Econometric Estimates of the Victorian Gas Distribution Businesses' Efficiency and Future Productivity Growth

Report prepared for
SP AusNet

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Denis Lawrence and John Kain

Economic Insights Pty Ltd
6 Kurundi Place, Hawker, ACT 2614, AUSTRALIA
Ph +61 2 6278 3628 Fax +61 2 6278 5358
WEB www.economicinsights.com.au
ABN 52 060 723 631

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EXECUTIVE SUMMARY

SP AusNet has commissioned Economic Insights to:

- assess the efficiency of its gas distribution business (GDB) taking opex and capital input trade–offs and business conditions into account within a statistical framework; and
- forecast its future GDB opex partial productivity growth rates.

We do this by forming econometric estimates of total cost function and operating cost function parameters using data for 9 Australian GDBs and 2 New Zealand GDBs sourced from the public domain to the maximum extent possible.

The estimated total cost function parameters are then used to form predicted total costs and opex series which are compared with actual total costs and opex in assessing overall and opex efficiency, respectively.

The estimated operating cost function parameters are combined with forecasts of output and capital input levels to form forecasts of future opex partial productivity growth. These are an important component of the 'rate of change' formula for rolling forward opex allowances often used in the application of building blocks regulation.

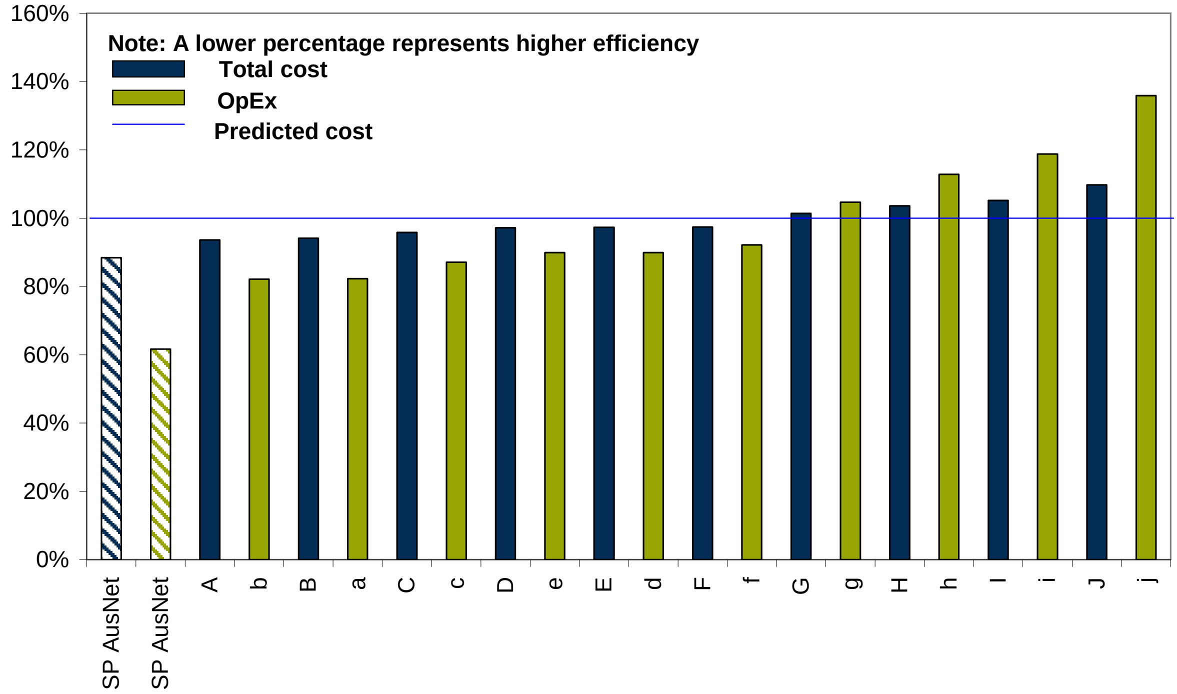
Key findings – efficiency

The main findings from the total cost function efficiency analysis are:

- SP AusNet's actual total cost was 11.6 per cent less than that predicted by the model for 2010 – SP AusNet is the best overall cost efficiency performer compared to its peers when scale, customer density and energy density effects are taken into account with the next best performer's actual total cost being 6.4 per cent less than that predicted by the model;
- SP AusNet's actual opex cost was 38.4 per cent less than that predicted by the model for 2010 – SP AusNet is the best opex cost efficiency performer by a wide margin when scale, customer density and energy density effects are taken into account with the next best performer's actual opex cost being 17.8 per cent less than that predicted by the model;
- SP AusNet has marginally better than average capital efficiency when scale, customer density and energy density effects are taken into account; and
- in terms of relative rankings among the 11 included GDBs, SP AusNet has the best total cost performance and best opex performance when adjusted for differences in market and operating conditions and, on the basis of the statistical analysis, can therefore be considered to be an efficient total and opex cost performer.

The cost function efficiency results are plotted in figure A which shows actual total costs and opex as a percentage of the respective costs predicted by the model for 2010 (the most recent year for all the included GDBs). 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 SP AusNet are identified only by the letters A, B, C, etc.

Figure A Actual total cost and opex as a percentage of those predicted by the translog cost function model, 2010



Source: Economic Insights estimates

Key findings – forecast opex partial productivity growth

We form objective forecasts of opex partial productivity growth using parameter estimates for two separate operating cost functions and forecasts of future output growth, non–opex input growth and changes in operating environment conditions.

The first operating cost function includes two outputs (throughput and customer numbers), uses kilometres of distribution pipelines as the proxy for the quantity of capital and includes a time trend to proxy technological change. In this instance the key operating environment characteristics of customer density and energy density enter through interactions of the two output variables and the capital quantity variable.

We present results for SP AusNet and also for Multinet by way of comparison. Both GDBs are forecasting lower growth rates for throughput going forward than have been observed historically. Over the next regulatory period, SP AusNet is forecasting its average annual throughput growth to fall to 0.2 per cent annually while Multinet is forecasting its annual throughput growth to fall to –0.6 per cent.

Both GDBs are forecasting smaller reductions in their customer number growth rates compared to their forecast reductions in throughput growth rates. Correspondingly, forecast annual growth in distribution pipeline length is somewhat lower than that observed over the last 10 years.

The model predicts that technological change leads to a 0.6 per cent increase in annual forecast opex partial productivity growth, changes in returns to scale contribute between 0.1

percentage points and 0.6 percentage points and the capital quantity growth impact deducts between zero and 0.7 per cent from annual opex partial productivity growth.

The accumulation of these separate effects leads to opex partial productivity average annual forecast growth rates of 0.6 per cent for both SP AusNet and Multinet.

These forecast partial productivity growth rates are lower than those observed over the last five years. Looking at the last 10 years, opex partial productivity growth was considerably higher in the first half of that period for Multinet and has progressively reduced over the second half of the period. SP AusNet, on the other hand, started the opex usage reform process later and so has exhibited higher productivity growth in the second half of the last 10 years than the first but its productivity growth has also tapered off in recent years as available cost savings have progressively been implemented. Forecast reductions in throughput and a slowing in customer number growth are the major drivers of the model's forecast reduction in opex partial productivity growth going forward along with the need to continue network expansion to serve new customers.

The second operating cost function estimated contains customer numbers as the primary output, customer density as the key operating environment variable, constant price asset value as the capital quantity proxy and a time trend as technological change proxy.

The model predicts that technological change leads to a 1 per cent increase in annual forecast opex partial productivity growth, changes in returns to scale contribute between 0.4 percentage points and 1.1 percentage points and business conditions growth deducts between 0.6 and 1.1 per cent from annual opex partial productivity growth.

The accumulation of these separate effects leads to opex partial productivity average annual forecast growth rates of 0.9 per cent for Multinet and 1.1 per cent for SP AusNet.

The magnitudes of the forecast opex partial productivity growth rates are broadly similar across the two alternative operating cost function models although the second model forecasts marginally higher growth rates than in the first model. This is due to the second model not explicitly including the much slower growing throughput as an output variable. But the second model is able to explicitly include the important customer density operating environment effect. This broad similarity in results points to the results being relatively robust when two quite different specifications produce broadly similar outcomes. Since there is no basis to prefer either of the models over the other, standard practice is to take an average of the two sets of results for use in subsequent opex rate of change analysis. Doing this produces an average annual forecast opex partial productivity growth rate of 0.8 per cent for both SP AusNet and Multinet.

1 INTRODUCTION

SP AusNet has commissioned Economic Insights Pty Ltd ('Economic Insights') to assess the efficiency of its gas distribution business (GDB) taking operating cost (opex) and capital input trade–offs and business conditions into account within a statistical framework and to forecast its future GDB opex partial productivity growth rate. We do this by forming econometric estimates of total cost function and operating cost function parameters using data for 9 Australian GDBs and 2 New Zealand GDBs sourced from the public domain to the maximum extent possible.

The estimated total cost function parameters are then used to form predicted total costs and opex series which are compared with actual total costs and opex in assessing overall and opex efficiency, respectively. The estimated operating cost function parameters are combined with forecasts of output and capital input levels to form forecasts of future opex partial productivity growth. The latter are an important component of the 'rate of change' formula for rolling forward opex allowances frequently used in the application of building blocks regulation.

This report extends similar work reported by the authors in Lawrence, Fallon and Kain (2007) and Lawrence (2007). The database used in this report is similar to that used in Economic Insights (2012a) to benchmark the opex, capital expenditure (capex) and overall capital cost performance of Australian and New Zealand GDBs using a range of partial indicators. The differences here are that the three smallest GDBs – Envestra Albury, Envestra Wagga and GasNet – are excluded and, where available, regulators' forecast data for years beyond 2011 are included for the non–Victorian GDBs. The comprehensive efficiency and productivity performance indicators presented in this report complement the partial productivity indicators presented in Economic Insights (2012a). A separate stream of work reported in Economic Insights (2012b) forms comprehensive total factor productivity measures of the productivity performance of the three Victorian GDBs and three other Australian GDBs using detailed survey–based data.

The following parts of this section of the report list the terms of reference for the report and Economic Insights' efficiency benchmarking and productivity measurement experience and the qualifications of the consultants involved.

Section 2 then outlines in broad terms the database used and the included GDBs.

Section 3 then reports the total cost function efficiency analysis and findings.

Section 4 then reports forecast opex partial productivity growth for SP AusNet based on the operating cost function estimation and analysis.

1.1 Terms of reference

The terms of reference provided to Economic Insights by SP AusNet required the preparation of an expert report which:

a) quantifies its GDB efficiency, taking operating expenditure and capital input trade–offs and business conditions into account within an appropriate statistical framework; and

b) forecasts its future GDB operating cost partial productivity growth rates.

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

1.2 Economic Insights' experience and consultants' qualifications

Economic Insights has been operating in Australia for 17 years as an infrastructure consulting firm. Economic Insights provides strategic policy advice and rigorous quantitative research to industry and government. Economic Insights' experience and expertise covers a wide range of economic and industry analysis topics including:

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

This report has been prepared by Dr Denis Lawrence who is a Director of Economic Insights and John Kain who is an Associate of Economic Insights. Summary CVs for Denis and John are presented in Attachment B.

Denis Lawrence has undertaken several major energy supply industry benchmarking studies including: benchmarking the productivity of Australian and US gas distribution businesses, benchmarking the performance of New Zealand's 29 electricity lines businesses and 5 gas pipeline 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; 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, Victoria, South Australia and Queensland. Denis recently assisted the Australian Energy Market Commission in its review of productivity–based regulation. Denis holds a PhD in Economics from the University of British Columbia, Canada, where his thesis supervisor was Professor Erwin Diewert who is one of the world's leading productivity and efficiency measurement academics.

John Kain has extensive energy supply industry experience at both an operational and analytical level. 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 Economic Insights including assisting the NZ Commerce Commission with setting price caps for electricity lines and gas pipeline businesses and providing advice to the AEMC on data requirements for performance measurement. John holds Science and Engineering degrees from Sydney University.

Denis Lawrence and John Kain have 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 DATA

2.1 Data sources

The data used in this study have been sourced from documents in the public domain to the maximum extent possible and relate to the period from 1999 onwards. Data for most of the Australian GDBs in the study are publicly available for most of this period. However, there are fewer consistent observations publicly available for the New Zealand GDBs, reflecting the impact of mergers, asset sales and industry restructuring. As a result, Powerco (New Zealand) only has observations for 2004 onwards and Vector (New Zealand) only has observations for 2006 onwards. For the Victorian GDBs only historic data up to 2011 are included. For the non–Victorian GDBs regulators' forecast data for years beyond 2011 are also included, where available. The database used in this study includes a total of 144 observations.

The public domain data sources used for the Australian GDBs include:

- Access Arrangement Information (AAI) filings as proposed and as amended by a regulator's decision;
- Regulators' final decisions, sometimes with amendment following appeal; and
- Annual Reports from the GDB or its parent firm.

The public domain data source used for the NZ GDBs are the Information Disclosure Data filings required by the Gas (Information Disclosure) Regulations 1997.

Data used includes revenue, throughput, customer numbers, distribution pipeline length, opex, capex and regulatory asset value. In a few cases missing observations were estimated based on growth rates for the variable or a related variable before and after the missing year. In a number of cases adjustments were made to ensure the data related to comparable activities and measures (eg unaccounted for gas allowances for non–Victorian GDBs have been excluded to put those GDBs on a comparable basis with Victorian reporting).

The data used for the Australian GDBs cover only their regulated activities. Data relating to large industrial users whose supply is not regulated are not included. Inclusion of this data would require access to information not generally in the public domain and has been beyond the scope and timeframe of this study.

Despite the existence of the National Gas Law and Regulations and their predecessors, the amount of detail provided by both regulators and GDBs differs and data are typically not drawn together in the one location. The progressive transfer of regulatory responsibilities from jurisdictional regulators to the Australian Energy Regulator (AER) has also tended to fragment the historic data available, at least in the short run. Some differences remain in the coverage of distribution activities across states although this is now more consistent than in earlier years.

In some cases the regulators' final approvals have used forecast data substantially different from that presented by the GDBs in their initial AAIs. Not all jurisdictions have required the

GDBs to supply revised AAIs consistent with the final approvals. We have used the final approval information, where possible, as we consider that it is the most consistent and objective source of information available.

Economic Insights (2009a, p.v) noted that:

> 'The extent, quality, uniformity and continuity of currently available historical regulatory data are very variable both between jurisdictions and over time. Regulatory data have to date concentrated almost exclusively on financial variables ... (and) there are significant gaps and changes in coverage over time and across jurisdictions. ... This compromises comparability across businesses, across jurisdictions and over time.'

While every effort has been made to make the publicly available data used in this study as consistent as possible, the limitations of currently available public domain data need to be recognised.

While relatively recent regulatory reviews are available for most Australian States, this is not the case for Victoria where the last regulatory review was undertaken by the Essential Services Commission (ESC) in 2007. Furthermore, with the subsequent transfer of regulatory responsibilities to the AER, the ESC ceased publication of its *Gas Distribution Businesses Comparative Performance Reports* with data for the 2007 year being the last reported.

Given the importance of current and consistent Victorian data to this study, we have sourced the data used for the three Victorian GDBs from the detailed Economic Insights (2011b) survey–based gas distribution business database. Construction of this detailed survey–based productivity database involved collection of specified data from each GDB and then extensive checking and clarification with the GDBs where necessary to ensure data compatibility both over time and between GDBs. Data collected covers revenue, billed and functional outputs, opex, system physical data, system capacity, initial asset values, remaining and overall regulatory asset lives and capex. Regulatory asset values are formed using data on the initial capital base, capex and regulatory asset lives and application of a simplified version of the AER (2008) roll forward model (see Economic Insights 2010 for an illustration of the method).

The data from the public domain and survey–based databases relate to the time periods normally reported by each GDB – some GDBs use calendar year reporting while others use financial year reporting. The public domain data were in a mix of nominal and real terms based on different years. All cost data were first converted to nominal terms (where necessary) using the all groups consumer price indexes for each country. The nominal series were then converted to real series in 2010 dollars using the all groups consumer price indexes for each country. The New Zealand data were then converted to Australian dollars using the OECD (2011) purchasing power parity for 2010. 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.

2.2 Gas distribution businesses included in the study

The database formed for the study includes 9 Australian GDBs and 2 New Zealand GDBs. A brief summary of the operations of the included GDBs follows.

2.2.1 Australian GDBs

ActewAGL, Australian Capital Territory

ActewAGL is the distribution business supplying gas and electricity in the Australian Capital Territory (ACT). The total population of the ACT in 2010 was 358,000 (ABS 2011). Gas is distributed to a predominantly residential customer base with Canberra the largest market. There are few industrial users of any significance. Canberra covers a large geographical area and the majority of urban development is low density. Moreover, gas distribution in residential areas utilises a dual mains configuration with mains on both sides of a street, rather then a single sided system with longer cross-road service connection. This results in a commensurately low density distribution network measured in terms of customers per kilometre of main and TJ supplied per customer.

In 2010 ActewAGL supplied 116,164 customers with 7,663 TJ of gas from a distribution network of around 4,200 kilometres of mains.

APT Allgas Pty Ltd (Allgas), Queensland

Allgas supplies gas to consumers in several areas in and around Brisbane and to several Queensland regional areas. The Allgas distribution system is separated into three operating regions. These are:

- the Brisbane region (south of the Brisbane river to the Albert River);
- the Western region (including Toowoomba and Oakey); and,
- the South Coast region (including the Gold Coast and Tweed Heads in NSW).

About 59 per cent of the network is located in Brisbane, 19 per cent in the Western region and the remaining 22 per cent on the South Coast and Tweed Heads.

Queensland's mild to hot climate means that residential and commercial heating demand is low. Residential demand for gas is mainly for hot water systems and cooking. In 2010 southeast Queensland's population was around 3 million (ABS 2011). More than 70 per cent of Allgas' gas demand is from around 100 large demand class customers.

In 2010 Allgas supplied 81,824 customers with 10,962 TJ of gas from a distribution network of 2,970 kilometres of mains.

ATCO Gas Australia, Western Australia

ATCO acquired the network previously operated by WA Gas Networks (WAGN) in July 2011. ATCO Gas Australia is the principal GDB for Western Australian businesses and households. It operates the gas distribution system in the mid-west and south-west of Western Australia. It services the Perth Metropolitan region, the Albany region and Kalgoorlie with three separate gas distribution networks.

In 2010, ATCO supplied 610,109 customers with 32,158 TJ of gas from a distribution network of 12,640 kilometres of mains.

Envestra Queensland, Queensland

Envestra Queensland's distribution network can be divided into two regions:

- the Brisbane region (including Ipswich and suburbs north of the Brisbane river); and,
- the Northern region (serving Rockhampton and Gladstone).

The network consists of 2,560 kilometre of low, medium, high and transmission pressure mains. Assets used to service the Brisbane region comprise 88 per cent of the network with the balance of 12 per cent attributable to the Northern region.

Envestra Queensland is subject to similar climatic influences on residential gas demand as Allgas. Customer numbers are greater than those for Allgas but regulated volumes are smaller. However, Envestra has a number of unregulated industrial customers with very large volumes that are not reflected in the data used in this study. In 2010 there were 79,042 residential customers and 4,850 non–residential customers.

In 2006, for its regulated distribution network, Envestra Queensland supplied its 76,175 customers with 5,701 TJ of gas from a distribution network of 2,560 kilometres of mains.

Envestra SA, South Australia

Envestra SA's distribution network services the Adelaide (including the Barossa Valley), Peterborough, Port Pirie, Riverland, South–East and Whyalla regions. Adelaide's population in 2010 was 1.2 million. As with Melbourne, Adelaide's winter climate is conducive to relatively high residential gas demand for heating. In 2010 there were 391,025 residential customers and 10,312 non–residential customers.

In 2010, Envestra SA supplied its 401,337 customers with 23,841 TJ of gas from a distribution network of 7,887 kilometres of mains. The Adelaide network makes up 93 per cent of the total network length.

Envestra Victoria, Victoria

Envestra Victoria serves parts of the Melbourne gas market (population of 4.8 million in 2010) as do Multinet and SP AusNet. Envestra Victoria also serves several areas in north central Victoria. As described by Envestra Victoria in their 2008 AAI, 'the Distribution System serves the northern, outer eastern and southern areas of Melbourne, Mornington Peninsula and rural communities in northern and north–eastern Victoria, south-eastern rural townships in Gippsland and a number of outlying towns such as Bairnsdale and Paynesville (which are in the new Eastern Zone). The Distribution System is divided into four Zones – North, Central, Murray Valley and Eastern.'

Melbourne's gas market is well established and cool to mild climatic conditions result in high residential gas consumption for heating, cooking and hot water systems. A relatively high concentration of industry also supports industrial gas demand provided that prices are competitive with other sources of energy supply. In 2010 there were 528,992 residential customers and 23,450 non–residential customers.

In 2010, Envestra Victoria supplied its 552,442 customers with 56,442 TJ of gas from a distribution network of 10,341 kilometres of mains.

Jemena Gas Network, NSW

Jemena was formed from the sale of Alinta Ltd in 2007, Alinta itself having acquired the gas assets of AGL Gas Networks (AGLGN) in 2006. Jemena distributes gas to Newcastle (population of 540,800 in June 2010), north of Sydney, Sydney (population of 4,504,500 in June 2010), and Wollongong, south of Sydney (population of 203,500 in 2010), along with several smaller population centres located between these larger markets and regional country centres in NSW. Jemena has the largest distribution network and customer base of the Australian GDBs.

In 2010 Jemena supplied 1,082,706 customers with 99,200 TJ of gas from a distribution network of 24,028 kilometres of mains.

Multinet Gas, Victoria

The Multinet gas distribution system covers the eastern and south–eastern suburbs of Melbourne extending over an area of approximately 1,600 square kilometres as well as rural extensions to townships in the Yarra Valley and South Gippsland. In 2010 there were 651,551 residential customers and 16,822 non–residential customers.

In 2010, Multinet supplied its 668,373 customers with 58,686 TJ of gas from a distribution network of 9,910 kilometres of mains. Multinet has the highest customer density per kilometre of mains of the Australasian GDBs.

SP AusNet, Victoria

SP AusNet was formerly TXU networks which was formerly Westar (Assets) Pty Ltd. SP AusNet is the trading name of SPI Networks. It delivers gas to over 500,000 customers across a geographically diverse region spanning the western half of Victoria, from the Hume highway in metropolitan Melbourne west to the South Australian border and from Bass Strait to Horsham and just north of Bendigo. In 2010 there were 561,168 residential customers and 15,891 non–residential customers.

In 2010, SP AusNet supplied its 577,059 customers with 83,325 TJ of gas from a distribution network of 9,697 kilometres of mains.

2.2.2 New Zealand GDBs

Powerco Limited

Powerco is based in New Plymouth (population 52,200 in 2010) and distributes gas in the upper central and lower central North Island. It is a dual gas and electricity network business. Powerco’s gas networks are in the Taranaki, Manawatu, Hutt Valley (estimated population 140,900), Porirua (district population of 52,000), Wellington City (population of 186,900), Horowhenua and Hawkes Bay regions. Powerco acquired part of UnitedNetworks’ gas operations in 2002 comprising the Hawkes Bay, Wellington, Horowhenua and Manawatu networks.

In 2010, Powerco supplied its 102,346 customers with 9,269 TJ of gas from a distribution network of 6,170 kilometres of mains.

Vector Ltd

Vector Ltd operates the gas distribution network in Auckland (estimated population of 863,600 including the adjacent Manukau area) as well as other major North Island centres and 40 smaller towns and cities.

Vector acquired the remaining part of UnitedNetworks' gas operations in 2002 comprising its Auckland gas network and the National Gas Corporation's gas distribution business in 2004 and 2005. The Vector data from 2006 represent the combined operations of Vector and the former NGC Distribution.

Vector also owns and operates significant transmission pipelines and power line networks throughout the North Island. It is listed on the NZ Stock Exchange, but is around 75 per cent owned by the Auckland Energy Consumer Trust.

In 2010, Vector supplied 150,892 gas distribution customers with 21,226 TJ of gas from a distribution network of 10,155 kilometres of mains.

2.3 Output and input variables

The limited amount of GDB data currently available in the public domain limits the number of outputs, inputs and operating environment variables we can include in the current study. It also restricts us from developing detailed system capacity and capital input quantity measures as done in Economic Insights (2012b) based on detailed survey data for a smaller number of GDBs.

Customer numbers is generally used as the primary output quantity measure in this study. Differences in consumption characteristics across GDBs are allowed for by the inclusion of energy density and customer density variables. In some cases two GDB outputs – customer numbers and energy throughput – are included.

Opex 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. Unaccounted for gas is excluded from opex in all cases. The quantity of the GDB's opex is derived by deflating the opex value series by the operations and maintenance price index reported in Economic Insights (2012b). 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). For the New Zealand GDBs the opex price index is a similar weighted average of labour costs and the consumer price index. The price indexes were projected forward beyond 2011 based on the average annual growth rate from 2007 to 2011.

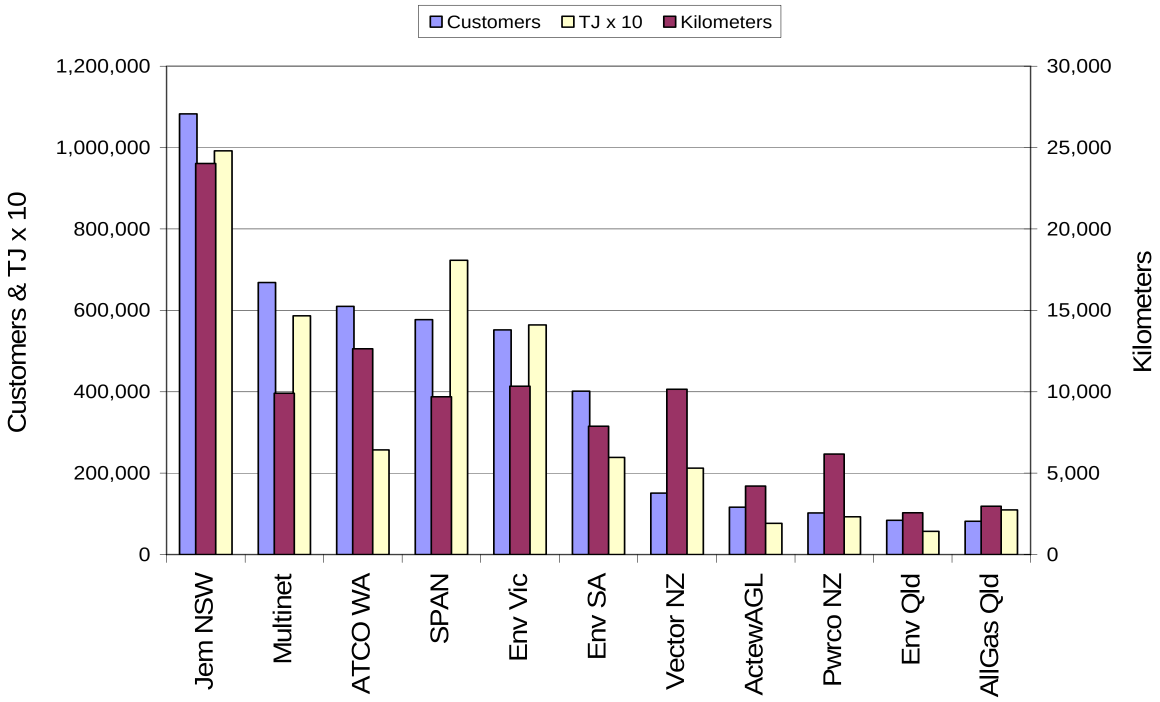
Capital input costs are calculated as 12.5 per cent of the Regulatory Asset Base (RAB) for each GDB. Economic Insights (2009b) showed that this method provided a very close approximation to the sum of the return on and return of capital calculated using a standard regulatory post–tax revenue model. This approximation is used because regulatory data on the return on and return of capital are not consistently available. The price of capital inputs was derived as 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. Although a less preferred quantity measure, in some cases we also use the real RAB as a proxy for the quantity of capital to avoid multicollinearity problems.

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.

2.4 Operating environment features

The 11 Australasian distribution businesses operate in varying environments with often substantial differences in network size, amount of throughput, demand growth, number and type of customers, and the mix of rural, urban and CBD customers.

Figure 1: **Key measures of GDB size, 2010**

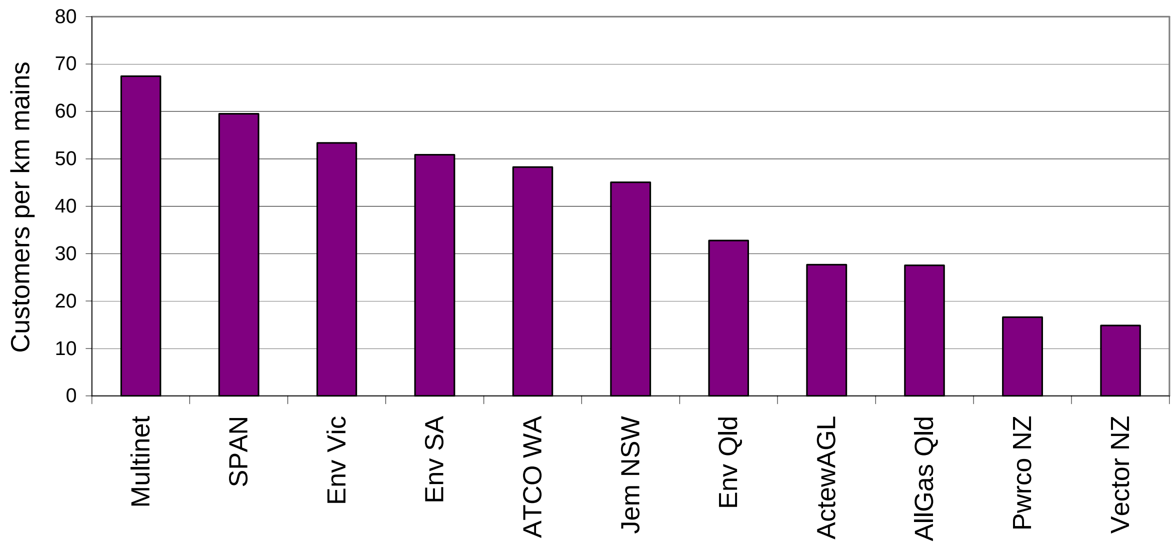


Source: Economic Insights gas utility database

While Jemena's NSW distribution network is by far the largest of the 11 included GDBs, the three Victorian GDBs occupy either the second to fourth or second to fifth positions in terms of the three key measures of size included – throughput, customer numbers and network length (Figure 1). Multinet is the second largest GDB in terms of customers while SP AusNet and Envestra Victoria are fourth and fifth largest behind ATCO WA. SP AusNet is the second largest GDB in terms of throughput (TJ) while Multinet and Envestra Victoria are third and fourth largest, respectively. The network lengths of the three Victorian GDBs are very similar in magnitude with Envestra Victoria having the second longest length of the included GDBs followed by Multinet and SP AusNet.

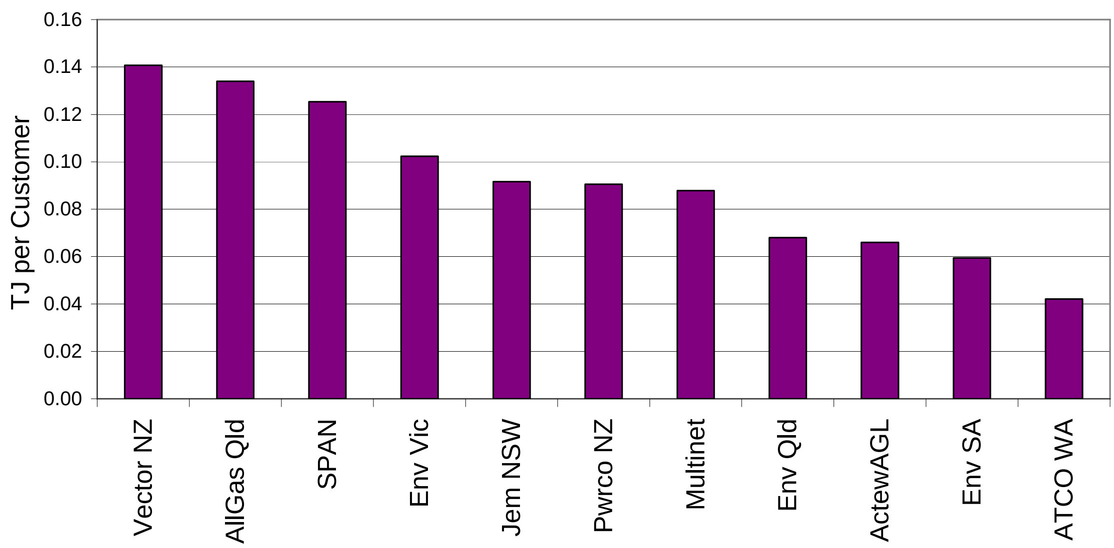
The two key operating environment characteristics which influence energy distribution business productivity levels and costs are customer density (customers per kilometre of mains) and energy density (throughput per customer). A GDB with lower customer density will require more pipeline length to reach its customers than will a GDB with higher customer

Figure 2: **Customer density, 2010**



Source: Economic Insights gas utility database

Figure 3: **Energy density per customer, 2010**



Source: Economic Insights gas utility database density but the same consumption per customer. This would make the lower density distributor appear less efficient unless the differing densities are allowed for. Being able to deliver more energy to each customer means that a GDB will usually require less inputs to deliver a given volume of gas as it will require less pipelines than a less energy dense GDB would require to reach more customers to deliver the same total volume. These density measures for all companies in the sample for all available years are presented in Figures 2 and 3.

Multinet had the highest customer density with around 67 customers per kilometre compared to the sample average of 40 customers per kilometre in 2010 (Figure 2). SP AusNet and Envestra Victoria had the next highest customer densities with 60 and 53 customers per kilometre, respectively. There has been a marginal decline in Multinet’s and Envestra Victoria’s customer densities since 2006, while customer density for SP AusNet and GDBs on average has increased marginally over the same period.

Multinet currently has below average energy density per customer for the 11 GDBs with around 0.088 TJ per customer compared to an average of 0.092 TJ per customer (Figure 3). SP AusNet and Envestra Victoria, on the other hand, have higher than average energy density with 0.125 and 0.102 TJs per customer, respectively. The energy density per customer of the three Victorian GDBs has generally fallen over the period. The two GDBs with the highest energy densities per customer are smaller GDBs with a higher concentration on serving large industrial customers compared to the more domestic customer–oriented focus of the Victorian GDBs and Jemena in NSW.

3 COST FUNCTION EFFICIENCY ANALYSIS

In this report we outline SP AusNet's overall and opex efficiency results compared to the other GDBs, none of which are named except for SP AusNet. Instead, the other GDBs are given an alphabetic code, depending on their relative order.

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 supplied, 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, multicollinearity problems often limit the scope to include more than a few operating environment variables in practice, particularly where the number of observations available is relatively small.

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 SP AusNet 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 providing 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 input 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;
- customer density as measured by total customers per kilometre of mains; and
- a time trend representing technological change.

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 (2004) and improves the statistical properties of the estimated function.

The translog cost function system estimated has the following form:

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

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, t is the time trend proxy for technological change 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 all bar one second order term are highly statistically significant.

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.

All else unchanged, costs decrease marginally each year due to technological change.

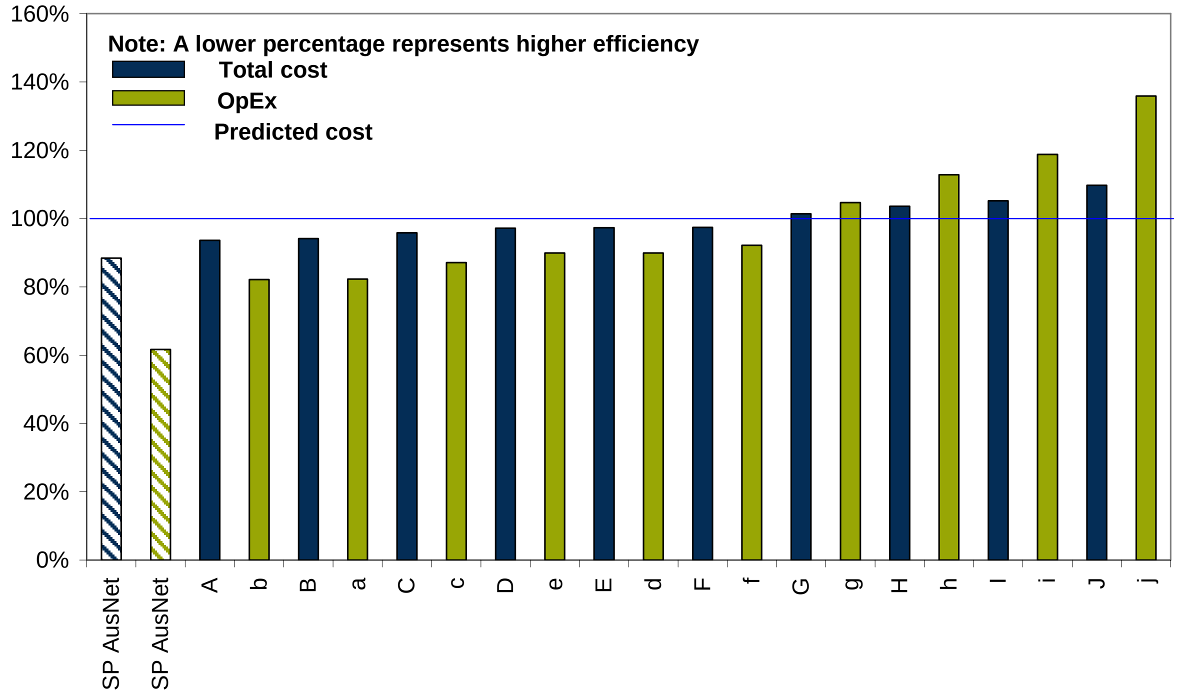
Table 1: **Cost function regression estimates**[1]

Coefficient	Estimate	t–statistic[2]	Coefficient	Estimate	t–statistic
b_0	0.831	11.274	b_{EX}	0.045	9.652
b_Q	0.893	43.063	b_{EQ}	–0.009	–2.873
b_{QQ}	0.009	3.593	b_C	–0.667	–11.357
b_X	0.539	27.676	b_{CC}	0.044	4.121
b_{XX}	0.202	75.624	b_{CX}	0.150	18.097
b_{QX}	–0.043	–12.764	b_{CQ}	–0.015	–1.698
b_E	0.130	6.299	b_{EC}	0.039	5.532
b_{EE}	0.007	2.812	b_t	–0.0001	–2.251

1 R^2 between observed and predicted is 0.99

2 Critical t-statistics for testing are: 1.289, 1.658, 1.980 and 2.617 for the 20, 10, 5 and 1 per cent significance levels, 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.

Figure 4 **Actual total cost and opex as a percentage of those predicted by the translog cost function model, 2010**



Source: Economic Insights estimates

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 4 which shows actual total costs and opex as a percentage of the respective costs predicted by the model for 2010 (the most recent year for all the included GDBs). 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 SP AusNet are identified only by the letters A, B, C, etc with upper case letters for the total cost results and lower case letters for the opex results.

From figure 4 we see that of the 11 included GDBs SP AusNet had the most efficient total cost performance on the basis of the cost function analysis. In terms of opex performance, the cost function analysis indicates that SP AusNet was again the most efficient performer of the 11 included GDBs.

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

- SP AusNet's actual total cost was 11.6 per cent less than that predicted by the model for 2010 – SP AusNet is the best overall cost efficiency performer compared to its peers when scale, customer density and energy density effects are taken into account with the next best performer's actual total cost being 6.4 per cent less than that predicted by the model;
- SP AusNet's actual opex cost was 38.4 per cent less than that predicted by the model for 2010 – SP AusNet is the best opex cost efficiency performer by a wide margin when scale, customer density and energy density effects are taken into account with the next best performer's actual opex cost being 17.8 per cent less than that predicted by the model;
- SP AusNet has marginally better than average capital efficiency when scale, customer density and energy density effects are taken into account; and
- in terms of relative rankings among the 11 included GDBs, SP AusNet has the best total cost performance and best opex performance when adjusted for differences in market and operating conditions and, on the basis of the statistical analysis, can therefore be considered to be an efficient total and opex cost performer.

4 FORECASTING FUTURE OPEX PRODUCTIVITY GROWTH

To forecast future opex partial productivity growth we use an approach similar to that presented in PEG (2004) and Lawrence (2007) and later adopted by the ESC in its 2007 Gas Access Arrangement Review. The starting point for this approach is the following relationship between the GDB's actual opex cost, C_{OM}, and its efficient opex cost C^*_{OM}:

(2) $$C_{OM} = C^*_{OM} \cdot \eta$$

where η is an inefficiency factor. Using standard microeconomic theory, the GDB's efficient opex cost can be shown to be a function of vectors of opex prices (W), output quantities (Y), capital quantities (X_k), operating environment variables (Z) and time (T) as follows:

(3) $$C^*_{OM} = g(\boldsymbol{W}, \boldsymbol{Y}, \boldsymbol{X}_k, \boldsymbol{Z}, T).$$

Totally differentiating equation (3) with respect to time produces the following:

(4) $$\dot{C}^*_{OM} = \left(\sum_i \varepsilon_{Y_i} \cdot \dot{Y}_i + \sum_j \varepsilon_{W_j} \cdot \dot{W}_j + \sum_m \varepsilon_{X_{K,m}} \cdot \dot{X}_{K,m} + \sum_n \varepsilon_{Z_n} \cdot \dot{Z}_n \right) + \dot{g}.$$

The ε coefficients are elasticities with respect to opex cost and the dot over a variable represents the variable's growth rate. Combining equations (2) and (4) we get:

(5) $$\dot{C}_{OM} = \left(\sum_i \varepsilon_{Y_i} \cdot \dot{Y}_i + \sum_j \varepsilon_{W_j} \cdot \dot{W}_j + \sum_m \varepsilon_{X_{K,m}} \cdot \dot{X}_{K,m} + \sum_n \varepsilon_{Z_n} \cdot \dot{Z}_n \right) + \dot{g} + \dot{\eta}.$$

That is, the growth rate in actual opex cost is the sum of three terms: the sum of the products of outputs, opex prices, capital quantities and operating environment variables by their respective opex elasticities; the shift in the cost function over time; and, the growth rate in the inefficiency factor.

Applying Shephard's Lemma (which states that the derivative of efficient cost with respect to price is equal to the efficient quantity), the elasticity of efficient cost with respect to the price of each input j can then be shown to equal the optimal share of that input in minimum cost (SC^*_j). Equation (5) can be rewritten as:

$$\dot{C}_{OM} = \sum_i \varepsilon_{Y_i} \cdot \dot{Y}_i + \sum_j SC^*_j \cdot \dot{W}_j + \sum_m \varepsilon_{X_{K,m}} \cdot \dot{X}_{K,m} + \sum_n \varepsilon_{Z_n} \cdot \dot{Z}_n + \dot{g} + \dot{\eta}.$$

(6) $$= \sum_i \varepsilon_{Y_i} \cdot \dot{Y}_i + \dot{W}^*_{OM} + \sum_m \varepsilon_{X_{K,m}} \cdot \dot{X}_{K,m} + \sum_n \varepsilon_{Z_n} \cdot \dot{Z}_n + \dot{g} + \dot{\eta}.$$

The second term on the right hand side of (6) is the growth rate of the opex price index, denoted here by W^*_{OM}, where the weights in the price index are the efficient cost shares.

The next step is to multiply the numerator and denominator of the first term on the right–hand side of (6) by the sum of the output cost elasticities:

$$\dot{C}_{OM} = \sum_i \varepsilon_{Y_i} \cdot \sum_i \left(\varepsilon_{Y_i} / \sum_i \varepsilon_{Y_i} \right) \cdot \dot{Y}_i + \dot{W}^*_j + \sum_m \varepsilon_{X_{K,m}} \cdot \dot{X}_{K,m} + \sum_n \varepsilon_{Z_n} \cdot \dot{Z}_n + \dot{g} + \dot{\eta}.$$

(7) $$= \sum_i \varepsilon_{Y_i} \cdot \dot{Y}^{\varepsilon} + \dot{W}^*_{OM} + \sum_m \varepsilon_{X_{K,m}} \cdot \dot{X}_{K,m} + \sum_n \varepsilon_{Z_n} \cdot \dot{Z}_n + \dot{g} + \dot{\eta}$$

$$\dot{C}_{OM} = \sum_i \varepsilon_{i\,Y_i} \cdot \dot{Y}^{\varepsilon} + \dot{W}^* + \sum_m \varepsilon_{X_{K,m}} \cdot \dot{X}_{K,m} + \sum_n \varepsilon_{Z_n} \cdot \dot{Z}_n + \dot{g} + \dot{\eta} + \dot{Y}^{\varepsilon} - \dot{Y}^{\varepsilon}$$
$$= \dot{W}^*_{OM} + \dot{Y}^{\varepsilon} - (1 - \sum_i \varepsilon_{i\,Y_i}) \cdot \dot{Y}^{\varepsilon} + \sum_m \varepsilon_{X_{K,m}} \cdot \dot{X}_{K,m} + \sum_n \varepsilon_{Z_n} \cdot \dot{Z}_n + \dot{g} + \dot{\eta}.$$

where Y^{ε} is an output quantity index where the weights for each output are the relevant cost elasticity divided by the sum of the output cost elasticities.

We next make use of the definition of opex partial productivity which is the ratio of an output index to an index of opex. The growth rate of this partial productivity index is given by:

(8) $$P\dot{F}P_{OM} = \dot{Y}^{\varepsilon} - \dot{X}_{OM} .$$

The growth rate of opex quantity is given by:

(9) $$\dot{X}_{OM} = \dot{C}_{OM} - \dot{W}_{OM} .$$

The input weights here are actual opex cost shares. Combining equations (8) and (9) we have:

(10) $$P\dot{F}P_{OM} = \dot{Y}^{\varepsilon} - (\dot{C}_{OM} - \dot{W}_{OM})$$

If we assume that optimal and actual cost shares are equal, from equations (5) and (10) we have:

(11) $$P\dot{F}P_{OM} = (1 - \sum_i \varepsilon_{i\,Y_i}) \cdot \dot{Y}^{\varepsilon} - \sum_m \varepsilon_{X_{K,m}} \cdot \dot{X}_{K,m} - \sum_n \varepsilon_{Z_n} \cdot \dot{Z}_n - \dot{g} - \dot{\eta}$$

And, hence:

(12) $$\dot{C}_{OM} = \dot{W}_{OM} - P\dot{F}P_{OM} + \dot{Y}^{\varepsilon} .$$

This is the familiar 'rate of change' formula which has been used in a number of building blocks decisions as the basis for forming the opex component of the revenue requirement. It says the proportional change in opex is equal to the proportional change in an index of opex prices less the proportional change in the partial productivity of opex plus the proportional change in an index of output quantities. To operationalise the rate of change formula we require forecasts for the next regulatory period of opex input prices, of opex partial productivity growth and of output quantities.

Forecasts of achievable opex partial productivity growth have been the source of much contention in the past. However, equation (11) provides a more objective basis for forecasting future opex partial productivity growth based on estimated industry characteristics and GDB–specific output and non–opex input changes. The partial productivity of opex can be seen from (11) to incorporate a range of factors including scale economies, capital interaction effects, the impact of changes in operating environment factors, technological change and changes in efficiency levels. No additional allowance, thus, needs to be made for any of these factors as they should be captured by the change in opex partial productivity.

To operationalise equation (11) we require parameter estimates for an operating cost function from which we can derive the necessary elasticities and forecasts of future output growth, non–opex input growth and changes in operating environment conditions.

An operating cost function differs from the total cost function estimated in section 3 by focusing on opex as the dependent variable and assuming that capital is a fixed rather than variable input in the decision period. This is also sometimes referred to as a variable cost function or short–run cost function. The exogenous variables are thus opex input prices, fixed input quantities, operating environment conditions and technological change. If a translog function is used, derivation of the necessary elasticities can be simplified by dividing all variables (excluding the time trend) by their respective mean values prior to estimation – when this is done the first order coefficients are the relevant elasticities required in equation (11).

The amount of consistent and robust GDB data available in the public domain is very limited below high level aggregate variables. As a result the amount of detail we can include in the operating cost function is relatively limited. For example, no consistent disaggregations of opex into either labour and materials or into operating costs and maintenance are available across GDBs. Consequently, we have not been able to include a share equation along with the operating cost function as we only have the opex aggregate to work with. Similarly, only limited and variable information is available on operating environment factors other than the key ones of customer density and energy density. And, multicollinearity issues limit the scope to include density variables along with multiple outputs in the one operating cost function.

Given the limited scope to estimate a comprehensive and fully specified detailed operating cost function, we have instead adopted the approach of estimating two relatively simple operating cost functions which use different output and operating environment combinations. The first one is presented in equation (13) and contains throughput and customer numbers as outputs, pipeline length as the capital quantity proxy and a time trend as a technological change proxy:

$$\begin{aligned}(13)\qquad \ln C_{OM} &= b_0 + b_D \ln D + b_C \ln C + \ln W_{OM} + 0.5 b_{DD} \ln D \ln D + 0.5 b_{CC} \ln C \ln C \\ &\quad + b_K \ln K + b_t t\end{aligned}$$

where D is deliveries (or throughput), C is customer numbers, W_{OM} is the opex input price, K is pipeline length and t is a time trend. Note that the opex input price enters the operating cost function with a coefficient of one in this instance to ensure homogeneity of degree one in prices. Second order terms are included for outputs. In this instance the key operating environment characteristics of customer density and energy density enter through interactions of the two output variables and the capital quantity variable. The density drivers cannot be included as separate terms in addition to their constituent components due to multicollinearity.

Parameter estimates for equation (13) are presented in table 2. The parameters are all of the expected sign with increases in the two outputs and also increases in pipeline length leading to increases in operating costs. Technological change leads to a small reduction in annual operating costs, all else equal. The second order output interactive term was not statistically significant and was excluded from the estimating equation.

In table 3 we combine the parameter estimates reported in table 2 with the GDBs' forecasts of average growth in throughput, customer numbers and pipeline length over the next regulatory period to form forecasts of opex partial productivity growth using equation (11). Results are presented for SP AusNet and for Multinet by way of comparison.

Table 2: **Two output operating cost function regression estimates**[1]

Coefficient	Estimate	t–statistic[2]	Coefficient	Estimate	t–statistic
b_0	0.029	0.797	b_{CC}	–0.218	–3.098
b_D	0.234	4.465	b_K	0.378	6.577
b_C	0.288	4.010	b_t	–0.006	–1.743
b_{DD}	0.350	6.681			

1 R^2 between observed and predicted is 0.95

2 Critical t-statistics for testing are: 1.289, 1.658, 1.980 and 2.617 for the 20, 10, 5 and 1 per cent significance levels, 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.

Table 3: **Two output operating cost function opex partial productivity forecasts**

Model's estimated cost elasticities:		*Output Weights:*
Energy	0.2338	44.80%
Customers	0.2880	55.20%
Capital (kms)	0.3778	
Technology	–0.0061	
GDB's forecast driver growth rates (2013-2017):		
	Multinet	SP AusNet
Energy	–0.57%	0.18%
Customers	0.75%	2.12%
Weighted Average Output Growth	0.16%	1.25%
Capital (kms)	0.10%	1.73%
PP Opex Growth Rates Components:		
	Multinet	SP AusNet
Technology (A)	0.61%	0.61%
Returns to Scale (B)	0.07%	0.60%
Business Conditions (C)	0.04%	0.65%
PP Opex Growth Rates (=A+B-C):	0.64%	0.55%

Both GDBs are forecasting lower growth rates for throughput going forward than have been observed historically. While throughput is influenced by climatic conditions and thus tends to be somewhat volatile, over the last 10 years SP AusNet's throughput has grown annually by 0.8 per cent while Multinet's has declined marginally. Over the next regulatory period, SP AusNet is forecasting its average annual throughput growth to fall to 0.2 per cent annually while Multinet is forecasting its annual throughput growth to fall to –0.6 per cent.

Both GDBs are forecasting smaller reductions in their customer number growth rates compared to their forecast reductions in throughput growth rates. Correspondingly, forecast annual growth in distribution pipeline length is somewhat lower than that observed over the last 10 years.

From table 3 we see that technological change leads to a 0.6 per cent increase in annual forecast opex partial productivity growth. Changes in returns to scale contribute between 0.1 percentage points and 0.6 percentage points to forecast opex partial productivity growth. This is derived as the product of one minus the sum of the output elasticities and the weighted average output growth rate (where the weights are derived from the share of each output elasticity in the sum of the two output elasticities). Finally, we deduct the business conditions component which covers the capital quantity interaction and operating environment effects. As density operating environments effects are included via the output and capital quantity interactions, in this case the capital quantity term is the only explicit business condition variable. The capital quantity growth impact deducts between zero and 0.7 per cent from annual opex partial productivity growth. This is because installing additional capital generally requires additional opex for its operation and maintenance.

The accumulation of these separate effects leads to opex partial productivity average annual forecast growth rates of 0.6 per cent for both SP AusNet and Multinet. Year–by–year forecast opex partial productivity growth rates for the two GDBs are presented in appendix A. These forecast partial productivity growth rates are lower than those observed over the last five years where the average annual growth rates reported in Economic Insights (2012b) were 1.6 per cent for Multinet and a very high 8.4 per cent for SP AusNet. Looking at the last 10 years, opex partial productivity growth was considerably higher in the first half of that period for Multinet and has progressively reduced over the second half of the period. SP AusNet, on the other hand, started the opex usage reform process later and so has exhibited higher productivity growth in the second half of the last 10 years than the first but its productivity growth has also tapered off in recent years as available cost savings have progressively been implemented. Forecast reductions in throughput and a slowing in customer number growth are the major drivers of the model's forecast reduction in opex partial productivity growth going forward along with the need to continue network expansion to serve new customers.

The second operating cost function estimated is presented in equation (14) and contains customer numbers as the primary output, customer density as the key operating environment variable, constant price asset value as the capital quantity proxy and a time trend as a technological change proxy:

$$\begin{aligned}(14)\quad \ln C_{OM} &= b_0 + b_C \ln C + \ln W_{OM} + b_{CD} \ln CD + 0.5 b_{CC} \ln C \ln C + 0.5 b_{CDCD} \ln CD \ln CD \\ &+ 0.5 b_{CCD} \ln C \ln CD + b_K \ln CPAV + b_t t\end{aligned}$$

where C is customer numbers, W_{OM} is the opex input price, CD is customer density, $CPAV$ is the constant price asset value and t is a time trend. Note that the opex input price again enters the operating cost function with a coefficient of one to ensure linear homogeneity in prices. Second order terms are included for outputs and customer density. Multicollinearity prevents the inclusion of our preferred capital quantity proxy, pipeline length, when customer numbers and customer density are already included. Consequently, in this instance we use the less preferred capital quantity proxy of the constant price asset value. This is formed using 2010 RAB values as the starting point and moving the series backwards and forwards using a depreciation rate of 4 per cent (the average regulatory depreciation rate observed historically in Victoria) and capex deflated by the ABS (2011b) capital goods price index for the Electricity, gas, water and waste sector. The price index is extrapolated to 2017 using the average annual growth rate observed over the decade from 2002 to 2011. Given the relatively one hoss shay physical depreciation characteristics of pipelines, the constant price depreciated asset value proxy is somewhat less likely to accurately reflect the actual movement in the quantity of capital compared to the physical proxy.

Table 4: **Single output operating cost function regression estimates**[1]

Coefficient	Estimate	t–statistic[2]	Coefficient	Estimate	t–statistic
b_0	2.7737	6.7205	b_{CDCD}	0.8730	5.1230
b_C	0.4656	8.4264	b_{CCD}	–1.2321	–7.5184
b_{CD}	–0.4624	–7.0584	b_{CPAV}	0.3834	6.3368
b_{CC}	0.2931	4.3112	b_t	–0.0102	–3.9104

1 R^2 between observed and predicted is 0.96

2 Critical t-statistics for testing are: 1.289, 1.658, 1.980 and 2.617 for the 20, 10, 5 and 1 per cent significance levels, 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.

Table 5: **Single output operating cost function opex partial productivity forecasts**

Model's estimated cost elasticities:		
Customers	0.4656	
Customer Density	–0.4624	
Capital (constant price asset value)	0.3834	
Technology	–0.0102	
GDB's forecast driver growth rates (2013-2017):		
	Multinet	SP AusNet
Customers	0.75%	2.12%
Customer Density	0.65%	0.39%
Capital (constant price asset value)	2.22%	3.36%
PP Opex Growth Rates Components:		
	Multinet	SP AusNet
Technology (A)	1.02%	1.02%
Returns to Scale (B)	0.40%	1.13%
Business Conditions (C)	0.55%	1.11%
PP Opex Growth Rates (=A+B-C):	0.87%	1.05%

Parameter estimates for equation (14) are presented in table 4. The parameters are all of the expected sign with an increase in output and also an increase in capital quantity leading to increases in operating costs. Increases in customer density lead to a decrease in opex, all else equal, while technological change leads to a reduction in annual operating costs, all else equal. All parameter estimates are highly statistically significant.

In table 5 we combine the parameter estimates reported in table 4 with the GDBs' forecasts of average growth in customer numbers, customer density and constant price asset value over the next regulatory period to form forecasts of opex partial productivity growth using equation (11). As noted above, both GDBs are forecasting a reduction in the growth rate of customer numbers going forward. However, both are forecasting slightly higher growth rates of customer density going forward compared to those observed over the last decade.

The forecast increases in the constant price asset value for each GDB over the next regulatory period implied by their forecast capex series are higher than their forecast growth in distribution pipeline lengths. Multinet again has the lower forecast capital quantity proxy growth rate reflecting the more mature market it serves with correspondingly lower forecast customer numbers growth.

From table 5 we see that technological change leads to a 1 per cent increase in annual forecast opex partial productivity growth under this model. Changes in returns to scale contribute between 0.4 percentage points and 1.1 percentage points to forecast opex partial productivity growth. This is derived as the product of one minus the customer numbers output elasticity and the average customer numbers output growth rate. Finally, we deduct the business conditions component which covers the capital quantity interaction and customer density operating environment effects. The business conditions growth impact deducts between 0.6 and 1.1 per cent from annual opex partial productivity growth.

The accumulation of these separate effects leads to opex partial productivity average annual forecast growth rates of 0.9 per cent for Multinet and 1.1 per cent for SP AusNet. Year–by–year forecast growth rates for the two GDBs are presented in appendix A.

The magnitudes of the forecast opex partial productivity growth rates are broadly similar across the two alternative operating cost function models although the second model forecasts marginally higher growth rates than in the first model. This is due to the second model not explicitly including the much slower growing throughput as an output variable. But the second model is able to explicitly include the important customer density operating environment effect. This broad similarity in results points to the results being relatively robust when two quite different specifications produce broadly similar outcomes. Since there is no basis to prefer either of the models over the other, standard practice is to take an average of the two sets of results for use in subsequent opex rate of change analysis. Doing this produces an average annual forecast opex partial productivity growth rate for the period 2013 to 2017 of 0.8 per cent for both Multinet and SP AusNet.

APPENDIX A: ANNUAL OPEX PRODUCTIVITY FORECASTS

Table A1: **Annual opex partial productivity forecasts for two output operating cost function, 2013–2017**

Year	Multinet	SP AusNet
2013	0.72%	0.48%
2014	0.51%	0.57%
2015	0.63%	0.54%
2016	0.68%	0.58%
2017	0.68%	0.58%

Table A2: **Annual opex partial productivity forecasts for single output operating cost function, 2013–2017**

Year	Multinet	SP AusNet
2013	0.11%	0.85%
2014	0.93%	0.98%
2015	1.15%	0.96%
2016	0.99%	1.30%
2017	1.17%	1.14%

Table A3: **Annual average opex partial productivity forecasts from operating cost functions, 2013–2017**

Year	Multinet	SP AusNet
2013	0.41%	0.66%
2014	0.72%	0.78%
2015	0.89%	0.75%
2016	0.84%	0.94%
2017	0.92%	0.86%

ATTACHMENT A: LETTER OF RETAINER

JOHNSON WINTER & SLATTERY

LAWYERS

Partner:	Anthony Groom +61 8 8239 7124
Email:	anthony.groom@jws.com.au
Associate:	Joanna Burrow +61 8 8239 7137
Email:	joanna.burrow@jws.com.au
Our Ref:	A7422
Your Ref:	
Doc ID:	62042748.1

27 March 2012

Dr Denis Lawrence
Economic Insights Pty Ltd
6 Kurundi Place
HAWKER ACT 2614

Dear Dr Lawrence

Victorian Gas Access Arrangement Review 2013 – 2017: SP AusNet

We act for SPI Networks (Gas) Pty Ltd (**SP AusNet**) in relation to the AER's review of SP AusNet's Access Arrangement for Victoria. SP AusNet wishes to engage you to prepare an expert report in connection with the AER's review of its Victorian Access Arrangement.

This letter sets out the matters which SP AusNet wishes you to address in your report and the requirements with which the report must comply.

Terms of Reference

The terms and conditions upon which SP AusNet provides access to its network are subject to five yearly reviews by the AER.

The AER undertakes that review by considering the terms and conditions proposed by SP AusNet against criteria set out in the National Gas Law and National Gas Rules.

Matters relevant to the tariffs proposed by SP AusNet include the forecast costs which will be incurred by SP AusNet over the regulatory period.

Given this context SP AusNet wishes to engage you to prepare an expert report, which:

(a) assesses its efficiency, taking operating expenditure and capital input trade-offs and business conditions into account within an appropriate statistical framework; and

Level 10, 211 Victoria Square
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(b) forecasts SP AusNet's future operating cost partial productivity growth rates.

In preparing those aspects of your report which relate to the making of forecasts or estimates, you should have regard to the relevant requirements of Rule 74(2) of the National Gas Rules which provides:

"A forecast or estimate:

(a) must be arrived at on a reasonable basis; and

(b) must represent the best forecast or estimate possible in the circumstances."

Use of Report

It is intended that your report will be included by SP AusNet in its access arrangement revision proposal for its Victorian network for the access arrangement period from 1 January 2013 to 31 December 2017. The report may be provided by the AER to its own advisers. The report must be expressed so that it may be relied upon both by SP AusNet and by the AER.

The AER may ask queries in respect of the report and you will be required to assist SP AusNet in answering these queries. The AER may choose to interview you and if so, you will be required to participate in any such interviews.

The report will be reviewed by SP AusNet's legal advisers and will be used by them to provide legal advice to SP AusNet as to its rights and obligations under the National Gas Law and National Gas Rules. You will be required to work with these legal advisers and SP AusNet personnel to assist them to prepare SP AusNet's access arrangement revision proposal and submissions in response to the draft and final decisions made by the AER.

If SP AusNet chooses to challenge any decision made by the AER, that appeal will be made to the Australian Competition Tribunal and the report will be considered by the Tribunal. SP AusNet may also seek review by a court and the report would be subject to consideration by such court. You should therefore be conscious that the report may be used in the resolution of a dispute between the AER and SP AusNet as to the appropriate level of SP AusNet's tariffs. Due to this, the report will need to comply with the Federal Court requirements for expert reports, which are outlined below.

You must ensure you are available to assist SP AusNet until such time as the Access Arrangement Review and any subsequent appeal is finalised.

Time Frame

SP AusNet's access arrangement revision proposal is due by 30 March 2012. We request that you provide your report to us or to SP AusNet by 29 March 2012 so that SP AusNet may finalise its submissions in advance of the due date.

Compliance with the Code of Conduct for Expert Witnesses

Attached is a copy of the Federal Court's Practice Note CM 7, entitled "Expert Witnesses in Proceedings in the Federal Court of Australia", which comprises the code of conduct for expert witnesses in the Federal Court of Australia (**the Code of Conduct**).

Please read and familiarise yourself with the Code of Conduct and comply with it at all times in the course of your engagement by SP AusNet.

In particular, your report prepared for SP AusNet should contain a statement at the beginning of the report to the effect that the author of the report has read, understood and complied with the Code of Conduct.

Your report must also:

(a) contain particulars of the training, study or experience by which the expert has acquired specialised knowledge;

(b) identify the questions that the expert has been asked to address;

(c) set out separately each of the factual findings or assumptions on which the expert's opinion is based;

(d) set out each of the expert's opinions separately from the factual findings or assumptions;

(e) set out the reasons for each of the expert's opinions; and

(f) otherwise comply with the Code of Conduct.

The expert is also required to state that each of the expert's opinions is wholly or substantially based on the expert's specialised knowledge.

It is also a requirement that the report be signed by the expert and include a declaration that *"[the expert] has made all the inquiries which [the expert] believes are desirable and appropriate and that no matters of significance which [the expert] regards as relevant have, to [the expert's] knowledge, been withheld from the report."*

Please also attach a copy of these terms of reference to the report.

Terms of Engagement

Your contract for the provision of the report will be directly with SP AusNet. You should forward to SP AusNet any terms you propose govern that contract as well as your fee proposal.

Please sign a counterpart of this letter and forward it to us or to SP AusNet to confirm your acceptance of the engagement by SP AusNet.

Yours faithfully

Johnson Winter & Slattery

Enc: Federal Court of Australia Practice Note CM 7, "Expert Witnesses in Proceedings in the Federal Court of Australia"

D.A. Lawrence

....
Signed and acknowledged by Dr Denis Lawrence

Date 27 March 2012

Doc ID: A6403 - 62042748.1

ATTACHMENT B: CURRICULA VITAE

Dr Denis Lawrence

Position	Director, Economic Insights
Business address:	6 Kurundi Place, Hawker, ACT 2614
Business telephone number:	02 6278 3628
Mobile:	0438 299 811
Email address	denis@economicinsights.com.au

Qualifications

Doctor of Philosophy (Economics), University of British Columbia, Canada, 1987.

Bachelor of Economics (Honours), Australian National University, 1977.

Key Skills and Experience

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 has been a consultant on energy regulation since 1996. Recent key energy network projects include:

- Assisting the AEMC with its review of total factor productivity-based regulation including advice on data requirements and specification issues, constructing a detailed model comparing outcomes under productivity-based and building block regulation and drafting and review of sections of AEMC reports (2008-2011).
- Advice to the New Zealand Commerce Commission on asset valuation and total factor productivity measurement in the presence of sunk costs and incorporating the principle of financial capital maintenance (2008–09).
- Advice to the Northern Territory Utilities Commission on the setting of key price control parameters for electricity distribution (2008–09).
- Advice to the Commerce Commission on using the comparative or benchmarking option for resetting the price path threshold for electricity transmission and distribution businesses using total factor productivity and econometric techniques (2003–09).
- Advised ENMAX Corporation (Alberta, Canada) on developing the case for moving from cost–of–service to formula–based regulation (2006–09).
- Advice to the Commerce Commission on key aspects of its inquiry into whether the distributor Unison Networks should be subject to price control for having breached price thresholds (2006–07).
- Benchmarked the productivity, operating and capital expenditure, reliability and price performance of 13 of Australia’s 15 electricity distributors for a consortium of distribution businesses (2004).
- Reviewed total factor productivity modelling of electricity distribution in Victoria

undertaken for the Essential Services Commission (2005).

- Econometric modelling of operating and maintenance expenditure efficiency based on a sample of electricity distributors and taking operating environment differences into account (2005).
- Presented commentaries on the principles behind incentive regulation and the implementation of total factor productivity measurement to support incentive regulation for a Utility Regulators' Forum workshop on future electricity networks regulation (2003).
- Examined the relative efficiency performance of Australian State electricity supply industries in response to energy reforms from 1975 to 2001 for the Parer Review of Energy Market Reform (2001).
- Prepared case studies for the Ontario Energy Board of international best practice in distribution pricing structures, allowing for distributed generation, incorporating energy conservation and demand management incentives (2006).
- Advised the Australian Energy Networks Association on development of a nationally consistent suite of service quality performance indicators and assisted with developing the ENA's position on service quality incentive regulation (2006).
- Advised CitiPower and Powercor on developing a robust and defendable case for a revised Service Incentive Scheme for their 2006 Price Review submissions (2005).
- Assisting the Commerce Commission with reviewing the regulated gas distribution businesses' pricing principles and quantitative cost of service models (2007–09).
- Studies of the comparative efficiency performance of gas distribution for the Victorian gas distribution businesses (2006–07).
- Benchmarking of the efficiency of gas transmission and distribution pipelines in Australia and New Zealand for the Commerce Commission (2004).
- Advised the Commerce Commission on the allocation of joint costs in firms supplying electricity and gas (2007–08).

Selected Publications

Coelli, T.J. and D. Lawrence (eds.) (2006), Performance Measurement and Regulation of Network Utilities, Edward Elgar Publishing, Cheltenham, UK.

Lawrence, D., W.E. Diewert and K.J. Fox (2006), "The Contribution of Productivity, Price Changes and Firm Size to Profitability", Journal of Productivity Analysis 26, 1–13.

Zeitsch, J. and D. Lawrence (1996), "Decomposing Economic Inefficiency in Base Load Power Plants", Journal of Productivity Analysis 7(4), 359-378.

Zeitsch, J., D. Lawrence and J. Salerian (1994), "Comparing Like With Like in Productivity Studies - Apples, Oranges and Electricity", Economic Record 70(209), 162-70.

Lawrence, D., P. Swan and J. Zeitsch (1991), 'The Comparative Efficiency of State Electricity Authorities', in P. Kriesler (ed.), Contemporary Issues in Australian Economics, MacMillan.

John Kain

Position	Associate, Economic Insights
Business address:	27 Erldunda Circuit, Hawker, ACT 2614
Business telephone number:	02 6254 6133
Email address	JohnKain@bigpond.com

Qualifications

BSc, Sydney University

BE (1st Class Hons), Sydney University

Key Skills and Experience

Prior to becoming a consultant John Kain was Chief Engineer and General Manager Engineering with ACT Electricity and Water (ACTEW) and its predecessor organisations. John has extensive experience in electricity distribution engineering including underground and overhead mains, transmission circuits, zone and distribution substations, protection design, setting and commissioning, system planning and system operations. He also acquired experience in supply cost analysis and tariff formulation as well as bulk–supply purchases. Since leaving ACTEW, John has operated as an independent consultant specialising in the analysis of electricity network costs and tariffs. John was a Board Member of the former National Electricity Code Administrator (NECA). Recent key projects include:

- Advice to the AEMC on the data and other requirements for the implementation of productivity–based regulation.
- Constructed a database for total factor productivity and econometric analyses for the New Zealand Commerce Commission's resetting of price regulation parameters for electricity distribution businesses for the period 2009–2014.
- Constructed detailed database of US gas business outputs and inputs for efficiency analysis.
- Advised the ENA on development of a nationally consistent suite of service quality performance indicators and assisted with developing the ENA's position on incentive regulation and embedded generation issues.
- Benchmarked the operating and capital expenditure performance of the two Queensland distributors, Energex and Ergon Energy, against Australian and US distributors.
- Reviewed proposals for a Network Access Regime in the Northern Territory including asset valuation, analysis of retail tariffs and revenues.
- Examination of higher voltage network elements of New South Wales distributors likely to be regarded as "Transmission Elements" under the National Electricity Code, and advice as to their relevance for regulatory inclusion.
- Provided Cost and Tariff analysis and advice to the Network arms of Electricity Trust of South Australia in anticipation of market operations in that state.

- Assisted NorthPower in the examination of network costs, and the development of an allocation methodology for determining network charges. Assistance in negotiations with neighbouring network operators over disputed charges.
- Assistance to TransGrid as the then NSW market and system operator in a review of the National Grid Metering Code requirements associated with the extension of contestability to the 160-750 MWh customer tranche.
- Assistance to TransGrid as then NSW market and system operator at the time in a review for IPART of the methodologies used by the New South Wales Network operators in the determination of loss factors, and the results of those determinations.
- Prepared a report on Electricity Distributors' Costs and Cost Allocation Methodology and Analysis of Suppliers' Responses. This study confirmed and better quantified the cross-subsidy as well as highlighting the difference between Tariff formats, and the format of allocated costs, particularly for the 'simple' energy only tariffs.
- Assisted the Pricing Oversight Commission in understanding of the Electricity Supply Industry Cost and Tariff Structures, and in the understanding, analysis and questioning of the Cost and Tariff Proposals of the Hydro Electric Commission of Tasmania.
- Advised on cost and tariff analysis and the preparation of Integral Energy Networks Division's Submission to IPART and undertook subsequent analysis of tariff separation on various potentially contestable customers.
- Reviewed Electricity Distributors Retail and Network Costs and Allocations, including separation of the 'wires' and 'retail' operations of distributors with indications of appropriate directions and amounts of change.
- Identified cross subsidies in electricity distribution for various clients.

ATTACHMENT C: DECLARATION

I, Denis Anthony Lawrence, Director of Economic Insights Pty Ltd, 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.

D.A. Lawrence

Denis Anthony Lawrence

28 March 2012

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Australian Bureau of Statistics (ABS) (2011a), *Australian Demographic Statistics*, June Quarter 2011, Catalogue No 3101.0, Canberra.

Australian Bureau of Statistics (ABS) (2011b), *Australian System of National Accounts, Table 63: Net Capital Stock, by Industry by type of asset*, Catalogue No 5204.0, Canberra.

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Economic Insights (2012a), *Benchmarking the Victorian Gas Distribution Businesses' Operating and Capital Costs Using Partial Productivity Indicators*, Report prepared for Envestra Victoria, Multinet and SP AusNet, March, Canberra.

Economic Insights (2012b), *The Total Factor Productivity Performance of Victoria's Gas Distribution Industry*, Report prepared for Envestra Victoria, Multinet and SP AusNet, March, Canberra.

Lawrence, Denis (2007), *Victorian Gas Distribution Business Opex Rate of Change*, Report by Meyrick and Associates for Envestra, Multinet and SP AusNet, Canberra, 26 March.

Lawrence, D., J. Fallon and J. Kain (2007), *Efficiency Comparisons of Australian and New Zealand Gas Distribution Businesses Allowing for Operating Environment Differences*, Report prepared by Meyrick and Associates for Multinet Pty Ltd, 19 March, Canberra.

Organisation for Economic Cooperation and Development (OECD) (2011), *Economics: Key tables from OECD - Purchasing power parities for GDP*, ISSN 2074-384x.

Pacific Economics Group (2001a), *Envestra Gas Distribution Operations and Maintenance Cost Performance: Results from International Benchmarking*, Madison, Wisconsin.

Pacific Economics Group (2001b), *Multinet Gas Distribution Operations and Maintenance Cost Performance: Results from International Benchmarking*, Madison, Wisconsin.

Pacific Economics Group (2001c), *TXU Gas Distribution Operations and Maintenance Cost Performance: Results from International Benchmarking*, Madison, Wisconsin.

Pacific Economics Group (2004), *Predicting Growth in SPI's O&M Expenses*, Report prepared for SPI, October, Madison.

Pacific Economics Group (2007), *Opex Rate of Change and Productivity: Response to Meyrick and Associates Reports*, Report prepared for the Essential Services Commission, July, Madison.

Zellner, A. (1962), "An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests for Aggregation Bias", *Journal of the American Statistical Association* 57, 348–68.