Efficiency Comparisons of Australian and New Zealand Gas Distribution Businesses Allowing for Operating Environment Differences

Prepared for
Multinet Pty Ltd

19 March 2007

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AUSTRALIAN CAPITAL TERRITORY NEW SOUTH WALES VICTORIA

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EXECUTIVE SUMMARY

The Essential Services Commission (ESC) is presently conducting a Gas Access Arrangement Review for 2008 to 2012. Multinet Pty Ltd has engaged Meyrick and Associates to compare Multinet's total costs and operating and maintenance expenditure (opex) efficiency with other Australian and New Zealand gas distribution businesses (GDBs), taking differences in operating environments beyond management control into account.

We examine the efficiency of Multinet's total cost and opex use relative to a sample of 8 other Australian GDBs and three New Zealand GDBs.

As a relatively large distributor, Multinet could be expected to be at something of an advantage in raw efficiency comparisons if economies of scale exist, as is likely in a network industry like gas distribution. Multinet also has a relatively high customer density which should lead to some cost efficiency advantages. However, Multinet has a relatively low energy density which would tend to disadvantage it in raw efficiency comparisons.

We develop and estimate three separate econometric models to examine Multinet's relative total cost and opex efficiency taking differences in scale, energy and customer density, and production technologies into account. The models developed are:

- a translog cost function model;
- an opex requirements function model; and,
- a second stage regression model.

By estimating a translog cost function model for the Australian and New Zealand data we are able to compare Multinet's actual total and opex costs with those forecast by the model to apply to an average firm operating under Multinet's conditions and, hence, determine whether Multinet is more efficient than the average GDB included in the sample.

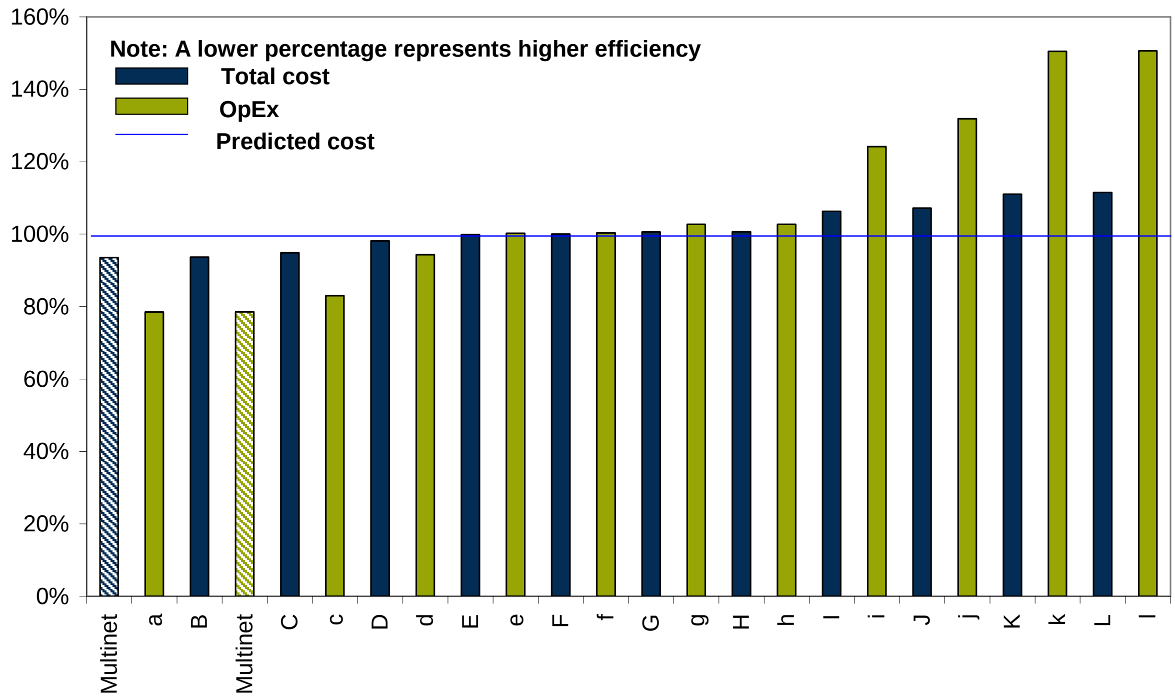
The main findings from the cost function analysis are:

- Multinet's actual total cost is on average 6.5 per cent less than that predicted by the model for the seven year period, 1998 to 2005 – this means that Multinet is a better than average overall cost efficiency performer compared to its peers when scale, customer density and energy density effects are taken into account;
- Multinet's actual opex cost is on average 21.5 per cent less than that predicted by the model – this means that Multinet has a much better than average opex efficiency performance when scale, customer density and energy density effects are taken into account;

- by implication, Multinet also has about average capital efficiency when scale, customer density and energy density effects are taken into account; and,
- in terms of relative rankings, Multinet has the best total cost performance and second best opex performance when adjusted for differences in market and operating conditions.

Ratios of actual relative to predicted cost for total cost and opex are presented in Figure A.

Figure A **Actual total cost and opex as a percentage of those predicted by the translog cost function model**



The estimation of an opex input requirements function has some similarities to a cost function model but looks at the relationship between the quantity of inputs used by each GDB and its operating environment conditions. By including dummy variables for each GDB other than Multinet we are able to test whether the other GDBs are statistically different in their efficiency relative to Multinet if they faced the same operating environment conditions as Multinet. The operating environment conditions included are energy throughput, customer numbers, kilometres of network mains, the capital stock and technology.

The main findings from the opex requirements function analysis are that:

- 7 GDBs are statistically less efficient in terms of opex input requirements than Multinet;
- only one GDB is statistically more efficient in terms of opex input requirements than Multinet; and,
- there is no statistical difference relative to the other three GDBs.

In the third method reported in this study we regress an opex partial productivity measure, constructed using a multilateral index of customer numbers and terajoules of energy deliveries as the output measure, against output, customer density, energy density and a time trend. This allows us to calculate the range of adjusted multilateral opex partial productivity scores that are not statistically different from Multinet's.

This second stage regression model provides strong statistical evidence that:

- two GDBs are statistically less efficient in terms of opex input requirements than Multinet;
- only one GDB is statistically more efficient in terms of opex input requirements than Multinet; and,
- there is no statistical difference relative to the other 8 GDBs.

Despite the strengths and weaknesses of the three quite different types of econometric efficiency models estimated, the similar results we have obtained from each lend support to the robustness of the findings. Considering the models collectively, the similar results obtained from each of the methods lead to the robust finding that Multinet's total cost and opex efficiency is better than most of the other 11 Australian and New Zealand GDBs in the database.

1 INTRODUCTION

Multinet Pty Ltd operates a gas distribution business (GDB) in Victoria and has engaged Meyrick and Associates ('Meyrick') to conduct an econometric analysis of the efficiency of Australian and New Zealand GDBs. We compare Multinet's total costs and operating and maintenance expenditure (opex) with other Australian and New Zealand GDBs, making allowance for differences in operating environment characteristics to the extent data are available. This study is part of the information being compiled by Multinet for input to the Gas Access Arrangement Review for 2008 to 2012 being conducted by the Essential Services Commission (ESC).

Meyrick and Associates have provided regulatory and performance measurement advice to a wide range of regulators and infrastructure utilities in Australia, New Zealand and Canada over the past decade. The authors of this report pioneered the application of total factor productivity and efficiency measurement to energy supply in Australia.

This report presents the statistical results of benchmarking Multinet relative to a sample of 11 other Australian and New Zealand GDBs. Three techniques are applied: cost function analysis, estimation of an input requirements function and second stage partial productivity analysis. Multiple methods are examined because successful implementation of a particular method cannot be guaranteed given the characteristics of a particular database, particularly where there are relatively few observations and data are assembled from a range of public domain sources. However, if multiple methods can be successfully estimated and they provide a similar picture, then the robustness of the conclusions is correspondingly enhanced.

The following parts of this section of the report summarise the terms of reference for the study and list Meyrick and Associates' benchmarking experience and the qualifications of the consultants involved. We then outline key features of the methodology adopted in the current study, highlighting a number of measurement issues, and describe the database used in the following section. We then present the econometric results from estimating a translog cost function in Section 3, from estimating input requirements functions in Section 4 and from second stage productivity regression estimation in Section 5. Based on this econometric evidence we draw conclusions regarding Multinet's total cost efficiency and opex efficiency relative to firms in the database in Section 6.

1.1 Terms of reference

Multinet's terms of reference to Meyrick requested an econometric analysis of the efficiency of Australian and New Zealand gas distribution businesses. This was to include an estimate of a translog cost function model using the Australia and New Zealand database constructed in Meyrick and Associates (2007a). The terms of reference also requested estimation of an econometric inputs requirements function and inclusion of dummy variables for each GDB other than Multinet to permit testing whether the other GDBs would be statistically different in their efficiency relative to Multinet if they faced the same operating environment conditions as Multinet. In addition, the terms of reference requested a second stage regression analysis to adjust the multilateral productivity scores for operating environment differences to allow the calculation of the range of adjusted multilateral productivity scores that are not statistically different from Multinet's.

A copy of the letter of retainer for the study is presented in Attachment A.

1.2 Meyrick and Associates' experience and consultants' qualifications

Meyrick and Associates has been operating in Australia for 15 years as a specialist infrastructure consulting firm. Meyrick provides strategic policy advice and rigorous quantitative research to industry and government, particularly on infrastructure matters. Meyrick's experience and expertise covers a wide range of economic and industry analysis topics including:

- infrastructure regulation;
- benchmarking of firm and industry performance;
- productivity measurement;
- infrastructure pricing issues;
- corporatisation and privatisation of government enterprises; and
- analysis of competitive neutrality issues.

This report has been prepared by Dr Denis Lawrence, Director of Meyrick and Associates, with assistance from Meyrick Associates Dr John Fallon and John Kain.

Denis Lawrence has undertaken several major energy supply industry benchmarking studies including: benchmarking the performance of New Zealand's 29 electricity lines businesses and advising the Commerce Commission on appropriate X factors for each of the distribution businesses; benchmarking the performance of Australian and New Zealand gas distribution businesses for the Commerce Commission; benchmarking the productivity performance of the Australian state electricity systems against best practice in the US and Canada at both the system–wide level and for individual power plants; benchmarking the productivity, service quality and financial performance of 13 Australian electricity distribution businesses; and reviewing benchmarking work undertaken for regulators in NSW and Victoria. Denis has worked on regulatory issues for electricity utilities, regulators, state Treasury departments, international agencies and prospective investors.

Denis holds a PhD in Economics from the University of British Columbia, Canada. Denis' summary CV is presented in Attachment B.

John Fallon is an Associate of Meyrick and Associates and Director of Economic Insights. John has extensive experience in economic modelling, econometric techniques, cost–benefit analysis, discounted cash flow analysis, and performance measurement. He has also been an adviser on economic regulation issues in several major price determinations and regulatory hearings in relation to airports, electricity, gas, rail, seaports and water infrastructure, for both private and public clients. John has been an adviser on competition issues in relation to several high profile mergers in the airline, energy, wholesale and retail sectors. John holds a PhD in Economics from the University of Western Ontario, Canada.

John Kain is an Associate of Meyrick and Associates and Principal of Erldunda Associates. Prior to becoming a consultant John was employed by ACT Electricity and Water (ACTEW) as Chief Engineer and General Manager Engineering. Since leaving ACTEW, John has operated as an independent consultant in the energy distribution industry, specialising in the analysis of network costs and tariffs. John's clients have included the ACCC and distribution businesses. He has worked on several major benchmarking studies for Meyrick including assisting the NZ Commerce Commission with setting CPI–X thresholds for lines businesses. John holds Science and Engineering degrees from Sydney University.

Denis Lawrence has read the Federal Court Guidelines for Expert Witnesses and this report has been prepared in accordance with the Guidelines. A declaration to this effect is presented in Attachment C to the report.

2 BENCHMARKING METHODOLOGY

This study extends the partial indicator comparisons of opex and capital performance of Australian and New Zealand GDBs reported in Meyrick and Associates (2007a) by undertaking a range of econometric and indexing modelling using the database constructed in the earlier study. Economic efficiency can be estimated using a range of modelling techniques. The most common of these are cost function estimation and the use of multilateral TFP indexes. In this report we use three different econometric techniques to assess relative efficiency:

- estimation of a translog cost function;
- estimation of an input requirements function; and
- second stage regression analysis of measured productivity.

By estimating a translog cost function model for the Australian and New Zealand data we are able to compare Multinet's actual total and opex costs with those forecast by the model to apply to an average firm operating under Multinet's conditions and, hence, determine whether Multinet is more efficient than the average GDB included in the sample.

The second econometric method we use is the estimation of an inputs requirements function. This function has some similarities to a cost function model but looks at the relationship between the quantity of inputs used by each gas distribution business and its operating environment conditions. By including dummy variables for each distributor other than Multinet we are able to test whether the other GDBs are statistically different in their efficiency relative to Multinet if they faced the same operating environment conditions as Multinet.

Multilateral TFP indexes allow us to compare productivity levels as well as productivity growth rates. In Meyrick and Associates (2004) we constructed Multilateral TFP indexes for a range of Australian and New Zealand GDBs. In that instance we only had one observation per business and had to use ad hoc methods to adjust for operating environment differences. In the third method reported in this study we use second stage regression analysis to adjust the multilateral opex partial productivity scores for a range of operating environment differences. This allows us to calculate the range of adjusted multilateral opex partial productivity scores that are not statistically different from Multinet's. If this range includes the most efficient scores observed then Multinet can be demonstrated to be an efficient performer.

2.1 Measuring productivity

Productivity is a measure of physical output produced from the use of a given quantity of inputs. In practice, productivity is measured by expressing output quantity produced as a ratio of the quantity of inputs used. Previous network productivity studies have used two methods for measuring productivity:

- total factor productivity (TFP); and
- partial factor productivity (PFP).

TFP measures the total output produced relative to all inputs used. TFP, thus, measures the impact of all the factors affecting growth in output other than changes in input levels. The partial productivities of each input can then be found by dividing either individual output quantity indexes or the aggregate output index by the respective index of the quantity of the input under consideration. PFP, thus, measures one or more outputs relative to one particular input. For example, labour productivity of the repairs field workforce is the ratio of the number of repairs relative to the number of persons engaged in repairs in the field. PFP measures are widely used, as they are simple to calculate. However, used in isolation, PFP measures should be interpreted with caution as a misleading impression of overall performance may result if the analysis concentrates on only one input and differences in operating environments are not allowed for.

In undertaking comparisons of productivity performance it is, thus, important to use comprehensive productivity measures wherever possible and recognise the limitations of using partial productivity measures that represent output relative to a particular input. It is the overall productivity of all inputs combined that is most important for assessing efficiency and ensuring prices are as competitive as possible.

Partial productivity comparisons do, on the other hand, have an important role to play in helping explain differences in overall productivity performance. When comparing partial productivities across utilities, however, it is important to make adjustments for key operating environment differences. For example, the relative efficiency of operating and maintenance expenditure (opex) can be influenced by:

- the scale of operations – larger utilities tend to have higher productivity than smaller utilities, other factors equal;
- the structure of the network served – the greater the proportion of the network which is made up of cast iron and low pressure mains, the lower the PFP of opex activities; and,
- the more capital intensive a GDB is, the higher the PFP of operations and maintenance expenditure, other factors equal.

In this study we examine both comprehensive and partial productivity and efficiency measures using a range of econometric methods that allow operating environment differences to be taken into account.

2.2 Measurement issues

In common with other network industries, measuring the total output of gas distribution is not straightforward. An important dimension of output for network industries is provision of the capacity to deliver the product to customers. This is in addition to the amount of throughput delivered in any one period.

Early energy supply productivity studies simply measured output by system throughput. However, this simple measure ignores important aspects of what gas mains really do. Like all network infrastructure industries, a major part of gas mains' output is providing the capacity to supply the product. In this sense, there is an analogy between a gas distribution system and a road network. The GDB has the responsibility of providing the 'road' and keeping it in good condition but has little, if any, control over the amount of 'traffic' that goes down the road. Consequently, the GDB's output should also be mainly measured by the availability of the infrastructure it has provided and the condition in which it has maintained it. Other outputs the distributor provides are directly related to its number of connections ('local access roads') as well as call centre operations responding to queries, connection requests, etc.

Meyrick and Associates (2003) captured these multiple dimensions of network for electricity distribution business output by including three outputs: throughput, system line capacity and connection numbers. This also had the advantage of incorporating the major density effects (consumption per customer and customers per MVA–kilometre of line) directly into the output measure. Meyrick and Associates (2007b) has developed a similar system capacity output measure for the three Victorian GDBs using detailed data on lengths, diameters and pressures of different mains types for each GDB. A paucity of data on mains characteristics has precluded using this approach in this study.

Pacific Economics Group (2004a, 2006) also included three output dimensions in their electricity distribution business TFP study: throughput, customer numbers and non–coincident peak demand. This measure of peak demand was used as a proxy for maximum contracted demand which was the concept of system capacity thought to be appropriate. A paucity of consistent data on GDB peak demand has precluded using this approach in this study.

Previous gas network efficiency studies have typically only included two of the three principal output dimensions – throughput and customer numbers. BIE (1994), PEG (2001a,b,c) and Meyrick and Associates (2004) included throughput and total customer numbers as the outputs while IPART (1999) included throughput, residential customer numbers and other customer numbers. IPART (1999) also included the reciprocal of unaccounted for gas as an output in an alternate specification as an attempt to include service quality although this measure abstracts from the main reliability dimensions.

Following PEG (2004b), in this study we use customer numbers as the primary output measure in the estimation of the cost function and include measures of energy and customer densities as environmental variables. This is a simple but effective approach, especially when there are limited data available. PEG (2004b) used customer numbers as a single output measure in estimating a translog cost function model for electricity distribution based on data for 72 US electricity distribution companies for the period 1991–2003. In the second stage productivity regression model we use a multilateral index of customer numbers and terajoules of energy as the output measure and explore the impact of customer and energy density on the partial productivity of opex expenditure. The input requirements function that we specify also focuses on opex and explores the impact of energy output, customers, kms of mains, and the capital stock as explanatory variables.

2.3 Data sources and variables

The database for this study was developed in Meyrick and Associates (2007a) and covers 9 Australian GDBs and 3 New Zealand GDBs. Two additional Australian GDBs (Envestra Albury and Country Energy Wagga) and one New Zealand GDB (Wanganui Gas) included in Meyrick and Associates (2007a) were not included in the current study because of their very small size compared to the other GDBs.

The 9 Australian GDBs included in the study are:

- ActewAGL (ACT);
- AGLGN (NSW);
- Alinta (Western Australia);
- Allgas Queensland;
- Envestra Queensland;
- Envestra South Australia;
- Envestra Victoria;

- Multinet (Victoria); and
- SP AusNet (Victoria).

The 3 New Zealand GDBs included in the study are:

- NGC Distribution;
- Powerco; and,
- Vector.

In this report we outline Multinet's results compared to the other GDBs, none of which are named except for Multinet. Instead, the other GDBs are given an alphabetic code in each graph or table, depending on their relative order. Thus, the code changes between graphs so that, for example, GDB "A" does not always refer to the same business.

For the estimation we pooled the data for all the GDBs to estimate single equations or systems of equations for each method implemented. This provided a sample of 97 observations spanning the period 1998–2011 with the number of years varying by company depending on data availability.

The data sources for the Australian GDBs are the final approvals for access arrangements by jurisdictional regulators, Access Arrangement Information (AAI) filings and the Essential Services Commission (2006) *Gas Distribution Businesses Comparative Performance Report*. In some cases information from annual reports was used to supplement the information provided in the final approvals and AAIs, mainly in relation to information on customer numbers and kilometres of network mains.

The data sources used for the NZ GDBs are the Information for Disclosure filings required by the Gas (Information Disclosure) Regulations 1997 and the New Zealand Commerce Commission (2004) *Gas Control Inquiry Final Report*.

Opex cost covers distribution activities only and excludes all capital costs and transmission fees. It includes all directly employed labour costs, contracted services and materials and consumables costs associated with operating and maintaining the distribution service. The quantity of the GDB's opex is derived by deflating the opex value series by the operations and maintenance price index reported in PEG (2006). This operating and maintenance price index is a weighted average of labour costs (62 per cent) and other costs represented by a range of producer price indexes (38 per cent). The price index was projected forward at an annual rate of 3.5 per cent based on the average annual growth rate from 2000 to 2005.

Capital input costs are calculated as 15 per cent of the depreciated optimised replacement cost for each GDB based on the sample average gross rate of return for the period. The gross rate of return includes both the depreciation rate and the residual return available to capital owners. The price of capital inputs was the annual value of capital inputs divided by kilometres of mains where the latter is used as a proxy for the quantity of annual capital inputs.

Energy density is measured by the average number of terajoules (TJ) delivered per customer while customer density is measured by the average number of customers per kilometre of network mains.

The original public domain cost data were in a mix of nominal and real terms based on different years. Cost data were initially converted to 2006 dollars using the all groups consumer price indexes for each country. The New Zealand data were then converted to 2006 Australian dollars using the (OECD 2006) estimate of purchasing power parity for 2005 of 1.06862 New Zealand dollars per Australian dollar. Purchasing power parities between Australia and New Zealand have shown little variation from year to year so the 2005 estimate should be a reasonable approximation for 2006. Purchasing power parities are the rates of currency conversion that eliminate differences in international price levels and are commonly used to make comparisons of real variables between countries. Input values were then formed by multiplying the respective price and constant dollar series together.

3.2 Characteristics of the included GDBs

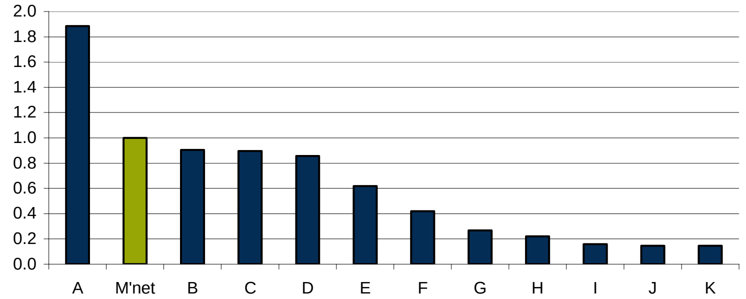
Multinet has the second largest output of the GDBs included in this study (Box 1) where output is the multilateral index of energy deliveries, customer numbers and kilometres of network mains formed in Meyrick and Associates (2007a).

Multinet also has the second highest capital intensity where capital intensity is the share of capital costs in total costs. Conversely, Multinet has the second lowest opex intensity in the sample. The spread of input intensities is relatively narrow across the sample.

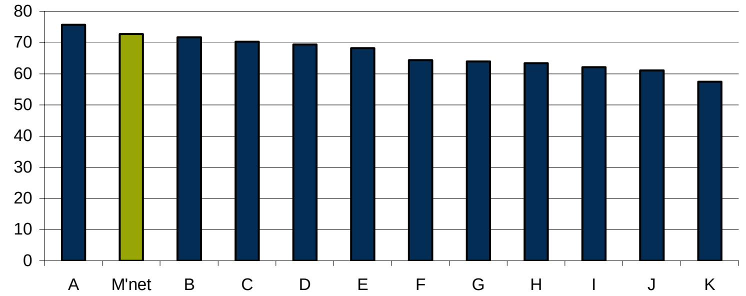
Multinet’s customers only consume moderate amounts of gas per customer on average giving it a ranking of eighth on energy density across all customers (both residential and industrial). However, Multinet has the highest customer density in the sample. Multinet’s relatively low energy density would be expected to disadvantage it in unadjusted productivity comparisons, all else equal. In contrast, the relatively high level of output and relatively high customer density would be likely to give Multinet some productivity advantage.

Box 1 **Operating and market characteristics of the GDBs, 2005**

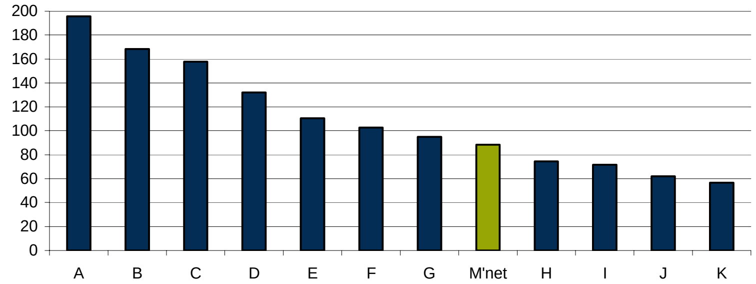
Output (Multilateral Index of Energy, Customers and Km of Mains, Multinet 2005=1.00)



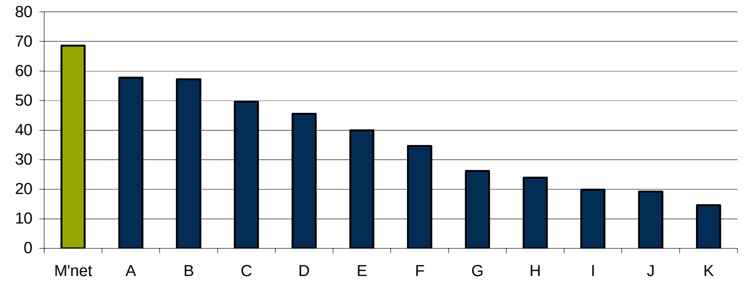
Capital intensity (%)



Energy density (MJ/customer)



Customer density (Customers/Km)



Source: Meyrick and Associates gas utility database

3 COST FUNCTION ANALYSIS

3.1 Overview of the technique

The use of cost function analysis to derive efficiency scores adjusted for environmental and operating effects has a long history. For example, Pacific Economics Group (2001a,b,c) evaluated the opex performance of the three Victorian GDBs relative to that of US gas distribution utilities by estimating an econometric cost function model that explained the effect on a company's gas distribution cost of some measurable business conditions. The parameters of the model were estimated by established statistical methods using recent data from a large sample of American investor–owned gas distribution utilities. The model was used to predict recent opex for the Australian utilities given the values for the (included) business conditions that the utilities faced. The business condition variables included input prices, the amount of outputs provided, and certain characteristics of the customer base and service territory. The model therefore controlled, among other things, for differences in realised scale economies. Cost performance was evaluated by comparing the Australian utilities' actual opex with those predicted by the model for an average US utility facing similar business conditions.

This general approach to cost performance measurement is argued to have some advantages over alternative benchmarking methods. One is that its effectiveness does not require a suitable peer group. The benchmark is based, instead, on the (included) business conditions that a company faces. For opex, an important advantage of the cost function approach is that it accounts for the possible substitution of capital for opex. This is because the opex prediction is derived from a comprehensive cost model that reflects potential opex–capital substitution. However, it should also be noted that, in common with other econometric models, cost function estimation is neither always transparent nor reproducible and multicollinearity problems often limit the scope to include more than a few operating environment variables in practice.

3.2 Estimation

In this study we estimate a translog cost function model for the pooled data set and use the parameter estimates to make inferences about the efficiency of Multinet relative to the sample average. The translog cost function has been widely used in economic research and in regulatory hearings. It has the major advantage of being an approximation to a wide range of functional forms and is generally a robust functional form for empirical work. The economic theory that underlies the translog cost function also enables a number of parameter restrictions to be imposed that are economically sensible and that also facilitate estimation.

In particular, linear homogeneity in prices is imposed (so that a doubling of all prices is reflected in a doubling of costs without any substitution effects occurring) and symmetry in the parameters of price terms is also imposed so that inputs respond in a symmetric manner to relative price effects.

We estimate a translog cost function model that includes the following variables:

- output as measured by the total number of customers;
- opex and capital input prices;
- energy density as measured by total terajoules per customer; and
- customer density as measured by total customers per kilometre of mains.

The approach of taking customer numbers as the primary output measure with energy and customer density as separate operating environment variables is similar to that used by Pacific Economics Group (2004b).

The translog cost function system estimated has the following form:

$$
\begin{aligned}
(1)\quad & \ln C = b_0 + b_Q \ln Q + 0.5 b_{QQ} \ln Q \ln Q + b_X \ln P_X + (1-b_X)\ln P_K + 0.5 b_{XX} \ln P_X \ln P_X - b_{XX} \ln P_X \ln P_K \\
& + 0.5 b_{XX} \ln P_K \ln P_K + b_{QX} \ln Q \ln P_X - b_{QX} \ln Q \ln P_K + b_E \ln ED \; + 0.5 b_{EE} \ln ED \ln ED \\
& + b_{EX} \ln ED \ln P_X - b_{EX} \ln ED \ln P_K + b_{EQ} \ln ED \ln Q + b_C \ln CD + 0.5 b_{CC} \ln CD \ln CD \\
& + b_{CX} \ln CD \ln P_X - b_{CX} \ln CD \ln P_K + b_{CQ} \ln CD \ln Q + b_{EC} \ln ED \ln CD \; + e_C \\
& S_X = b_X + b_{XX} \ln P_X - b_{XX} \ln P_K + b_{QX} \ln Q + b_{EX} \ln ED + b_{CX} \ln CD + e_X
\end{aligned}
$$

where 'ln' is the natural logarithm operator, *C*, *Q*, *X* and *K* represent total cost, output quantity, opex and capital, respectively. *P* and *S* represent the price and share in total costs, respectively, of the relevant input, *ED* is energy density, *CD* is customer density and *e* is the equation's error term. Restrictions are imposed on the coefficients as shown to ensure linear homogeneity of degree one in prices (ie if all prices double, cost should also double, all else equal) and symmetry of input responses to relative price changes. The capital share equation is dropped to facilitate the estimation process. The results are invariant to which share equation is dropped for estimation purposes.

The model was estimated using Zellner's (1962) seemingly unrelated regressions estimator which has superior statistical properties compared to ordinary least squares in this situation. An iterative process was used which produces results equivalent to maximum likelihood estimation.

The regression results for the cost function estimation are presented in table 1. The coefficients are all of the expected sign and highly statistically significant.

Table 1: **Cost function regression estimates**[1]

Coefficient	Estimate	t–statistic[2]	Coefficient	Estimate	t–statistic
b_0	1.217	15.173	b_{EX}	0.064	10.821
b_Q	0.795	39.775	b_{EQ}	–0.027	–7.190
b_{QQ}	0.019	8.441	b_C	–0.161	–2.487
b_X	0.589	26.477	b_{CC}	0.304	11.829
b_{XX}	0.188	42.560	b_{CX}	0.216	23.555
b_{QX}	–0.049	–13.870	b_{CQ}	–0.081	–9.708
b_E	0.258	8.376	b_{EC}	0.106	8.925
b_{EE}	0.025	3.056			

1 R^2 between observed and predicted is 0.99

2 Critical t-statistics for testing are: 1.289, 1.658, 1.980 and 2.358 for the 20, 10, 5 and 1 per cent levels significance, respectively. A 5 per cent level of significance is used as the standard measure and less than 1 per cent is considered to be a very high level of significance. Results at the 10 per cent level of significance are also considered to be statistically meaningful.

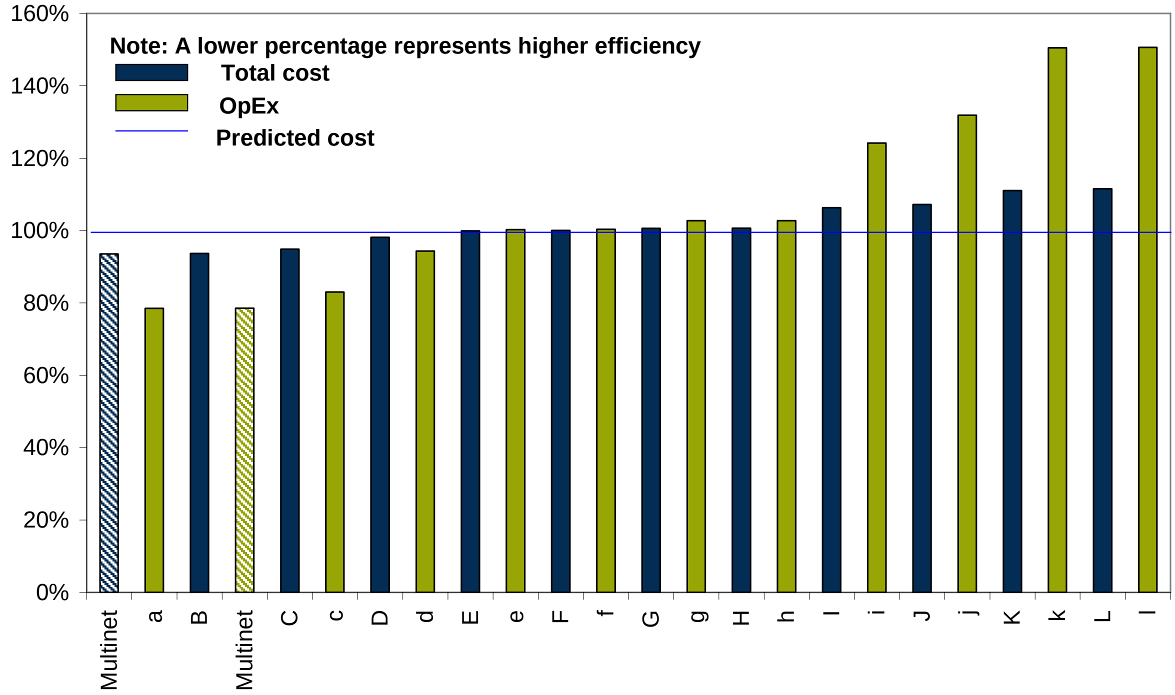
Costs increase with increases in output, opex prices and energy density, all else equal, while they decrease with increases in customer density, all else equal. The estimates indicate increasing returns to scale but the second order term suggests that increasing returns to scale diminishes as output increases.

Having estimated the cost function model, we can now proceed to examine the overall efficiency of each of the included GDBs by comparing their actual costs with the costs the model predicts for them. If their actual costs are less than their predicted costs then they have better than average efficiency after allowing for the included operating environment effects. If their actual costs exceed their predicted costs from the model then they have worse than average efficiency levels taking included operating environment effects into account. We can also assess relative efficiency in the use of a particular input in an analogous fashion by comparing actual cost for that input with the implied prediction derived by multiplying predicted total cost by the input's predicted cost share.

We plot the cost function efficiency results in figure 1 which shows actual total costs and opex as a percentage of the respective costs predicted by the model. The results for total costs and opex are plotted in rank order from lowest to highest percentage – that is, highest to lowest efficiency. GDBs other than Multinet are identified only by the letters A, B, C, etc. It should be noted that because total costs and opex are each presented in rank order, distributor 'A' that has the best total costs ratio is not necessarily the same as distributor 'a' that has the best opex ratio and so on.

From figure 1 we see that Multinet has the most efficient total cost performance on the basis of the cost function analysis and the second best opex performance.

Figure 1 **Actual total cost and opex as a percentage of those predicted by the translog cost function model**



In summary the main findings from the cost function analysis are:

- Multinet's actual total cost is on average 6.5 per cent less than that predicted by the model for the seven year period, 1998 to 2005 – this means that Multinet is a better than average overall cost efficiency performer compared to its peers when scale, customer density and energy density effects are taken into account;
- Multinet's actual opex cost is on average 21.5 per cent less than that predicted by the model – this means that Multinet has a much better than average opex efficiency performance when scale, customer density and energy density effects are taken into account;
- by implication, Multinet also has about average capital efficiency when scale, customer density and energy density effects are taken into account; and
- in terms of relative rankings Multinet has the best total cost performance and second best opex performance when adjusted for differences in market and operating conditions.

We turn now to focus specifically on opex cost efficiency performance and the second of our relative efficiency assessment methods, opex requirements function estimation.

4 OPEX REQUIREMENTS FUNCTION ANALYSIS

4.1 Overview of the technique

Christensen *et al* (1985) first used the input requirements function technique to adjust measured productivity in the United States postal system for changes in the number of delivery points in the postal network. They estimated Diewert's (1974) factor requirements function and this model was adapted to adjust measured productivity in electricity supply for differences in environmental factors by Zeitsch, Lawrence and Salerian (1994) who specified a function of the form;

(2) $I = C / W = \mathrm{f}(E, K, C, t)$

where I is an aggregate index of inputs used by the GDB, C is total cost incurred by the GDB, W is a measure of the GDB's unit input prices, E is an index of sales, K is the capacity of the GDB's system, C is the number of the GDB's customers and t is a time trend representing structural improvements.

Equation (2) can be rearranged to show that it is based on the joint cost function having the following separable form:

(3) $\mathrm{C}(W, Y, K, C, t) = \mathrm{c}(W)\ \mathrm{f}(Y, K, C, t)$

where c is a unit cost function (estimated via index number theory) and f is the input requirements function. Zeitsch, Lawrence and Salerian used a single output Multilateral TFP model of electricity distribution based on throughput and then used the input requirements function to adjust for differences in the system capacity per kilowatt hour of throughput for two systems, one of which had a much larger and more sparsely settled territory than the other. Attempts to include the customer variable failed due to its high correlation with the throughput variable.

The input requirements function approach has also been used in work for the ACCC on postal service efficiency (Meyrick and Associates 2002) and applied to electricity distribution efficiency measurement in New Zealand (Meyrick and Associates 2003). The input requirements function approach has generally worked better when there is a relatively long time–series of observations available for each firm.

4.2 Estimation

In the current study we adapt the input requirements function approach to estimate an opex requirements function, ie we apply the concept to the use of opex rather than total inputs as has commonly been done in previous studies. We start with the efficient industry surface, which involves efficient combinations of *E*, *C*, *K*, *M* and *X* (where *M* is the quantity of opex inputs and *X* is the quantity of non–opex (ie capital) inputs). Given *E*, *C*, *K* and *X*, we solve for the minimum amount of opex input that will put us on the efficient surface. The resulting function, *M* = g(*E*, *C*, *K*, *X*, *t*) is the period *t* industry (efficient) factor requirements function. Note that a factor requirements function is a perfectly general representation of the technology and no restrictions on the technology have been imposed. Given the limited degrees of freedom available, we estimate a linear factor requirements function with a constant term (so that there can be locally increasing or decreasing returns to scale), with a time variable to account for industry technical progress and 11 firm dummies to account for relative firm efficiencies. Thus, the models estimated are of the form:

(4) $$M = \alpha_0 + \alpha_e E + \alpha_c C + \alpha_k K_k + \alpha_x X + \sum_{j \neq MULTINET} \alpha_j D_j + \alpha_t t + e$$

This model can be expected to capture (at least to the accuracy of a first order approximation) the key exogenous operating environment, market and technology effects beyond management control. Customer and energy density differences are allowed for by incorporating the key outputs of energy throughput, customers and system capacity separately. Opex/capital substitution is captured by the inclusion of the quantity of non–opex inputs.

The coefficients on the dummy variables will again measure the efficiency of the relevant GDB relative to Multinet after allowing for the included operating environment, market and technology effects. However, the signs of the dummy variables have the opposite interpretation to what they did in the preceding second stage adjustment model. This is because higher efficiency is reflected in using less opex (the dependent variable in the opex requirements function) given the included effects whereas in the preceding two stage model higher efficiency was represented by higher opex partial productivity (the dependent variable in the two stage model). Hence, in this case a negative and significant dummy variable coefficient means that the relevant GDB is significantly more efficient than Multinet while a positive and significant coefficient means that the relevant GDB is significantly less efficient than Multinet.

The market, operating environment, input and technology variables and the dummy variables that were used in the opex input requirements function were.

- TJ – energy output in terajoules;
- CUS – total customer numbers;
- KM – kilometres of network mains;

- RCSTK – real depreciated optimised replacement cost asset value;
- TIME – a time trend to capture technology and structural improvements; and
- D_1 to D_{11} – dummy variables for all GDBs except Multinet.

Table 2 contains the results from estimating two versions of the opex input requirements function.

Table 2**: Opex requirements function regression results**

	Model 1			Model 2		
Variable	Coefficient	t–statistic[1]	Prob-value	Coefficient	t–statistic	Prob-value
TJ	0.0006	2.59	0.011	0.0007	3.97	0.000
CUS	–0.00002	–0.88	0.381	–0.00004	–4.93	0.000
KM	–0.0012	–0.83	0.412			
RCSTK	0.0586	3.57	0.001	0.04	3.80	0.000
TIME	–0.2356	–1.61	0.110			
D_1	1.52	0.39	0.698	–2.63	–1.50	0.14
D_2	–9.98	–1.92	0.058	–16.19	–5.20	0.000
D_3	15.74	2.59	0.012	15.40	2.69	0.009
D_4	19.93	2.86	0.005	14.37	3.50	0.001
D_5	9.71	1.26	0.211	2.86	0.71	0.479
D_6	18.74	2.23	0.029	13.37	3.55	0.001
D_7	17.70	2.08	0.041	10.61	2.84	0.006
D_8	25.81	3.18	0.002	21.46	5.93	0.000
D_9	17.14	1.87	0.066	8.85	2.17	0.033
D_{10}	20.96	1.87	0.066	10.76	3.18	0.002
D_{11}	20.51	1.34	0.185	5.98	1.44	0.152
CONSTANT	–14.23	–2.13	0.036	–9.36	–3.15	0.002
Adjusted R^2	0.99			0.99		

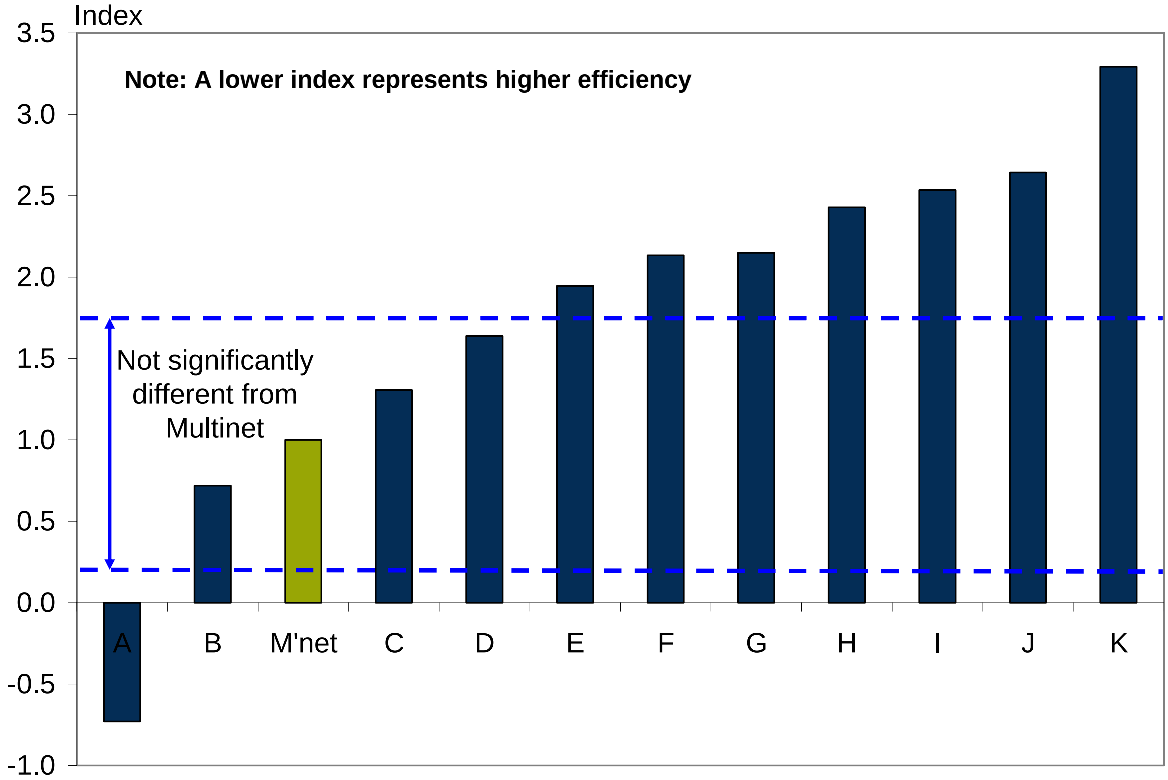
1 Critical t-statistics for testing are: 1.289, 1.658, 1.980 and 2.358 for the 20, 10, 5 and 1 per cent levels significance respectively. The prob (probability) value indicates the level of significance for which the coefficient estimate is statistically significant. A 5 per cent level of significance is used as the standard measure and less than 1 per cent is considered to be a very high level of significance. Results at the 10 per cent level of significance are also considered to be statistically meaningful.

Model 1 includes all of the variables described above, while Model 2 excludes the kilometres of network mains and the time trend. KM was excluded because it was not significant, had an unexpected negative sign on the coefficient and the network effects appeared to be captured by RCSTK. TIME was excluded because it was only marginally significant and the coefficient was implausibly large suggesting other coefficients may be affected because of multicollinearity. The conclusions in terms of significance were virtually the same whether or not TIME was included or excluded. CUS was retained because it was significant when other variables were excluded, although the coefficient had a negative sign suggesting that the variable may be capturing density effects when other variables are controlled for by the regression.

RCSTK is the main driver of opex input quantities apart from the time trend which, as noted, is only marginally statistically significant. RCSTK is highly statistically significant and, as it appears to capture the effect of system capacity, it is not possible to identify any significant substitution effects of opex for capital inputs.

Turning to the dummy variables, 9 dummy variables have a positive sign and 2 have a negative sign in Model 2 indicating that 9 other distribution businesses require more opex inputs when the various market and environmental factors are controlled for. Of the dummy variables with a negative sign, only one is highly statistically significant with the other being only very marginally statistically significant. Of the dummy variables with a positive sign 7 are highly statistically significant, one is very marginally statistically significant and the other is not statistically significant to any meaningful extent. Multinet is the third most efficient GDB when the dummy variables are used to indicate relative rankings.

Figure 2 **Normalised opex input requirements indexes**



The results are presented in graphical form in figure 2 which plots the normalised opex input requirements indexes from Model 2 after allowing for differences in energy deliveries, customer numbers and the value of the capital stock. They represent the sum of the constant term and the relevant dummy variable term for each GDB from the Model 2 regression expressed in index form so that Multinet's normalised input requirements index is set equal to one.

In summary, the input requirements analysis results provide strong statistical evidence that seven GDBs are statistically less efficient in terms of opex input requirements than Multinet, only one GDB is statistically more efficient in terms of opex input requirements than Multinet, and there is no statistical difference relative to the other three GDBs at the 95 per cent confidence level. The opex requirements function analysis, therefore, supports the findings of the translog cost function analysis reported in section 3.

5 TWO STAGE PARTIAL PRODUCTIVITY ESTIMATION

We turn now to the third modelling option that has been used in previous studies to adjust for operating environment differences, second stage regression analysis of opex partial productivity indexes.

5.1 Overview of the technique

Two stage regression analysis has the advantage of combining the strengths of both the standard index number based approach to calculating productivity (or the data envelopment analysis approach if sufficient observations are available) and the econometric approach to adjusting for operating environment effects. In the first stage, the standard partial productivity index is calculated and then in the second stage is regressed against a range of operating environment effects. The main advantage of second stage regression analysis of partial productivity scores over the cost function approach is that it has the potential to adjust measured efficiency for a greater number of operating environment factors.

Coelli, Rao and Battese (1998, p,170) describe the second stage process in the following terms:

> 'In the second stage, the efficiency scores from the first stage are regressed upon the environmental variables. The sign of the coefficients of the environmental variables indicate the direction of the influence, and standard hypothesis tests can be used to assess the strength of the relationship. The second–stage regression can be used to "correct" the efficiency scores for environmental factors by using the estimated regression coefficients to adjust all efficiency scores to correspond to a common level of environment (eg the sample means).'

Either ordinary least squares or Tobit regression methods can be used in the second stage analysis. Tobit analysis is a statistical technique that is used when it is known that the values the dependent variable can take must lie within a particular range or above some particular value. In the current case, for example, the calculated opex partial efficiency scores can never be negative. If the predicted dependent variables from OLS are positive then the estimates will coincide with those from Tobit analysis, as there are no binding constraints on the estimation process. If, however, OLS regressions produce negative predicted values then it will be necessary to move to Tobit analysis.

Coelli, Rao and Battese (1998, p.171) assessed the alternative approaches available for adjusting for operating environment differences and concluded the following:

> 'We have considered a number of possible approaches to the consideration of environmental variables. We recommend the two–stage approach in most cases. It has the advantages that:
>
> - it can accommodate more than one variable;
> - it can accommodate both continuous and categorical variables;
> - it does not make prior assumptions regarding the direction of the influence of the categorical variable;
> - one can conduct hypothesis tests to see if the variables have a significant influence upon efficiencies;
> - it is easy to calculate; and
> - the method is simple and therefore transparent.'

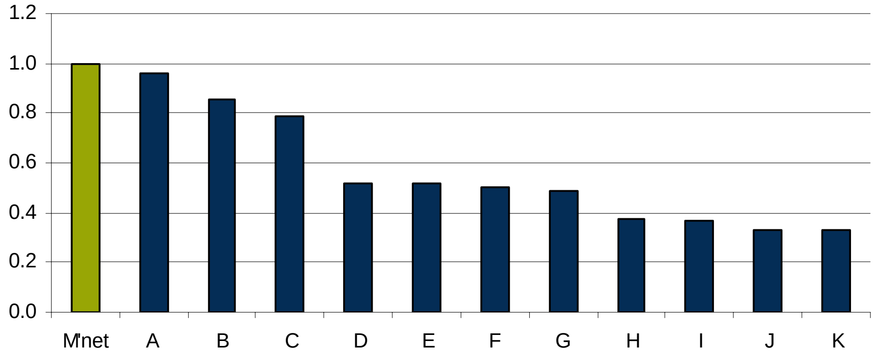
5.2 Opex partial productivities

The partial productivity of opex is obtained by dividing an index of output quantity by an index of the quantity of the opex input. Using different measures of distributor output will typically produce different opex partial productivity rankings across GDBs. In particular, urban based GDBs in densely settled areas will typically do well on output measures based on either throughput or customer numbers while GDBs in less densely settled areas will do poorly on these measures as they require more mains (and associated opex) to reach a given number of customers compared to their densely settled counterparts. Less densely settled area GDBs, on the other hand, will typically do relatively well where output is based on a measure of system capacity incorporating kilometres of mains. This is because they have large lengths of mains per customer compared to GDBs with more densely settled distribution areas.

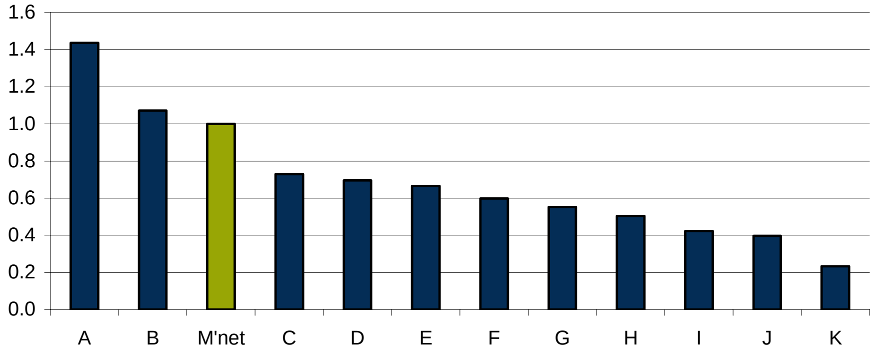
Customer and energy density differences, thus, play an important role in determining relative opex partial productivity scores. In previous work we have allowed for differing customer and energy densities by specifying a comprehensive measure of GDB output that includes measures of customer numbers, system capacity and throughput (see Meyrick and Associates 2007b). These three outputs have been weighted together using shares derived from econometric cost function estimates. In the current study there is insufficient data available to form measures of system capacity. We instead measure output principally by customer numbers (which is usually found to be the most important output in cost function studies such as PEG 2004b) and include customer and energy density as separate operating environment variables in the second stage regressions. This has the advantage of providing greater flexibility in the adjustment process with the imposition of a minimum number of assumptions.

Box 2 **Opex partial productivities using alternative output measures, 2005**

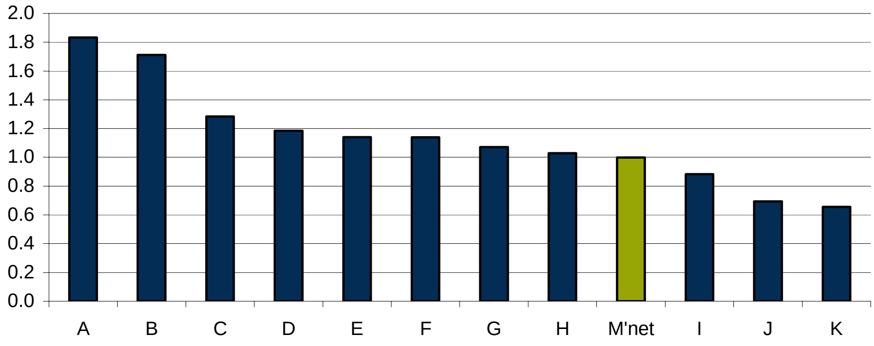
Customer number based opex partial productivity (Index Multinet 2005=1.00)



TJ based opex partial productivity (Index Multinet 2005=1.00)



Kilometres based opex partial productivity (Index Multinet 2005=1.00)



Source: Meyrick and Associates gas utility database

The effects of using different output measures in calculating opex partial productivity are illustrated in Box 2. Multinet has the highest opex partial productivity when output is measured by customer numbers, the third highest opex partial productivity when output is measured by terajoules of energy throughput and the third lowest opex partial productivity when output is measured by kilometres of mains. Meyrick and Associates (2007a) showed that the effect of combining these alternative output measures into a multilateral output index leads to Multinet having the third highest opex partial productivity.

Box 2 highlights the importance of making appropriate allowance for operating environment differences when considering relative opex efficiency levels.

In the current study we measure output by a multilateral index of customer numbers (which is usually found to be the most important output in cost function studies) and terajoules of energy. The respective weights in the index are 73.2 per cent and 26.8 per cent based on output cost elasticities shares from the two–output cost function reported in Meyrick and Associates (2007b).

5.3 Estimation

The productivity of the opex activities undertaken by each utility was hypothesised to be determined by several variables as follows:

- the level of output (a multilateral index of customer numbers and terajoules of energy);
- customer density (total customers per kilometre of mains);
- energy density (terajoules of energy per customer);
- a time trend; and
- dummy variables for all companies in the sample except Multinet.

A simple linear relationship was preferred as follows:

$$(5) \qquad PFPOM_i = \alpha_0 + \beta_1 Q_i + \beta_2 CD_i + \beta_3 ED_i + \beta_4 TIME + \sum_{j \neq MULTINET} \alpha_j D_{ji} + \mu$$

where, for utility *i*:

$PFPOM$ = partial factor productivity of opex;

Q = output;

CD = customer density;

ED = energy density;

$TIME$ = time trend;

D_j = dummy variable equals 1 for utility *j*, zero otherwise, for $j \neq AGLE$;

$\alpha_0, \alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5, \alpha_6, \alpha_7, \alpha_8, \alpha_9, \alpha_{10}, \alpha_{11}, \beta_1, \beta_2, \beta_3, \beta_4$ are the parameters to be estimated; and

μ = error term.

Since dummy variables are included for all the GDBs other than Multinet, the constant term represents the level of 'unexplained' opex partial productivity for Multinet. That is, it is the level of opex partial productivity which is left after allowance has been made for the included operating environment variables. The dummy variables then represent the difference between the constant (Multinet's average unexplained opex partial productivity level) and the constant that would apply for the relevant GDB (ie its average unexplained opex partial productivity level after allowing for the included operating environment factors). Hence, we can readily test for statistically significant differences in opex partial productivity levels after the included operating environment effects have been allowed for by examining the t–statistics on the dummy variables. The sign of the coefficient for the dummy variable indicates whether a particular GDB is more efficient (a positive sign on the dummy variable coefficient) or less efficient (a negative sign on the dummy variable coefficient) than Multinet while the t–statistic indicates whether the efficiency difference is formally statistically significant.

A statistically significant negative dummy variable means that the relevant GDB has statistically significantly lower opex partial productivity then Multinet after allowance is made for the included operating environment effects. Conversely, a statistically significant positive dummy variable means that the relevant GDB has statistically significantly higher opex partial productivity than Multinet after allowance is made for the included operating environment effects.

Similar coefficients on the non–dummy variables would be obtained using the alternative approach of including a dummy variable for each of the 12 GDBs in the sample but no constant term. A statistical test could be carried out to test for significant differences between the coefficients on the 12 dummy variables. Again the results would be the same as those obtained in the specification used here but the procedure is far less transparent. We, hence, prefer the specification where we include a constant term and a dummy variable for each GDB other than Multinet due to its simplicity and ease of interpretation.

The regression results for the second stage regressions of opex efficiency are presented in table 3. Overall, the statistical properties of the second stage regressions are less attractive than those of the opex requirements function reported in the preceding section. The coefficient of the output variable is positive and significant at the 8.2 per cent level of significance suggesting that partial opex productivity has a positive relationship with the multilateral output measure. The coefficient on the time trend also indicates that partial productivity of opex increases over time but formally the effect is only significant at the 12.1 per cent level of significance. The coefficient on the customer density variable indicates that partial productivity of opex increases as customer density increases but formally the effect is only significant at the 16.7 per cent level of significance. The coefficient on the energy density variable indicates that the partial productivity of opex decreases as energy density increases and formally the effect is significant at the 2.8 per cent level of significance. This result suggests that the more larger customers there are, the higher opex requirements will be.

Table 3: **Second stage regressions of operations and maintenance efficiency**[1]

Variable	Coefficient	t–statistic[2]	Prob-value	Variable	Coefficient	t–statistic	Prob-value
Q	0.004	1.761	0.082	D_5	0.003	0.407	0.685
CD	0.010	1.393	0.167	D_6	–0.011	–1.832	0.071
ED	–0.044	–2.235	0.028	D_7	–0.007	–1.143	0.256
$TIME$	0.0002	1.568	0.121	D_8	–0.006	–1.335	0.186
D_1	0.002	1.066	0.290	D_9	0.009	1.043	0.300
D_2	0.009	2.346	0.021	D_{10}	0.0003	0.050	0.960
D_3	–0.015	–5.005	0.000	D_{11}	0.006	0.677	0.500
D_4	–0.019	–3.973	0.000	α_0	0.031	2.471	0.016

1 R^2 between observed and predicted is 0.90

2 Critical t-statistics for testing are: 1.289, 1.658, 1.980 and 2.358 for the 20, 10, 5 and 1 per cent levels significance respectively. The prob (probability) value indicates the level of significance for which the coefficient estimate is statistically significant. A 5 per cent level of significance is used as the standard measure and less than 1 per cent is considered to be a very high level of significance. Results at the 10 per cent level of significance are also considered to be statistically meaningful.

Six of the dummy variables are positive in sign and five are negative in sign, after allowing for the effects of output, environmental variables and a time trend. However, most of the dummy variables are not statistically significant indicating that formally there is no statistical difference in the efficiency of those GDBs and Multinet.

Of the dummy variables that are negative, the prob values indicate that there is strong statistical evidence that two companies are clearly less efficient than Multinet in terms of the partial productivity of opex (as indicated by the results for D_3 and D_4). This can be expressed alternatively as we can reject that there is no difference in efficiency with a 99.9 per cent level of confidence for two of the companies where the negative sign of the coefficient on the dummy variable indicates these companies are less efficient than Multinet.

At this level of confidence all of the other efficiency differences are not statistically significant. However, one GDB is found to be more efficient at the 2.1 per cent level of significance (D_2) and an additional GDB is found to be less efficient at the 7.1 per cent level of significance (D_6).

It is also useful to evaluate the results being generated by this model by examining the elasticities of opex efficiency with respect to the variables in the model. These elasticities vary depending on the value taken for the particular variable and given the level of opex partial factor productivity. We have therefore chosen to evaluate the variables at the means of the variables for all utilities included in the study. These elasticities are given in table 4.

The elasticities given in Table 4 are plausible. They imply scale economies exist in utility operations as an expansion in output increases productivity somewhat. Similarly, an increase in customer density would increase opex productivity. However, an increase in energy density holding constant customer density and other variables would decrease it considerably. The time trend suggests that holding other variables constant the partial productivity of opex would increase over time.

Table 4 **Elasticities of opex partial productivity with respect to key variables** (percent change given a 1 per cent change in the variable)

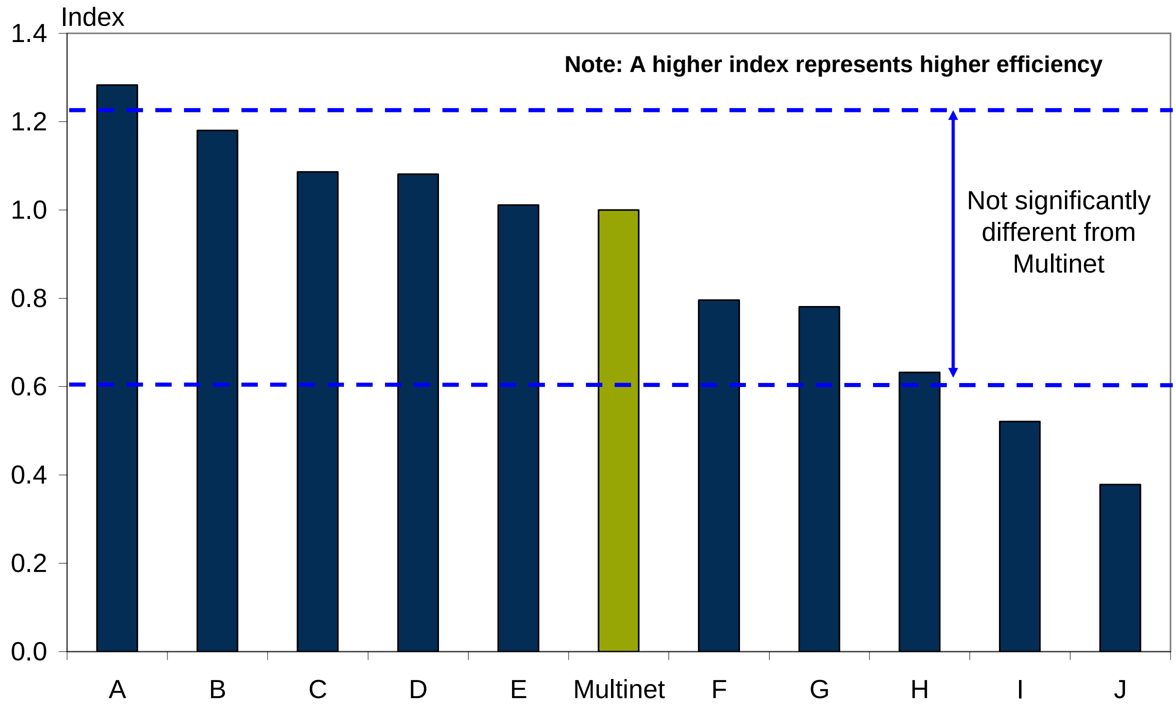
Variable	Unit	Elasticity evaluated at mean of database
Output	Multilateral index of customers & terajoules	0.13
Customer density	Customers per kilometre of network mains	0.36
Energy density	terajoules/customer	–0.50
Technology variable	Time	0.06

It is also possible to use the coefficient estimates for the dummy variables and the constant term to rank the relative performance of Multinet in terms of opex partial productivity. Using this approach Multinet has the seventh best performance in terms of opex partial productivity. However, such a ranking is not based on formal statistical evidence which confirmed that only one GDB was significantly more efficient than Multinet and two were less efficient than Multinet at a 95 per cent level of confidence.

The results are presented in graphical form in figure 2 which plots the average opex partial productivity for each of the included GDBs after allowing for scale, and energy and customer density differences. These opex partial productivities have thus been 'normalised' for the operating environment differences. They are the sum of the constant term and the relevant dummy variable term for each GDB from the second stage opex partial productivity regression expressed in index form so that Multinet's normalised opex is set equal to one.

The effect of the normalisation process can be seen by comparing figure 3 with the top graph in box 2 which presents the corresponding 'raw' opex partial productivities. On the raw opex partial productivity indexes Multinet ranked first in terms of customer numbers, third in terms of energy deliveries and ninth in terms of km of mains and there was a much wider spread of opex partial productivity levels in terms of energy deliveries. Using a multilateral measure of output that combines customer numbers and energy deliveries and normalising for the operating environment variables leads to the statistical inference that only one firm has a better opex partial productivity performance than Multinet and that two clearly have an inferior performance at the 95 per statistical confidence level. At this level of confidence the other firms' performance was not statistically different from Multinet's performance.

Figure 3 **Normalised opex partial productivity indexes**



In summary, while the second stage regression model does not perform as well statistically as the opex requirements function model, the results support the findings of the opex requirements function and cost function models that Multinet is a good opex efficiency performer. The results provide strong statistical evidence that Multinet's opex partial productivity, after allowing for the included exogenous effects, is statistically significantly higher than two of the other 11 GDBs, statistically significantly lower than only one other GDB and not significantly different from that of the other 8 GDBs.

6 CONCLUSION

In this report we have examined the efficiency of Multinet's total cost and opex use relative to a sample of 9 other Australian GDBs and 2 New Zealand GDBs. The models estimated allow for operating environment, market and technology differences between the distributors to put comparisons on a more like–with–like basis. This is particularly important given the range of GDB sizes and diversity of operating environment conditions found in Australia and New Zealand.

As a relatively large distributor, Multinet could be expected to be at something of an advantage in raw efficiency comparisons if economies of scale exist, as is likely in a network industry like gas distribution. Multinet has a relatively high customer density which should also lead to some cost efficiency advantages. However, Multinet has a relatively low energy density which would tend to disadvantage it in raw efficiency comparisons.

We have developed and estimated three separate econometric models to examine Multinet's relative cost and opex efficiency and adjust for differences in scale and operating environments. The main conclusions are as follows.

Estimation of a translog cost function model indicates that:

- after allowing for scale, customer and energy density differences, Multinet has the most efficient total cost performance and the second best opex performance;
- Multinet's actual total cost is on average 6.6 per cent less than that predicted by the model with most of the efficiency explained by opex performance; and
- Multinet's actual opex cost is on average 21.5 per cent less than that predicted by the model.

The estimation of an opex input requirements function that isolates the impact of energy throughput, customer numbers, kilometres of network mains, the capital stock and a time trend representing technological change provides strong statistical evidence that:

- 7 GDBs are statistically less efficient in terms of opex input requirements than Multinet;
- only one GDB is statistically more efficient in terms of opex input requirements than Multinet; and,
- there is no statistical difference relative to the other three GDBs.

The regression of an opex partial productivity measure, constructed using a multilateral index of customer numbers and terajoules of energy deliveries as the output measure, against output, customer density, energy density and a time trend provides strong statistical evidence that:

- two GDBs are statistically less efficient in terms of opex input requirements than Multinet;
- only one GDB is statistically more efficient in terms of opex input requirements than Multinet; and,
- there is no statistical difference relative to the other 8 GDBs.

Despite the strengths and weaknesses of the three quite different types of econometric efficiency models estimated, the similar results we have obtained from each lend support to the robustness of the findings. Considering the models collectively, the similar results obtained from each of the methods lead to the robust finding that Multinet’s total cost and opex efficiency is better than most of the other 11 Australian and New Zealand GDBs in the database.

ATTACHMENT A: LETTER OF RETAINER

321 Ferntree Gully Road
Mount Waverley Vic 3149
Australia

5 January 2007

Attention: Denis Lawrence
Director - Economics
Meyrick and Associates
6 Kurundi Place
Hawker ACT 2614

Dear Denis

Multinet Gas – 2008-2012 Access Arrangement Revision – Stage 2

Multinet Gas (Multinet) is required to submit a revised Access Arrangement on 30 March 2007. As part of this review Multinet is required to submit a forecast of costs for the 2008 – 2012 period inclusive.

The Essential Services Commission (the Commission) has issued Consultation Paper No1 and No2 for the purposes of providing the businesses with guidance.

You are asked to provide an econometric analysis of the efficiency of Australia and New Zealand gas distribution businesses.

Specifically this is an extension of the partial indicator comparison that you are completing by undertaking a range of econometric and indexing modelling using the first stage's database. In this stage an estimate of a basic translog cost function model for the Australia and New Zealand data is required. The degree of detail that can be included in the model will depend on the number of observations available. A minimum of approximately 40 observations is required

In addition a multilateral TFP index is required to compare productivity levels as well as productivity growth rates. In this study a Tobit regression analysis to adjust the Multilateral TFP scores for operating environment differences is preferred. This will allow the calculation of the range of adjusted Multilateral TFP scores that are not statistically different from Multinet's.

The third econometric method in this second stage is the estimation of an inputs requirements function. This function has some similarities to a cost function model but looks at the relationship between the quantity of inputs used by each gas distribution business and its operating environment conditions. By including dummy variables for each distributor other than Multinet you will be able to test whether the other distributors are statistically different in their efficiency relative to Multinet if they faced the same operating environment conditions as Multinet.

A full report that fully documents the methodology used in detail and discuss the results obtained. They must be suitable for submission to the Commission if Multinet chose to use them in this way.

As a result of comments made by the Commission in Consultation Paper No 1, it is important for your report to comply with the Federal Court Guidelines for Expert Witnesses (attached).

Please read the attached Guidelines and ensure your report complies with the Code.

Summarise your experience and qualifications and attach your curriculum vitae.

Summarise your instructions and attach this letter of retainer.

In the introduction to the report, list the facts, matters and assumptions on which your opinion is based and the source of those facts, matter and assumptions.

Acknowledge that you have read the Guidelines.

List all reference material and information on which you have relied.

Identify any person and their qualifications, who assists you in preparing the report or in carrying out any research or test for the purposes of the report.

Include detailed reasons for your opinion.

Provide a summary of your opinions.

List any limitations, incomplete matters or qualifications to your opinion.

At the end of your report, you should include a declaration that you have read the attached Guidelines and that you "*have made all inquiries I believe are desirable and appropriate and that no matters of significance which I regard as relevant have, to the best of my knowledge, been withheld.*"

We look forward to hearing from you.

Yours faithfully

Andrew Schille
Access Arrangements & Pricing Manager

ATTACHMENT B: CURRICULUM VITAE

Denis Lawrence

Director, Meyrick and Associates

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Australia
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For the past 20 years Dr Denis Lawrence has played a leading role in the regulation, benchmarking and performance measurement of infrastructure enterprises. He has advised Australian and overseas regulators and utilities on a wide range of quantitative and strategic issues in the energy, telecommunications, post and transport sectors.

Denis' consulting projects include advising the New Zealand Commerce Commission on the implementation of a leading–edge productivity based regulatory regime for electricity distribution; advising Australian electricity and gas distribution businesses on productivity measurement issues and their regulatory implications; advising the Commerce Commission on gas network benchmarking and regulation; reviewing the work of Australian regulators for utilities; advising the Australian Competition and Consumer Commission on incentive regulation in electricity supply; and, advising the Queensland Competition Authority on service quality incentives.

Denis has also advised electricity regulators and utilities in Canada, Saudi Arabia and Hong Kong.

Denis has developed a quantitative framework for calculating the distribution of benefits from a firm's productivity improvements among the key stakeholder groups of customers, employees and shareholders. He has applied this framework for leading telecommunications and transport firms.

Denis joined Meyrick and Associates in 2001. Prior to that Denis was Director of Tasman Economics' Canberra office and held senior executive positions in the Australian Bureau of Industry Economics and the Australian Industry Commission.

Denis holds a PhD in Economics from the University of British Columbia, Canada, and a BEc (Hons) from the Australian National University.

Recent Projects

- Total factor productivity modelling and benchmarking of gas distribution businesses
- Construction of total factor productivity models for electricity distribution businesses
- Advising the NZ Commerce Commission on the regulation of key gas distribution companies
- Critique of total factor productivity modelling of electricity distribution in Victoria undertaken by the Essential Services Commission and assessment of regulatory implications
- Econometric modelling of the operating and maintenance expenditure efficiency of electricity distributors taking operating environment differences into account
- Examining the effects of changes in the terms of trade and productivity growth on national welfare
- Advice to regulators and utilities in Canada, Hong Kong and Saudi Arabia on electricity tariff setting, incentive regulation and best practice pricing principles
- Benchmarking study of the operating and capital expenditure performance of 13 of Australia's 15 electricity distributors
- Total factor productivity modelling of the efficiency and profitability of electricity lines businesses for the NZ Commerce Commission
- Development of service quality incentive schemes for electricity distributors.

ATTACHMENT C: DECLARATION

I, Denis Anthony Lawrence, Director of Meyrick and Associates, declare that I have read the Federal Court Guidelines for Expert Witnesses and that I have made all inquiries I believe are desirable and appropriate and that no matters of significance which I regard as relevant have, to the best of my knowledge, been withheld.

Denis Anthony Lawrence

14 March 2007

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