century the answer to this potential problem has generally involved one of two options: (i) government ownership, or (ii) private ownership combined with some form of cost plus rate-of-return regulation, where the regulated firm is allowed to set prices so as to cover non-capital costs plus a ''fair'' rate-of-return on capital. The latter has been favored in the U.S., while the former has been favored in Europe, the U.K., and many other countries.

However, these two options are not without problems. In particular, both options suffer from a lack of efficiency incentives, which tends to result in costs that are above minimum costs. This has led to the recent development of new forms of regulation which seek to be incentive compatible. These incentive regulation methods were championed by U.K. telecommunications regulators in the 1980s, and have since been adopted in various forms by many regulators in many industries around the world.[1]

Incentive regulation can take many forms, but the most common form involves a combination of ''unbundling'' the network services from other parts of the industry (production and retail) and the application of some type of ''price-cap'' (or CPI-X) regulation to the (natural monopoly) network component. CPI-X regulation involves the setting of maximum allowable price increases equal to the rate of increase in the consumer price index (CPI) minus an X factor. The value of X is based upon the regulator's expectations regarding future possible productivity improvements, plus other relevant information. The regulator's assessment of potential productivity growth is generally based upon assessments of the present level of efficiency of the firm and past rates of productivity growth in the industry. Hence, the effective implementation of CPI-X regulation requires high quality, defendable measures of firm performance.

In this paper we describe an attempt to measure the efficiency of Australian gas distributors relative to each other and relative to U.S. counterparts. The benchmarking study coincided with the Independent Pricing and Regulatory Tribunal of New South Wales (IPART) review of the AGL Gas Network Ltd (AGLGN) Access Arrangement for its network in the State of New South Wales (NSW) in Australia. Several performance measurement techniques are used in the exercise, including partial productivity measures, regression analysis, data envelopment analysis (DEA), corrected ordinary least squares (COLS) and stochastic frontier analysis (SFA). We describe some of this analysis, and then discuss how the results of the exercise contributed to the setting of price caps for AGLGN's NSW network.[2]

We have chosen to publish the results of this benchmarking exercise for a number of reasons. First, we hope to obtain feedback from a wider audience, regarding the appropriateness of the methods that we have employed. The use of benchmarking techniques in the implementation of incentive regulation is a relatively new area of

1 See Crew and Kleindorfer (1996) for further discussion of incentives and regulatory structures.
2 See IPART (1999a) for a detailed description of the benchmarking analysis reported in this paper.

endeavor. We are continuously striving to improve our methods, so as to ensure higher quality regulatory outcomes. Second, we believe that many of the performance measurement studies conducted for regulators (usually by consultants) tend to confine their attention to a single empirical technique, such as DEA or ordinary least squares (OLS) regression, without much discussion of the possible impact that choice of technique may have upon the results obtained. In this paper, we seek to apply a range of techniques to our data, and discuss the relative merits of these techniques.

Some of the performance measurement techniques considered in this paper, such as DEA and SFA, are ''data hungry,'' to the extent that a large sample size is required for one to obtain robust estimates of the production frontier. Since our data on Australian gas distribution companies was limited to only seven firms, we sought to increase our sample size by the inclusion of data on U.S. firms. The inclusion of data from more than one country in an analysis of this type introduces a range of potential problems, including differences in environment (climatic, regulatory, etc.), differences in data reporting definitions, and so on. However, it also has the advantage of including firms from an (arguably) more competitive environment, and thus potentially providing a closer approximation to the ''world best practice'' production frontier.[3] The relative merits of international benchmarking are discussed in some detail in this paper, particularly in reference to the construction of consistent data across these two countries.

The structure of the paper is as follows: section 2 provides information on the regulatory regime for Australian gas distributors and the characteristics of the Australian gas distribution industry. Section 3 presents partial productivity measures for the Australian distributors. Section 4 describes the frontier methods used to measure the efficiency of Australian and U.S. gas distribution. Section 5 provides a description of the sample data. Section 6 discusses the frontier results. Section 7 presents IPART's views on the scope for AGLGN to reduce non-capital costs. Section 8 provides some concluding remarks.

2. Background Information

2.1. Form of Regulation

Under the Australian Gas Code (the Code), IPART is required to introduce a regulatory framework for gas distributors that provide incentives to improve performance.[4] The key features of incentive regulation are: the regulation of prices or revenues; the use of price or

3 Previous comparisons of the Australian gas supply industry with international counterparts have suggested that Australian performance may lag behind other countries. For example, see BIE (1994). However, it should also be kept in mind that U.S. best practice may still be an understatement of *potential* best practice, given that past regulatory structures in the U.S. have introduced incentives which do not always encourage productivity improvement.

4 The Code's formal title is the National Third Party Access Code for Natural Gas Pipeline Systems. The Code is endorsed by several Australian States to comply with their obligations with Australia's National Government (the Commonwealth Government) to freer trade in gas.

revenue controls that extend over several years; and incentives for utilities to pursue efficiency gains through their ability to retain the benefits of improved efficiency for a period beyond the regulatory determination. Advocates of incentive regulation argue that it provides greater incentives for utilities to improve performance and reduces regulatory costs compared to cost plus regulation (Crew and Kleindorfer 1996).[5]

The Code requires the regulator to set gas prices that reflect the efficient costs of supply of a prudent service provider.[6] While the Code requires the regulator to have regard to the efficient costs of a prudent service provider it is structured around the separate review of the major costs of the service provider. Hence, the regulator is required to examine separately the non-capital costs, depreciation and the risk-adjusted return of capital of a utility in making judgments on the potential scope to improve performance and the revenue requirements of the utility.[7]

A number of stakeholders support this approach because it links revenues to specific costs and identifies the benefits of improved efficiency to be shared with customers. For the utility it establishes existing costs and cost structures as the starting point and may reduce the risks that the regulator will come to a significantly different view on costs.

However, the approach requires the utility to provide detailed financial information to the regulator. Paradoxically, the focus on detailed cost items may increase the likelihood of information asymmetry from the regulator's perspective. The arbitrary allocation of costs to various markets supplied by the utility can also hinder the assessment of efficient costs.

An alternative approach to assess efficient costs involves the use of benchmarking techniques to develop measures of efficiency. This approach places less reliance on detailed cost information to assess efficient costs, and the measures of efficiency obtained also help the regulator determine the productivity offset (X) in the price or revenue cap. This approach is extensively used in the U.S. to regulate telecommunications. Proponents argue that the approach provides incentives to minimize costs over the longer term and reduces asymmetric information problems and regulatory costs. However, reliable and extensive data sets are often required to produce robust measures of efficiency.

IPART (1999b) acknowledges the strengths and weaknesses of the approaches that assist in determining the efficient costs. The Code requires IPART to use the building block approach to assess efficient costs of prudent gas distributor for each major cost item. But to reduce the problem of asymmetric information it also used benchmarking

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5 State Governments regulated gas supply prior to the introduction of the Code. The distributors provided bundled services and the regulatory approach varied from cost plus regulation to limited intervention in setting gas prices—that is, prices were set by negotiation between the distributors and customers and the Government intervened to settle disputes. New South Wales introduced incentive regulation in 1996–1997, and it enacted the Code in 1998. Prior to this arrangement, maximum prices were set under a CPI-X framework for smaller customers and larger customers negotiated prices directly with the distributor.

6 Section 8.37 of the Code states that IPART can allow a distributor to recover all non-capital costs except any such cost that would not be incurred by a prudent service provider, acting efficiently, in accordance with accepted and good industry practice, and to achieve the lowest cost of delivering the Reference Service.

7 This building block approach is often used by regulators in Australia and overseas to assess the efficient costs of supply for other network businesses, such as electricity and water.

techniques to help assess efficient costs at an aggregate level. This benchmarking is the subject of the present paper.

2.2. Australian Gas Distribution

The main characteristics of the Australian gas distribution industry are presented in table 1.[8,9] Victoria and New South Wales have the greatest demand for gas, which is mainly sold to commercial and industrial customers.[10] The major gas users (based on the Australian New Zealand Industry Classification) in 1997–1998 were ''other'' industry, electricity generation and mining. These activities consumed about 65% of the local supply of gas that was available for domestic consumption. Retail demand accounted for about 13% of the local gas supply that was available for domestic consumption (ABARE 1999).

Most gas customers are households. Information published by the ABS (1999) suggests that residential customers provide the main source of revenue for distributors located in Victoria and the Australian Capital Territory. By contrast, the commercial and industrial market provides the main source of revenue for distributors located in New South Wales. To a large extent, relatively high residential gas prices and lower market penetration rates in New South Wales explain the lower revenues from the residential market.

Victoria and New South Wales possess the largest networks and account for 35% and 30% of the total length of distribution network, respectively. Employee numbers need to be interpreted with care because the data for Victoria and South Australia includes people that are involved in non-distribution activities, such as retailing gas or selling appliances AGA (1999).

The information in table 1 provides broad insights on the performance of the local distributors. However, governments, regulators and the broader community require specific information on the scope for individual distributors to achieve productivity and efficiency improvements to help assess pricing proposals submitted by distributors. This study provides information on the potential to improve the efficiency of local gas distributors.

3. Measuring Efficiency

Efficiency is a relative concept. In the situation where an organization produces a single output using a single input, it may be measured by comparing the actual ratio of output over input to some optimal ratio (usually defined by reference to another more efficient

8 Australia is divided into six States and two Territories. The States are New South Wales (NSW), Victoria (VIC), Queensland (QLD), South Australia (SA), Western Australia (WA) and Tasmania (TAS). The Territories are the Australian Capital Territory (ACT) and Northern Territory (NT). Natural gas is not distributed in Tasmania.

9 A Gigajoule (GJ) is a measure of the heat content of gas. An average residential customer in New South Wales consumes about 20 GJ of gas per year. A Terajoule (TJ) is equivalent to 1 000 GJ.

10 The commercial and industrial market is the largest market in Victoria and Western Australia based on the latest information for these States, which was 1996–1997 and 1994–1995, respectively AGA (1999).

Table 1. Characteristics of Australian Gas Distribution, 1997–1998

	NSW	VIC (a)	QLD	SA	WA	NT	ACT	Total
Sales (TJ)	106,652	176,280	11,407	38,810	np	84[c]	5,181	338,414[b, c]
Customers (no.)	754,184	1,421,619[d]	134,826	325,097	396,326	480[c]	64,762	3,097,294[c]
Revenue ($m)	722.0	1,175.2[d]	np	na	316.4	1.1[c]	55.3	2,269.1[c, e]
Average unit revenue ($/GJ)	6.77	6.67[d]	np	na	np	13.31[c]	10.68	6.46[c, f]
Average revenue per customer ($)	957	827[d]	np	na	798	2,329[c]	854	733[c, e]
Mains (km)	20,570	23,990	3,990	6,552	10,125	np	3,439	68,666
Employees (FTE no.)	591	742[g]	288	212[g]	420	np	57	2,310

Notes. (a) Sales in Albury, New South Wales included in Victoria. (b) Excludes Western Australia. (c) Excludes industrial customers in the Northern Territory. (d) Estimated by AGA. (e) Excludes Queensland and South Australia. (f) Excludes South Australia and calculated from all available data which includes that shown as np in the table. (g) Includes employees involved in activities other than gas distribution.
Source. ABS (1999) and AGA (1999).

organization). However, when a firm uses multiple inputs (and/or produces multiple outputs) a simple ratio measure of efficiency can produce quite misleading information. In this section we present and discuss various simple partial productivity ratios that are in common use in the gas supply industry. Then in section 4 we describe the methods that one can use to attempt to overcome some of the shortcomings of the partial productivity ratios.

3.1. Partial Productivity Measures

Partial productivity measures are often used to measure efficiency because they are simple to calculate and are readily understood. Tables 2 and 3 present several measures that help to form judgments on the efficiency of the local distributors. The physical measures provide information on technical efficiency, whereas the unit cost measures best reflect cost efficiency, which comprises both technical efficiency and allocative efficiency.[11]

The use of a broad suite of indicators encourages discussion on the reasons for differences in performance. It also reduces the risk of interpreting a performance measure in isolation from other factors that influence the efficiency of gas distribution. However, partial productivity measures need to be interpreted with care. The measures do not provide a complete view of performance because they do not consider the various relationships or trade-offs between the inputs and outputs of gas distribution. Furthermore,

11 See Coelli, Rao and Battese (1998) for discussion of these various types of efficiency.

Table 2. Partial Productivity Measures for Australian Gas Distributors, 1998[12]

Company	State	O&M/Delivery ($/TJ)	O&M/Customer ($/no.)	Customer/Main (no./km)	Deliveries/Main (TJ/km)
AGLGN	NSW	954	134	35	4.9
AGLGN	ACT	2,142	171	19	1.5
Envestra	SA	938	102	48	6.7
Envestra	QLD	2,236	119	37	5.2
Multinet	VIC	782	78	68	10.2
Stratus	VIC	714	98	57	7.8
Westar	VIC	461	82	57	8.7

Notes. Figures for Envestra (SA) 1998–1999, AGLGN, and Envestra (QLD) 1997–1998. O&M = operating and maintenance costs.
Source. Estimates based on information from Access Arrangement Information (various), Envestra (1998), Envestra (1997) and information supplied by local distributors.

they can vary for reasons other than inefficiency—for example, a distributor may have a different mix of customers or population density.

A nice example of the potential conflict that can arise from partial productivity measures is provided by the measures of O&M/delivery and O&M/customer for the Multinet Gas and Stratus Networks firms. Stratus Networks is more efficient on the first ratio, but less efficient on the second ratio. The use of partial measures leaves us more confused than when we began, in this instance. In some (rare) cases, the partial measures can be informative. For example, AGLGN (NSW) has uniformly higher values of these two ratios than its Victorian counterparts. However, this poorer efficiency could be driven, in part, by a lower density, reflected in the lower ratio of customers per km of main for AGLGN (NSW). The use of a more sophisticated technique, such as DEA or SFA, along with the inclusion of additional data on firms with a range of densities, should help shed some light on this issue.

The partial ratios reported in table 3 provide further insights on relative performance. AGLGN has a lower value of O&M per km of main, relative to most other firms, suggesting better performance on this measure. However, this is most likely driven by the lower customer densities and the relatively young age of its assets, reflected in the asset

12 IPART used the terms non-capital costs and operating and maintenance (O&M) costs interchangeably until the final determination for AGLGN (NSW), where it defined non-capital costs as O&M costs, overheads, network marketing costs, unaccounted for gas (UAG), government levies, costs associated with retail contestability and other operating costs (IPART 2000). The terms are used interchangeably in this paper when presenting the results of the benchmarking exercise to maintain consistency with the benchmarking report (IPART 1999a), which was released prior to the final determination for AGLGN (NSW). In the benchmarking exercise, O&M costs included most of the narrower defined O&M costs, network marking costs and overheads, but UAG, customer accounts expenses and government levies were excluded from O&M costs to help develop similar cost structures for Australian and U.S. distributors. The excluded costs are relatively minor compared to the O&M costs that were included in the benchmarking exercise. See IPART (1999a, 2000) for further details.

Table 3. Partial Productivity Measures for Australian Gas Distributors, 1998 (continued)

Company	State	O&M/Main ($/km)	Asset Life Expired (%)	UAG (%)	NM Costs/O&M (%)
AGLGN	NSW	4,666	21	2.3	37
AGLGN	ACT	3,255	23	0.9	46
Envestra	SA	4,875	22	4.4	17
Envestra	QLD	4,350	20	13.3	11
Multinet	VIC	5,325	33	2.0	2
Stratus	VIC	5,578	28	1.6	12
Westar	VIC	4,684	31	1.3	2

Notes. Asset life expired is the ratio of depreciated optimized replacement cost to optimized replacement cost. Envestra's (QLD) UAG is for the 12 months to 31 May 1999. NM costs = network marketing costs.
Source. Estimates based on information from Access Arrangement Information (various), Envestra (1998), Envestra (1997) and information supplied by local distributors.

life expired measure. Unaccounted for gas (UAG) is fairly uniform across the firms (with the exception of Envestra (QLD)).[13]

The final measure in table 3 is the percentage of network marketing costs in O&M costs. This figure is reported because it plays an important role in the regulator's price-cap determination for AGLN (NSW) (as discussed later in this paper). AGLGN (NSW)'s network marketing costs are high relative to other distributors. AGLGN have argued that marketing costs are high because New South Wales has a warm climate, compared to Victoria, and it must heavily promote the use of gas to overcome the relatively high connection and appliance costs compared to electricity. Otherwise, it cannot increase throughput to achieve economies of scale. Most of AGLGN's marketing costs relate to energy retailer rebates which aim to increase gas consumption in the tariff market by increasing either new customers or the average consumption of existing customers.[14]

Network marketing is a valid approach to increase throughput, however there are several concerns with AGLGN's program. First, gas consumption is not determined solely by climate. Other factors influence the demand for gas, such as the price of gas relative to other sources of energy; economic growth; the socioeconomic characteristics of households (e.g., income and number of people); population growth; building activity; and the cost of acquiring and maintaining gas appliances relative to electric appliances.

Second, AGLGN's network marketing costs are high compared to Envestra (QLD) which is located in a sub-tropical region.[15] Finally, several participants submitted to

13 UAG is the difference between the quantity of gas that is metered as having entered the gas network and the (metered) amount delivered to end-users. UAG can arise from losses in the network, metering error or theft.

14 Tariff market customers consume less than 10 TJ of gas a year. The vast majority of customers are households.

15 Further partial productivity measures for network marketing costs, such as network marketing costs per customer and network marketing costs per new customer, are presented in IPART (1999a, 2000). These measures also suggest that AGLGN's network marketing costs are relatively high.

IPART that while in principle the retail market for gas in New South Wales is contestable there is only a single retailer with substantial market power. The retailer is a subsidiary of AGLGN's parent company, the Australian Gas Light Company. The participants stated that AGLGN's network marketing scheme is not designed to expand the market for gas but only to protect the retailer's dominant market position by lowering its supply costs. After network marketing costs are excluded from O&M costs, AGLGN's performance is comparable to other distributors (IPART 1999a, 2000).

Inevitably, the different partial productivity measures suggest different levels of relative performance. Yet there is often no basis for determining the weight that should be given to the different measures. In the next section we discuss one possible way of overcoming this problem: the use of technical efficiency measures.

4. Technical Efficiency Measures

To address some of the shortcomings of our analysis of partial productivity ratios, we used empirical techniques, such as DEA and SFA, to measure the technical efficiency of the Australian gas distributors. Because of the limited size of our sample, and the minimum data requirements of these techniques, we decided to include data from U.S. gas distributors in our sample. As noted in the introduction, the inclusion of data from more than one country in an analysis of this type introduces a range of potential problems, including differences in environment (climatic, regulatory, etc.), differences in data reporting definitions, and so on. However, it also has the advantage of including firms from an (arguably) more competitive environment, and thus potentially providing a closer approximation to the ''world best practice'' production frontier.

Our frontier analysis is confined to the measurement of technical efficiency relative to an estimated production frontier. We could have attempted to also measure allocative efficiency, but we chose not to do so in this instance. There were several reasons for assessing only the technical efficiency of gas distributors. First, some Australian distributors are government organizations that may have different objectives and constraints from private providers—community service obligations, for example. This may restrict their ability to maximize profits or minimize costs.

Second, comparing the technical efficiency of distributors avoids the difficulties associated with obtaining detailed information on the appropriate prices of inputs; for example, the price of capital and wages and salaries. Controversy still prevails over the correct method of calculating the price of capital, and market characteristics for inputs vary between regions, probably distorting input prices. Therefore, judgments on the performance of public and private service providers are often made on comparisons of technical efficiency only.[16]

Still, international benchmarking is fraught with difficulties. Utilities operate under different regulatory regimes, consequently regulators focus on different aspects of the

16 See arguments in Pestieau and Tulkens (1993).

business. This encourages the collection of different data sets, which reduces the potential number of variables to include in the analysis.

Moreover, regulatory regimes and government ownership have created incentives that have distorted production decisions. For example, rate of return regulation can encourage over capitalization, and government-owned utilities may have excess employees due to union and/or political pressures. Capital inefficiencies cannot be easily addressed in the short term and the reduction of excess labor is subject to union pressure and community acceptance. Thus, the efficiency frontier reflects the best existing practice rather than best potential practice. Therefore, it is possible that we are underestimating the potential efficiency gains.

That said, the limitations of current data sets should not discourage regulators from undertaking international benchmarking to help assess the performance of utilities. Waiting for perfect data results in excessive delays, which would unduly restrict the regulators' assessments of performance. Further, the use of existing data provides a catalyst for utilities and regulators to improve the consistency and the range of data that is reported to regulators and the broader community. Better information encourages more sophisticated analysis that would assist regulators and the general public to gain further insights on the performance of utilities.[17] Such insights are important to setting regulatory frameworks that encourage the utilities to improve performance.

In this paper, the initial frontier method used is DEA. Detailed descriptions of this method are available in a number of publications. For example, see the books by Coelli et al. (1998) or Färe et al. (1994). DEA is a non-parametric method that uses linear programming to construct a piece-wise linear frontier over data on the input and output quantities of a sample of firms. One then measures the efficiency of each firm by measuring the distance that each firm lies from the constructed frontier.

Alternative, parametric (econometric) approaches to the construction of production frontiers are SFA and COLS. See Coelli et al. (1998) and Coelli and Perelman (1996) for discussion of these methods. These parametric frontiers have advantages over DEA in that traditional hypothesis tests can be conducted, and that they attempt to account for the effects of noise (in the case of SFA). However, DEA has advantages over these parametric methods in that it does not require the specification of a functional form or distributional forms (for the error terms) and it produces information on groups of efficient peer (or benchmark) firms for each inefficient firm in the sample.[18] SFA and COLS are used in this study to test the sensitivity of the DEA results.

4.1. Data Envelopment Analysis

Two DEA models are used in this study. A constant returns to scale (CRS) model and a variable returns to scale (VRS) model. We argue that the efficiency scores obtained from

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17 It should be stressed that any efficiency measure obtained should only be used as a basis for discussion between the firm and the regulator. No empirical model can hope to capture every minor factor which can influence performance. The firm must make a strong case to the regulator if it believes the model has not captured all important factors relevant to its situation.

18 The term ''inefficient'' is used purely in a technical sense to refer to firms that are not on the frontier.

the VRS model are the relevant ones for an analysis of gas distribution, because it is difficult to change ones scale of operation in the short run. However, we also calculate the CRS model so we can calculate and report scale efficiency information, which is equal to the difference between the CRS and VRS scores, as described below.

4.1.1. The Constant Returns to Scale (CRS) Model

We begin by defining some notation. Assume there is data on K inputs and M outputs on each of N firms. For the ith firm these are represented by the vectors $\mathbf{x}_i$ and $\mathbf{y}_i$, respectively. The $K \times N$ input matrix, X, and the $M \times N$ output matrix, Y, represent the data of all N firms. The purpose of DEA is to construct a non-parametric envelopment frontier over the data points such that all observed points lie on or below the production frontier.

The input orientated DEA problem may be specified as:

$$\begin{aligned} &\min_{\theta,\lambda} \theta \\ &\text{st} \quad -\mathbf{y}_i + Y\lambda \geq 0, \\ &\qquad \theta\mathbf{x}_i - X\lambda \geq 0, \\ &\qquad \lambda \geq 0, \end{aligned} \tag{1}$$

where θ is a scalar and λ is a $N \times 1$ vector of constants. The value of θ obtained will be the efficiency score for the ith firm. It reflects the amount by which the ith firm can proportionally reduce inputs, without leaving the production possibility space (defined as the area under the frontier). It will satisfy $\theta \leq 1$, with a value of 1 indicating a point on the frontier and hence a technically efficient firm. Note that the linear programming problem must be solved N times, once for each firm in the sample. A value of θ is then obtained for each firm.

4.1.2. The Variable Returns to Scale (VRS) Model

The CRS linear programming problem can be easily modified to account for VRS by adding the convexity constraint: $\mathbf{N1}'\lambda = 1$ to (1) to provide:

$$\begin{aligned} &\min_{\theta,\lambda} \theta \\ &\text{st} \quad -\mathbf{y}_i + Y\lambda \geq 0, \\ &\qquad \theta\mathbf{x}_i - X\lambda \geq 0, \\ &\qquad \mathbf{N1}'\lambda = 1, \\ &\qquad \lambda \geq 0, \end{aligned} \tag{2}$$

where $\mathbf{N1}$ is an $\mathbf{N} \times \mathbf{1}$ vector of ones. This VRS model forms a convex hull of intersecting planes which envelope the data points more tightly than the conical hull produced by CRS and thus provides technical efficiency (TE) scores which are greater than or equal to those obtained using the CRS model. The scale efficiency (SE) of the ith firm can be calculated as:

$$SE = TE_{CRS}/TE_{VRS}, \tag{3}$$

which will also vary between zero and one in value. A scale efficiency score of one indicates that the firm is operating at a point of technically optimal scale.

4.2. Parametric Frontier Methods

In addition to DEA, parametric techniques are also used to estimate the technical efficiency of the gas distributors, to test whether the distributors' efficiency is sensitive to the choice of the benchmarking technique. For this exercise, a translog input distance function is used to estimate the technical efficiency of the gas distributors.

A distance function is chosen because it is capable of describing the multiple-input and multiple-output production technology of gas distributors and does not require assumptions about the behavior of the distributors (e.g., cost minimization or profit maximization). A translog functional form is used because it provides a second-order approximation to any arbitrary functional form. This is what is commonly termed a ''flexible functional form''. Following Coelli and Perelman (1996), the translog input distance function may be written as follows[19]

$$\begin{aligned} d_I = \alpha_0 + \sum_{m=1}^{M} \gamma_m y_m + \frac{1}{2}\sum_{m=1}^{M}\sum_{n=1}^{M} \gamma_{mn} y_m y_n + \sum_{k=1}^{K} \beta_k x_k \\ + \frac{1}{2}\sum_{k=1}^{K}\sum_{l=1}^{K} \beta_{kl} x_k x_l + \sum_{k=1}^{K}\sum_{m=1}^{M} \delta_{km} x_k y_m. \end{aligned} \tag{4}$$

where d_I is the log of the input distance, y_m is the log of the mth output, x_k is the log of the kth input and the Greek letters are parameters to be estimated. The input distance function must be symmetric and be homogenous of degree $+1$ in inputs. The restrictions required for homogeneity of degree $+1$ in inputs are

$$\sum_{k=1}^{K} \beta_k = 1 \tag{5a}$$

and

$$\sum_{l=1}^{K} \beta_{kl} = 0, \quad k = 1, 2, \ldots, K, \quad \text{and} \quad \sum_{k=1}^{K} \delta_{km} = 0, \quad k = 1, 2, \ldots, K, \tag{5b}$$

and those required for symmetry are

$$\gamma_{mn} = \gamma_{nm}, \quad m, n = 1, 2, \ldots, M, \quad \text{and} \quad \beta_{kl} = \beta_{lk}, \quad k, l = 1, 2, \ldots, K. \tag{6}$$

19 The firm subscript is omitted to minimize notational clutter.

Imposing the homogeneity restrictions, we obtain

$$
\begin{aligned}
-x_K = \alpha_0 &+ \sum_{m=1}^{M} \gamma_m y_m + \frac{1}{2}\sum_{m=1}^{M}\sum_{n=1}^{M} \gamma_{mn} y_m y_n + \sum_{k=1}^{K-1} \beta_k (x_k - x_K) \\
&+ \frac{1}{2}\sum_{k=1}^{K-1}\sum_{l=1}^{K-1} \beta_{kl}(x_k - x_K)(x_l - x_K) + \sum_{k=1}^{K-1}\sum_{m=1}^{M} \delta_{km}(x_k - x_K) y_m - d_l. \qquad (7)
\end{aligned}
$$

In equation (7) we have the estimating form of the model. The distance term, d_l, is equivalent to an error term. When using COLS, we estimate this model using OLS and then adjust the intercept by adding the largest positive residual to it, to ensure that all observations are enveloped by the estimated frontier. This model implicitly assumes that there is no noise in the model, as is assumed in DEA. The efficiency score for the ith firm will be equal to $\exp(-d_{li})$.

When using SFA, we assume the distance error term has two components, $d_l = v - u$. The v term is a symmetric error to account for data noise and the u term is a one-sided error to account for technical inefficiency. We make the standard assumptions that these terms are distributed as a normal and truncated-normal, respectively, and estimate the parameters using maximum likelihood. The efficiency score for the ith firm is predicted as the conditional expectation of $\exp(-u_i)$ given d_{li}. For more on COLS and SFA estimation of translog distance functions, see Coelli and Perelman (1996, 1999, 2000) and Morrison Paul et al. (2000).

5. Empirical Model of Gas Distribution

5.1. The Nature of Gas Distribution

The least cost method of transporting natural gas from the wellhead to the customer is usually by dedicated pipelines and mains (BIE 1994; EIA 1997). This method of transporting gas has the characteristics of a natural monopoly because it: requires large and lumpy capital investments that have no alternate use (i.e., large sunk costs); embodies large-scale economies; and requires special rights-of-way.[20]

Distributors use a combination of assets to reticulate gas from city gate stations to customers served by retailers. The assets include: high and medium to low pressure mains; services (pipes connecting households to mains); meters; and regulators to maintain the pressure of the gas. For example, a detailed description of AGLGN's distribution assets is presented in Ewbank Preece (1999).

20 Gas pipelines are generally presumed to be a natural monopoly. However competition in gas networks has commenced in New South Wales and electricity competes with gas in some industrial and household applications.

5.2. Model Specification

The technical relationship that describes how resources are used to distribute gas to different categories of customer provides the foundation for specifying the inputs and outputs for the benchmarking exercise. Discussions with industry and community participants and previous studies of the efficiency of gas distribution help further to define the inputs and outputs of gas distribution (BIE 1994; Rushdi 1994; Waddams Price and Wayman-Jones 1996; Kim et al. 1999). The input and output measures used in this study are discussed below. The data is described in IPART (1999a).

5.2.1. Sample Size

A sample of 59 distributors is used to calculate the technical efficiency of local and U.S. distributors (see IPART 1999a, for details). Local distributors included in the sample are: AGLGN (NSW), AGLGN (ACT), Envestra (SA), Envestra (QLD), Multinet Gas (VIC), Stratus Networks (VIC), Westar (VIC) and Allgas (QLD).[21] Data is obtained from local and U.S. regulatory returns, statutory reports issued by local distributors, and local distributors.[22]

DEA is sensitive to the specification of the inputs and the outputs and the size of the sample. Inflating the number of inputs and outputs relative to the sample size will generally increase the efficiency of the distributors, because each firm will tend to become unique in some way and hence has few or no benchmark partners. The BIE (1994) study provides an example where the specification of a large number of inputs and outputs relative to the sample size produced results suggesting that most of the distributors were VRS technically efficient. However, the higher levels of apparent efficiency may be caused by the inclusion of a greater number of variables in the analysis rather than improvements in relative efficiency. Given the relatively small sample of distributors included in the study, we focus on the major inputs and outputs to avoid degrees of freedom problems.[23]

5.2.2. Inputs

Capital is a major expense incurred by the distributors. It can be represented by physical or monetary measures. Both approaches have strengths and weaknesses. Physical measures are often used in studies that focus on the technical efficiency of organizations. However, physical measures have several disadvantages. First, physical measures cannot capture all the capital equipment used in the production process. Second, it is difficult to

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21 The Australian State or Territory where the distributors' network is located is included in parenthesis. Two NSW distributors, Great Southern Energy Gas Networks and the Albury Gas Company, were excluded from the study because they are relatively small compared to the sample. United States transmission companies were excluded from the study according to information gas utilities submit to the Energy Information Agency, and American Gas Association (1996).

22 The study used 1997 data for the U.S. distributors and a combination of financial and calendar year information for the years 1997–1998, 1998–1999 and 1998 for the local distributors. Information on length of mains for the U.S. distributors was obtained from the *Pipeline & Gas Journal*.

23 See Zhang and Bartels (1998) for an illustration of the effect of sample size upon average technical efficiency scores obtained using DEA.

account for differences in asset quality, age, and composition—for example, different sizes of mains or materials used to construct the mains.

Monetary measures better reflect the capital used in the production process. However, creating monetary measures of capital is problematic. First, it is difficult to obtain a consistent series of capital values because accounting methods and revaluation policies are not uniform within organizations. Therefore, variations in efficiency may reflect different accounting standards. Second, there is still debate over the correct method of calculating the monetary values of capital.

For this exercise, the length (kilometers) of distribution mains is used to measure capital for several reasons. Mains are the major capital component of distribution networks and the information on mains is likely to be accurate because distributors collect this information to help monitor and report on performance.

However, length of mains may not readily account for different sizes of main, or the different material composition of the mains, which could influence the efficiency of a distributor. For example, a distributor with a higher proportion of cast iron mains is likely to have higher O&M costs than another distributor with similar network length and size of mains because cast iron mains require greater maintenance to prevent gas leakages.

The ability of distributors to ''control'' the length of mains is limited. To a large extent, the length of the mains reflects the size of the region where customers reside or conduct business activities. However, a distributor, to some extent, can influence the length of mains through system design and by making decisions not to serve certain areas.

The O&M costs incurred by distributors include labor,[24] network marketing, corporate overheads, expenses on contracting, and spare parts. A monetary measure is used for O&M costs because it is not possible to combine the diverse range of inputs into a single physical measure.

After consulting with industry participants, local and U.S. distributors' O&M costs were adjusted to reflect similar cost structures. The federal energy regulatory commission (FERC) regulatory codes that are consistent with AGLGN's activity-based cost structure are used to develop O&M costs for local and U.S. distributors. Customer accounts expenses, UAG, and government levies are excluded from the distributors' O&M costs because certain local distributors do not incur these costs.[25] Still, differences in O&M costs could arise because distributors use different definitions and assumptions to allocate costs to FERC codes. The purchasing power parity (PPP) exchange rate for Australia and the U.S. is used to convert the U.S. distributors' O&M costs into Australian dollars (OECD 1998).[26]

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24 Initially, we attempted to specify a separate labor variable in this study. However, the large amount of out-sourcing (or contracting out) evident in many firms in our sample led us to decide to construct a single non-capital input variable. This also had the advantage of reducing the number of variables in the model and hence improving degrees of freedom.

25 See IPART (1999a) for the list of FERC codes used in the analysis.

26 This price index is less than ideal, since it is a PPP for all industrial activities. An index which referred solely to gas distribution inputs would have been preferred, but no such index could be identified.

5.2.3. Outputs

The capacity to deliver gas is a fundamental output of gas distribution. For example, AGLGN charges industrial (contract) customers (which consume greater than or equal to 10 TJ of gas per year) for the transportation of gas in accordance with their maximum daily throughput per annum. By contrast, residential, commercial and industrial (tariff) customers (which consume less than 10 TJ of gas per year) are charged for total annual throughput plus a fixed charge for access to the network.[27] Other local distributors have similar charging regimes. However, the information on capacity to deliver gas is inconsistent across distributors. Some distributors present information on maximum daily quantities of gas or maximum hourly quantities of gas for contract customers. Few distributors present information on the capacity to deliver gas to the tariff market. Furthermore, we could not locate information on the capacity of U.S. distributors.

Because data for the benchmarking exercise is restricted to one year, total deliveries (TJ) was used as a proxy for the capacity to transport gas.[28] It is assumed that greater deliveries imply a greater capacity to deliver gas. Deliveries of gas are used in lieu of sales, because it includes the transport of gas for other parties. This practice is common in the U.S. and the Code provides for these arrangements in Australia. We recognize that this measure of capacity may, to some extent, reflect different sizes of mains or load factors rather than differences in efficiency.[29]

The ability to deliver gas to sites is influenced by the number of supply or connection points, and the mix of tariff and contract customers that distributors serve. Consistent information on connection points is not available. Therefore, customer numbers are used as a proxy for connection points in this study. Distributors generally incur greater costs in delivering gas to tariff customers than to contract customers, because more infrastructure (mains, services and meters) is required to deliver gas to tariff customers. In Australia, tariff customers include residential customers and some businesses. However, definitions of commercial and industrial customers vary between the U.S. and Australia. Customers are split into residential customers and other customers to mitigate the effects of differences in customer definitions. For example, in the case of DEA, the specification of these two customer variables will ensure that firms with similar residential/non-residential ratios are benchmarked against each other.

Quality of service is influenced by several factors, including the price of services. Customers require a reliable supply of gas for business and household activities. However, there is little information on the reliability of services, such as interruptions to gas supply. UAG (expressed as a ratio of UAG to deliveries) reflects some aspects of quality because customers usually bear the cost of UAG according to prescribed targets set by regulators. The lower the prescribed targets are for UAG, the lower the costs of UAG borne by

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27 The vast majority of these customers are residential customers.

28 UAG is excluded from total deliveries.

29 Ideally, we would prefer to have data for a number of years for each firm, to reduce the possibility that the study year chosen may have unusual climatic effects influencing the demand for gas in particular geographical areas.

Table 4. Preferred Model Specification

Inputs	Outputs
Length of mains (km)	Deliveries (TJ)
O&M costs ($A)	Residential customers (no.)
	Other customers (no.)

customers. The reciprocal of UAG is used to measure quality because a higher UAG will result in a smaller output.

5.3. The Preferred Model

The preferred model is presented in table 4. The preferred model was selected on the basis that: key inputs of the capacity to deliver gas are included in the model; the model's output measures provide the best representation of activities associated with gas distribution, given limited information on outputs; the number of inputs and outputs is reasonable, given the limited sample size; the model provides a reasonable comparison between similar sized distributors; sensitivity analysis (which is discussed below) suggests the model is robust to changes in model structure and estimation method.

The reciprocal of unaccounted for gas (UAG), which is a measure of quality of service, is included in an alternative DEA model to help test the robustness of the preferred model. The specification of the alternative model is presented in table 5.

5.4. Accounting for the Operating Environment

The operating environment, such as climate and age of network, may influence the distributors' efficiency. A better assessment of the technical efficiency of the distributors requires that the environmental influences be measured and, where relevant, excluded from the DEA efficiency scores.

AGLGN (1999) stated that the following environmental factors could influence the gas distributors' efficiency: climate; soil type; topography; mains materials; age of mains; degree of urbanization; and location of industrial loads within the network.

However, it provided little information on the relative importance these environmental factors have on the efficiency of gas distribution and did not suggest sources of information for the environmental factors. Information was obtained on climate and age of network only and these factors are included in the analysis. Information is not available to include other environmental variables in the analysis. Further effort is required to assess the influence of the other environmental variables on the efficiency of gas distribution. We

Table 5. Alternative Model Specification

Inputs	Outputs
Length of mains (km)	Deliveries (TJ)
O&M costs ($A)	Customers (no.)
	The reciprocal of UAG (%)

note that the U.K. water regulator, the office of water services (Ofwat), requires water companies:

> ... to explain, justify and quantify the weight to be placed on these [environmental] factors. The burden of proof should rest on the higher cost companies to justify why they should not be classed as less efficient than their peers (Ofwat 1998, 3).

The study adopted two approaches to account for the influence of the operating environment on the efficiency of each distributor in DEA: (i) via the careful specification of the DEA model; and (ii) via a second-stage Tobit regression which tested the influence of the environmental variables upon the predicted efficiency scores.

The specification of the DEA model used in this study accounts for some aspects of the operating environment. This is because the DEA technique will bring together benchmark partners that use a broadly similar mix of inputs and outputs. For example, companies which serve areas with low population densities will tend to have higher ratios of length of mains to O&M costs. Hence, one tends to find that inefficient firms from low density areas are compared with efficient firms from low density areas, and so on.

Further analysis of environmental factors is undertaken by regressing the VRS technical efficiency scores produced by DEA against environmental variables, such as climate and age of network.[30] If these environmental variables are statistically significant, the DEA scores are adjusted to account for the environmental differences faced by distributors. Estimated regression coefficients are used to adjust the DEA scores for differences in the operating environment.

6. Empirical Results

6.1. DEA Results

6.1.1. DEA Scores

The DEA scores presented in table 6 indicate the potential for local distributors to reduce inputs while maintaining existing outputs. The distributors may not be able to achieve maximum savings in inputs because of regulatory constraints, labor constraints, limited opportunities to reduce length of mains and the operating environment. However, the DEA scores do reflect some aspects of the operating environment, such as population density and customer mix. A list of the efficiency scores for the entire sample is presented in IPART (1999a).

The CRS technical efficiency scores indicate the presence and extent of the inefficiency of input use. For example, on average, the local distributors are 72.9% efficient. This suggests they could reduce their inputs, on average, by about 27%. The extent of the

30 A Tobit procedure is used instead of OLS because the VRS technical efficiency scores are censored from above at one. Under these circumstances OLS produces biased and inconsistent results Judge et al. (1988).

Table 6. Summary Statistics: Technical Efficiency of Australian Gas Distributors

Distributor	CRS Technical Efficiency (%) (1)	VRS Technical Efficiency (%) (2)	Scale Efficiency (%) (3) = (1)(2)
AGLGN (NSW)	59.1	59.2	99.8
AGLGN (ACT)	41.6	67.4	61.7
Envestra (SA)	77.3	81.2	95.2
Envestra (QLD)	63.8	98.3	64.9
Multinet (VIC)	100.0	100.0	100.0
Stratus (VIC)	84.8	86.6	98.0
Westar (VIC)	96.9	100.0	96.9
Allgas (QLD)	59.3	100.0	59.3
Aust. mean	72.9	86.6	84.5
Sample mean	73.0	82.0	89.9
Minimum	41.6	47.8	42.1
Maximum	100	100	100
Efficient distributors (no.)	8	16	9

inefficiency is a combination of VRS technical efficiency (i.e., how well a distributor converts inputs into outputs) and scale effects. A score of 100% indicates that the distributor is technically efficient.

The emphasis of the exercise is on VRS technical efficiency. To a large extent, the size of a distributor is beyond the control of current management. The local distributors' VRS technical efficiency ranges from 59.2% to 100%, compared to the sample mean of 82%. Most local distributors are more efficient than the sample average. The scale efficiency scores suggest that scale is not a major source of inefficiency for the larger distributors (i.e., AGLGN (NSW), Envestra (SA), Multinet Gas, Stratus Networks and Westar (VIC)). However, scale is a significant source of inefficiency for the smaller distributors (i.e., AGLGN (ACT), Envestra (QLD) and Allgas (QLD)).

6.1.2. Influence of the Operating Environment on Efficiency

VRS technical efficiency scores are regressed against climate and age of network to assess their impact on efficiency. Climate is measured by heating degree days. A heating degree day is defined as the ''sum of degrees which the mean temperature is below 18° C in any day'' (AGA 1998, 72). The age of the local networks is measured by the ratio of depreciated optimized replacement cost to optimized replacement cost, and the age of the U.S. networks is measured by one minus the ratio of accumulated depreciation to asset value. Both approaches provide an equivalent measure of the extent that the life of asset has expired (see IPART 1999a, for details). Information on climate was obtained from the AGA (1999) and the American Gas Association (1996). The information on age of network was obtained from regulatory returns and local distributors.

The regression results indicate that climate and age of network explain about 5% of the variation in the efficiency scores, and the estimated coefficients of climate and the age of the network were not significantly different from zero at any standard level of significance. Therefore, the DEA scores are not adjusted for these environmental factors. Similarly, climate and age of network were not significant at the 5% level of significance in the SFA and COLS models and were hence excluded from the analysis (IPART 1999a). Consequently, the SFA and COLS efficiency scores are comparable to the DEA VRS technical efficiency scores.

The insignificant influence of climate on efficiency may appear counter-intuitive to some people. However, it is not unreasonable for the net benefits of delivering gas in a cold climate to be small. A cold climate increases the demand for gas for heating, but the distributors located in cold regions have to install additional capacity to satisfy peak winter demands. Adverse climatic conditions and peak loads may impact on the cost of operating and maintaining the system. Furthermore, additional costs may be incurred in maintaining and repairing mains and other assets in adverse conditions; managing the risks of interruptions; reduced asset lives; and constraints on scheduling maintenance.

6.2. Sensitivity Analysis

A variety of approaches were used to test the sensitivity of the DEA results. Namely: (i) adjusting the O&M costs for AGLGN (NSW) and AGLGN (ACT) to include additional O&M estimates provided by AGLGN, resulting in lower O&M costs for AGLGN (NSW) and AGLGN (ACT);[31] (ii) changing the manner in which efficiency is measured relative to the frontier, by assuming that the distributors can reduce O&M costs only (i.e., mains are held fixed);[32] (iii) changing the variable set used in the model for gas distribution (i.e., including the reciprocal of UAG as an output quality variable and aggregating customer numbers into a single output variable); and (iv) using alternative methods of estimation (i.e., SFA and COLS).

The results of the sensitivity analysis are presented in table 7. The general patterns of efficiency and the ranking of distributors' efficiency are consistent between most of the models.[33] Furthermore, most of the distributors that form the DEA frontier for the preferred model also form the frontier for the other DEA models.

The parametric techniques produce lower efficiency scores for the preferred model because the estimated frontier bounds the data less tightly than DEA. However, in some instances (e.g., Envestra (QLD) and Multinet Gas), the efficiency scores are about 20–30%

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31 See IPART (1999a) for more details.

32 See Coelli et al. (1998, 171–172) for a description of the DEA model involved.

33 The correlation coefficient and the Spearman rank correlation coefficient between the efficiency scores of the preferred model are 0.65 and 0.62 respectively when estimated by DEA and SFA. The correlation coefficient and Spearman rank correlation between the efficiency scores of the preferred model are 0.64 and 0.57 respectively when estimated by DEA and COLS. Stronger correlations exist between patterns of efficiency produced by the various DEA models. The correlation coefficient and the Spearman rank correlation coefficient between the efficiency scores of the preferred model and the preferred model with mains fixed are 0.95 and 0.95, respectively. And the correlation coefficient and Spearman rank correlation between the efficiency scores of the preferred model and the alternative model are 0.90 and 0.91, respectively.

Table 7. Summary of Sensitivity Analysis of VRS Technical Efficiency Scores

Distributor	Original DEA Scores (%)	Revised O&M Costs (%)	Network Fixed (%)	Alternative Output Variables (%)	SFA (%)	COLS (%)
AGLGN (NSW)	59.2	60.6	50.0	57.6	57.1	52.7
AGLGN (ACT)	67.4	72.0	67.4	69.0	59.6	59.3
Envestra (SA)	81.2	81.2	76.2	79.5	79.5	73.7
Envestra (QLD)	98.3	98.3	96.9	98.0	89.4	72.9
Multinet (VIC)	100	100	100	100	88.9	76.8
Stratus (VIC)	86.6	86.6	80.4	86.0	69.9	62.7
Westar (VIC)	100	100	100	99.7	99.9	100
Allgas (QLD)	100	100	100	100	90.0	89.9
Aust. mean	86.6	87.3	84.0	86.2	79.3	73.5
Sample mean	82.0	82.1	72.7	77.9	78.8	71.4
Minimum	47.8	47.8	35.0	41.6	47.3	44.7
Maximum	100	100	100	100	99.9	100
Observations (no.)	59	59	59	59	59	59
Efficient distributors (no.)	16	16	16	15	0	1

lower than the DEA results.[34] Nevertheless, as noted above, for the sample as a whole, and AGLGN (NSW) in particular, the techniques produce results that are similar to DEA.

Fewer efficient distributors are identified when the frontier is estimated by the parametric techniques. SFA recognizes that some of the distance from the frontier is due to random events or statistical noise in the data. Therefore, it is common not to have efficient organizations in a sample. The COLS frontier is formed by a two step procedure. First, the average frontier is estimated by OLS. Then the intercept is adjusted upwards until all the residuals are non-positive and at least one residual is zero. Distributors associated with the residuals that are zero form the frontier. Therefore, the COLS method often identifies only a single organization as efficient. Parameter estimates of the input distance function that is estimated by SFA and COLS are presented in IPART (1999a). A list of the SFA and COLS scores for the entire sample is also presented in IPART (1999a).

To sum up, the results presented in this paper suggest that there is scope for most local distributors to improve performance, especially AGLGN (NSW). The choice of the benchmarking technique did not unduly influence the results of the exercise. Furthermore, the sensitivity analysis does not contradict initial impressions of the efficiency rankings of the Australian distributors, which were formed after examining a variety of partial productivity measures.

34 If these empirical results were to be used for setting a price determination for these two firms, one would need to attempt to explain these varying results. The extra flexibility of DEA, relative to parametric methods may explain part of this difference.

7. Ipart's Decision on AGLGN's Non-Capital Costs

7.1. The Role of Benchmarking

According to the Code, IPART can only permit AGLGN to raise revenues that are consistent with the efficient costs of a prudent supplier. Benchmarking analysis using formal techniques, such as DEA, provide important input to the assessment of efficient costs. The more robust the model and the data, the more weight that can be placed on the outcomes. However, IPART has highlighted the important role for judgment in assessing both the scope for efficiency gains and the pace at which a prudent service provider could achieve these gains. These judgments will also be informed by other cost analyses and benchmarking tools.

In assessing efficiency, IPART endeavors to maintain a clear separation between responsibilities of the regulator and the operational responsibilities of AGLGN. The predominant regulatory interest is in the overall efficiency of gas distribution. One view is that the regulator should not dictate the utility's operational decisions in the conduct of its business. A detailed examination of the prudency of individual cost elements entails the risk that the regulator will ''run the business.'' The benchmarking exercise provides a ''top down'' view of efficiency. This form of benchmarking is in addition to, not an alternative to, the ''bottom up'' approach of process benchmarking. The latter is particularly useful to management and is regularly undertaken by business. Process benchmarking can also contribute to the regulator's assessment regarding the overall scope for improvements in efficiency.[35]

However, the Code requires IPART to disaggregate major costs, like non-capital costs, and to examine opportunities to form judgments on the level of the cost components. Consequently, IPART used a combination of the two approaches to assess the scope for potential improvements in efficiency for AGLGN.

In accordance with the Code, IPART proposed an incentive framework that encourages AGLGN to continuously improve its performance. The price cap and benchmarking studies provide incentives in the short term.[36] The real incentive for long-term efficiency improvements is delivered through the form of regulation and the approach adopted in resetting the regulated revenues at the end of each regulatory period. Key factors for effective incentive regulation are the extent to which prices at each review are based on actual costs or industry benchmarks and the extent to which the utility may continue to benefit from efficiency gains made in the previous period.[37] IPART recognizes that regulation must be sustainable and consistent, and should seek to minimize the risk of intervention between reviews. In setting sustainable regulated revenues, it is desirable to reduce the risk of excessive profits or losses due to forecasting errors. This requires careful

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35 In 1995, when it was an integrated gas company, the Australian gas light company (AGL) participated in a process benchmarking study conducted by the American Gas Association.

36 The price caps for AGLGN's gas services is determined by a regime based on CPI-*X*, where *X* is the prescribed productivity gains to be achieved by AGLGN over the access determination. For further details see IPART (2000, 1999c).

37 See IPART (1999b) for a discussion of these issues.

consideration of the scope for efficiency gains so as to base the regulatory framework on realistic assessments of efficient costs.

7.2. The Scope for AGLGN to Reduce Non-Capital Costs

IPART stated that the various approaches used to benchmark AGLGN's non-capital costs generally suggest that it has higher costs than local and U.S. counterparts. Consequently, reductions in AGLGN's costs are necessary to align its costs with more efficient operations. Further cost reductions are required to reflect the ongoing productivity improvements, which will cause best practice costs to continue to decline. While techniques such as DEA and SFA focused on overall costs, partial indicators of non-capital costs showed a similar pattern.

In considering these results IPART had to have regard to the requirements of the Code to consider, and come to a view on, each major cost category separately. IPART commissioned independent reviews of the capital base and the scope for optimization of the network assets. The consultants' reports highlight the uncertainties associated with asset optimization studies Ewbank Preece (1999).

In considering the scope for the reductions in non-capital costs IPART had regard to the results of partial productivity measures as well as the aggregate benchmarking analysis using DEA and other techniques. However, a simple translation of the results of the latter to the potential reductions in non-capital costs is not appropriate. The aggregate benchmarking results had to be interpreted in the context of the separate reviews which examined the scope for optimization of the asset base. Furthermore, it is necessary to have regard to the inevitable uncertainties in the assessment of the potential efficiency gains. Therefore, the translation of the efficiency gains into the CPI-X framework has to consider factors other than efficiency—for example, managing the risks that the utility makes excessive profits or losses.[38]

In determining the cost reduction target for AGLGN, IPART considered: the reductions in costs being pursued by best practice companies; AGLGN's performance relative to local and U.S. counterparts; and the scope for reduction in network marketing costs.

IPART noted that AGLGN's performance is comparable to other local distributors when network marketing costs is excluded from the analysis. Further, IPART stated that AGLGN should be capable of achieving national trends in industry productivity growth, which is about 3% per annum (Industry Commission 1997).[39] Therefore, IPART considered that non-capital costs net of marketing costs could be reduced by 3% per annum.

An important factor in IPART's assessment of prudent non-capital costs is network marketing costs. The partial productivity measures suggest that AGLGN's network marketing costs are relatively high. Therefore, a substantial reduction in AGLGN's non-capital costs is achieved through the reduction of network marketing costs. After considering the analysis and the views of participants, IPART decided that AGLGN could reduce network marketing costs by 19% per annum.

38 See IPART (1999b) for further details.

39 Recent work by the Productivity Commission (1999) suggests that productivity growth for the electricity, gas and water sector was about 3.4% over 1988–1989 to 1997–1998.

In considering the above factors, IPART stated that AGLGN could reduce controllable non-capital costs by about 28% over five years. Controllable non-capital costs are defined as non-capital costs less government levies, UAG and market contestability costs. The calculation of the controllable cost reduction net of marketing costs is adjusted with an equal weighting for growth in total throughput and total customer numbers.[40] Network marketing costs are adjusted with equal weighting on the growth in tariff throughput and tariff customer numbers. IPART proposed that the reduction in controllable non-capital costs be phased in over the Access Arrangement (i.e., 1998–1999 to 2003–2004) to allow AGLGN adequate time to implement the changes. IPART (2000, 1999c) present further details on the reasons to reduce AGLGN's non-capital costs.

8. Future Directions

This study suggests that the ability of Australian distributors to achieve and maintain world best practice for efficient delivery of gas varies from firm to firm. For most Australian distributors there is scope to improve performance.

The study provides indicative information on performance and should not be used in a mechanical manner to set efficiency targets for the distributors. A wide range of factors, including the operating environment, could influence performance. Moreover, the regulatory issue of whether the targets for the improvement in performance for the less efficient distributors are set according to their best practice peers requires further consideration.

The results need to be interpreted with care because of variations in the quality of data. Assistance was sought from local distributors to reconcile differences in local and overseas data. However, there remains significant scope for improving the data. Further effort is required to ensure consistent and reliable information is collected in the future. In particular, information published by local distributors on non-capital costs and network capacity requires greater consistency. Greater effort is required to determine the actual influence of the operating environment on the efficiency of gas distribution. Finally, we need to examine opportunities to expand the data set, which would further strengthen the robustness of the benchmarking exercise.

That said, the benchmarking exercise provided important information on the relative efficiency of Australian gas distributors, which helped IPART to determine the non-capital costs for AGLGN. Some Australian distributors acknowledge the potential for benchmarking to assist in forming regulatory judgments and have suggested that local pricing and access regulators and network businesses acquire a better understanding of the various benchmarking techniques and to identify approaches to improve the information that underpins these analyses.

On a more general note, there is little doubt that the models used in this paper, even though quite sophisticated, are imperfect. However, whenever one attempts to build an

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40 IPART (1999a) presents regression analysis that suggests gas throughput and customer numbers have a significant influence on O&M costs.

empirical model of any description, one must decide where to draw the line, in terms of the complexity of the model (otherwise one will produce a model with very little discriminatory power). Thus, benchmarking results should never be used in an entirely prescriptive manner to set X factors for use in price-cap regulation. However, the performance measures can be combined with other relevant information, including submissions from the firms regarding possibly important omitted factors, to assist the regulator in implementing regulatory structures which provide incentives for performance improvement.

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