Operating Expenditure Forecasting Using the Revealed Cost Approach report (Scale), Acil Allen November 2014

Appendix 6.2

27 November 2014

Response to the ERA's Draft Decision on required amendments to the Access Arrangement for the Mid-West and South-West Gas Distribution System

Connecting WA to natural gas

ACIL ALLEN CONSULTING

REPORT TO
ATCO GAS AUSTRALIA

20 NOVEMBER 2014

OPERATING EXPENDITURE

FORECASTING USING THE REVEALED COST APPROACH

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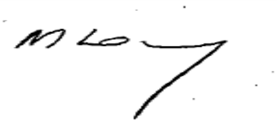
Compliance with the Code of Conduct for Expert Witnesses

I am a Director of ACIL Allen Consulting and have prepared this expert report.

I have read, understood and complied with the Expert Witness Guidelines (Federal Court Practice Note CM 7, entitled "*Expert Witnesses in Proceedings in the Federal Court of Australia*") in preparing this report.

I have made all inquiries that I believe are desirable and appropriate and no matters of significance that I regard as relevant have, to my knowledge, been withheld from the report.

Necessary limitations to the scope and depth of the analysis undertaken, and the resulting findings that can be made based on the analysis, are outlined in the report.



Marianne Lourey
Director

Consultant qualifications

Marianne Lourey, a Director of ACIL Allen Consulting, has prepared this expert report. Marianne has nearly 30 years experience, predominantly in the energy sector, working in, and consulting to, government, regulators and industry. Since joining ACIL Allen in January 2010, Marianne has provided advice to a range of clients which draws on her policy, regulatory, technical and analytical skills and experience.

Marianne was previously the Manager, Network Regulation at the Essential Services Commission where she was responsible for assessing the expenditure proposals as part of the 2006-10 Electricity Distribution Price Review, during which the "revealed cost" approach to assessing operating expenditure was developed.

She has subsequently provided advice to Western Power and the Victorian Government in relation to the "revealed cost" approach to assessing operating expenditure proposals.

Marianne holds a Bachelor of Engineering (First Class Honours) and a Masters of Business Administration from Monash University.

A CV is provided in Appendix C.

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1 Introduction

On 14 October 2014, the Economic Regulation Authority (ERA) published its Draft Decision on the Access Arrangement Review Proposal submitted by ATCO Gas Australia Pty Ltd (ATCO Gas) for the period July 2014 to December 2019 (the fourth access arrangement period).

The ERA assessed ATCO Gas's proposed forecast operating expenditure by considering:

- labour escalation factor
- network operating expenditure
- corporate operating expenditure
- IT operating expenditure
- unaccounted for gas (UAFG) operating expenditure
- ancillary service operating expenditure.[1]

The ERA adopted a "revealed cost" to assess the proposed operating expenditure (excluding UAFG and ancillary services). Of the $373.66 million proposed by ATCO Gas for operating expenditure (excluding UAFG and ancillary services) in the fourth access arrangement period, the ERA decided that $301.05 million satisfies the National Gas Rules (NGR).

1.1 Scope

ACIL Allen Consulting (ACIL Allen) has been engaged by ATCO Gas to prepare an expert report which considers the ERA's revealed cost approach to assessing ATCO Gas's operating expenditure forecasts in the Draft Decision and, in particular, the ERA's decision to disallow any real escalation in labour costs and the implicit assumption that any costs associated with growth will be offset by productivity improvements.

ATCO Gas has also requested ACIL Allen to provide opinion on:

- the increase in operating expenditure that would be associated with an increase in the number of customers and pipeline lengths and the relationship between line length and/or capital expenditure and operating expenditure
- based on ACIL Allen's benchmarking of ATCO Gas, the productivity improvements offset that ATCO Gas would be expected to be able to achieve during the 2014-2019 period.

The full terms of reference (TOR) for the study are shown in Appendix B.

1.2 Report structure

The report is structured as follows:

- section 2 provides background information on the "revealed cost" approach to forecasting operating expenditure in an economic regulatory decision-making environment

[1] Economic Regulation Authority, *Draft Decision on Proposed Revisions to the Access Arrangement for the Mid-West and South-West Gas Distribution System,* 14 October 2014, para 207

- section 3 summarises how the ERA has applied the "revealed cost" approach to forecasting ATCO Gas's operating expenditure for the July 2014 to December 2019 period
- section 4 sets out a more appropriate application of the "revealed cost" approach to forecast ATCO Gas's operating expenditure for the July 2014 to December 2019 period
- section 5 provides concluding comments on the application of the "revealed cost" approach to forecast ATCO Gas's operating expenditure for the July 2014 to December 2019 period, and provides responses to the opinions specifically sought in the TOR.

2 Background

The requirements in the NGR that are applicable to ATCO Gas's forecast of operating expenditure are set out in section 2.1. Background information on the "revealed cost" approach to forecasting operating expenditure in regulatory decision making is provided in section 2.2.

2.1 Requirements in the National Gas Rules

ATCO Gas's proposed operating expenditure for the fourth access arrangement period must satisfy rules 74 and 91 of the NGR.

Rule 91(1) provides:

> Operating expenditure must be such as would be incurred by a prudent service provider acting efficiently, in accordance with accepted good industry practice, to achieve the lowest sustainable cost of delivering pipeline services.

Rule 74 provides:

> (1) Information in the nature of a forecast or estimate must be supported by a statement of the basis of the forecast or estimate.
>
> (2) 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.

2.2 The "revealed cost" approach

The "revealed cost" approach has been used in regulatory decision making in Australia over the last decade for forecasting operating expenditure of electricity and gas distribution network service providers.

The "revealed cost" approach relies on the incentive-based regulatory framework to incentivise network service providers to reveal an efficient level of operating expenditure, noting that operating expenditure tends to be relatively consistent from one year to the next. The revealed efficient level of operating expenditure in one access arrangement period is the starting point for forecasting an efficient level of operating expenditure for the following access arrangement period.

Having determined the starting point, the focus for forecasting an efficient level of operating expenditure is on the reasons why future expenditure is likely to vary from the revealed level of efficient expenditure. The reasons why future expenditure may vary from the revealed level of efficient expenditure include:

- the impact of growth to be able to operate and maintain the network as the number of connections increases and the network of pipelines grows
- real price increases in the inputs – labour and materials
- productivity improvements
- new or changed legislative or regulatory obligations, which require additional operating and maintenance activity.

Over the last decade, a variety of approaches have been used in assessing the impact of growth, real increases in input prices and productivity improvements. The approach used by the ERA in assessing ATCO Gas's forecast network operating expenditure is discussed in section 2.2.1, an approach previously adopted by the ERA is discussed in section 2.2.2, and the "rate of change" approach is discussed in section 2.2.3.

Changes in future expenditure arising from new or changed legislative or regulatory obligations are generally assessed by considering:

- firstly, whether there has been a new or changed legislative or regulatory obligation
- secondly, assessing whether the forecast expenditure for that new or changed legislative or regulatory obligation satisfies the NGR, that is, that it would be incurred by a prudent service provider acting efficiently, in accordance with good industry practice.

2.2.1 Recent application of the revealed cost approach by ERA

In its report for ERA on the technical aspects of ATCO Gas's proposed revised access arrangement, Energy Market Consulting Associates (EMCa) has stated that for network operating expenditure[2]:

> We consider that a revealed cost approach provides a reasonable means of determining a prudent and efficient cost, given that ATCO's forecasting method does not incorporate assumptions that can be modified because at the base level it involves manual forecasts at the activity level. … We … consider that the actual costs incurred by ATCO in the penultimate year of AA3 (i.e. 2013) form a reasonable basis for forecasting ATCO's recurring cost requirements.

In assessing the impact of growth, real increases in input prices and productivity improvements on the forecast network operating expenditure for ATCO Gas for the fourth access arrangement period, EMCa has considered:

- changes in the projected demand due to growth capital expenditure during the fourth access arrangement period
- productivity improvements
- real increase in unit costs, noting that ATCO Gas's forecast operating expenditure allowed for a real increase in labour costs but not a real increase in material costs.[3]

The ERA appears to have accepted this approach.[4]

EMCa has similarly considered a revealed cost approach for corporate costs[5] and some of the IT costs[6], but with no consideration of growth, productivity improvements or the real increase in unit costs.

ERA's application of the revealed cost approach in assessing ATCO Gas's forecast network operating expenditure is discussed further in section 3.

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2 Energy Marketing Consulting Associates, *ATCO Gas Australia Proposed Access Arrangement for the Mid-West and South-West Gas Distribution Systems: Review of Technical Aspects of the Proposed Access Arrangement, Public (redacted) Version,* June 2014, para 512

3 Op cit, para 513

4 Economic Regulation Authority, *Draft Decision on Proposed Revisions to the Access Arrangement for the Mid-West and South-West Gas Distribution System,* 14 October 2014, paras 227 and 228

5 Energy Marketing Consulting Associates, *ATCO Gas Australia Proposed Access Arrangement for the Mid-West and South-West Gas Distribution Systems: Review of Technical Aspects of the Proposed Access Arrangement, Public (redacted) Version,* June 2014, paras 543 and 574

6 Op cit, paras 598 and 601

2.2.2 Previous application of the revealed cost approach by the ERA

In its Final Decision of Proposed Revisions to Western Power's Access Arrangement for the period from July 2012 to June 2017, the ERA also used a revealed cost approach to assess the forecast operating expenditure.[7]

In assessing the impact of growth on the forecast network operating expenditure for Western Power, ERA considered[8]:

- scale escalators – rates of growth in the number of customers (for call centre and metering costs) and the growth in the network (for all other network operating costs)[9]
- economies of scale – to take into account that the growth in the network should result in economies of scale. The economy of scale factor takes into account that the variable network operating costs will increase in line with the growth rate, while the fixed network operating costs will increase by less than the growth rate.

The net growth rate that was applied to each category of network operating costs was calculated by multiplying the relevant scale escalator by the relevant economy of scale.

When considering the growth rate for the network, the ERA used the historic growth rate rather than the forecast growth rate[10]:

> The rationale is that new assets installed have a 'honeymoon period' during which little maintenance is required. This results in a lag between when assets are installed and when they must be inspected or maintained. In other words, the maintenance effort is driven not so much by the new assets installed but by the assets that were installed during the previous regulatory periods.

On the basis that Western Power operates an integrated transmission and distribution network[11], and that ERA does not consider that Western Power is as efficient as relevant peers in the industry[12], the ERA considered that an economy of scale factor of 30 per cent for network operations and 95 per cent[13] for other network operating costs was appropriate for Western Power[14].

ERA also provided for real increases in labour costs[15] and a productivity improvement offset[16].

2.2.3 An alternative application of the revealed cost approach

An alternative approach to assessing the impact of growth, increases in input prices and productivity improvements is to determine the "rate of change", which is used to escalate the operating expenditure.

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7 Economic Regulation Authority, *Final Decision on Proposed Revisions to the Access Arrangement for the Western Power Network,* 5 September 2012, para 318

8 Op cit, paras 338-360

9 Average of the rates of growth in the line length, number of distribution transformers and zone substation capacity

10 Economic Regulation Authority, *Final Decision on Proposed Revisions to the Access Arrangement for the Western Power Network,* 5 September 2012, para 345

11 Op cit, para 352

12 Op cit, para 357

13 An economy of scale factor of 95 per cent is applied to those costs that are largely variable.

14 Economic Regulation Authority, *Final Decision on Proposed Revisions to the Access Arrangement for the Western Power Network,* 5 September 2012, para 358

15 Op cit, para 531

16 Op cit, para 561

$$Opex_t = (1 + rate\ of\ change) \times Opex_{t-1}$$

where:

$Opex_t$ is the operating expenditure (opex) in year t

$Opex_{t-1}$ is the opex in year t-1

The rate of change is a function of:

- the forecast real increase in input cost (labour and materials) escalators (Δreal opex price)
- the expected productivity improvement (Δopex partial productivity)
- the expected increase in output (Δoutput quantity).

$$Rate\ of\ change = \Delta real\ opex\ price - \Delta opex\ partial\ productivity + \Delta output\ quantity$$

The expected productivity improvement generally incorporates productivity improvements associated with technological change, economies of scale and operating environment factors.

The rate of change approach to estimating the expected productivity improvements and expected increase in output is a more sophisticated approach than using scale escalators and economies of scale factors as discussed in section 2.2.2.

3 Application of the revealed cost approach by ERA

The ERA's approach to applying the revealed cost approach in its Draft Decision on ATCO Gas's:

- network operating expenditure is discussed in section 3.1
- corporate operating expenditure is discussed in section 3.2
- IT operating expenditure is discussed in section 3.3.

The real increase in input prices is discussed in section 3.4.

3.1 Network operating expenditure

In its Draft Decision, the ERA decided that[17]:

> of the $182.80 million that ATCO [Gas] proposes to spend on network operating expenditure in the fourth access arrangement period:
>
> - $163.65 million satisfies rules 74 and 91 of the NGR.
> - $19.15 million does not satisfy rules 74 and 91 of the NGR.

In its decision on the forecast network operating expenditure, the ERA[18]:

- set a base network operating expenditure of $27.10 million per annum, based on ATCO Gas's proposed level of expenditure in 2014 and 2015, which is discussed in section 3.1.1
- included a step change of $3.60 million per annum for ATCO Gas to comply with its Safety Case, based on ATCO's proposed level of expenditure in 2014 and 2015, but disallowed any further step changes in the fourth access arrangement period, which is discussed in section 3.1.2
- included no allowance for the impact of growth, which is discussed in section 3.1.3
- included an IT efficiency gain of $1.10 million per annum, which is discussed in section 3.1.4
- disallowed any real increases in input prices, which is discussed in section 3.4, and included a labour cost de-escalation of $0.40 million in 2015
- included one-off network operating expenditure of $1.80 million over the access arrangement period.

However, in making these decisions, the ERA has not considered each of the components of the "revealed cost" approach separately, but has made assumptions that certain costs will offset others, without any assessment as to whether they will.

3.1.1 Base level of operating expenditure

ERA's consultant, EMCa, considers that[19]:

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[17] Economic Regulation Authority, *Draft Decision on Proposed Revisions to the Access Arrangement for the Mid-West and South-West Gas Distribution System,* 14 October 2014, para 235

[18] Op cit, paras 236 and 237

> … ATCO [Gas] has had an incentive to reduce operating expenditure during the current access arrangement because it can capture all the cost savings. As a result, EMCa considers that the actual costs incurred by ATCO [Gas] in 2013 form a reasonable basis for forecasting ATCO's recurring network operating expenditure.

However, the ERA has not used ATCO Gas's most recent actual operating expenditure as the baseline for the forecast operating expenditure, consistent with the revealed cost approach. Rather, it has adopted the level of network operating expenditure proposed by ATCO Gas, capped at the proposed 2015 levels.

Appendix 2A of ATCO Gas's Access Arrangement Information states that the network operating expenditure in 2013/14 was $28.6 million (in $real, June 2014) which is higher than the baseline operating expenditure adopted by ERA ($27.1 million).

3.1.2 Step change

While the ERA has accepted that ATCO Gas will incur a higher level of network operating costs during the fourth access arrangement period for it to comply with its Safety Case, it is of the view that the expenditure will be capped at the proposed 2015 levels. The ERA is of the view that the cost of any additional incremental activities associated with the Safety Case, between 2016 and 2019, will be offset by cost reductions arising from[20]:

- capital expenditure for asset replacement and on telemetry and monitoring, which will impact the requirement to carry out unplanned and reactive maintenance, and/or on-site monitoring
- optimising maintenance and inspection activities[21].

In making this assumption, the ERA has not separately assessed the productivity offsets that can be derived from these activities to ensure that they will offset the proposed increase in ATCO Gas's network operating expenditure to comply with its Safety Case.

3.1.3 Impact of growth

The ERA has not included any allowance for the impact of the growth in the network as[22]:

> … the majority of ATCO's proposed capital expenditure on the Two Rocks, Peel and Baldivis spur lines and the greenfield subdivision developments is expected to occur after 2015. Therefore, operating expenditure in relation to these projects would occur in the fifth access arrangement period, rather than fourth.

The rationale for not including any allowance for growth is based on the forecast growth in the network, rather than by considering the historic growth in the network.

The ERA has previously explicitly recognised a lag between capital expenditure and network operating expenditure in this draft decision and in the 2012 final decision on Western Power's access arrangement. However, in assessing the network operating expenditure for the next access arrangement period, it has not included any allowance for the growth in the network during the current access arrangement period.

The ERA has included no allowance for the impact of growth in the number of customers. There is no discussion in the ERA's Draft Decision or in the report of its consultants, EMCa, as to why there is no allowance.

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[19] Op cit, para 227

[20] Op cit, para 229

[21] Op cit, para 224

[22] Op cit, para 229

3.1.4 Productivity improvements

The ERA has included a range of productivity improvements in its draft decision on network operating expenditure:

- productivity improvements associated with the capital expenditure for asset replacements and on telemetry and monitoring
- productivity improvements associated with optimising maintenance and inspection activities
- implicit productivity improvements by not allowing for the impact of growth or for the real increase in labour costs
- an explicit IT efficiency gain of $1.10 million per annum.

The explicit IT efficiency gain incorporated by ERA is based on EMCa's opinion that a 10 per cent annual efficiency dividend from the IT capital expenditure incurred in the current access arrangement period should be applied to the operating expenditure for the fourth access arrangement period.[23]

In my opinion, while EMCa has considered a number of factors in determining the level of the annual efficiency dividend, the 10 per cent annual dividend appears to have been relatively arbitrarily determined.

3.1.5 ERA's Draft Decision on ATCO Gas's network operating costs

While the ERA appears to have adopted a revealed cost approach for determining ATCO Gas's network operating costs based on the advice from its consultant, it has, in my opinion, not properly applied the revealed cost approach.

It has:

- not used the most recent actual network operating expenditure as the starting point for forecasting network operating expenditure
- arbitrarily capped the step changes in network operating expenditure at the proposed 2015 expenditure level
- not explicitly considered the impact of growth and productivity offsets on these costs over the fourth access arrangement period
- included a relatively arbitrarily determined 10 per cent annual IT efficiency gain
- rejected ATCO Gas's proposal for a real increase in labour costs.

3.2 Corporate operating expenditure

In its Draft Decision, the ERA decided that[24]:

> of the $132.16 million that ATCO [Gas] proposes to spend on corporate operating expenditure in the fourth access arrangement period:
>
> - $93.75 million satisfies rules 74 and 91 of the NGR.
> - $38.43 million does not satisfy rules 74 and 91 of the NGR.

In its decision on the forecast corporate operating expenditure, the ERA:

[23] Energy Marketing Consulting Associates, *ATCO Gas Australia Proposed Access Arrangement for the Mid-West and South-West Gas Distribution Systems: Review of Technical Aspects of the Proposed Access Arrangement, Public (redacted) Version,* June 2014, para 342

[24] Economic Regulation Authority, *Draft Decision on Proposed Revisions to the Access Arrangement for the Mid-West and South-West Gas Distribution System,* 14 October 2014, para 276

- set a base operating expenditure for corporate support expenditure of $12.30 million per annum, which was ATCO Gas's actual expenditure in 2013[25]
- set a base operating expenditure for business development and marketing of $1.76 million per annum, which was ATCO Gas's actual expenditure in 2013[26]
- set a base operating expenditure for licence fees of $14.30 million over the fourth access arrangement period[27]
- included a one-off expenditure of $2.10 million for the preparation of the next access arrangement proposal[28]
- included no allowance for the impact of growth
- disallowed any real increases in input prices, which is discussed in section 3.4
- included no explicit offset for productivity improvements.

In my opinion, the ERA has implicitly offset any impact of growth with productivity improvements, with no commentary in the draft decision as to why there is no allowance for the impact of growth.

While the ERA has adopted a revealed cost approach for determining ATCO Gas's corporate support costs and business development and marketing costs by using the actual expenditure in 2013 as the baseline operating expenditure, it has, in my opinion, not properly applied the revealed cost approach.

It has:

- not explicitly considered the impact of growth and productivity offsets on these costs over the fourth access arrangement period
- rejected ATCO Gas's proposal for a real increase in labour costs.

3.3 IT operating expenditure

In its Draft Decision, the ERA decided that[29]:

> of the $58.70 million of IT operating expenditure that is forecast by ATCO [Gas] for the fourth access arrangement period:
>
> - $43.67 million satisfies rules 74 and 91 of the NGR; and
> - $15.03 million does not satisfy rules 74 and 91 of the NGR.

In its decision on the forecast IT operating expenditure, the ERA[30]:

- accepted ATCO Gas's originally proposed IT licence fees of $13.46 million over the fourth access arrangement period
- rejected a subsequent proposed increase of $0.94 million in IT licence fees
- set a base operating expenditure for IT services fees of $5.45 million per annum, which was ATCO Gas's actual expenditure in 2013
- included no allowance for the impact of growth on IT services fees
- included no explicit allowance for productivity improvements in IT services fees

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25 Op cit, para 250

26 Op cit, para 256

27 Op cit, paras 273 and 274

28 Op cit, para 251

29 Op cit, para 274

30 Op cit, paras 236 and 237

- disallowed any real increases in input prices
- included a one-off IT usage fee of $0.20 million in 2014, prior to this fee being rolled into the IT services fee with a change in contracting arrangements.

While the ERA has adopted a revealed cost approach for determining ATCO Gas's costs associated with the IT services fee by using the actual expenditure in 2013 as the baseline operating expenditure, it has, in my opinion, not properly applied the revealed cost approach.

It has:

- not explicitly considered the impact of growth and productivity offsets on these costs over the fourth access arrangement period
- rejected ATCO Gas's proposal for a real increase in labour costs.

3.4 Real increase in input prices

While ATCO Gas did not propose any real increase in material costs, it proposed a real increase in labour costs of 2.0 percent per annum.

Despite noting that a recent regulatory determination provided a real increase in labour costs of 2.0 percent per annum[31] and that the real increase in labour cost should not be above 1.75 per cent per annum based on:

- Western Australia's Treasury's forward estimates of the Western Australian Wage Price Index (WPI)
- the average differential between the WPI for the Electricity, Gas, Water and Waste Sector and the Western Australian WPI[32],

the ERA has not included any allowance for a real increase in labour costs. The ERA's decision to not include a real increase in labour costs is due to it not being satisfied that ATCO Gas's proposal meets rule 74 of the NGR[33].

ERA has not stated that ATCO Gas's proposal does not satisfy rule 91 of the NGR. Furthermore, its consultant, EMCa, has stated that it accepted "the validity of the assumed labour unit cost increase"[34].

Notwithstanding its decision to not include an allowance for a real increase in labour costs, the ERA is of the view that the cost reductions arising from[35]:

- capital expenditure for asset replacement and on telemetry and monitoring which will impact the requirement to carry out unplanned and reactive maintenance, and/or on-site monitoring
- optimising maintenance and inspection activities[36]

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31 Op cit, para 211

32 Op cit, para 212

33 Op cit, para 214

34 Energy Marketing Consulting Associates, *ATCO Gas Australia Proposed Access Arrangement for the Mid-West and South-West Gas Distribution Systems: Review of Technical Aspects of the Proposed Access Arrangement, Public (redacted) Version,* June 2014, para 513

35 Economic Regulation Authority, *Draft Decision on Proposed Revisions to the Access Arrangement for the Mid-West and South-West Gas Distribution System,* 14 October 2014, para 229

36 Op cit, para 224

will offset any increase in unit prices as well as the additional incremental activities associated with the Safety Case, between 2016 and 2019.

In my opinion, these statements indicate that ERA has recognised there will be real increases in input prices.

3.5 ERA's application of the revealed cost approach

The ERA has adopted a revealed cost approach to assessing ATCO Gas's proposed network operating costs, corporate support costs, business development and marketing costs, and IT support fees.

However, in my opinion, it has erred in not properly applying the revealed cost approach. It has:

- not used the most recent actual network operating expenditure as the starting point for forecasting network operating expenditure
- arbitrarily capped the step changes in network operating expenditure at the proposed 2015 expenditure level
- not explicitly considered the impact of growth and productivity offsets on the network operating costs, corporate support costs, business development and marketing costs, and IT support fees over the fourth access arrangement period
- included a relatively arbirtrarily determined IT efficiency gain
- rejected ATCO Gas's proposal for a real increase in labour costs.

4 Proper application of the revealed cost approach to ATCO Gas

Economic Insights and its Director, Dr Denis Lawrence, have undertaken a number of studies since 2004 of gas pipeline efficiency performance in Australasia.[37]

In section 4.1, Economic Insights most recent (2014) study on gas pipeline efficiency performance is examined to determine whether any opinions can be drawn from the study on the relative efficiency of ATCO Gas's operating expenditure.

On the basis of the conclusions drawn from section 4.1, section 4.2 considers the applicability of a rate of change approach for determining the impact of growth, increases in input prices and productivity improvements on the forecast operating expenditure for ATCO Gas for the fourth access arrangement period based on the parameters estimated by Economic Insights for other gas distribution network service providers.

To provide a sensibility check on the conclusions drawn from section 4.2, an alternative approach to forecasting ATCO Gas's operating expenditure for the fourth access arrangement period by extrapolating historic expenditure is set out in section 4.2.4.

4.1 How efficient is ATCO Gas?

4.1.1 Economic Insights study for Jemena

Economic Insights recently produced a report for Jemena Gas Networks (Jemena), *Relative Opex Efficiency and Forecast Opex Productivity Growth of Jemena Gas Networks,* which estimated the operating expenditure (opex) cost function for gas distribution businesses. This was used to examine Jemena's opex efficiency compared to ten other gas distribution businesses (eight from Australia, including ATCO Gas, and two from New Zealand).[38]

Economic Insights estimated a translog variable cost function model that included the following variables:

- output as measured by the total number of customers and the quantity of gas throughput
- opex input prices
- capital inputs
- a time trend representing technological change
- operating environment factors.[39]

For the purposes of the analysis, opex covered distribution activities only and excluded all capital costs, transmission fees and UAFG.[40]

37 Refer to Economic Insights, *Relative Opex Efficiency and Forecast Opex Productivity Growth of Jemena Gas Networks,* 14 April 2014, pages 57-62

38 The report is provided as Appendix D.

39 Economic Insights, *Relative Opex Efficiency and Forecast Opex Productivity Growth of Jemena Gas Networks,* 14 April 2014, pages 35-36

40 Op cit, page 40

The opex input price was a weighted index of labour costs (62 per cent) and other costs represented by a range of producer price indexes (38 per cent).[41]

The capital input price was calculated using reported historic real regulatory asset base (RAB) values and regulator approved forecasts.

Operating environment factors are exogenous influences affecting the cost efficiency of the network which are largely beyond management's control. Economic Insights included the following operating environment factors which it was of the view were key to influencing a gas distribution network service provider's operating cost levels[42]:

- **Customer density**, as measured by total customers per kilometre of mains, is a product of the degree of urban density in the reticulated area and the rate of gas penetration in these areas.
- **Network age**, as measured by the proportion of the network that is made up of cast iron or unprotected steel. Gas networks that are made of cast iron and unprotected steel have higher maintenance requirements. The progressive replacement of cast iron/unprotected steel mains with new mains made with modern materials substitutes capital for non-capital inputs and is a source of reduction in maintenance costs over time.
- **Network fragmentation**, as measured by the number of city gates supplying the distribution network service provider from the transmission system. The greater the dispersion of the area supplied may reduce the efficiency of work crews that maintain the networks and necessitate more duplication of some inputs than would be the case for a distribution network service provider serving a very compact and contiguous area.[43]

Economic Insights has developed the dataset from public domain data sources.[44] The summary data for the 11 gas distribution network service providers included in the Economic Insights 2014 report are set out in Appendix A.

Economic Insights set out the opex cost function specification as follows[45]:

$$\begin{aligned} InC_{OM} = InW_{OM} &+ b_0 + b_D InD + b_C InC + 0.5b_{DD}(InDInD) + b_{DC}(InDInC) \\ &+ 0.5b_{CC}(InCInC) + b_{CPAV}InCPAV + b_t t + b_{NCI}InNCI \\ &+ b_{CD}InCD + 0.5b_{CDCD}(InCDInCD) + b_{CG}InCG \end{aligned}$$

where:

D is the quantity of gas throughput

C is the number of customers

CPAV is the capital (constant price RAB)

t is technology changes over time

NCI is the proportion of pipelines that are cast iron or unprotected steel

CD is the customer density

CG is the number of city gates

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41 Op cit, page 41

42 Op cit, pages 41-42

43 Op cit, pages 40-42

44 Op cit, pages 39-40

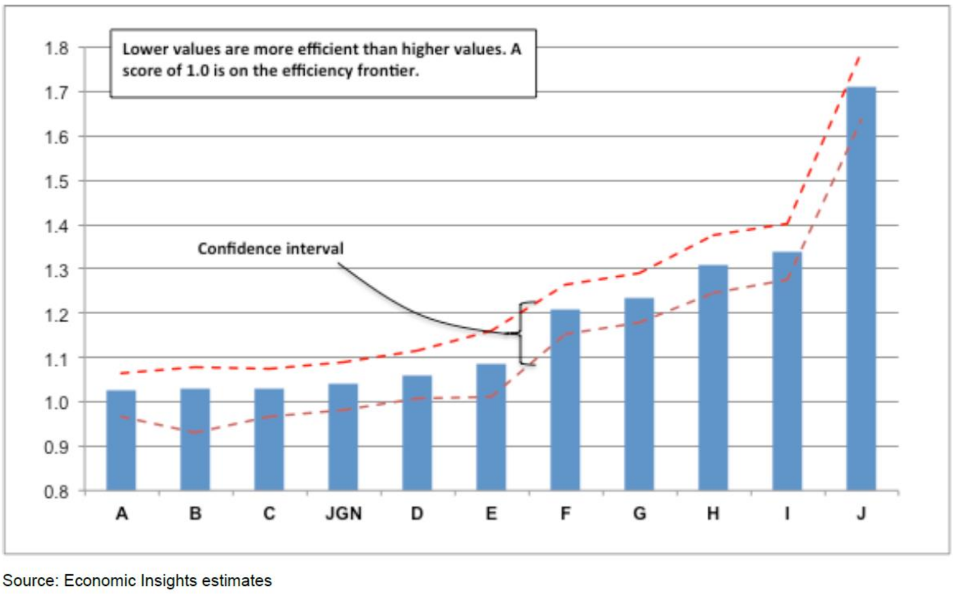
45 Op cit, page 46

Economics Insights used two estimation methods:

- feasible generalised least squares (FGLS), which estimates the coefficients of the opex cost function but does not provide estimates of the comparative efficiency of gas distribution network service providers
- stochastic frontier analysis (SFA), which provides estimates of the technical efficiency of each gas distribution network service provider.

Having estimated the opex cost function model using these two estimation models, Economic Insights plotted estimates of the opex cost inefficiency of each gas distribution network service provider in the sample, as replicated in Figure 1.

Figure 1 **Economic Insights opex cost function – comparative cost inefficiency (per cent)**



Source: Economic Insights, *Relative Opex Efficiency and Forecast Opex Productivity Growth of Jemena Gas Networks,* 14 April 2014, Figure 5.2

Only Jemena (JGN) is identified in Figure 1. The other gas distribution network service providers are identified only by the letters A, B, C, etc.

Economic Insights concluded from the results of the modelling that[46]:

> JGN is among a group of four GDBs [gas distribution businesses] that are close to the opex cost efficiency frontier, after taking into account the largely exogenous operating environment effects. The 95 per cent confidence interval shown in [Figure 1] indicates that JGN's estimated opex cost efficiency was not significantly different from the other three or four GDBs that are close to the efficiency frontier. Furthermore, JGN's opex efficiency is not statistically different from the efficiency frontier level.

4.1.2 Efficiency of ATCO Gas relative to Jemena

From the information and data provided in the Economic Insights report for Jemena, ACIL Allen has not been able to replicate Figure 1 to identify which gas distribution network service provider is ATCO Gas. ACIL Allen has therefore undertaken further analysis, based

[46] Op cit, page 48

on the benchmarking study recently undertaken by ACIL Allen for ATCO Gas[47], to be able to infer where ATCO Gas lies on the graph relative to Jemena.

Two approaches have been modelled – one based on developing a relationship of best fit of the operating expenditure for the nine Australian gas distribution network service providers in the benchmarking study and one based on a composite opex index. The nine Australian gas distribution network service providers that were included in the benchmarking study were:

- ATCO Gas
- Envestra SA
- Envestra Victoria
- Multinet Gas (Victoria)
- AusNet Services (Victoria)
- ActewAGL (ACT)
- Jemena (NSW)
- Envestra Queensland
- Allgas Energy (Queensland).

Relationship of best fit across the gas distribution network service providers

ACIL Allen has modelled the relationship between the historic operating expenditure for the nine gas distribution network service providers in the benchmarking study and the following variables:

- quantity of gas throughput
- number of customers
- system capacity (pipeline length).

The relationship also included a constant and a productivity variable.

The relationship has been modelled using EViews, a statistical, forecasting and modelling tool.

The data in the benchmarking study provided either 9 or 10 observations for each of the nine Australian gas distribution network service providers.

Two forms of relationship were tested:

- a linear relationship of the following form:

$$Opex = b_0 + b_t t + \sum b_i x_i$$

- a Cobb-Douglas production function – a logarithmic relationship, similar to that used by Economic Insights:

$$LNOpex = b_0 + b_t t + \sum b_i LNx_i$$

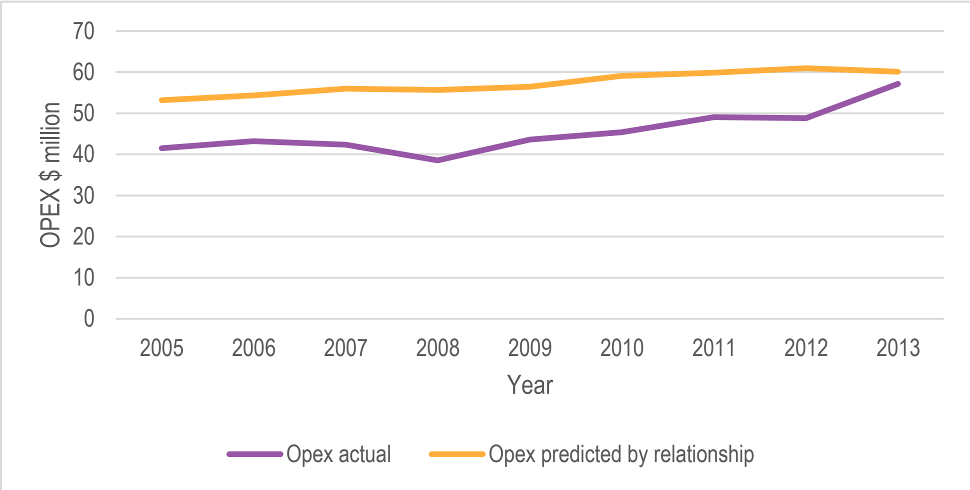
The objective was to identify the relationship with the highest correlation (R-squared) coefficient.

47 ACIL Allen Consulting, *Gas Distribution Benchmarking – Partial Productivity Measures, Final Report,* 11 March 2014

The relationship controls for the differences in the characteristics of the gas distribution network service providers and was then used to predict the operating expenditure for ATCO Gas over the historic period.

The results from the modelling are provided in Figure 2. Figure 2 illustrates the operating expenditure incurred by ATCO Gas over the historic period and the expenditure predicted by the relationship to be incurred over that period.

Figure 2 **ATCO Gas's actual operating expenditure compared to the operating expenditure predicted to be incurred**



Note: Opex in $December 2013
Source: ACIL Allen

Figure 2 indicates that ATCO Gas's actual operating expenditure has been less than predicted by the relationship over the historic period. In my opinion, this would indicate that ATCO Gas is one of the more efficient gas distribution network service providers of those that have been benchmarked.

Composite index approach

In its report, Economic Insights provided information on the output quantity, input quantity, opex partial productivity and capital partial productivity indexes for Jemena, Envestra (Victoria), Multinet, SP AusNet (now AusNet Services) and Envestra South Australia.[48]

In developing these indexes, Economic Insights has assumed output cost shares as follows:

- quantity of gas throughput – 13 percent
- number of customers – 49 percent
- system capacity (pipeline length) – 38 percent[49].

On this basis, ACIL Allen has constructed a composite opex index by:

- setting each of the three opex partial productivity indexes (opex per quantity of gas throughput, opex per customer and opex per kilometre of mains) for ATCO Gas in 2005-06 to 1.00

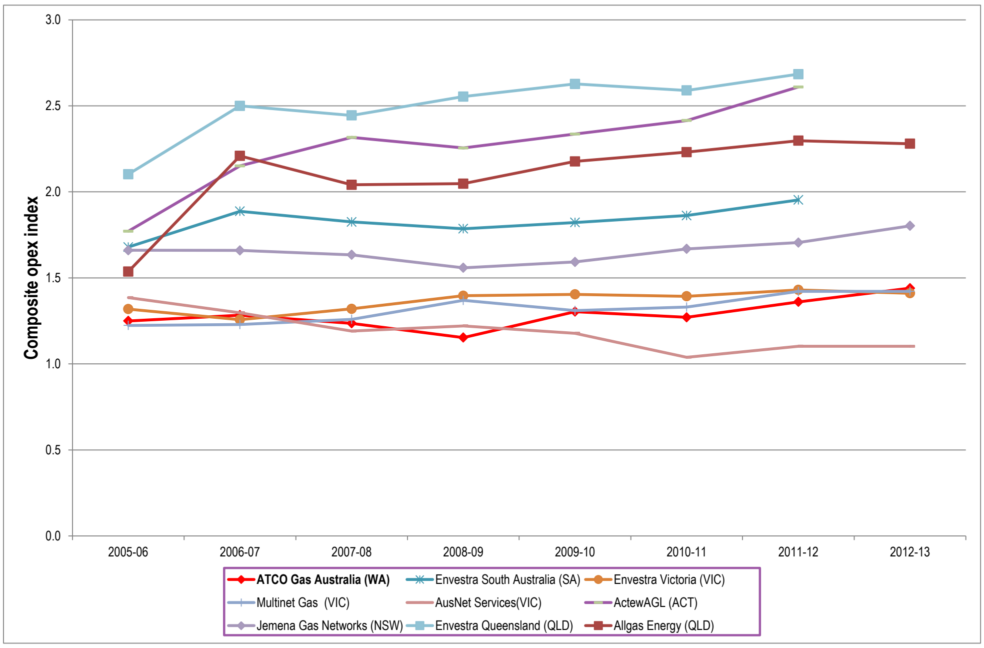
[48] Op cit, pages 20-25

[49] Op cit, page 17

- for each of the three opex partial productivity indexes, in each subsequent year, determining a ratio relative to the value for ATCO Gas in 2005-06
- for each of the three opex partial productivity indexes, for each gas distribution network service provider in ACIL Allen's benchmarking study, in each year, determining a ratio relative to the value for ATCO Gas in 2005-06
- aggregating the three opex partial productivity indexes using the weightings in the Economic Insights report.

The composite opex index, which has been calculated for each gas distribution network service provider included in ACIL Allen's benchmarking study, is illustrated in Figure 3.

Figure 3 **Composite opex index**



Note: The composite opex index is a weighted aggregate of the opex per quantity of gas throughput, the opex per customer and opex per kilometre of mains

Source: Partial productivity indexes – ACIL Allen, *Gas Distribution Benchmarking: Partial Productivity Measures, Final Report,* 11 March 2014; Weightings – *Relative Opex Efficiency and Forecast Opex Productivity Growth of Jemena Gas Networks,* 14 April 2014, page 17

Figure 3 illustrates that the group of gas distribution network service providers that have the lowest composite opex index up to 2012-13 are ATCO Gas and the three Victorian gas distributors – Envestra (Victoria), Multinet and AusNet Services.

The exogenous operating environment effects (customer density, network age and network fragmentation) considered by Economic Insights for these gas distribution network service providers and Jemena are provided in detail in Table A1. The factors are summarised in Table 1 by rating the factor a 3 if the factor will enable the distributor to operate relatively efficiently, a 1 if the factor will not enable the distributor to operate relatively efficiently and a 2 if the factor is between these two extremes. The ratings for each of the factors are then aggregated.

Table 1 **Exogenous operating environment effects**

Gas distribution network service provider	Customer density	Network age	Network fragmentation	Total
Jemena	2+	3	1	6+
ATCO Gas	2+	3	2	7+
AusNet Services	3	2	2	7
Envestra (VIC)	3	2	3	8
Multinet	3	1	1	5

Note: 3 – exogenous operating environment factor will enable distributor to operate relatively efficiently; 1 - exogenous operating environment factor will not enable the distributor to operate relatively efficiently; 2 – exogenous operating environment factor lies between these two extremes.

Source: ACIL Allen assessment of data provided in Economic Insights, *Relative Opex Efficiency and Forecast Opex Productivity Growth of Jemena Gas Networks,* 14 April 2014, Table 5.2

Table 1 indicates that the exogenous operating environment factors that apply to Envestra (Victoria) are likely to enable it to operate more efficiently than Jemena, ATCO Gas, AusNet Services and Multinet. The exogenous operating environment factors that apply to ATCO Gas are likely to enable it to operate more efficiently than Jemena, AusNet Services and Multinet.

Of these five gas distribution network service providers, Multinet has the greatest opportunity to improve the efficiency of its operations by replacing cast iron and unprotected steel pipelines.

Conclusion

Based on the information provided in Figure 2, it is my opinion that ATCO Gas is most likely to be one of the gas distribution network service providers A, B, C or D in Figure 1.

Based on the information provided in Figure 3 and Table 1, it is my opinion that ATCO Gas, AusNet Services, Envestra (Victoria), and Multinet are most likely to be gas distribution network service providers A, B, C and D in Figure 1.

If Economic Insights can conclude from Figure 1 that Jemena is close to the opex cost efficiency frontier, after taking into account the largely exogenous operating environment effects, it is my opinion that ATCO Gas is also close to the opex cost efficiency frontier.

It is my opinion that the future productivity gains that can be achieved by ATCO Gas are likely to be similar to those that can be achieved by AusNet Services, Envestra (Victoria), Multinet and Jemena. Further, it is my opinion that the opex productivity improvements that have been estimated by Economic Insights for these gas distribution network service providers could also be applied to ATCO Gas. Any errors arising from adopting such an approach will be within a reasonable range given the inherent inaccuracies associated with forecasting operating expenditure through to December 2019.

4.2 Rate of change approach

The rate of change approach, which was discussed in section 2.2.3, can be used to forecast operating expenditure for each year in the period July 2014 to December 2019 by escalating the operating expenditure in the previous year by a rate of change.

$$Opex_t = (1 + rate\ of\ change) \times Opex_{t-1}$$

where:

$Opex_t$ is the opex in year t

$Opex_{t-1}$ is the opex in year t-1

The rate of change includes three components:

— the forecast real increase in input cost (labour and materials) escalators, which is discussed in section 4.2.1
— the expected productivity improvement, which is discussed in section 4.2.2
— the expected increase in output, which is discussed in section 4.2.3.

The rate of change is then calculated as follows:

$$Rate\ of\ change = \Delta real\ opex\ price - \Delta opex\ partial\ productivity + \Delta output\ quantity$$

where:

Δreal opex price is the change in real input prices (labour and materials)

Δopex partial productivity is the expected productivity improvements

Δoutput quantity is the expected increase in output

The forecast operating expenditure using the rate of change approach is set out in section 4.2.4.

4.2.1 Change in real input prices

In adopting a rate of change approach, the input prices to consider are labour and materials.

ATCO Gas has not forecast any real increase in material costs.[50]

ATCO Gas proposed a real increase in labour costs of 2.0 per cent per annum.[51] While the ERA was of the view that the real increase in labour costs did not satisfy rule 74 of the NGR[52], the ERA considers that ATCO Gas's:

> proposed labour cost escalation factor should not be higher than 1.75 per cent as per the following evidence:
>
> - Western Australia's Treasury's forward estimates for the Western Australian WPI for 2014-2015 to 2017-2018 is 0.50 to 1.25 per cent higher than CPI; and
> - over the four years from 2009-2013, the EGWWS [Electricity, Gas, Water and Waste Sector] has experienced a WPI of 0.50 per cent (on average) above the all-industry Western Australian WPI[53].

In my opinion, if this is the only data available on the real increase in labour costs, then a reasonable estimate of the real increase in labour costs for the fourth access arrangement period is set out in Table 2. In the absence of any other information to the contrary, the estimates for 2018-19 and 2019-20 have been assumed to be the same as for 2017-18.

Based on this data, it is not reasonable to assume that there is no real increase in labour costs.

50 ATCO Gas Australia, *Access Arrangement Information 1 July 2014-31 December 2019 (AA4),* March 2014, page 66

51 Op cit, page 66

52 Economic Regulation Authority, *Draft Decision on Proposed Revisions to the Access Arrangement for the Mid-West and South-West Gas Distribution System,* 14 October 2014, para 214

53 Op cit, para 212

Table 2 **Real increase in labour costs for the fourth access arrangement period**

Year	WPI (%)	CPI (%)	Industry premium (%)	Real increase in labour costs (%)
2014-15	3.25	2.75	0.5	1.0
2015-16	3.5	2.5	0.5	1.5
2016-17	3.5	2.5	0.5	1.5
2017-18	3.75	2.5	0.5	1.75
2018-19	3.75	2.5	0.5	1.75
2019-20	3.75	2.5	0.5	1.75

Note: Real increase in labour costs = WPI – CPI + Premium for the Electricity, Gas, Water and Waste sector

Source: WPI and CPI for 2014-15 to 2017-18 – Western Australia's Treasury's forward estimates available at http://www.treasury.wa.gov.au/cms/content.aspx?id=604; WPI and CPI for 2018-19 and 2019-20 assumed to be the same as for 2017-18; Industry premium – ERA's Draft Decision

In my opinion, this forecast of the real increase in labour costs satisfies rule 74 of the NGR. The basis for my opinion is set out in Table 3.

Table 3 **How the real increase in labour costs satisfies rule 74 of the NGR**

Requirement of rule 74	How the real increase in labour costs satisfies rule 74
Information in the nature of a forecast or estimate must be supported by a statement of the basis of the forecast or estimate.	The basis of the forecast or estimate of the real increase in labour costs is set out in Table 2.
A forecast or estimate must be arrived at on a reasonable basis A forecast or estimate must represent the best forecast or estimate possible in the circumstances	In its Draft Decision, the ERA has provided evidence for the maximum real increase in labour costs using this approach to forecasting or estimating the real increase in labour costs. In my opinion, this would indicate that this is a reasonable basis for arriving at the forecast or estimate of the real increase in labour costs, and that, based on the data provided in this section, it represents the best forecast or estimate possible in the circumstances.

The change in real opex price is determined by weighting the real increase in labour prices and the real increase in material prices by the proportion of the operating expenditure that is labour and material, respectively. That is:

$$\Delta real\ opex\ price = \left({}^{Labour\ costs}/_{(Labour\ costs + Material\ costs)}\right) \times real\ increase\ in\ labour\ price \\ + \left({}^{Material\ costs}/_{(Labour\ costs + Material\ costs)}\right) \times real\ increase\ in\ materials\ price$$

On the basis of the forecast labour costs as a proportion of total costs provided by ATCO Gas, the real increase in input prices for each year of the fourth access arrangement period is as set out in Table 4.

Table 4 **Real increase in input prices for the fourth access arrangement period**

Year	Labour weighting (%)	Increase in labour costs (% pa)	Materials weighting (%)	Increase in materials costs (% pa)	Real increase in input prices (% pa)
July – December 2014	43.1	1.00	56.9	0.0	0.43
2015	58.7	1.25	41.3	0.0	0.73
2016	60.1	1.50	39.9	0.0	0.90
2017	60.8	1.63	39.2	0.0	0.99
2018	61.5	1.75	38.5	0.0	1.08
2019	61.7	1.75	38.3	0.0	1.08

Source: Increase in labour costs from Table 2

4.2.2 Change in opex partial productivity

For the reasons as set out in section 4.1.2, it is my opinion that the opex partial productivity factor for ATCO Gas is likely to be similar to the opex partial productivity factors that have been estimated by Economic Insights for Jemena, AusNet Services, Envestra (Victoria) and Multinet.

Economic Insights has forecast the opex partial productivity factor on an annual basis for Jemena (in its 2014 study), and for AusNet Services and Multinet (in a 2012 study[54]). The average results from these studies are summarised in Table 5.

Table 5 **Opex cost function partial productivity forecasts**

Gas distribution network service provider	Source	Period	Approach	Average forecast opex partial productivity
Jemena	A	2016-20	FGLS model	0.90%
Jemena	A	2016-20	SFA model	1.15%
AusNet Services	B	2013-17	Throughput included as an output	0.55%
AusNet Services	B	2013-17	Throughput not included as an output	1.05%
Multinet	B	2013-17	Throughput included as an output	0.64%
Multinet	B	2013-17	Throughput not included as an output	0.87%

Source: A – Economic Insights, *Relative Opex Efficiency and Forecast Opex Productivity Growth of Jemena Gas Networks,* 14 April 2014, Table 5.7; B – Economic Insights, *Econometric Estimates of the Victorian Gas Distribution Business' Efficiency and Future Productivity Growth,* 28 March 2012

A breakdown of the components of each of the forecast opex partial productivity rates (technology, returns to scale and operating environment factors) is provided in Table 6.

[54] The report (*Econometric Estimates of the Victorian Gas Distribution Business' Efficiency and Future Productivity Growth*) is provided as Appendix E.

Table 6 **Opex cost function partial productivity forecasts**

Gas distribution network service provider	Technology (A)	Returns to scale (B)	Operating environment factors (C)	Average forecast partial productivity opex growth rate (=A+B-C)
Jemena (FGLS)	0.82%	0.30%	0.21%	0.90%
Jemena (SFA)	0.88%	0.26%	-0.01%	1.15%
AusNet Services (throughput included)	0.61%	0.60%	0.65%	0.55%
AusNet Services (throughput not included)	1.02%	1.13%	1.11%	1.05%
Multinet (throughput included)	0.61%	0.07%	0.04%	0.64%
Multinet (throughput not included)	1.02%	0.40%	0.55%	0.87%
Average (mean)				**0.86%**

Source: Economic Insights, *Relative Opex Efficiency and Forecast Opex Productivity Growth of Jemena Gas Networks,* 14 April 2014, Table 5.7; Economic Insights, *Econometric Estimates of the Victorian Gas Distribution Business' Efficiency and Future Productivity Growth,* 28 March 2012

In both these studies, Economic Insights has forecast the opex partial productivity rate using two different models and has then averaged the results to derive a single point estimate.

If the results from the two models for each of the three gas distribution network service providers are averaged, the single point forecast of the opex partial productivity rate is 0.86 per cent per annum.

It is my opinion that it is reasonable to apply a single point estimate of 0.86 per cent in each year of the access arrangement period. In my opinion, the errors resulting from using a single point estimate are within a reasonable range given the inherent inaccuracies with forecasting expenditure over a five and a half year period. Using a single point estimate is also consistent with the application of the rate of change by the Essential Services Commission in 2005.[55]

If the opex partial productivity rate is used, it would incorporate the productivity improvements that have been included by the ERA in its Draft Decision, including the IT efficiency gain, and the efficiency gains associated with the capital expenditure for assets replacements and on telemetry and monitoring, and optimising maintenance and inspection activities. There should be no additional allowance for productivity improvements.

In my opinion, this forecast of the opex partial productivity rate of 0.86 per cent per annum satisfies rules 74 and 91 of the NGR. The basis for my opinion is set out in Table 7.

[55] Essential Services Commission, *Electricity Distribution Price Review 2006-10, Final Decision Volume 1: Statement of Purpose and Reasons,* October 2005, page 210

Table 7 **How the opex partial productivity rate satisfies the NGR**

Requirement of the NGR	How the opex partial productivity rate satisfies the NGR
Information in the nature of a forecast or estimate must be supported by a statement of the basis of the forecast or estimate.	The basis of the forecast or estimate of the opex partial productivity rate is set out in Table 5 and Table 6.
A forecast or estimate must be arrived at on a reasonable basis A forecast or estimate must represent the best forecast or estimate possible in the circumstances	The opex partial productivity rate for ATCO Gas has been forecast based on analysis undertaken by Economic Insights to forecast the opex partial productivity rate for Jemena, AusNet Services and Multinet. Economic Insights and its Director, Dr Denis Lawrence, have undertaken a number of studies since 2004 on gas pipeline efficiency performance in Australasia. For the reasons set out in section 4.1.2, it is my opinion that the opex partial productivity rate for ATCO Gas is likely to be similar to that estimated by Economic Insights for Jemena, AusNet Services and Multinet. The averaging of the results from the Economic Insights results for Jemena, AusNet Services and Multinet to produce a single point estimate is consistent with the approach adopted by Economic Insights.
Operating expenditure must be such as would be incurred by a prudent service provider acting efficiently, in accordance with accepted good industry practice, to achieve the lowest sustainable cost of delivering pipeline services.	For the reasons set out in section 4.1.2, it is my opinion that ATCO Gas, Jemena, AusNet Services, Envestra Victoria and Multinet are operating relatively efficiently. If ATCO Gas continues to achieve productivity gains that are consistent with those being achieved by these gas distribution network service providers then it will continue to incur a level of operating expenditure that would be incurred by a prudent service provider acting efficiently, in accordance with accepted good industry practice, to achieve the lowest sustainable cost of delivering pipeline services.

4.2.3 Change in growth rate

If the Economic Insights studies estimating the opex partial productivity rates for Jemena, AusNet Services and Multinet are used to estimate an opex partial productivity rate for ATCO Gas, it is my opinion that the approach used by Economic Insights in estimating the change in growth rate should also be adopted in estimating the change in growth rate for ATCO Gas.

The growth rates that were used in the 2014 Economic Insights report for Jemena were a composite of the growth in the quantity of gas throughput and the growth in the number of customers.[56] AusNet Services also adopted a growth rate based on a composite of the growth in the quantity of gas throughput and the number of customers on the basis of the 2012 Economic Insights report. [57]

The weightings that were applied in determining the growth rates are summarised in Table 8.

[56] Economic Insights, *Relative Opex Efficiency and Forecast Opex Productivity Growth of Jemena Gas Networks,* 14 April 2014, page 50

[57] SP AusNet, *2013-2017 Gas Access Arrangement Review – Access Arrangement Information,* 30 March 2012, page 148

Table 8 **Weightings applied to determine growth rates**

Gas distribution network service provider	Source	Approach	Weighting – number of customers	Weighting – quantity of gas throughput
Jemena	A	FGLS model	46.4%	53.6%
Jemena	A	SFA model	42.8%	57.2%
AusNet Services	B		55.2%	44.8%
Multinet	B		55.2%	44.8%
Average (mean)			**49.9%**	**50.1%**

Source: A – Economic Insights, *Relative Opex Efficiency and Forecast Opex Productivity Growth of Jemena Gas Networks,* 14 April 2014, Table 5.7; B – Economic Insights, *Econometric Estimates of the Victorian Gas Distribution Business' Efficiency and Future Productivity Growth,* 28 March 2012

In my opinion, if a rate of change approach were adopted, then based on Economic Insights' reports, the growth rate should be determined based on the change in the number of customers and the change in the quantity of gas throughput. Based on the weightings as set out in Table 8, an appropriate weighting to be applied would be estimated based on the average of the weightings determined by Economic Insights for Jemena, AusNet Services and Multinet, that is, 49.9% for the number of customers and 50.1% for the quantity of gas throughput.

The growth rate would be calculated as follows:

$$\begin{aligned} Growth\ rate &= 0.499 \times change\ in\ number\ of\ customers\ (\%) \\ &\quad + 0.501\ \times\ change\ in\ quantity\ of\ gas\ throughput (\%) \end{aligned}$$

On the basis of the growth in the number of customers and the quantity of gas throughput forecast by ATCO Gas, the growth rate for each year of the fourth access arrangement period is as set out in Table 9.

Table 9 **Rate of growth in operating expenditure for the fourth access arrangement period**

Year	Customer weighting (%)	Growth in customers (%)	Throughput weighting (%)	Growth in throughput (%)	Rate of growth (%)
July – December 2014	49.9	0.25	50.1	0.47	0.36
2015	49.9	1.70	50.1	1.22	1.46
2016	49.9	2.63	50.1	1.56	2.09
2017	49.9	2.57	50.1	2.27	2.42
2018	49.9	2.51	50.1	2.67	2.59
2019	49.9	2.45	50.1	2.78	2.62

Source: Growth in customers and throughput as forecast by ATCO Gas

In my opinion, this growth forecast satisfies rules 74 and 91 of the NGR. The basis for my opinion is set out in Table 10.

Table 10 **How the rate of growth forecast satisfies the NGR**

Requirement of the NGR	How the rate of growth forecast satisfies the NGR
Information in the nature of a forecast or estimate must be supported by a statement of the basis of the forecast or estimate.	The basis of the forecast or estimate of the rate of growth is set out in Table 9.
A forecast or estimate must be arrived at on a reasonable basis A forecast or estimate must represent the best forecast or estimate possible in the circumstances	The rate of growth for ATCO Gas has been forecast based on analysis undertaken by Economic Insights to forecast the rate of growth for Jemena, AusNet Services and Multinet. Economic Insights and its Director, Dr Denis Lawrence, have undertaken a number of studies since 2004 on gas pipeline efficiency performance in Australasia. For the reasons set out in sections 4.1.2 and 4.2.3, it is my opinion that the approach used by Economic Insights to calculate the rate of growth for Jemena, AusNet Services and Multinet should also be adopted for ATCO Gas. The averaging of the results from the Economic Insights results for Jemena, AusNet Services and Multinet to produce a single point estimate of the weightings is consistent with the approach adopted by Economic Insights.
Operating expenditure must be such as would be incurred by a prudent service provider acting efficiently, in accordance with accepted good industry practice, to achieve the lowest sustainable cost of delivering pipeline services.	For the reasons set out in section 4.1.2, it is my opinion that ATCO Gas, Jemena, AusNet Services, Envestra Victoria and Multinet are operating relatively efficiently. If ATCO Gas continues to increase operating expenditure with growth at a similar rate as these gas distribution network service providers, then it will continue to incur a level of operating expenditure that would be incurred by a prudent service provider acting efficiently, in accordance with accepted good industry practice, to achieve the lowest sustainable cost of delivering pipeline services.

4.2.4 Forecast operating expenditure using the rate of change approach

If ATCO Gas was to forecast operating expenditure using the rate of change approach properly applied, and the step changes and one-off increases in expenditure are as proposed by ATCO Gas, the forecast operating expenditure (excluding ancillary services and UAFG) for the fourth access arrangement period is as set out below in Table 11.

Table 11 **Operating expenditure (excluding ancillary services and UAFG) for the fourth access arrangement period forecast using the rate of change approach**

Real $ million at 30 June 2014	Jul 2014 – Dec 2014	2015	2016	2017	2018	2019	Total
Base opex	28.55	57.10	57.10	57.10	57.10	57.10	314.05
Growth	0.10	0.94	3.36	6.28	9.57	13.08	33.34
Increase in real prices	0.06	0.48	1.52	2.72	4.08	5.53	14.40
Productivity gain	(0.12)	(0.62)	(1.62)	(2.66)	(3.76)	(4.91)	(13.68)
Step changes	1.20	3.60	4.30	4.80	5.20	5.60	24.70
One-off changes	0.20	0.60	0.40	0.30	0.10	0.20	1.80
Total	**29.99**	**62.11**	**65.08**	**68.55**	**72.31**	**76.61**	**374.65**

Source: Base opex – Appendix 2A of ATCO Gas's Access Arrangement Information, Growth, Increase in real prices and productivity gain have been calculated by ACIL Allen, Step changes and one-off changes as forecast by ATCO Gas

4.3 Modelling the factors that impact operating expenditure

An alternative approach to forecasting the impact of growth, increases in input prices and productivity improvements on ATCO Gas's operating expenditure for the fourth access arrangement period is to extrapolate the historic trend in operating expenditure.

Using the statistical, forecasting and modelling tool Eviews, ACIL Allen has sought to identify a relationship between ATCO Gas's historic operating expenditure and a range of variables.

The variables that were tested to develop a relationship were various combinations of the following:

- capex in aggregate (excluding capex associated with Full Retail Contestability (FRC))
- capex disaggregated by cost category
- capex disaggregated by purpose (sustaining or growth)
- quantity of gas throughput
- customer numbers
- length of pipeline.

The opex and capex excluded costs associated with Full Retail Contestability and once off bridging costs as these were considered to be once off costs.

The variables were tested with various lead and lag times to test the commonly held view that there is a lag between capital expenditure on the network and an increase in the operating expenditure, and also to test whether the converse applies, that is, that there is an increase in operating expenditure in the lead up to the replacement of assets.

The data provided by ATCO Gas included 15 observations for some variables (from 2000 to 2013-14[58]) and 10 observations for other variables (from 2005 to 2013-14).

The number of observations was significantly less than used in the Economic Insights analysis (171 observations in the 2014 report and 144 observations in the 2012 report[59]). As a result, this approach will develop a more simplistic relationship than the approach adopted in the Economic Insights reports.

Two forms of relationship were tested:

- a linear relationship of the following form:

$$Opex = b_0 + b_t t + \sum b_i x_i$$

- a Cobb-Douglas production function – a logarithmic relationship, similar to that used by Economic Insights:

$$LNOpex = b_0 + b_t t + \sum b_i LNx_i$$

The objective was to identify the relationship with the highest correlation (R-squared) coefficient.

The relationship of best fit was of the form:

---

[58] Includes one observation for a six month period in 2010

[59] Economic Insights, *Relative Opex Efficiency and Forecast Opex Productivity Growth of Jemena Gas Networks,* 14 April 2014, page 39

$$Opex_t = 0.193Capex_{t-1} + 0.006Mains_t - 0.001Throughput_{t-1} + 3.317$$
$$-3.056(t - 2000)$$

where:

$Opex_t$ is the opex (excluding FRC costs, UAFG, ancillary services and once off bridging costs) in year t, in \$2014 million

$Capex_{t-1}$ is the capex (excluding FRC costs) in year t-1, in \$2014 million

$Mains_t$ is the length of pipelines in year t, in kilometres

$Throughput_{t-1}$ is the quantity of gas throughput in year t-1, in TJ

t is the year where 2000≤t≤2008 and t=2008 where t>2008

The correlation coefficient (R squared) of this relationship was 0.93.

Relationships using variables with 15 observations had a higher correlation coefficient than relationships using variables with 10 observations. ACIL Allen was only provided with 10 observations for customer numbers and hence any relationship that included customer numbers had a lower correlation coefficient.

The relationship indicates that the opex will increase as the capex and length of pipeline increases, with a one year lag on the capex, and will decrease as the quantity of gas throughput increases although the coefficient is very small. If the throughput variable is removed from the equation, the correlation coefficient reduces slightly to 0.90.

The relationship indicates that productivity improved by \$3.06 million (in real \$2014) per annum to 2008, but did not continue thereafter. This is consistent with the findings from various Economic Insights' studies that have found that the productivity improvements were greatest immediately following reform and privatisation but then slowed "as cost reductions become progressively harder to achieve after these initial gains are made"[60].

The Victorian gas distributors were privatised in the late 1990s with productivity gains slowing around 2006-07. ATCO Gas was privatised in 2000 with productivity gains slowing in 2008.

Extrapolating the relationship to forecast opex assumes that input prices will increase in real terms at the same rate as occurred since 2000 and productivity will continue to improve at the same rate as occurred since 2008.

Extrapolating the relationship to forecast opex incorporates the productivity improvements that have been included by the ERA in its Draft Decision, including the IT efficiency gain, and the efficiency gains associated with the capital expenditure for assets replacements and on telemetry and monitoring, and optimising maintenance and inspection activities. There should be no additional allowance for productivity improvements.

It is my opinion that the rate of change approach discussed in section 4.2 is a more robust methodology for forecasting ATCO Gas's operating expenditure. However, given the number of assumptions that have been made in estimating the parameters for the rate of change approach, extrapolating forecast operating expenditure based on the historic trend in expenditure provides a check on the operating expenditure forecast.

60 Op cit, page 61

4.3.1 Forecast operating expenditure by extrapolating historic expenditure

If ATCO Gas was to forecast operating expenditure by extrapolating historic expenditure, the forecast operating expenditure (excluding ancillary services and UAFG) for the fourth access arrangement period is as set out below in Table 12.

Table 12 **Operating expenditure (excluding ancillary services and UAFG) for the fourth access arrangement period forecast by extrapolating historic expenditure**

Real $ million at 30 June 2014	Jul 2014 – Dec 2014	2015	2016	2017	2018	2019	Total
Total	**31.11**	**64.81**	**70.09**	**72.95**	**74.71**	**75.70**	**389.36**

Source: Calculated by ACIL Allen using the relationship identified above and ATCO Gas forecasts of capital expenditure, pipeline length, and quantity of gas throughput

4.4 Comparison with the ERA Draft Decision on ATCO Gas's operating expenditure

The operating expenditure (excluding ancillary services and UAFG) as forecast using the revealed cost approach properly applied and by extrapolating historic expenditure are compared with ATCO Gas's original proposal and ERA Draft Decision in Table 13.

Table 13 **Operating expenditure (excluding ancillary services and UAFG) for the fourth access arrangement period**

Real $ million at 30 June 2014	Jul 2014 – Dec 2014	2015	2016	2017	2018	2019	Total
ATCO Gas original proposal	31.42	65.90	66.70	68.14	70.03	71.47	373.66
Forecast using the revealed cost approach	29.99	62.11	65.08	68.55	72.31	76.61	374.65
Forecast by extrapolating historic expenditure	31.11	64.81	70.09	72.95	74.71	75.70	389.36
ERA Draft Decision	26.96	54.29	54.44	54.40	55.36	55.60	301.05
Variance between forecast using the revealed cost approach and ERA's draft decision	**3.03**	**7.82**	**10.64**	**14.15**	**16.95**	**21.01**	**73.60**

Source: ATCO Gas original proposal – Table 11 in ERA's Draft Decision; ERA Draft Decision – Table 17 in ERA's Draft Decision; Forecast using the revealed cost approach - Table 11; Forecast by extrapolating historic expenditure - Table 12

Table 13 indicates that the operating expenditure (excluding ancillary services and UAFG) forecast using the revealed cost approach properly applied is similar to ATCO Gas's forecast as originally proposed.

On the basis that the revealed cost approach is a robust methodology for forecasting operating expenditure, the productivity gains effectively incorporated in ERA's Draft Decision are $73.60 million (real $, June 2014) over the fourth access arrangement period.

5 Conclusion

The revealed cost approach has been applied in regulatory decision-making over the last ten years to forecast operating expenditure of electricity and gas distribution network service providers, including ERA's Draft Decision on ATCO Gas's forecast operating expenditure.

In my opinion, if a regulator is to apply a revealed cost approach to forecasting operating expenditure, then an appropriate methodology is to determine the operating expenditure on the basis of:

- base level of operating expenditure (or starting point)
- plus step changes in operating expenditure (includes one off adjustments)
- plus impact of growth
- plus real increase in input prices
- less productivity improvements.

Collectively, the impact of growth, the real increase in input prices and productivity improvements are referred to as the rate of change.

The rate of change can be estimated using sophisticated analysis as has been undertaken previously by Economic Insights for gas distribution network service providers. Alternatively a simpler approach can be adopted by estimating the variables that have influenced the historic trend in operating expenditure and extrapolating forward using this same relationship.

5.1 Calculation of the rate of change

5.1.1 Based on the Economic Insights report for Jemena

In my opinion, an analysis of the Economic Insights' reports for Jemena and the three Victorian gas distribution network service providers indicate that these gas distribution network service providers and ATCO Gas operate "close to the opex cost efficiency frontier". I am therefore of the opinion that ATCO Gas will have a similar rate of productivity improvements that has been estimated by Economic Insights for Jemena, AusNet Services and Multinet.

The average of the productivity improvement rates estimated by Economic Insights is 0.86 per cent per annum.

Similarly, the growth rate for ATCO Gas's operating expenditure could be estimated using the same output variables (number of customers and quantity of gas throughput) and weightings as estimated by Economic Insights for Jemena, AusNet Services and Multinet. Using the average weightings, the growth rate would be calculated as follows:

$$Growth\ rate = 0.499 \times change\ in\ number\ of\ customers\ (\%) \\ + 0.501\ \times\ change\ in\ quantity\ of\ gas\ throughput (\%)$$

The rate of change is then calculated as follows:

$$Rate\ of\ change = \ \Delta real\ opex\ price - \ \Delta opex\ partial\ productivity \\ +\ \Delta output\ quantity$$

On the basis of the growth in the number of customers and the quantity of gas throughput forecast by ATCO Gas, the growth rate for each year of the fourth access arrangement period is as set out in Table 14.

Table 14 **Rate of growth in operating expenditure for the fourth access arrangement period**

Year	Customer weighting (%)	Growth in customers (%)	Throughput weighting (%)	Growth in throughput (%)	Rate of growth (%)
July – December 2014	49.9	0.25	50.1	0.47	0.36
2015	49.9	1.70	50.1	1.22	1.46
2016	49.9	2.63	50.1	1.56	2.09
2017	49.9	2.57	50.1	2.27	2.42
2018	49.9	2.51	50.1	2.67	2.59
2019	49.9	2.45	50.1	2.78	2.62

Source: Growth in customers and throughput as forecast by ATCO Gas

ERA has determined that a real increase in labour costs of up to 1.75 per cent per annum is appropriate based on the Western Australia's Treasury's forecast estimates and the average differential between the WPI for the Electricity, Gas, Water and Waster sector and the Western Australian WPI.

In my opinion, if this is the only data available on the real increase in labour costs, then it is appropriate to use a real increase in labour costs of 1.0 per cent in 2014-15, 1.5 per cent in 2015-16 and 2016-17, and 1.75 per cent for the balance of the fourth access arrangement period.

On the basis of the forecast labour costs as a proportion of total costs provided by ATCO Gas, the real increase in input prices for each year of the fourth access arrangement period is as set out in Table 15.

Table 15 **Real increase in input prices for the fourth access arrangement period**

Year	Labour weighting (%)	Increase in labour costs (% pa)	Materials weighting (%)	Increase in materials costs (% pa)	Real increase in input prices (% pa)
July – December 2014	43.1	1.00	56.9	0.0	0.43
2015	58.7	1.25	41.3	0.0	0.73
2016	60.1	1.50	39.9	0.0	0.90
2017	60.8	1.63	39.2	0.0	0.99
2018	61.5	1.75	38.5	0.0	1.08
2019	61.7	1.75	38.3	0.0	1.08

Source: Increase in labour costs from Table 2

If ATCO Gas was to forecast operating expenditure using the rate of change approach properly applied, and the step changes and one-off increases in expenditure are as proposed by ATCO Gas, the forecast operating expenditure (excluding ancillary services and UAFG) for the fourth access arrangement period is as set out below in Table 16.

Table 16 **Operating expenditure (excluding ancillary services and UAFG) for the fourth access arrangement period forecast using the rate of change approach**

Real $ million at 30 June 2014	Jul 2014 – Dec 2014	2015	2016	2017	2018	2019	Total
Base opex	28.55	57.10	57.10	57.10	57.10	57.10	314.05
Growth	0.10	0.94	3.36	6.28	9.57	13.08	33.34
Increase in real prices	0.06	0.48	1.52	2.72	4.08	5.53	14.40
Productivity gain	(0.12)	(0.62)	(1.62)	(2.66)	(3.76)	(4.91)	(13.68)
Step changes	1.20	3.60	4.30	4.80	5.20	5.60	24.70
One-off changes	0.20	0.60	0.40	0.30	0.10	0.20	1.80
Total	**29.99**	**62.11**	**65.08**	**68.55**	**72.31**	**76.61**	**374.65**

Source: Base opex – Appendix 2A of ATCO Gas's Access Arrangement Information, Growth, Increase in real prices and productivity gain have been calculated by ACIL Allen, Step changes and one-off changes as forecast by ATCO Gas

5.1.2 Extrapolating historic expenditure

An alternative approach to forecasting the impact of growth, increases in input prices and productivity improvements on ATCO Gas's operating expenditure for the fourth access arrangement period is a continuation of the historic trend in operating expenditure.

The relationship that was found to be of best fit was of the form:

$$Opex_t = 0.193Capex_{t-1} + 0.006Mains_t - 0.001Throughput_{t-1} + 3.317$$
$$-3.055(t - 2000)$$

where:

$Opex_t$ is the opex (excluding FRC costs, UAFG and ancillary services) in year t, in $2014 million

$Capex_{t-1}$ is the capex (excluding FRC costs) in year t-1, in $2014 million

$Mains_t$ is the length of pipelines in year t, in kilometres

$Throughput_{t-1}$ is the quantity of gas throughput in year t-1, in TJ

t is the year where 2000≤t≤2008 and t=2008 where t>2008

If ATCO Gas was to forecast operating expenditure by extrapolating historic expenditure, the forecast operating expenditure (excluding ancillary services and UAFG) for the fourth access arrangement period is as set out below in Table 17.

Table 17 **Operating expenditure (excluding ancillary services and UAFG) for the fourth access arrangement period forecast by extrapolating historic expenditure**

Real $ million at 30 June 2014	Jul 2014 – Dec 2014	2015	2016	2017	2018	2019	Total
Total	**31.11**	**64.81**	**70.09**	**72.95**	**74.71**	**75.70**	**389.36**

Source: Calculated by ACIL Allen using the relationship identified above and ATCO Gas forecasts of capital expenditure, pipeline length, and quantity of gas throughput

5.2 Responses to the specific questions in the TOR

The TOR has specifically sought opinions on the following two matters.

The increase in operating expenditure that you consider would be associated with an increase in the number of customers and pipeline lengths and the relationship between line length and/or capital expenditure and operating expenditure.

As discussed in section 4.2.4, the historic best-fit relationship between operating expenditure and other variables is of the form:

$$Opex_t = 0.193Capex_{t-1} + 0.006Mains_t - 0.001Throughput_{t-1} + 3.317 - 3.055(t - 2000)$$

where:

$Opex_t$ is the opex (excluding FRC costs, UAFG and ancillary services) in year t, in $2014 million

$Capex_{t-1}$ is the capex (excluding FRC costs) in year t-1, in $2014 million

$Mains_t$ is the length of pipelines in year t, in kilometres

$Throughput_{t-1}$ is the quantity of gas throughput in year t-1, in TJ

t is the year where 2000≤t≤2008 and t=2008 where t>2008

As discussed in section 4.1.2, an analysis of the Economic Insights' reports for Jemena and the three Victorian gas distribution network service providers indicate that these gas distribution network service providers and ATCO Gas operate "close to the opex cost efficiency frontier". I am therefore of the opinion that ATCO Gas will have a similar rate of productivity improvements that has been estimated by Economic Insights for Jemena, AusNet Services and Multinet.

Similarly, the growth rate for ATCO Gas's operating expenditure could be estimated using the same output variables (number of customers and quantity of gas throughput) and weightings as estimated by Economic Insights for Jemena, AusNet Services and Multinet. Using the average weightings, the growth rate would be calculated as follows:

$$Growth\ rate = 0.499 \times change\ in\ number\ of\ customers\ (\%) + 0.501 \times change\ in\ quantity\ of\ gas\ throughput\ (\%)$$

This is discussed further in section 4.2.3.

On the basis of the growth in the number of customers and the quantity of gas throughput forecast by ATCO Gas, the growth rate for each year of the fourth access arrangement period is as set out in Table 18.

Table 18 **Rate of growth in operating expenditure for the fourth access arrangement period**

Year	Customer weighting (%)	Growth in customers (%)	Throughput weighting (%)	Growth in throughput (%)	Rate of growth (%)
July – December 2014	49.9	0.25	50.1	0.47	0.36
2015	49.9	1.70	50.1	1.22	1.46
2016	49.9	2.63	50.1	1.56	2.09
2017	49.9	2.57	50.1	2.27	2.42
2018	49.9	2.51	50.1	2.67	2.59
2019	49.9	2.45	50.1	2.78	2.62

Source: Growth in customers and throughput as forecast by ATCO Gas

Based on ACIL Allen's benchmarking of ATCO Gas, the productivity improvements offset that you would expect ATCO Gas to be able to achieve during the 2014-19 period.

If ATCO Gas has a similar rate of productivity improvements that has been estimated by Economic Insights for Jemena, AusNet Services and Multinet, the forecast productivity improvement offset for operating expenditure (excluding unaccounted for gas) is expected to be 0.86 per cent per annum.

Appendix A Summary data in Economic Insights analysis

Table A1 **Key characteristics of gas distribution network service providers, 2012**

Service provider	Throughput (TJ)	Customers	Nominal opex ($m)	Real RAB ($m)
Envestra VIC	55,492	576,804	56.9	1,063
Multinet VIC	56,858	669,631	56.7	1,004
SP AusNet VIC	74,707	609,290	46.7	1,213
Envestra SA	22,256	411,199	52.5	1,047
Envestra QLD	6,030	89,098	17.9	324
Allgas QLD	9,897	87,315	17.1	436
Jemena NSW	90,877	1,147,291	95.3	2,253
ActewAGL	7,696	123,470	23.1	315
ATCO WA	28,103	640,936	55.0	880
Powerco NZ	9,067	102,696	17.8	367
Vector NZ	21,740	153,585	28.8	440

Service provider	Distribution mains length (km)	Customer density (customer/km)	Cast iron/unprotected steel mains (%)	City gates
Envestra VIC	10,135	56.9	3.7	56
Multinet VIC	10,147	66.0	13.2	6
SP AusNet VIC	9,719	62.7	8.0	38
Envestra SA	8,010	51.3	15.4	16
Envestra QLD	2,643	33.7	8.5	11
Allgas QLD	3,022	28.9	15.7	7
Jemena NSW	23,628	48.6	0.6	74
ActewAGL	4,364	28.3	0.0	2
ATCO WA	13,035	49.2	0.2	15
Powerco NZ	6,216	16.5	0.1	36
Vector NZ	10,326	14.9	0.5	63

Source: Economic Insights, *Relative Opex Efficiency and Forecast Opex Productivity Growth of Jemena Gas Networks,* 14 April 2014, Table 5.2

Appendix B Terms of reference

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LAWYERS

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Our Ref: B1299
Doc ID: 66214122.1.1

31 October 2014

Ms Marianne Lourey
Deputy Executive Director
ACIL Allen Consulting Pty Ltd
Level 9
60 Collins Street
MELBOURNE VIC 3000

Dear Ms Lourey

ATCO Gas Australia Pty Ltd - ERA Price Determination

We act for ATCO Gas Australia Pty Ltd (**ATCO Gas**) in relation to the Economic Regulation Authority's (**ERA**) review of the Gas Access Arrangement for ATCO Gas under the National Gas Law and Rules for the period July 2014 to December 2019.

As you are aware, on 14 October 2014 the ERA published its Draft Decision on ATCO Gas Access Arrangement Review Proposal. ATCO Gas wishes to engage you to prepare an expert report in connection with the ERA's Draft Decision.

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

Terms of Reference

Legal Framework

A fundamental aspect of the Access Arrangement review and the Draft Decision is the ERA's assessment of the efficiency of proposed expenditure.

In this context the following provisions of the National Gas Rules are of note:

Under Rule 79 to be Conforming Capital Expenditure, capital expenditure must, amongst other things:

> "*...be such as would be incurred by a prudent service provider acting efficiently, in accordance with accepted good industry practice, to achieve the lowest sustainable cost of providing services*".

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Rule 91(1) provides:

> "*Operating expenditure must be such as would be incurred by a prudent service provider acting efficiently, in accordance with accepted good industry practice, to achieve the lowest sustainable cost of delivering pipeline services.*"

Rule 74 provides:

> "*(1) Information in the nature of a forecast or estimate must be supported by a statement of the basis of the forecast or estimate.*
>
> *(2) 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.*"

Rule 75 provides:

> "*Information in the nature of an extrapolation or inference must be supported by the primary information on which the extrapolation or inference is based.*"

Capital expenditure is defined as:

> "*...costs and expenditure of a capital nature incurred to provide, or in providing, pipeline services.*"

Operating expenditure is defined as:

> "*...operating, maintenance and other costs and expenditure of a non-capital nature incurred in providing pipeline services and includes expenditure incurred in increasing long-term demand for pipeline services and otherwise developing the market for pipeline services.*"

Opinion

Your report is prepared in the context of assessing whether ATCO Gas is an efficient operator.

In March 2014, ACIL Allen prepared a report which was submitted to the ERA titled: "*Gas Distribution Benchmarking Partial Productivity Measures*".

ATCO Gas wishes to engage you to prepare an expert report which considers the ERA's revealed cost approach to the operating expenditure forecasts in the Draft Decision and, in particular, the ERA's decision to disallow any real escalation in labour costs and the effective assumption that any costs associated with growth will be offset by productivity improvements. Please provide your opinion on:

(a) the increase in operating expenditure that you consider would be associated with an increase in the number of customers and pipeline lengths and the relationship between line length and/or capital expenditure and operating expenditure; and

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(b) based on ACIL Allen's benchmarking of ATCO Gas, the productivity improvements offset that you would expect ATCO Gas to be able to achieve during the 2014-2019 period.

It is intended that your report will be submitted by ATCO Gas to the ERA with its response to the Draft Decision. The report may be provided by the ERA to its own advisers. The report must be expressed so that it may be relied upon both by ATCO Gas and by the ERA.

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

The report will be reviewed by ATCO Gas' legal advisers and will be used by them to provide legal advice as to its respective rights and obligations under the National Gas Law and National Gas Rules.

If ATCO Gas was to challenge any decision ultimately made by the ERA, that appeal will be made to the Australian Competition Tribunal and your report will be considered by the Tribunal. ATCO Gas 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 ERA and ATCO Gas. Due to this, the report will need to comply with the Federal Court requirements for expert reports, which are outlined below.

Timeframe

ATCO Gas' response to the Draft Decision must be submitted by **25 November 2014.** Your report will need to be finalised by 18 November 2014.

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 guidelines for expert witnesses in the Federal Court of Australia (**Expert Witness Guidelines**).

Please read and familiarise yourself with the Expert Witness Guidelines and comply with them at all times in the course of your engagement by ATCO Gas.

In particular, your report 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 Expert Witness Guidelines.

Your report must also:

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

2 identify the questions that the expert has been asked to address;

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

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

5 set out the reasons for each of the expert's opinions; and

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6 otherwise comply with the Expert Witness Guidelines.

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 that [the expert] believes are desirable and appropriate and that no matters of significance that [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 ATCO Gas. You should forward ATCO Gas any terms you propose govern that contract as well as your fee proposal.

Please sign a counterpart of this letter and return it to us to confirm your acceptance of the engagement.

Yours faithfully

Johnson Winter & Slattery

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

M Lourey
....
Signed and acknowledged by Marianne Lourey

Date ..31/10/14.............................

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FEDERAL COURT OF AUSTRALIA
Practice Note CM 7
EXPERT WITNESSES IN PROCEEDINGS IN THE FEDERAL COURT OF AUSTRALIA

Practice Note CM 7 issued on 1 August 2011 is revoked with effect from midnight on 3 June 2013 and the following Practice Note is substituted.

Commencement

1. This Practice Note commences on 4 June 2013.

Introduction

2. Rule 23.12 of the Federal Court Rules 2011 requires a party to give a copy of the following guidelines to any witness they propose to retain for the purpose of preparing a report or giving evidence in a proceeding as to an opinion held by the witness that is wholly or substantially based on the specialised knowledge of the witness (see **Part 3.3 - Opinion** of the *Evidence Act 1995* (Cth)).

3. The guidelines are not intended to address all aspects of an expert witness's duties, but are intended to facilitate the admission of opinion evidence[1], and to assist experts to understand in general terms what the Court expects of them. Additionally, it is hoped that the guidelines will assist individual expert witnesses to avoid the criticism that is sometimes made (whether rightly or wrongly) that expert witnesses lack objectivity, or have coloured their evidence in favour of the party calling them.

<u>**Guidelines**</u>

1. General Duty to the Court[2]

1.1 An expert witness has an overriding duty to assist the Court on matters relevant to the expert's area of expertise.

1.2 An expert witness is not an advocate for a party even when giving testimony that is necessarily evaluative rather than inferential.

1.3 An expert witness's paramount duty is to the Court and not to the person retaining the expert.

[1] As to the distinction between expert opinion evidence and expert assistance see *Evans Deakin Pty Ltd v Sebel Furniture Ltd* [2003] FCA 171 per Allsop J at [676].
[2] The "*Ikarian Reefer*" (1993) 20 FSR 563 at 565-566.

2. The Form of the Expert's Report[3]

2.1 An expert's written report must comply with Rule 23.13 and therefore must

(a) be signed by the expert who prepared the report; and

(b) contain an acknowledgement at the beginning of the report that the expert has read, understood and complied with the Practice Note; and

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

(d) identify the questions that the expert was asked to address; and

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

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

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

(ga) contain an acknowledgment that the expert's opinions are based wholly or substantially on the specialised knowledge mentioned in paragraph (c) above[4]; and

(h) comply with the Practice Note.

2.2 At the end of the report the expert should declare that "[the expert] has *made all the inquiries that* [the expert] *believes are desirable and appropriate and that no matters of significance that* [the expert] *regards as relevant have, to* [the expert's] *knowledge, been withheld from the Court*."

2.3 There should be included in or attached to the report the documents and other materials that the expert has been instructed to consider.

2.4 If, after exchange of reports or at any other stage, an expert witness changes the expert's opinion, having read another expert's report or for any other reason, the change should be communicated as soon as practicable (through the party's lawyers) to each party to whom the expert witness's report has been provided and, when appropriate, to the Court[5].

2.5 If an expert's opinion is not fully researched because the expert considers that insufficient data are available, or for any other reason, this must be stated with an indication that the opinion is no more than a provisional one. Where an expert witness who has prepared a report believes that it may be incomplete or inaccurate without some qualification, that qualification must be stated in the report.

2.6 The expert should make it clear if a particular question or issue falls outside the relevant field of expertise.

2.7 Where an expert's report refers to photographs, plans, calculations, analyses, measurements, survey reports or other extrinsic matter, these must be provided to the opposite party at the same time as the exchange of reports[6].

---

[3] Rule 23.13.

[4] See also *Dasreef Pty Limited v Nawaf Hawchar* [2011] HCA 21.

[5] The *"Ikarian Reefer"* [1993] 20 FSR 563 at 565

[6] The *"Ikarian Reefer"* [1993] 20 FSR 563 at 565-566. See also Ormrod *"Scientific Evidence in Court"* [1968] Crim LR 240

3. Experts' Conference

3.1 If experts retained by the parties meet at the direction of the Court, it would be improper for an expert to be given, or to accept, instructions not to reach agreement. If, at a meeting directed by the Court, the experts cannot reach agreement about matters of expert opinion, they should specify their reasons for being unable to do so.

J L B ALLSOP
Chief Justice
4 June 2013

Appendix C CV for Marianne Lourey

Marianne Lourey is a Director at ACIL Allen. Marianne has nearly 30 years experience, predominantly in the utilities sector, working in, and consulting to, government, regulators and industry. She has worked in a broad range of areas including energy and climate change policy, economic regulation, energy supply security, business management, business development, manufacturing and power system planning.

Over the last 15 years Marianne's work has focused on the interface of technical and economic issues, with her detailed understanding of technical, policy, regulatory and commercial matters, her analytical skills, and her practical and pragmatic approach to resolving issues.

Marianne has a deep understanding of the economic regulatory regime. This has been gained through previous work experience and consulting assignments, including:

- From 2010 to 2014, Marianne has provided advice to the Victorian Government on the economic regulatory regime including:
  - Metering service charges – drafted a submission for the Victorian Department of State Development, Business and Innovation from the Minister of Energy to the Australian Energy Regulator on the Victorian electricity distributors' metering services charges applications for 2015.
  - Victorian electricity distributors revenue determination for 2016-20 – provided advice to the Victorian Department of State Development, Business and Innovation on preparing a submission to the Australian Energy Regulator on the Framework and Approach for the Victorian electricity distributors revenue determination for 2016-20.
  - Rule changes on the economic regulation of network service providers – drafted submissions for the Victorian Department of Primary Industries on a rule change request received from the Australian Energy Regulator on the economic regulation of network service providers and the Australian Energy Market Commission's subsequent Directions Paper and Draft Determination on that rule change request.
  - Victorian electricity distributors revenue determination for 2011-15 – drafted submissions for the Victorian Department of Primary Industries to the Australian Energy Regulator (AER) on the Victorian electricity distributors' regulatory proposals for 2011-15 and on the AER's draft decision, and provided advice during the subsequent appeals process.
- In 2013, Marianne prepared a submission for Envestra that reviewed and assessed the arguments made by the National Competition Council in its draft decision on the revocation of coverage of Wagga Wagga gas pipeline in relation to the pipeline coverage criterion which relates to competition.
- From 2010 to 2012, Marianne provided advice to Western Power on its access arrangement review for its electricity distribution and transmission networks for the period 2012-13 to 2016-17, and in the preparation of performance reporting to the regulator. The advice focused on the capital and operating expenditure and the development of a new service standard and incentive regime.
- As the Executive Director for Energy Policy within the Victorian Government from 2005 to 2010, Marianne was heavily involved with the development of Chapter 6 of the National Electricity Rules, the National Gas Rules and the National Gas Law, and amendments to the National Electricity Law, to facilitate the transfer of state-based economic regulation to the AER. Marianne was also responsible for a Victorian Government rule change proposal to allow the use of the total factor productivity

methodology as a regulatory economic methodology to be applied by the Australian Energy Regulator.

- During 2004 and 2005 Marianne was the Manager, Network Regulation at the Essential Services Commission (ESC). She was responsible for the capital and operating expenditure forecasts including a detailed review of the regulatory accounting statements, the metering expenditure and price control, and the service standard framework as part of the 2006-10 Electricity Distribution Price Review. Marianne also provided expert advice in relation to the initial information requests, demand forecasts, price control and modelling. During this period, the ESC was actively investigating the use of index-based approaches to regulating monopoly services. The change in partial factor productivity was used as a component to forecasting the operating expenditure.
- As a consultant at KPMG from 1999 to 2004, Marianne's projects included:
  - providing advice to the former Office of the Regulator-General in relation to the allocation of costs between the retail and distribution businesses and the benchmarking of non-network costs as part of the 2001-05 Electricity Distribution Price Review
  - managing a customer survey to determine South Australian electricity customers' willingness to pay for electricity distribution standards for the Essential Services Commission of South Australia as part of the 2005-10 Electricity Distribution Price Review
  - managing a similar customer survey on a pilot scale to determine NSW electricity customers' willingness to pay for electricity distribution standards for NSW Treasury as an input to the 2004-09 Electricity Distribution Price Review.

Marianne has a degree in engineering (first class honours) and a masters degree in business administration.

Appendix D Economic Insights 2014 report – Relative Opex Efficiency and Forecast Opex Productivity Growth of Jemena Gas Networks

Appendix E Economic Insights 2012 report – Econometric Estimates of the Victorian Gas Distribution Businesses' Efficiency and Productivity Growth

Jemena Gas Networks (NSW) Ltd

2015-20 Access Arrangement Information

Appendix 4.3

Economic Insights – Productivity study and opex output growth

Public

30 June 2014

Relative Opex Efficiency and Forecast Opex Productivity Growth of Jemena Gas Networks

Report prepared for
Jemena Gas Networks

14 April 2014

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CONTENTS

EXECUTIVE SUMMARY

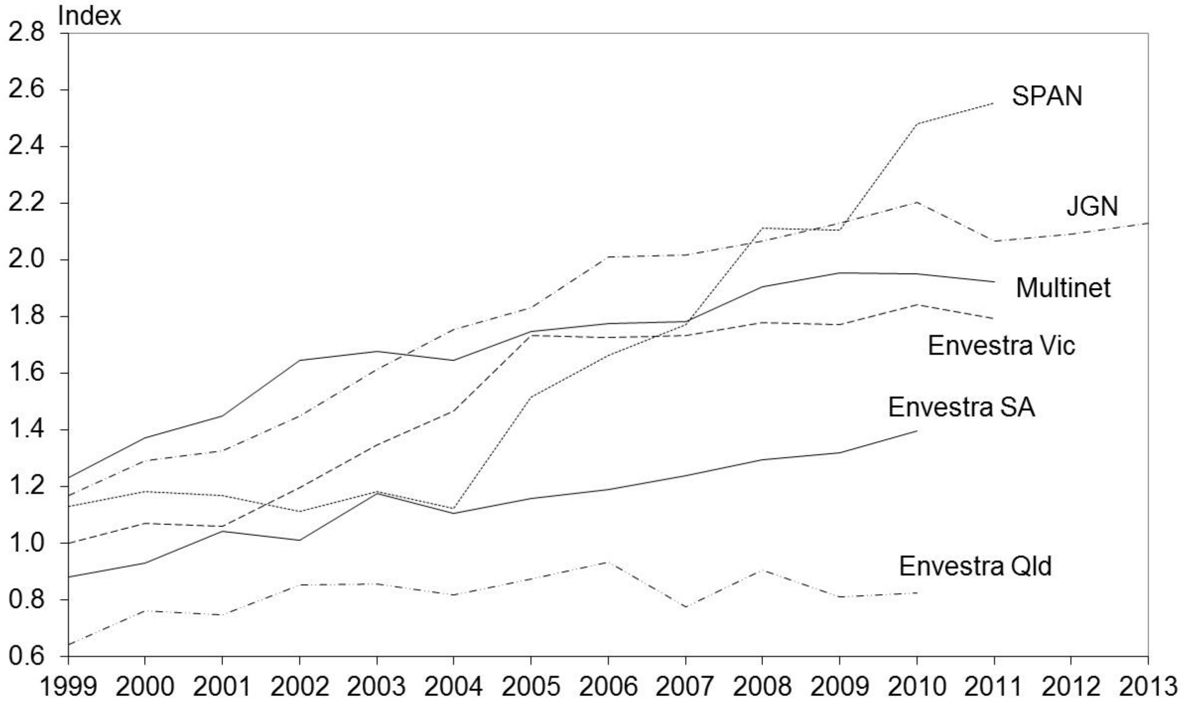
Jemena Gas Networks (NSW) Ltd ('JGN') has commissioned Economic Insights to carry out an analysis of the total factor productivity (TFP) and partial productivity (PFP) performance of JGN's New South Wales gas distribution system. Economic Insights has been requested to compare JGN's productivity levels with the Victorian, South Australian and Queensland gas distribution businesses for which similar analysis has been previously been undertaken. The report is also required to include an estimated opex cost function, and using that model, provide a forecast of JGN's opex partial productivity growth rate. The opex cost function is also used to compare JGN's opex cost efficiency with that of other Gas Distribution Businesses (GDBs).

The time series TFP index analysis provides estimates of the changes in JGN's TFP over the period 1999 to 2013, and these changes are compared to the changes in TFP for other GDBs. This analysis finds that JGN's TFP grew at an average annual rate of 1.2 per cent between 1999 and 2011, but taken over the period to 2013, the average is 1.0 per cent due to productivity reductions in 2011 and 2012. JGN resumed TFP growth in 2013. JGN's TFP growth over the period 1999 to 2011 was at a similar rate to those of Multinet and Envestra SA, although Envestra Vic and SP AusNet both achieved average TFP growth rates of over 2 per cent over the same period. The main source of TFP growth for most GDBs over this period was strong growth in opex partial productivity in the period from 1999 to 2006. JGN had the equal highest growth rate of opex partial productivity over this period. For most GDBs, this source of productivity gain was considerably more modest in the period from 2006 to 2011.

Multilateral TFP analysis is used for measuring the TFP levels of all GDBs in the sample using a common base, so that TFP levels can be compared. This analysis finds that JGN has had similar multilateral TFP levels to SP AusNet and Multinet since around 2005. Envestra Vic has had consistently higher multilateral TFP levels than these three GDBs but they have had higher multilateral TFP levels than Envestra SA and Envestra Queensland.

In terms of multilateral opex partial productivity, JGN had the highest or second highest opex partial productivity level for the last 15 years, exceeded only by SP AusNet in 2010 and 2011 (see Figure A). JGN's opex partial productivity increased by over 80 per cent during the same 15 year period. JGN has had similar levels of multilateral capital partial productivity to Multinet and SP AusNet over the last decade but lower than those of Envestra Vic and Envestra SA. Overall, the index number productivity analysis shows JGN to have been a good performer in terms of both opex partial productivity levels and growth rates. And it has had similar TFP levels to two of the three Victorian GDBs for the last decade.

Figure A: **Australian GDB Multilateral Opex PFP indexes, 1999–2013**



Source: Economic Insights GDB database

To assess JGN's opex efficiency levels and forecast its achievable opex productivity growth for the next regulatory period, we have used an operating cost function model similar to that reported in Economic Insights (2012a). The operating cost function model presented here contains several advances compared to our earlier study. In particular, two additional operating environment factors – network age and network fragmentation – are included and the larger number of observations now available has enabled us to directly estimate GDB opex efficiency levels using a stochastic frontier model.

The main findings from the opex cost function econometric analysis are:

- JGN is found to be among the most efficient of the GDBs in terms of opex cost efficiency when the effects of scale, customer density, network age and network fragmentation are taken into account. Its opex efficiency is not statistically different from the efficient frontier level.
- JGN's forecast average annual opex partial productivity growth rate over the period 2015-16 to 2019-20 is 1.03 per cent when returns to scale, the impact of operating environment factors and technical change are allowed for.

1 INTRODUCTION

1.1 Terms of reference

Jemena Gas Networks (NSW) Ltd ('JGN') has commissioned Economic Insights Pty Ltd ('Economic Insights') to provide advice on efficiency measurement and benchmarking in relation to its New South Wales (NSW) gas distribution business, which is the principal gas distribution business in that State.

The terms of reference provided to Economic Insights by JGN required the preparation of an expert report detailing:

a) an analysis of time series and multilateral total factor productivity (TFP) estimates and partial productivity estimates (PFP) estimates, where that analysis is to be suitable for comparing JGN's productivity level and productivity growth rate performance with the Victorian, South Australian and Queensland gas distribution businesses (GDBs) for which similar analysis has previously been undertaken; and

b) an estimate of the opex cost function and forecast opex partial productivity growth rate for JGN, in a form that is suitable for incorporation into the rate of change approach for forecasting opex in JGN's revised Access Arrangement proposal.

The first part of this study is similar in scope to previous studies by Economic Insights (2009, 2010, 2012c), which examined TFP and PFP trends for most of the major Australian gas distribution businesses (GDBs). This study updates Economic Insights (2012c) using similar analysis to maintain comparability and incorporates the latest data for JGN.

The second part of the study is broadly similar in scope to the Economic Insights (2012a) econometric study of GDB productivity using cost functions undertaken for the Victorian GDBs. While the earlier study estimated both the total cost and opex cost functions, the present study is confined to estimating the opex cost function. The purpose of this analysis is to forecast the opex partial productivity growth rate. An innovation included in the current study is the direct measurement of relative opex efficiency levels within the opex cost function.

The terms of reference require Economic Insights to have regard to:

- historical and forecast cost, input and output data provided by JGN;
- subject to the agreement of the relevant GDBs, the data set that informed the previous Economic Insights studies mentioned;
- relevant published research literature;
- relevant government decisions on energy policy and policy implementation;
- factors such as the scale, topography and configuration of the JGN network, that may contribute to or explain observed differences between the results obtained for JGN and for other GDBs in the data set on which the analysis is based;
- recent regulatory reviews for gas that have considered efficiency measures within the context of establishing cost forecasts; and

- any other information that Economic Insights considers should be taken into account to address the scope of work.

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

1.2 Discussion

The TFP performance of network industries is of considerable interest to both managers and regulators. As a comprehensive measure of overall economic performance, TFP can provide managers with important information on the overall performance of their business from one year to the next. It enables targets to be set for productivity growth and its progress to be monitored. This provides managers and owners of GDBs with a ready means of gauging the success of reform efforts. Measurement of industry level and firm-specific TFP performance is of interest to regulators seeking to determine price outcomes that are consistent with competitive market outcomes in an industry operating under natural monopoly conditions. Information from industry and firm-level TFP studies can be used when setting X factors in CPI–X regulation. It also provides the regulator with a means of assessing whether available efficiency improvements have been achieved during the past regulatory period and may provide insights into what further efficiency improvements are available in the forecast period.

This study addresses the issues of whether JGN's past performance was efficient relative to its peers, and whether it has improved its efficiency over time, both matters that the Australian Energy Regulator (AER) has regard to in its access arrangement approval processes (AER 2013a, p. 8).

Part B of this report presents an index analysis of TFP and PFP performance of the major Australian GDBs. The analysis concentrates on performance in the period from 1999 to 2013, and is similar in scope to several previous studies by Lawrence (2007a) and Economic Insights (2009, 2010, 2012c) which have compared the productivity growth rates and levels of Australian GDBs. The GDBs included in this part of the study, in addition to JGN, are the three Victorian GDBs, namely Envestra's Victorian network (Envestra Vic), Multinet and SP Ausnet, as well as Envestra's South Australian network (Envestra SA) and Envestra's Queensland network (Envestra Qld).

The primary data source for the index analysis is survey-based data gathered by Economic Insights from six major Australian GDBs. For JGN, the survey data covers the period from 1999 to 2013, while data for the other GDBs generally extends only to 2010 or 2011. This survey-based data provides a detailed decomposition of capital assets into categories which permits improved measurement of capital inputs. It also enables the estimation of system capacity, which can be included in the analysis as an output of GDBs.

In Part C of this report, we develop forecasts of JGN's opex partial productivity growth rate by forming econometric estimates of the variable cost function (or operating cost function) for GDBs. The estimated parameters of this model are then used to predict opex productivity for JGN given the forecasts of a number of explanatory variables, such as market demand and capex. The forecast of future opex partial productivity growth is an important component of the 'rate of change' formula for rolling forward opex allowances frequently used in the application of building blocks regulation.

The analysis in Part C extends similar work by Lawrence, Fallon and Kain (2007), Lawrence (2007b) and Economic Insights (2012a). The AER has previously said of that study:

> *SP AusNet's proposed approach to opex partial factor productivity forecasts is reasonable and represents the best methodology available in the circumstances. As such, the AER has applied SP AusNet's proposed methodology to the AER's adjusted base year forecast. (AER 2012c, p. 229)*

To ensure comparability with earlier studies and to ensure that the sample is as large and broad as possible, the econometric study uses a different database to the TFP and PFP index analysis (part (a)). The data used in this part of the study includes 9 Australian and two New Zealand gas distribution businesses. It has been sourced from documents in the public domain to the maximum extent possible. The sample periods differ between utilities, but in most cases includes historical data for the period from 1999 to 2012 or 2013. For most Australian DBs other than JGN, forecast data from final regulatory determinations are also included to maximise the number of observations available. The data includes revenue, throughput, customer numbers, distribution pipeline length, opex, capex and regulatory asset value. In some cases missing observations were estimated based on growth rates for the variable or a related variable before and after the missing year. The database used for part (b) of this study includes a total of 171 observations.

1.3 Outline of the Report

Chapter 2 of this report briefly discusses the purposes and applications of productivity benchmarking within the context of the economic regulation of natural monopolies.

Chapter 3 presents an analysis of TFP and PFP indexes for the purpose of estimating the rates of growth in each GDB's TFP growth over the study period from 1999 to 2013. JGN's TFP growth is compared to the TFP growth of other GDBs.

Chapter 4 presents a comparative analysis of the TFP levels of the major GDPs using multilateral TFP analysis. The multilateral TFP method is explained and the results of the analysis of multilateral TFP and PFP are reported.

Chapter 5 presents the analysis of the operating cost function of Australasian GDBs. The econometric methodology used in the analysis is explained, and the econometric results are presented. The model is used for assessing JGN's opex efficiency, and together with JGN's forecasts of key explanatory variables, it is used to develop a forecast of opex partial productivity growth for JGN.

Finally, chapter 6 summarises all of the main conclusions of this study.

1.4 Economic Insights' experience and consultants' qualifications

Economic Insights has been operating in Australia for 20 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 Michael Cunningham who is an Associate of Economic Insights. A summary CV for Michael is presented in Attachment B. Michael Cunningham 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 PRODUCTIVITY MEASUREMENT AND BENCHMARKING

This chapter provides a brief discussion of the role of productivity benchmarking in the economic regulation of natural monopolies.

Productivity is a measure of the physical output produced from the use of a given quantity of inputs. All enterprises use a range of inputs including labour, capital, land, fuel, materials and services. If the enterprise is not using its inputs as efficiently as possible then there is scope to lower costs through productivity improvements and, hence, lower the prices charged to consumers. This may come about through the use of better quality inputs including a better trained workforce, adoption of technological advances, removal of restrictive work practices and other forms of waste, and better management through a more efficient organisational and institutional structure. When there is scope to improve productivity, this implies there is technical inefficiency. This is not the only source of economic inefficiency. For example, when a different mix of inputs can produce the same output more cheaply, given the prevailing set of inputs prices, there is allocative inefficiency.

Productivity is measured by expressing output as a ratio of inputs used. There are two types of productivity measures: TFP and PFP. TFP measures total output relative to an index of all inputs used. Output can be increased by using more inputs, making better use of the current level of inputs and by exploiting economies of scale. The TFP index measures the impact of all the factors effecting growth in output other than changes in input levels. PFP measures one or more outputs relative to one particular input (eg labour productivity is the ratio of output to labour input).

As noted in Lawrence (1992), by providing a means of comparing efficiency levels, TFP measurement is an ideal tool for promoting so–called ‘yardstick competition’ in non–competitive industries. It provides managers with useful information on how their business is performing overall and on how it is performing relative to its peers. TFP measurement, thus, provides a ready means of ‘benchmarking’ the business’s overall performance relative to other businesses supplying similar outputs.

Forecast future productivity growth rates can play a key role in setting the annual revenue requirement used in building blocks regulation. Productivity studies provide a means of benchmarking GDB performance to assist the regulator in determining whether the GDB in question is operating at efficient cost levels. They also assist the regulator in determining likely future rates of productivity growth to build into annual revenue requirement forecasts.

Government agencies and inquiries have given increasing attention to the role of productivity benchmarking in the economic regulation of natural monopolies. The Expert Panel on Energy Access Pricing (2006) advocated consideration of ‘productivity based’ approaches to regulation whereby X factors are set using information on industry productivity trends. The Australian Energy Market Commission (AEMC) emphasised the crucial role of benchmarking in assessing the efficiency of network service providers and informing the public about their performance (2012):

> “The Commission considers that benchmarking is a critical exercise in assessing the efficiency of a NSP and approving its capital expenditure and operating expenditure allowances. Benchmarking should take into account differences in the environments of

the different NSPs, being those factors that are outside the control of the NSP" (AEMC Nov 2012, p.vii).

Potential constraints within the governing regulatory instruments were removed by the AEMC to facilitate greater use of benchmarking by the Australian Energy Regulator (AER) in regulatory processes. A requirement that AER produce an annual benchmarking report was also introduced into the national electricity rules. The AER (2013a) has indicated it will be making greater use of benchmarking for assessing the efficiency of network businesses.

The AER has highlighted two forms of benchmarking that it intends to use as an integral part of future energy infrastructure price reviews. The first involves benchmarking a network business' expenditure when disaggregated into cost categories, termed category analysis. The second is economic benchmarking of the efficiency of a network business' regulatory operations as a whole. The latter permits a comparison of the efficiency of peer network businesses and can be used for 'top down' forecasting of a network business' expenditure and productivity growth. The analysis in this report is an application of economic benchmarking in this sense.

The AER has commenced an information collection process for benchmarking purposes with electricity network service providers, following the release of its regulatory information notices (RINs) in November 2013. This process will provide eight years of historical data and, together with annual information collection, will support the AER's forthcoming annual benchmarking reports and its other benchmarking activities (AER 2013b). It will also enable interested parties to conduct their own analysis and modelling. This information collection process for electricity network service providers will later be extended to gas network service providers.

The benchmarking techniques the AER is likely to have particular regard to in its access arrangement reviews include multilateral TFP analysis, data envelopment analysis (DEA) and econometric modelling (AER, 2013c, p. 13). Two of these methods are used in the present study.

In regard to establishing the allowed opex for a regulated business in a future regulatory period, AER uses a 'base-step-trend' method, which for each forecast year involves applying the forecast opex growth rate to the preceding year's actual or forecast opex and making any applicable adjustments for step changes. This extrapolation normally commences from the opex in the penultimate year of the previous regulatory period, adjusted for any assessed inefficiency and for any adjustments associated with the Efficiency Benefit Sharing Scheme (EBSS). The forecast opex growth rate is equal to the forecast output growth rate, plus real input price inflation, less the rate of opex partial productivity growth.

The AER states that when assessing forecast productivity, it will consider:

- forecast output growth
- forecast changes in network service provider operating environment factors
- forecast technological change
- how close the network service provider is to the efficient frontier
- historical productivity performance

- any difference between industry average productivity change and the rate of productivity change at the efficient frontier.

The analysis carried out in this study is relevant to key matters that the AER considers when assessing forecast productivity and determining the opex growth rate.

PART B: PRODUCTIVITY INDEX ANALYSIS

This part of the report analyses JGN's partial factor productivity (PFP) and total factor productivity (TFP) using time series and multilateral indexes, and compares its productivity levels and growth rates with the Victorian, South Australian and Queensland gas distribution businesses (GDBs).

The time series TFP analysis involves developing indexes of outputs and inputs using the Fisher index method. The analysis includes three outputs (throughput, customer numbers and system capacity) and eight inputs (opex, lengths of transmission pipelines, high pressure pipelines, medium pressure pipelines, low pressure pipelines, and services, meters and other capital). This specification is broadly consistent with the analogous preferred electricity distribution output and input specification presented in AER (2013a). The time series TFP analysis provides estimates of the changes in JGN's TFP over the period 1999 to 2013, and these changes are compared to those for other GDBs. This analysis is presented in chapter 3.

Multilateral TFP analysis is used for productivity level comparisons, and in this part of the analysis transmission pipelines and associated opex are excluded to allow like–with–like comparisons across GDBs, but in other respects the same database and output and input definitions are used. Multilateral TFP is a method of measuring the TFP levels of all of the GDBs in the sample using a common base, so their TFP levels can be compared. This analysis is presented in chapter 4.

3 PRODUCTIVITY GROWTH

3.1 TFP indexing methods

Productivity is a measure of the quantities of outputs produced in proportion to the quantities of inputs used in the production process, and changes in productivity are measured by changes in the ratio of outputs to inputs between two time periods. Since firms usually use several inputs, and may produce several different outputs, the levels of outputs and inputs are measured by indexes. Index numbers are perhaps the most commonly used means of measuring economic variables (Coelli et al. 2005, p. 85).[1] An index number measures a set of related variables relative to a base period. Growth rates for individual outputs and inputs are weighted together using revenue or output cost shares and input cost shares, respectively. In other words, the TFP index is essentially a weighted average of changes in output quantities relative to a weighted average of changes in input quantities.

Total factor productivity is measured by the ratio of an index of all outputs (Q) to an index of all inputs (I):

(3.1) $$TFP = Q/I$$

Since indexes are defined relative to a base period, the TFP index measures the *proportionate* change in productivity level relative to the base period. The *rate* of change in TFP between two periods is measured by:

(3.2) $$\dot{TFP} = \dot{Q} - \dot{I}$$

where a dot above a variable represents the rate of change of the variable.[2] TFP indexes have a number of advantages including:

- indexing procedures are simple and robust;
- they can be implemented when there are only a small number of observations;
- the results are readily reproducible;
- they have a rigorous grounding in economic theory;
- the procedure imposes good disciplines regarding data consistency; and
- they maximise transparency in the early stages of analysis by making data errors and inconsistencies easier to spot than using some of the alternative econometric techniques.

To operationalise TFP measurement we need to combine changes in diverse outputs and inputs into measures of change in total outputs and total inputs. There are alternative index number methods that calculate the weighted average change in outputs or inputs in different ways. The four most popular index formulations are:

[1] An index number is defined as a real number that measures a set of related variables.
[2] This measure of the change in TFP in terms of the difference between the growth rates of outputs and inputs is known as the Hicks-Moorsteen approach. Alternative methods are based on changes in profitability with adjustment for changes in input and output prices, or on changes in measures of technical efficiency (see: Coelli et al 2005, pp. 64-65).

- the Laspeyres base period weight index (Laspeyres, 1871);
- the Paasche current period weight index (Paasche, 1874);
- the Fisher ideal index (Fisher, 1922) which is the square root of the product of the Paasche and Laspeyres index, and used in previous studies including Economic Insights (2012c); and
- the Törnqvist index (Tornqvist, 1936), which has also been used extensively in previous TFP studies.

Diewert (1993) reviewed alternate index number formulations to determine which index was best suited to TFP calculations. Indexing methods were tested for consistency with a number of axioms which an ideal index number should always satisfy.[3] Diewert found that only the Fisher ideal index passed all of the axiomatic tests.[4] On the basis of his analysis, Diewert recommended that the Fisher ideal index be used for TFP work although he indicated that the Törnqvist index could also be used as it closely approximates Fisher's ideal index. For this study the Fisher ideal index was therefore chosen as the preferred index formulation for the TFP time series analysis. It is also increasingly the index of choice of leading national statistical agencies.

Mathematically, the Fisher ideal output index is given by:

(3.3) $$Q_F^t = [(\sum_{i=1}^m P_i^B Y_i^t / \sum_{j=1}^m P_j^B Y_j^B)(\sum_{i=1}^m P_i^t Y_i^t / \sum_{j=1}^m P_j^t Y_j^B)]^{0.5}$$

where: Q_F^t is the Fisher ideal output index for observation t;

P_i^B is the price of the ith output for the base observation;

Y_i^t is the quantity of the ith output for observation t;

P_i^t is the price of the ith output for observation t; and

Y_j^B is the quantity of the jth output for the base observation.

Similarly, the Fisher ideal input index is given by:

(3.4) $$I_F^t = [(\sum_{i=1}^n W_i^B X_i^t / \sum_{j=1}^n W_j^B X_j^B)(\sum_{i=1}^n W_i^t X_i^t / \sum_{j=1}^n W_j^t X_j^B)]^{0.5}$$

where: I_F^t is the Fisher ideal input index for observation t;

[3] These tests were: (a) the constant quantities test: if quantities are the same in two periods, then the output index should be the same in both periods irrespective of the price of the goods in both periods; (b) the constant basket test: this states that if prices are constant over two periods, then the level of output in period 1 compared to period 0 is equal to the value of output in period 1 divided by the value of output in period 0; (c) the proportional increase in outputs test: this states that if all outputs in period t are multiplied by a common factor, λ, then the output index in period t compared to period 0 should increase by λ also; and (d) the time reversal test: this states that if the prices and quantities in period 0 and t are interchanged, then the resulting output index should be the reciprocal of the original index.

[4] The Laspeyres and Paasche index fail the time reversal test while the Törnqvist index fails the constant basket test.

W_i^B is the price of the ith input for the base observation;

X_i^t is the quantity of the ith input for observation t;

W_i^t is the price of the ith input for observation t; and

X_j^B is the quantity of the jth input for the base observation.

The Fisher ideal TFP index is then given by:

(3.5) $TFP_F^t = Q_F^t / I_F^t$.

The Fisher index can be used in either the unchained form denoted above or in the chained form used in this study where weights are more closely matched to pair–wise comparisons of observations. Denoting the Fisher output index between observations i and j by $Q_F^{i,j}$, the chained Fisher index between observations 1 and t is given by:

(3.6) $Q_F^{1,t} = 1 \times Q_F^{1,2} \times Q_F^{2,3} \times .... \times Q_F^{t-1,t}$.

In this study we generally use the cost function method developed in Lawrence (2003) and applied to GDB data in Lawrence (2007a) to form output cost shares for the included output components and hence prices that are used in the index number application. This methodology is described in appendix B.

3.2 Data

The primary data source for this part of the study is information supplied by GDBs in response to common detailed data surveys, including by JGN in February 2014, Envestra Victoria, Multinet and SP AusNet in October 2011, and Envestra SA and Envestra Qld in 2010. This survey data is much more detailed than the dataset used in the econometric analysis in Part C, but covers fewer GDBs. The survey data has been subjected to detailed checking and, where necessary, clarification to ensure compatibility over time and between included GDBs.

The surveys covered key output and input value, price and quantity information for the periods 1999 to 2013 for JGN; 1999 to 2011 for the Victorian GDBs; and 1999 to 2010 for Envestra SA and Envestra Qld. The survey data is consistent with the GDBs' Regulatory Accounts, but the cost classifications used are intended to ensure the data reflects actual year–to–year operations. A number of accounting adjustments such as allowance for provisions were excluded as they do not reflect the actual inputs used by the businesses in a particular year which is what we need for TFP purposes. These adjustments ensure more like–with–like comparisons. Government levies and unaccounted for gas are excluded from opex for all GDBs to establish a comparable functional basis across the included businesses. Full retail contestability (FRC) costs are included. For the period prior to the introduction of FRC in each jurisdiction, an 'FRC equivalent' amount is added to opex based on the share of FRC costs in opex in the first full year of FRC operation to ensure comparability of coverage over time. In 2012 and 2013 (which are only available for JGN) carbon costs are excluded.

3.3 Outputs, inputs & weights

To measure productivity growth using index analysis we require data on the price and quantity of each output and input. Quantity data is needed because productivity is essentially a weighted average of the change in output quantities divided by a weighted average of the change in input quantities. Although the weights are complex and vary depending on the technique used, for outputs they are derived from output cost shares and for inputs from the share of each input in total costs. To derive output cost shares we require additional information on how cost drivers link to output components. This is usually derived from estimation of econometric cost functions.[5] To derive the cost shares for inputs we require information on the cost of each input (ie its price times its quantity). In a sense the quantity data are the primary drivers of productivity results while the value or price data are secondary drivers in that they are used to determine the weights for aggregation.

Quantity information can be obtained either directly or indirectly. Direct quantity data are physical measures of a particular output or input, eg terajoules of throughput or full–time equivalent employees. Indirect quantity data are obtained by deflating the revenue or cost of a particular output or input by an average price or a price index. There are arguments in favour of both methods. Some argue that the indirect method allows greater differences in the quality of outputs or inputs to be captured and for a greater range of items to be captured within the one measure (eg a greater extent of automation reflected in a higher capital value). However, the indirect method places more onus on having both the value and the price data completely accurate. Since generic price data are generally harder to match to the specific circumstances of a particular firm, there is more scope for error with the indirect method. Hence, it is a good policy to rely on direct quantity data wherever possible and to only use indirect quantity data in those cases where the category is too diverse to be accurately represented by a single quantity (eg materials and services inputs).

3.2.1 Output quantities

Throughput: The quantity of the GDB's throughput is measured by the number of terajoules of gas supplied. It is the sum of energy supplied to domestic and non–domestic 'tariff' or 'volumetric' customers, and to large 'demand' or 'contract' customers.

Customers: Connection dependent and customer service activities are proxied by the GDB's total number of customers.

[5] Economic Insights (2012c) also examined an alternative approach to output weights using revenue shares for each output. This method confines the outputs that can be used in the analysis to billed outputs, and given prevailing tariff structures, implies that most weight is given to gas throughput. The study compared the billed output approach to the method used here, based on functional outputs. It found that the TFP index based on billed outputs had a similar underlying trend as the TFP index based on functional outputs, but was considerably more volatile. This volatility was due to the high weight given to throughput, which is sensitive to the impact of climatic differences (and corresponding differences in the consumption of gas for heating) across years. Over longer time periods starting and ending in years with relatively average climatic conditions, the average annual growth rates of the billed and functional TFP indexes were relatively similar. However, there was a more significant difference in average growth rates for periods starting or ending in years with abnormal climatic conditions. The billed output approach is considered suitable to TFP-based price cap regulation, whereas the functional approach used in this study is considered more appropriate for use in building block regulation.

System capacity: Gas distribution networks have three primary functions: delivery of gas from supply point to demand point; the interim storage of gas to make available sufficient gas during peak periods; and, the performance of these functions safely and efficiently. We include a measure of system capacity to capture the GDB's functional responsibility of making capacity available to meet the needs of customers. The measure we require is somewhat analogous to the MVA–kilometre system capacity measure used in electricity DB TFP (see, for example, Lawrence 2003) but, in this case, it needs to also capture the interim storage function of pipelines.

The system capacity measure used in this study is that developed in Lawrence (2007a) which is the volume of gas held within a gas network converted to standard cubic meters using a pressure correction factor based on the average operating pressure. The volume of the distribution network is calculated based on pipeline length data for high, medium and low distribution pipelines and estimates of the average diameter of each of these pipeline types for each GDB.[6] The quantity of gas contained in the system is a function of operating pressure. Thus, a conversion to an equivalent measure using a pressure correction factor is necessary to allow for networks' different operating pressures.

From historical observations GDB engineers have forecast the approximate load on the system per month during periods of peak flow and as a result have approximated the mean pressure in the network for the twelve month period. Victorian gas networks are designed to deliver a regulated minimum operating pressure (1.4 kiloPascals (kPa) for low pressure, 15 kPa for medium pressure and 140 kPa for high pressure) as per the Gas Distribution Code. To maintain at least this minimum pressure at the fringe of the network and to ensure periods of peak demand can be accommodated while still meeting the minimum pressure requirement, average system pressures have to be considerably higher than these minimums. Average network pressure is, thus, a better representation of service to the majority of customers. The inlet pressure to each of the networks varies throughout the day and season, with a maximum of 450 kPa for high pressure, 70 kPa for medium pressure and 2.8 kPa for low pressure in Victoria and a maximum of 823 kPa for high pressure, 103 kPa for medium pressure and 3.5 kPa for low pressure for JGN. The average system pressure has been calculated to be 300 kPa for high pressure, 32 kPa for medium pressure and 2.2 kPa for low pressure pipelines for the Victorian GDBs and 525 kPa for high pressure, 70 kPa for medium pressure and 3.5 kPa for low pressure pipelines for JGN.[7]

The system capacity measure is the addition of the individual high, medium and low pressure network capacities. As noted above, pipelines owned by GDBs operating at very high pressures (above 1050 kPa) with characteristics normally associated with transmission or sub-transmission are excluded from the calculation.

3.2.2 Output weights

To aggregate a diverse range of outputs into an aggregate output index using indexing procedures, a weight must be attributed to each output. We have used the estimated output cost shares derived from the econometric cost function outlined in appendix B used in

[6] These estimates were provided by each GDB's engineers.
[7] See note 6.

Lawrence (2007a) on data for the three Victorian GDBs for the period 1998 to 2006. A weighted average of the output cost shares was formed using the share of each observation's estimated costs in the total estimated costs for all GDBs and all time periods following Lawrence (2003). This produced an output cost share for throughput of 13 per cent, for customers of 49 per cent and for system capacity of 38 per cent.

3.2.3 Input quantities

Opex: The quantity of the GDB's opex is derived by deflating the value of opex by an update of the opex price deflator developed by PEG (2006).[8] As noted above, the opex values supplied by the GDBs were consistent with the GDBs' Regulatory Accounts but the focus has been on ensuring data reflects actual year–to–year operations. A number of accounting adjustments such as allowance for provisions have been excluded as they do not reflect the actual inputs used by the businesses in a particular year which is what we need for TFP purposes. JGN's carbon costs in 2012 and 2013 were excluded. To ensure consistency in functional coverage throughout the period, for those years prior to the introduction of FRC each GDB's opex is increased by the amount of expenses incurred in the early years of FRC. In these early years FRC was expected to have only affected opex (and not capital) requirements.

Transmission network: The quantity of transmission network for JGN is proxied by the sum of its trunk and primary mains length while that for the Victorian GDBs, Envestra SA and Envestra Qld is proxied by their transmission pipeline length. Transmission and sub-transmission mains are included when measuring and comparing productivity growth in this section of the report, to ensure TFP growth estimates reflect the whole of the GDB regulated business. However, they are excluded in the analysis of comparative productivity levels (section 4), in order to ensure comparability between GDBs.[9] The effect of including transmission pipelines on the results presented in this section can be seen by comparing the the stand-alone TFP index for JGN shown in table 3.2 with the multilateral TFP index for JGN presented in table 4.1. JGN's stand-alone TFP index increased at an average annual rate of 0.97 per cent between 1999 and 2013, while over the same period the multilateral index (which excludes transmission pipelines) increased at an average annual rate of 1.06 per cent.

High pressure network: The quantity of each GDB's high pressure network is proxied by its high pressure pipeline length.

Medium pressure network: The quantity of each GDB's medium pressure network is proxied by its medium pressure pipeline length.

Low pressure network: The quantity of each GDB's low pressure network is proxied by its low pressure pipeline length.

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[8] The Australian Bureau of Statistics discontinued some of the Producer Price Indexes used in the PEG (2006) opex price deflator with its move to the latest industrial classification so it has been necessary to splice the series with the nearest proxies under the new classification.

[9] The Victorian GDBs, Envestra SA and Envestra Qld have few transmission pipelines whereas JGN has a significant amount of trunk and primary mains which operate at very high pressures (above 1050 kPa) with characteristics normally associated with transmission or sub-transmission.

Services network: The quantity of each GDB's services network is proxied by its estimated services pipeline length.

Meters: The quantity of each GDB's meter stock is proxied by its total number of meter installations.

Other assets: The quantity of other capital inputs is proxied by their deflated asset value. Other capital comprises city gate stations, cathodic protection, supply regulators and valve stations, SCADA and other remote control, other IT and other non–IT.

3.2.4 Input weights

For the update of earlier work and cross–State comparisons, we follow PEG (2006) in using the endogenous rate-of-return method for forming estimates of the user cost of capital. Using this approach the value of total costs equals total revenue by definition. As noted in previous studies (Lawrence 2007a; Economic Insights 2012b), the implicit gross rate-of-return for the six GDBs included in this analysis was relatively stable over the period studied, so there is likely be little difference in TFP estimates formed using this approach and the alternative exogenous user cost method.

Under the endogenous rate-of-return approach, the input weight given to opex is simply the ratio of opex to total revenue. The aggregate capital input weight is given by one minus the opex share. It is then necessary to divide this overall capital share among the 7 capital asset inputs. This is done using the share of each of the 7 asset categories' asset values in the total asset value for that year.

3.4 Key characteristics of the included GDBs

The key characteristics of JGN, the three Victorian GDBs, Envestra SA and Envestra Qld are presented in table 3.1 for 2010, the latest year of common coverage in the database. Further information about these businesses is provided in Appendix 1.

JGN is the largest of the GDBs in the sample. In terms of customer numbers, Envestra Victoria, Multinet and SP AusNet are just over half the size of JGN. However, SP AusNet has a comparatively high energy density per customer, so its throughput is three-quarters of JGN's. Envestra SA is about one-quarter the size of JGN on the basis of both customer numbers and throughput, while Envestra Queensland is less than 10 per cent of JGN's size by either measure.

Table 3.1 includes information on two key operating environment characteristics which influence the productivity of energy distribution businesses: energy density (throughput per customer) and customer density (customers per kilometre of mains). Envestra Queensland and JGN both have below average customer density, but while Envestra Qld's energy density is also below average, JGN's is around the average level for the included GDBs. Envestra SA and Vic both have approximately average levels of customer density, however, Envestra SA has below-average energy density while Envestra Vic has above-average energy density.

Table 3.1: **Included GDBs' key characteristics, 2010**

GDB	Throughput	Customers	System capacity	Distribution mains length	Energy density	Customer density
	TJ	No	Sm3	kms	GJ/cust	Cust's/km
Envestra Vic	56,442	551,925	138,429	10,341	102	53
Multinet	58,686	668,373	124,137	9,910	88	67
SP AusNet	72,325	576,987	123,982	9,679	125	60
JGN	96,994	1,080,102	369,628	24,196	90	45
Envestra SA	24,313	396,084	89,635	7,065	61	56
Envestra Qld	5,796	84,057	27,178	2,378	69	35

Source: Economic Insights GDB database

Multinet and SP AusNet both have above-average customer density, but while Multinet's energy density is approximately average, SP AusNet's is well above average and the highest in the sample. Since Envestra Qld, JGN and Envestra SA are each in some respects below average in regard to these measures, this can be expected to represent a disadvantage when comparing productivity levels against the other businesses (and especially SP AusNet), which are all in some respects above average in terms of the density measures. On the other hand, JGN's greater size can be expected to represent an advantage over other businesses if there are economies of scale.

3.5 JGN's productivity growth, 1999 to 2013

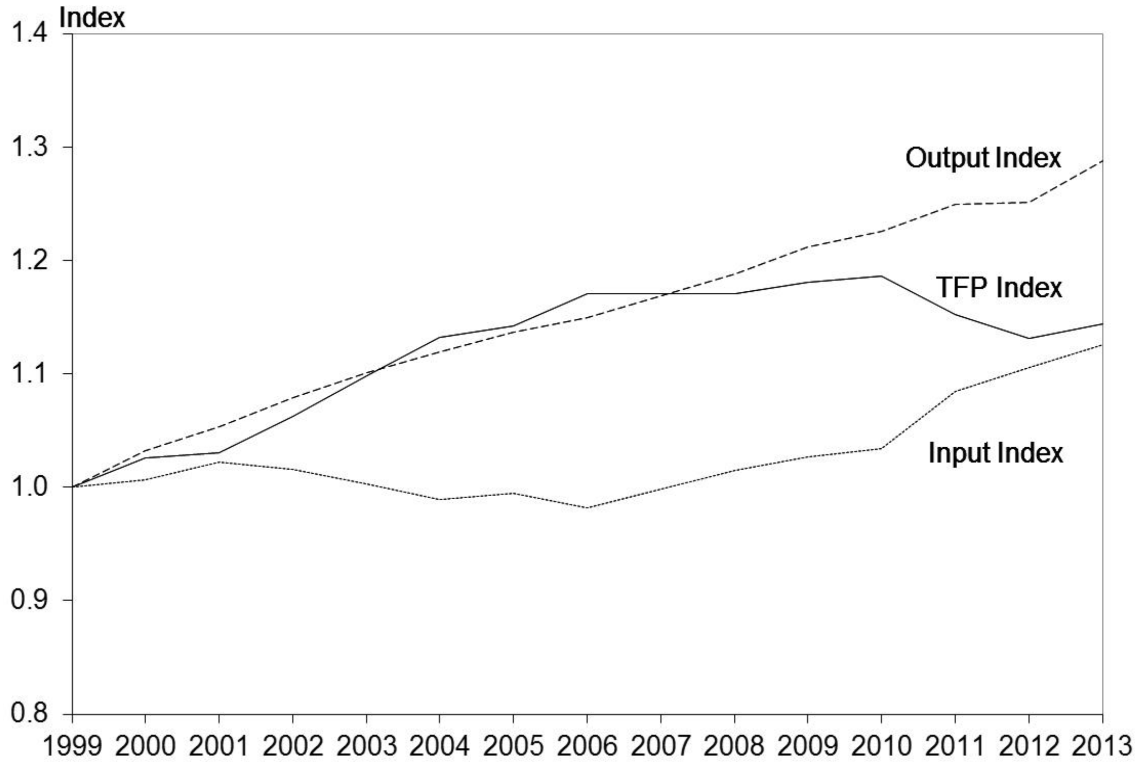
In this section we report JGN's TFP and PFP performance over the 15 year period 1999 to 2013. In the following section (3.6) these are compared with the productivity growth rates of the other GDBs included in the detailed productivity database. To maintain comparability with data available for the other included GDBs we use the same specification as used in Economic Insights (2009c, 2010a, 2012b).

The output quantity, input quantity and TFP indexes for JGN are presented in figure 3.1 and its partial productivity indexes for opex and capital are presented in figure 3.2. All of these indexes are also presented in table 3.2.

The increase in the output quantity index over the 14 years after 1999 has been relatively steady with an average annual growth rate of 1.8 per cent over the period as a whole; 2.0 per cent over the 7 years to 2006; and 1.6 per cent over the 7 years to 2013. The total quantity of inputs followed two distinct trends during the first and second halves of this 14 year period. From 1999 to 2006 inputs decreased at an average annual rate of 0.3 per cent. Over the second part of the period, inputs increased at an annual average rate of 2.0 per cent. Over the whole 14 year period, inputs increased at an average rate of 0.9 per cent per year.

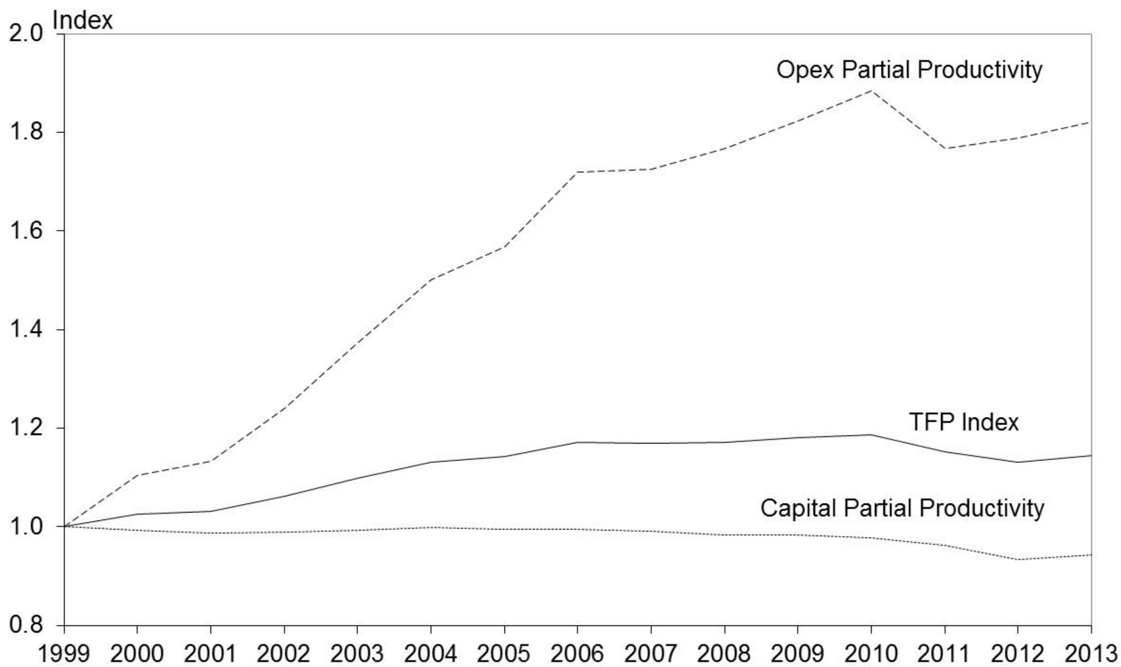
The pattern of input quantity growth has differed markedly between opex and capital. Capital inputs have increased at a relatively steady rate, averaging 2.3 per cent per year over the period from 1999 to 2013. Opex quantity fell markedly between 1999 and 2006 at an average rate of 5.6 per cent per year. In the period from 2006 to 2013, opex usage increased by 0.8 per cent per year on average.

Figure 3.1: **JGN output quantity, input quantity and TFP indexes, 1999–2013**



Source: Economic Insights GDB database

Figure 3.2: **JGN partial productivity and TFP indexes, 1999–2013**



Source: Economic Insights GDB database

Table 3.2: **JGN output quantity, input quantity and productivity indexes, 1999–2013**

Year	Output quantity	Input quantity	Opex Input quantity	Capital Input quantity	Opex PP	Capital PP	TFP
1999	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2000	1.032	1.006	0.934	1.040	1.104	0.992	1.025
2001	1.054	1.022	0.930	1.067	1.133	0.988	1.031
2002	1.079	1.016	0.870	1.090	1.240	0.990	1.062
2003	1.101	1.003	0.803	1.109	1.372	0.993	1.098
2004	1.120	0.989	0.746	1.121	1.500	0.999	1.132
2005	1.136	0.995	0.725	1.142	1.568	0.995	1.142
2006	1.150	0.982	0.669	1.156	1.719	0.994	1.171
2007	1.169	0.999	0.677	1.178	1.726	0.992	1.170
2008	1.188	1.015	0.672	1.208	1.768	0.983	1.171
2009	1.212	1.026	0.665	1.232	1.823	0.984	1.181
2010	1.226	1.034	0.651	1.254	1.884	0.977	1.186
2011	1.249	1.084	0.707	1.298	1.768	0.962	1.153
2012	1.251	1.106	0.699	1.339	1.788	0.934	1.131
2013	1.288	1.126	0.707	1.366	1.822	0.943	1.144
Average Annual Change							
1999–2006	2.01%	-0.26%	-5.59%	2.10%	8.05%	-0.08%	2.28%
2006–2013	1.63%	1.97%	0.80%	2.41%	0.83%	-0.76%	-0.33%
1999-2013	1.82%	0.85%	-2.45%	2.25%	4.38%	-0.42%	0.96%

Source: Calculations using Economic Insights GDB database

These changes in output and input quantities have led to a relatively strong productivity performance over the first half of the period studied, driven largely by significant reductions in opex. But JGN's productivity performance in the latter half of the period has been flat or slightly declining, primarily due to capital inputs growth consistently outstripping output growth. From figure 3.2 we see that the partial productivity of opex grew strongly in the first half of the period, but continued to increase at a modest rate in the second half of the period. However, the partial productivity of capital has been slightly negative over the whole period from 1999 to 2013.

The TFP index (which is effectively a weighted average of the two partial productivity indexes) also followed two distinct trends over the 14-year period since 1999. Over the first 7 years to 2006 TFP increased at 2.3 per cent on average, but over the second 7 years to 2013 it declined by 0.3 per cent per annum on average.

3.6 Productivity growth of other GDBs, 1999 to 2011

This section compares JGN's productivity growth rate with the three Victorian GDBs and Envestra SA.[10] The historical output, input and productivity indexes and growth rates for Envestra Vic, Multinet, SP Ausnet and Envestra SA are presented in tables 3.3 to 3.6.

[10] Comparisons with Envestra Qld are not made as it faces very different operating environment conditions.

Table 3.3: **Envestra Vic gas distribution productivity indexes, 1999–2011**

Year	Output quantity	Input quantity	Opex Input quantity	Capital Input quantity	Opex PP	Capital PP	TFP
1999	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2000	1.028	0.994	0.963	1.024	1.068	1.005	1.034
2001	1.051	1.014	0.994	1.033	1.057	1.017	1.037
2002	1.071	0.981	0.897	1.057	1.193	1.013	1.091
2003	1.119	0.971	0.831	1.097	1.347	1.020	1.152
2004	1.131	0.962	0.772	1.131	1.464	1.000	1.176
2005	1.143	0.915	0.660	1.142	1.732	1.001	1.249
2006	1.167	0.926	0.677	1.148	1.724	1.016	1.260
2007	1.218	0.970	0.704	1.208	1.732	1.008	1.256
2008	1.257	0.987	0.707	1.236	1.779	1.017	1.275
2009	1.283	1.007	0.725	1.258	1.770	1.020	1.275
2010	1.315	1.016	0.715	1.284	1.840	1.024	1.295
2011	1.347	1.045	0.751	1.308	1.793	1.030	1.289
Average Annual Change							
1999–2011	2.51%	0.37%	-2.36%	2.26%	4.99%	0.25%	2.14%

Source: Economic Insights (2012b, p.26)

Table 3.4: **Multinet gas distribution productivity indexes, 1999–2011**

Year	Output quantity	Input quantity	Opex input quantity	Capital input quantity	Opex PP	Capital PP	TFP
1999	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2000	1.016	0.965	0.910	1.002	1.116	1.014	1.052
2001	1.020	0.949	0.864	1.005	1.180	1.015	1.074
2002	1.026	0.932	0.767	1.040	1.338	0.986	1.101
2003	1.048	0.906	0.768	0.996	1.365	1.052	1.157
2004	1.054	0.916	0.787	1.001	1.339	1.053	1.151
2005	1.052	0.896	0.740	0.997	1.422	1.055	1.174
2006	1.072	0.898	0.742	1.000	1.445	1.071	1.193
2007	1.087	0.941	0.749	1.066	1.451	1.019	1.155
2008	1.099	0.926	0.709	1.068	1.550	1.029	1.187
2009	1.101	0.924	0.693	1.074	1.590	1.026	1.192
2010	1.113	0.933	0.701	1.083	1.588	1.027	1.193
2011	1.103	0.949	0.705	1.107	1.564	0.996	1.163
Average Annual Change							
1999–2011	0.82%	-0.44%	-2.87%	0.85%	3.80%	-0.03%	1.27%

Source: Economic Insights (2012b, p.28)

Table 3.5: **SP AusNet gas distribution productivity indexes, 1999–2009**

Year	Output quantity	Input quantity	Opex input quantity	Capital input quantity	Opex PP	Capital PP	TFP
1999	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2000	1.018	0.996	0.974	1.014	1.045	1.004	1.022
2001	1.028	1.014	0.994	1.030	1.035	0.998	1.014
2002	1.064	1.059	1.081	1.043	0.984	1.020	1.005
2003	1.086	1.069	1.037	1.094	1.047	0.992	1.015
2004	1.098	1.071	1.008	1.122	1.090	0.979	1.025
2005	1.142	1.018	0.848	1.159	1.346	0.985	1.122
2006	1.175	1.006	0.789	1.180	1.490	0.996	1.169
2007	1.188	0.994	0.741	1.194	1.603	0.995	1.195
2008	1.230	0.983	0.680	1.214	1.807	1.013	1.251
2009	1.254	1.001	0.673	1.248	1.864	1.005	1.253
2010	1.285	0.989	0.585	1.278	2.197	1.005	1.299
2011	1.304	1.010	0.576	1.317	2.262	0.990	1.291
Average Annual Change							
1999–2011	2.24%	0.08%	-4.49%	2.32%	7.04%	-0.08%	2.15%

Source: Economic Insights (2012b, p.31)

Table 3.6: **Envestra SA gas distribution productivity indexes, 1999–2010**

Year	Output quantity	Input quantity	Opex input quantity	Capital input quantity	Opex PP	Capital PP	TFP
1999	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2000	1.023	1.006	0.969	1.032	1.055	0.991	1.017
2001	1.066	0.986	0.900	1.046	1.184	1.018	1.081
2002	1.087	1.013	0.947	1.061	1.147	1.025	1.072
2003	1.099	0.973	0.825	1.076	1.331	1.021	1.129
2004	1.100	1.008	0.879	1.097	1.252	1.002	1.091
2005	1.110	0.999	0.847	1.106	1.311	1.004	1.111
2006	1.127	1.008	0.837	1.129	1.347	0.998	1.118
2007	1.139	1.007	0.812	1.144	1.403	0.996	1.132
2008	1.153	1.005	0.784	1.162	1.470	0.992	1.147
2009	1.167	1.010	0.780	1.175	1.496	0.993	1.155
2010	1.186	1.011	0.749	1.198	1.583	0.990	1.174
Average Annual Change							
1999–2010	1.55%	0.10%	–2.62%	1.64%	4.17%	–0.09%	1.46%

Source: Economic Insights (2010a, p.25)

Table 3.7 provides a brief summary of the TFP growth trends for each of the GDBs for comparison with JGN, and includes similar summaries for opex and capital PFP. The table shows that between 1999 and 2011, Envestra Vic and SP Ausnet had the largest TFP gains, averaging around 2.2 per cent per year. Over the same period JGN, Multinet and Envestra SA had lower productivity growth, averaging between 1.2 per cent and 1.4 per cent per year.

Most GDBs, with the exception of SP Ausnet, had considerably lower TFP growth in the period after 2006 than during the period up to 2006. The reversal was most significant with Envestra Vic, JGN and Multinet. The latter two GDBs had negative TFP growth over the period after 2006.

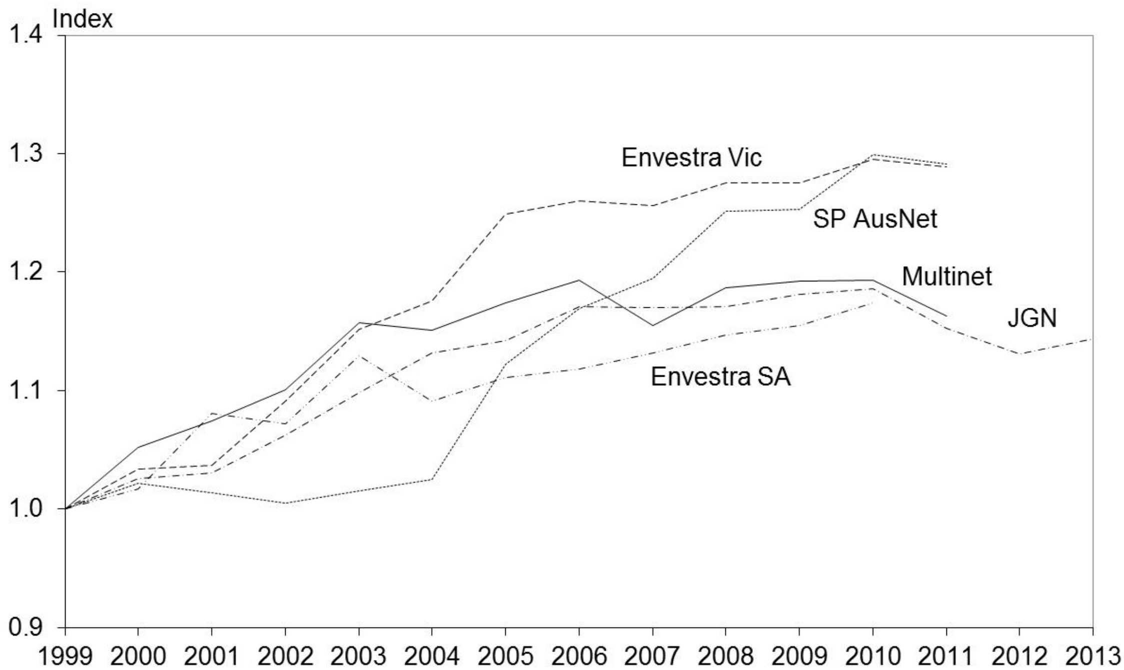
Table 3.7: **Gas distribution TFP growth summary, 1999–2011 (per cent)**

Year	JGN	Envestra Vic	Multinet	SP Ausnet	Envestra SA
		TFP			
1999-2006	2.28	3.36	2.55	2.26	1.61
2006-2011	-0.31	0.46	-0.51	2.01	0.98*
1999–2011	1.19	2.14	1.27	2.15	1.35*
		Opex PFP			
1999-2006	8.05	8.09	5.40	5.86	4.35
2006-2011	0.56	0.79	1.60	8.71	4.12*
1999–2011	4.86	4.99	3.80	7.04	4.26*
		Capital PFP			
1999-2006	-0.08	0.23	0.98	-0.06	-0.03
2006-2011	-0.65	0.27	-1.44	-0.12	-0.20*
1999–2011	-0.32	0.25	-0.03	-0.08	-0.09*

*Period to 2010 only.

Source: Economic Insights

Figure 3.3: **Victorian GDB, JGN, and Envestra SA TFP indexes, 1999–2013**



Source: Economic Insights GDB database

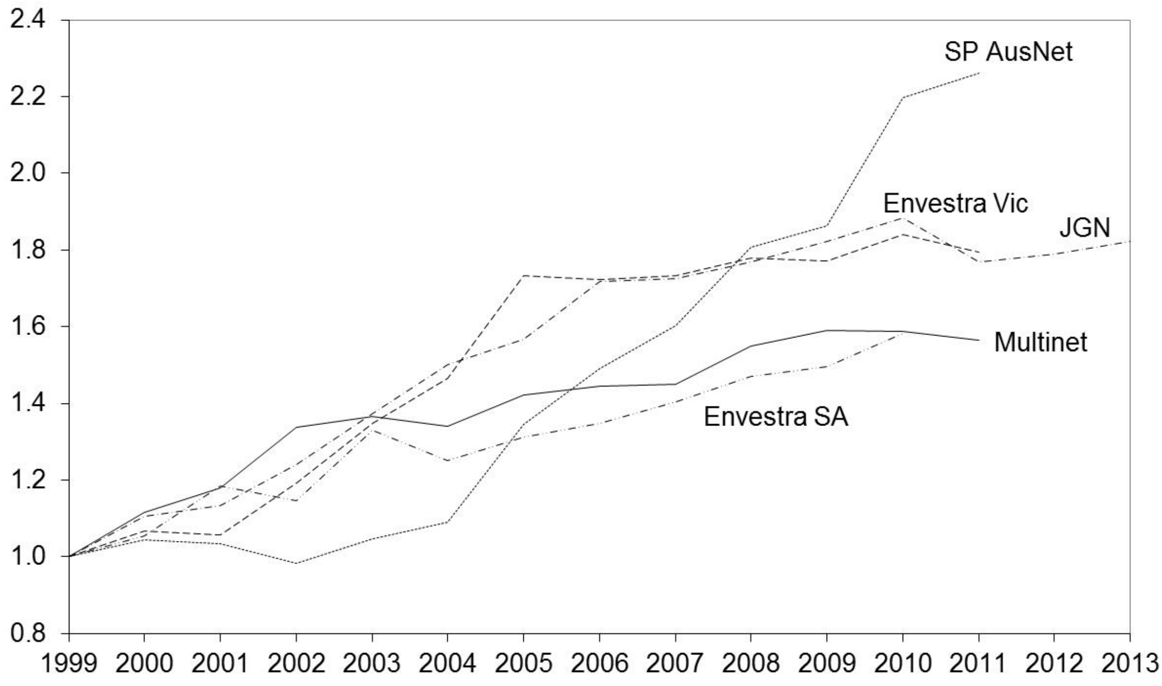
Figure 3.3 plots the trends in TFP for each GDB over the periods for which these estimates are available. JGN's TFP index followed a broadly similar pattern to those of Multinet and

Envestra SA. On the other hand, Envestra Vic had exceptionally strong TFP growth during the period 1999 to 2006 (3.4 per cent per annum), and SP Ausnet had particularly strong TFP growth in the period from 2006-2011 (2.0 per cent per year). It should be noted these results do not include allowance for differences in productivity levels (which will be examined in section 4).

Opex partial productivity indexes for JGN, the three Victorian GDBs and Envestra SA are plotted in figure 3.4 starting from 1999. All 5 included GDBs have exhibited strong opex partial productivity growth over the period 1999 to 2006. For example, JGN and Envestra Vic both had average annual opex PFP growth rates over this period of 8.1 per cent, and the corresponding average opex PFP growth rates for SP AusNet, Multinet and Envestra SA were 5.9 per cent, 5.4 per cent and 4.4 per cent respectively. However, in most cases there was much slower opex partial productivity growth in the period from 2006 to 2011. For example, JGN, Multinet and Envestra Vic's average annual growth opex PFP growth rates fell to 0.6 per cent, 0.8 per cent and 1.6 per cent respectively. During the whole 1999-2011 period, SP AusNet had the highest opex partial productivity growth with average annual rate of 7.0 per cent. Envestra Vic, JGN and Envestra SA had slightly lower opex partial productivity growth rates of 5.0 per cent, 4.8 per cent and 4.3 per cent, respectively.[11]

The trends in capital partial productivity were not graphed because they would essentially be a set of relatively flat lines, as the growth rates in Table 3.7 make clear. Only Envestra Vic's partial capital productivity grew over the period from 1999 to 2011, at an average annual rate of 0.3 per cent. All of the remaining GDBs had slightly declining partial capital productivity over this period.

Figure 3.4: **Victorian GDB, JGN, and Envestra SA Opex PFP indexes, 1999–2013**



Source: Economic Insights GDB database

[11] The figure reported for Envestra SA is for the period from 2006 to 2010.

3.8 Summary conclusions

To summarise the findings of this section, JGN's TFP grew at an average annual rate of 1.2 per cent between 1999 and 2011, but taken over the period to 2013, the average is 1.0 per cent due to productivity reductions in 2011 and 2012. JGN resumed TFP growth in 2013. JGN's TFP growth over the period 1999 to 2011 was at a similar rate to those of Multinet and Envestra SA, although Envestra Vic and SP AusNet both achieved average TFP growth rates of over 2 per cent over the same period. The main source of TFP growth for most GDBs over this period was strong growth in opex partial productivity in the period from 1999 to 2006. JGN had the equal highest growth rate of opex partial productivity over this period. For most GDBs, this source of productivity gain was considerably more modest in the period from 2006 to 2011. Furthermore, capital partial productivity for most GDBs was flat or slowly declining over the whole period from 1999 to 2011, and thus capital partial productivity mostly did not contribute to TFP growth and in fact it slightly weakened TFP growth in general.

4 COMPARATIVE PRODUCTIVITY LEVEL RESULTS

4.1 Multilateral TFP indexes

Traditional measures of TFP such as those discussed in chapter 3 have enabled comparisons to be made of rates of change of productivity between GDBs but have not enabled comparisons to be made of differences in the absolute levels of productivity in combined time series, cross section GDB data. This is due to the failure of conventional TFP measures to satisfy the important technical property of transitivity. This property states that direct comparisons between observations *m* and *n* should be the same as indirect comparisons of *m* and *n* via any intermediate observation *k*.

Caves, Christensen and Diewert (1982) developed the multilateral translog TFP (MTFP) index measure to allow comparisons of the absolute levels as well as growth rates of productivity. It satisfies the technical properties of transitivity and characteristicity which are required to accurately compare TFP levels within panel data. Lawrence, Swan and Zeitsch (1991) and the Bureau of Industry Economics (BIE 1996) have used this index to compare the productivity levels and growth rates of the five major Australian state electricity systems and the United States investor–owned system. Lawrence (2003a) and PEG (2004) also use this index to compare electricity distribution business TFP levels and Lawrence (2007) used it to compare TFP levels across the three Victorian GDBs.

The Caves, Christensen and Diewert (CCD) multilateral translog index is given by:

$$\begin{aligned}(4.1)\qquad \log (TFP_m/TFP_n) = \;& \Sigma_i (R_{im}+R_i^*) (\log Y_{im} - \log Y_i^*)/2 - \\ & \Sigma_i (R_{in}+R_i^*) (\log Y_{in} - \log Y_i^*)/2 - \\ & \Sigma_j (S_{jm}+S_j^*) (\log X_{jm} - \log X_j^*)/2 + \\ & \Sigma_j (S_{jn}+S_j^*) (\log X_{jn} - \log X_j^*)/2\end{aligned}$$

Where R_i^* (S_j^*) is the revenue (cost) share averaged over all utilities and time periods and $\log Y_i^*$ ($\log X_j^*$) is the average of the log of output *i* (input *j*). In this analysis we have three outputs (throughput, customers and system capacity) and, hence, *i* runs from 1 to 3. We have 7 inputs (opex, high pressure pipelines, medium pressure pipelines, low pressure pipelines, services pipelines, meters, and other capital) and, hence, *j* runs from 1 to 7. The Y_i and X_j terms are the output and input quantities, respectively. The R_i and S_j terms are the output and input weights, respectively.

Formula (4.1) gives the proportional change in MTFP between two adjacent observations (denoted *m* and *n*). An index is formed by setting some observation (usually the first in the database) equal to one and then multiplying through by the proportional changes between all subsequent observations in the database to form a full set of indexes. The index for any observation then expresses its productivity level relative to the observation that was set equal to one. However, this is merely an expositional convenience as, given the invariant nature of the comparisons, the result of a comparison between any two observations will be independent of which observation in the database was set equal to one.

This means that using equation (4.1) comparisons between any two observations *m* and *n* will be both base–distributor and base–year independent. Transitivity is satisfied since comparisons between the two GDBs for 2009 will be the same regardless of whether they are compared directly or via, say, one of the GDBs in 2002. An alternative interpretation of this index is that it compares each observation to a hypothetical average distributor with output vector $log\ Y_i*$, input vector $log\ X_j*$, revenue shares R_i* and cost shares S_j*.

For consistency with the previous related studies, the MTFP analysis in this section uses Envestra Vic 1999 as the base. As noted above, the results are invariant to the choice of the base observation.

4.2 Data

The database used in the MTFP analysis is the same as that used for the analysis of productivity trends, described in section 3.2, with one important difference. Transmission and sub-transmission mains were included when measuring productivity growth (section 3) in order to reflect the whole business of each GDB, but in the analysis of comparative productivity levels they are excluded to ensure comparability between GDBs. The functional coverage of JGN differs somewhat from that of the Victorian GDBs, Envestra SA and Envestra Qld with JGN having considerably longer lengths of trunk and primary mains given the relatively spread out territory it serves. The Victorian GDBs, Envestra SA and Envestra Qld have few transmission pipelines. To ensure comparability, trunk and primary mains for JGN (and associated opex[12]) are excluded for JGN and transmission mains are excluded for the three Victorian GDBs, Envestra SA and Envestra Qld in the comparison of productivity levels presented in this section. Because transmission and sub-transmission inputs are excluded, GDB productivity trends reported in this section differ somewhat from those reported in the last section.

4.3 Australian GDB productivity levels comparisons

We commence by comparing the TFP productivity levels of JGN against five other GDBs for the period 1999 to 2010 or 2011. The survey database only extends to 2013 for JGN, 2011 for the Victorian GDBs and 2010 for the South Australian and Queensland GDBs. Multilateral opex partial factor productivity (PFP) is presented in section 4.4.

Multilateral TFP indexes are presented in table 4.1, and plotted in figure 4.1.[13] In 1999, with the exception of Envestra Queensland, the GDBs had broadly similar productivity levels. JGN and Envestra SA's productivity levels were 10-11 per cent below Envestra Victoria, and Multinet and SPAN's productivity levels were 4-7 per cent lower than Envestra Victoria. On the other hand, Envestra Queensland's productivity level was much lower than the other 5 GDBs, being approximately 33 per cent below that of the highest productivity GDB (Envestra Victoria).

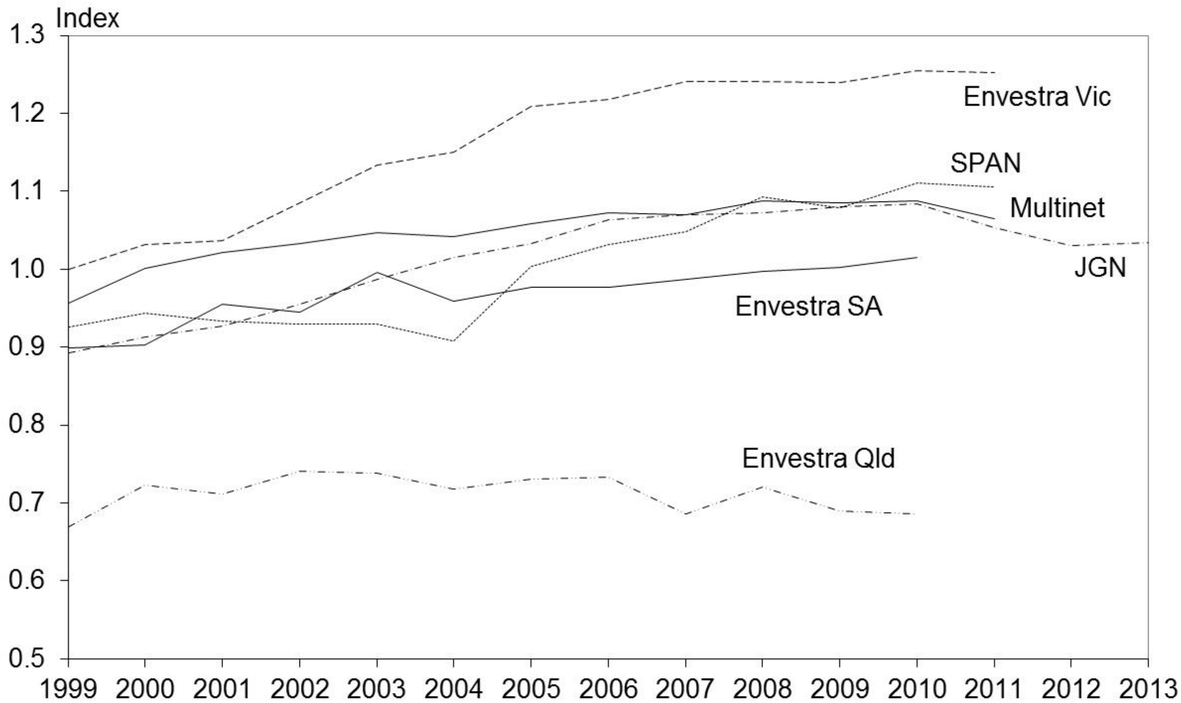
[12] As estimated by JGN.
[13] The indexes are presented relative to Envestra Victoria in 1999 having a value of one.

Table 4.1: **Australian GDB Multilateral TFP indexes, 1999–2013**

	Env Vic	Multinet	SP AN	JGN	Env SA	Env Qld
1999	1.000	0.956	0.925	0.892	0.899	0.669
2000	1.032	1.002	0.943	0.913	0.902	0.723
2001	1.037	1.022	0.934	0.927	0.955	0.711
2002	1.085	1.033	0.930	0.955	0.944	0.741
2003	1.134	1.047	0.930	0.987	0.996	0.738
2004	1.150	1.042	0.908	1.015	0.959	0.717
2005	1.209	1.059	1.003	1.033	0.977	0.730
2006	1.217	1.072	1.031	1.064	0.976	0.734
2007	1.241	1.069	1.048	1.070	0.987	0.686
2008	1.241	1.087	1.093	1.072	0.997	0.720
2009	1.240	1.085	1.079	1.080	1.002	0.689
2010	1.254	1.088	1.111	1.084	1.015	0.686
2011	1.253	1.064	1.105	1.053	.	.
2012	.	.	.	1.031	.	.
2013	.	.	.	1.034	.	.

Source: Calculations using Economic Insights GDB database

Figure 4.1: **Australian GDB Multilateral TFP indexes, 1999–2013**



Source: Economic Insights GDB database

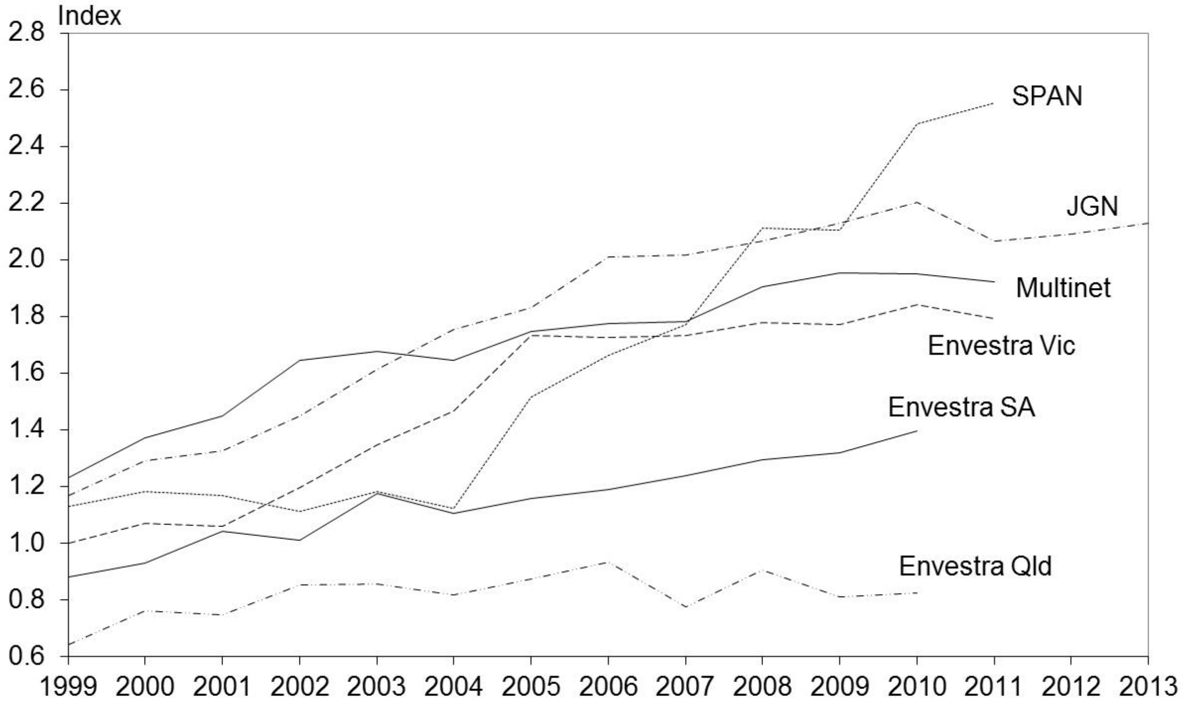
Over the period to 2010, the spread of comparative productivity levels between GDBs widened. The GDB with highest productivity in 1999 (Envestra Vic) also had the highest productivity growth over the 12 year period to 2010, while the lowest productivity GDB in 1999 (Envestra Qld), had virtually no net TFP growth over the same period. JGN and SPAN had stronger TFP growth than Multinet and Envestra SA, and by 2008-2010, JGN's productivity was at a similar level to Multinet and SPAN.

Since 2010, JGN's productivity level has declined by approximately 5 per cent. Although we do not have comparator GDBs available in the period after 2011, the three Victorian GDBs also had flat or declining productivity in 2011.

4.4 Multilateral Opex & Capital PFP Indexes

The multilateral opex PFP indexes are presented in table 4.2 and figure 4.2, and multilateral capital PFP indexes are presented in table 4.3 and figure 4.3.

Figure 4.2: **Australian GDB multilateral Opex PFP indexes, 1999–2013**



Source: Economic Insights GDB database

JGN and SP AusNet had the highest opex partial productivity levels throughout the period 1999 to 2011. By 2010, SP AusNet and JGN's opex PFP were 2.5 times and 2.2 times that of Envestra Vic in 1999 (the basis of comparisons). These were closely followed by Multinet and Envestra Victoria, which had opex PFP indexes of 2.0 and 1.8 in 2010, respectively. The strong growth and resulting high comparative levels of opex PFP for these four GDBs is contrasted with Envestra SA and Envestra Qld, which had opex PFP indexes in 2010 of 1.4 and 0.8 respectively. The comparatively high proportion of cast iron pipes and low energy density are likely to have affected the ability of these two smaller GDBs to match the opex partial productivity levels of the larger GDBs.

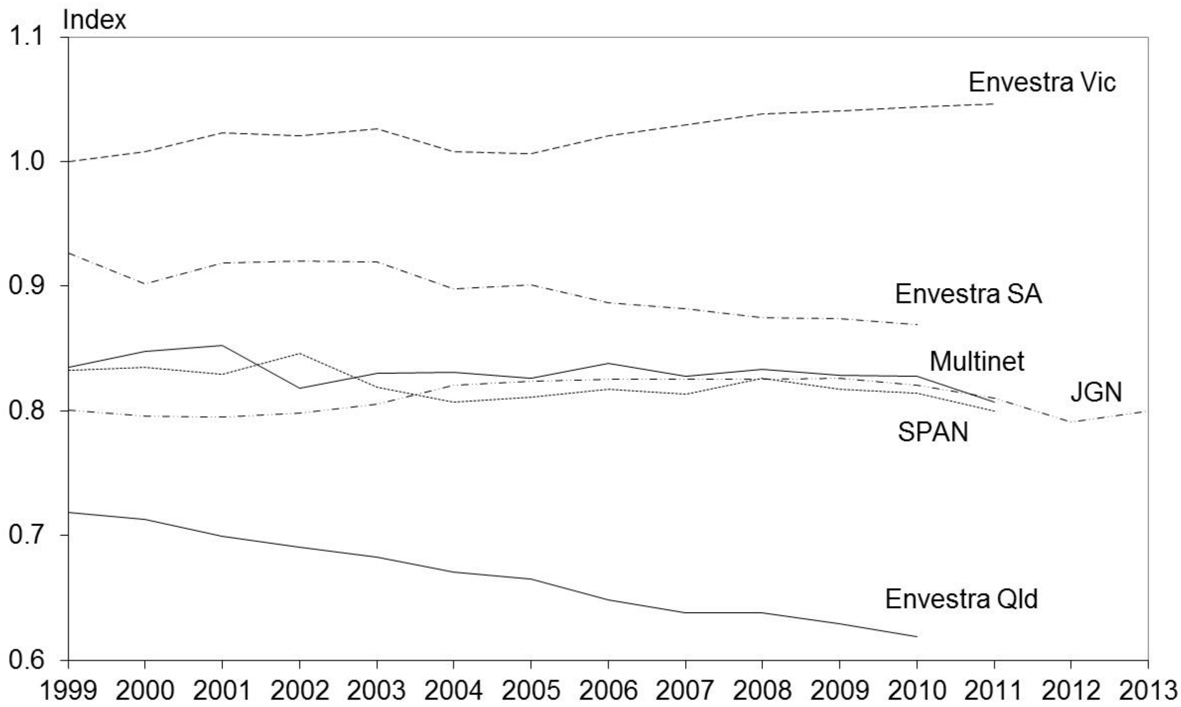
With regard to capital multilateral partial productivity levels, the most remarkable feature is that there has been little or no improvement in capital productivity among the GDBs over the period 1999 to 2010 or 2011. Envestra Victoria is the only GDB to achieve a significant improvement. By 2011, its capital PFP index had increased by 5 per cent compared to 1999, JGN's had remained static, while all of the others declined slightly, or significantly in the case of Envestra Qld. By 2010 or 2011, capital PFP for Multinet, SP Ausnet, JGN and Envestra SA were all around 20-25 per cent below that of Envestra Vic.

Table 4.2: **Australian GDB Multilateral Opex PFP indexes, 1999–2013**

	Env. Vic	Multinet	SP AusNet	JGN	Env. SA	Env. Qld
1999	1.000	1.229	1.129	1.168	0.881	0.640
2000	1.068	1.371	1.180	1.290	0.930	0.760
2001	1.057	1.449	1.169	1.324	1.042	0.747
2002	1.193	1.644	1.111	1.448	1.011	0.851
2003	1.347	1.677	1.183	1.613	1.172	0.855
2004	1.464	1.645	1.121	1.753	1.103	0.817
2005	1.732	1.747	1.513	1.831	1.155	0.871
2006	1.724	1.775	1.664	2.008	1.187	0.933
2007	1.732	1.783	1.770	2.016	1.236	0.774
2008	1.779	1.904	2.112	2.065	1.295	0.902
2009	1.770	1.953	2.105	2.130	1.318	0.811
2010	1.840	1.951	2.478	2.201	1.394	0.825
2011	1.793	1.922	2.552	2.065	.	.
2012	.	.	.	2.089	.	.
2013	.	.	.	2.128	.	.

Source: Calculations using Economic Insights GDB database

Figure 4.3: **Australian GDB multilateral capital PFP indexes, 1999–2013**



Source: Economic Insights GDB database

Table 4.3: **Australian GDB multilateral capital PFP indexes, 1999–2013**

	Env. Vic	Multinet	SP AusNet	JGN	Env. SA	Env. Qld
1999	1.000	0.835	0.833	0.801	0.927	0.718
2000	1.008	0.848	0.835	0.796	0.902	0.713
2001	1.023	0.852	0.829	0.795	0.919	0.699
2002	1.020	0.818	0.846	0.798	0.920	0.690
2003	1.026	0.830	0.819	0.806	0.920	0.683
2004	1.008	0.831	0.807	0.820	0.898	0.671
2005	1.006	0.826	0.811	0.824	0.901	0.665
2006	1.021	0.838	0.818	0.825	0.887	0.648
2007	1.030	0.828	0.814	0.825	0.882	0.638
2008	1.038	0.833	0.826	0.825	0.875	0.638
2009	1.041	0.828	0.817	0.827	0.874	0.629
2010	1.044	0.828	0.814	0.821	0.869	0.619
2011	1.046	0.807	0.800	0.810	.	.
2012	.	.	.	0.791	.	.
2013	.	.	.	0.800	.	.

Source: Calculations using Economic Insights GDB database

4.4 Summary conclusions

In summary, JGN has had the highest or second highest level of opex multilateral partial productivity for the last 15 years, exceeded only by SP AusNet in 2010 and 2011. JGN's opex partial productivity increased by over 80 per cent over this period. JGN has had similar capital multilateral partial productivity levels to Multinet and SP AusNet over the last decade but lower than those of Envestra Vic and Envestra SA. Looking at the overall productivity result, JGN has had similar multilateral TFP levels to SP AusNet and Multinet since around 2005. Envestra Vic has had consistently higher multilateral TFP levels than these three GDBs but they have had higher multilateral TFP levels than Envestra SA and Envestra Queensland.

The index number analysis thus shows JGN to have been a good performer in terms of both opex partial productivity levels and growth rates. And it has had similar TFP levels to two of the three Victorian GDBs for the last decade.

We now turn to statistical analysis and the econometric estimation of an opex cost function in the following section to further investigate JGN's relative efficiency levels and achievable future opex partial productivity growth.

PART C: ECONOMETRIC COST FUNCTION ANALYSIS

In this part of the report, we estimate the opex cost function for gas distribution businesses, and use this to examine JGN's opex efficiency compared to the other GDBs. The opex cost function is also used to forecast JGN's opex partial productivity growth rate for the period 2015-16 to 2019-20.

The use of cost function analysis to derive efficiency scores adjusted for environmental and operating effects has a long history. In the United States, Barcella (1992) estimated the cost function of gas distribution businesses based on a sample of 50 companies over the period 1969-1988. In the context of Australia and New Zealand, Pacific Economics Group (2001a, 2001b, 2001c) 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 data from a large sample of American investor–owned gas distribution utilities. The model was used to predict 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.

Economic Insights (2012a) used econometric analysis of the total cost function for gas distribution businesses to assess the comparative efficiency of SP AusNet. This analysis was based on a sample of 9 Australian GDBs and 2 New Zealand GDBs using data sourced from the public domain to the maximum extent possible. Total cost function analysis takes into account opex and capital input trade–offs, price effects and controls for certain operating environment factors in the analysis of comparative cost efficiency. The study also developed econometric estimates of the variable or operating cost function and the parameters of this function were combined with forecasts of output and capital input levels to forecast SP AuNet's future GDB opex partial productivity growth rates. Such forecasts are used in the 'rate of change' formula for rolling forward opex allowances often used in the application of building blocks regulation (see: ESC, 2008, pp. 224–250; AER, 2012a Appendix C).

The analysis in this part of the report is similar to that previously undertaken by Economic Insights in 2012. In this case the focus is on the comparative efficiency and forecast partial productivity of JGN. This study uses additional data available since the 2012 study was undertaken and includes a number of other enhancements. These include allowance for a wider range of operating environment factors, the use of more advanced econometric estimation methods and directly estimating opex efficiency levels in the opex cost function itself.

5 FORECASTING FUTURE OPEX PRODUCTIVITY GROWTH

In this section we estimate an opex cost function to assess JGN's opex efficiency level, and to use as an input to forecasting JGN's future opex partial productivity growth. Assessing JGN's opex efficiency level statistically provides information on whether the base year revealed costs are a reasonable starting point for calculating opex requirements for the next regulatory period. And the opex cost function parameter estimates can be used as input to an objective way of calculating future opex partial productivity growth to be included in rate of change calculations for recurrent opex requirements.

An operating cost function, or variable cost function, represents the minimum cost that can be achieved by a firm in the short–run, when capital inputs are fixed or quasi-fixed within the decision period. It differs from a total cost function which represents the minimum total cost when all inputs are fully variable and can be adjusted in response to changes in input prices within the decision period. The relationships between the short-run variable cost function, the short-run and long-run total cost functions, and short-run and long-run marginal costs, are defined in Varian (1984, pp. 35–36).

Some studies estimate the variable cost function in preference to the total cost function, particularly where the quantities of capital employed are lumpy and generally sunk in nature once put in place. Variable cost functions are also useful within the building block regulatory model, where capital expenditure plans and expenditures are separately forecast, and may be treated as given when forecasting efficient levels of operating costs.

5.1 Methodology

5.1.1 Opex cost function specification

In this study we estimate a translog variable cost function model for the pooled data set and use the parameter estimates to make inferences about the efficiency of JGN's opex relative to the sample average. The translog specification has been widely used in economic research and in regulatory hearings (eg: Barcella, 1992; Fabbri, Fraquelli and Giandrone, 2000; Farsi, Filippini and Kuenzle, 2007; Lowry and Getachew, 2009). It has the 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 also facilitate estimation. These include: linear homogeneity in prices (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 (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 and the quantity of gas throughput;
- opex input prices;
- capital inputs;

- a time trend representing technological change; and
- operating environment factors, including customer density as measured by total customers per kilometre of mains, network age as measured by the proportion of the network that is not made of cast iron or unprotected steel and network fragmentation as measured by the number of city gates supplying the GDB from the transmission system.

The translog variable cost function has the following form (in full):

(5.1)
$$\begin{aligned}\ln VC = {} & a_0 + a_t t + c_1 \ln K + \sum_h a_h \ln N_h + \sum_j \theta_j \ln Y_j + \sum_l b_l \ln P_l + c_2 \left[\ln K\right]^2 \\ & + \frac{1}{2}\sum_h \sum_i a_{hi} \ln N_h \ln N_i + \frac{1}{2}\sum_j \sum_k \theta_{jk} \ln Y_j \ln Y_k + \frac{1}{2}\sum_l \sum_m b_{lm} \ln P_l \ln P_m \\ & + \sum_l \sum_j d_{lj} \ln P_l \ln Y_j + \sum_l \sum_h e_{lh} \ln P_l \ln N_h + \sum_j \sum_h f_{jh} \ln Y_j \ln N_h \\ & + \sum_h g_{Nh} \ln N_h \ln K + \sum_j g_{Yj} \ln Y_j \ln K + \sum_l g_{Pl} \ln P_l \ln K\end{aligned}$$

where:

- Y_j (or Y_k) are outputs; $j,k = 1, 2, \ldots$
- P_l (or P_m) are price indices of variable inputs, $l,m = 1, 2, \ldots$
- N_h (or N_i) are variables that measure relevant operating environment factors; $h,i = 1, 2, \ldots$
- K is a service flow measure of fixed capital,[14] and
- t is a measure of time and reflects the principle that, all else unchanged, costs decrease marginally each year due to technical change.

The restrictions on this function from economic theory are as follows.

Symmetry: $b_{lm} = b_{ml}, \quad \theta_{jk} = \theta_{kj}$

Linear homogeneity: $\sum_l b_l = 1, \quad \sum_l b_{lm} = 0, \quad \sum_j d_{ij} = 0$

Other implied restrictions: $\sum_k \theta_{jk} = 0, \quad \sum_m b_{lm} = 0$

When there are not very many outputs and inputs, the foregoing restrictions derived from economic theory can greatly reduce the number of parameters that need to be estimated. In this study there are just two inputs, capital services and constant price opex, which means that nominal opex is a function of the quantities of the two outputs (customer numbers and

[14] This refers to the annual capital input quantity. Due to its durable nature, capital has two distinct economic characteristics, as a source of capital services in production and as a store of wealth. Measures of these characteristics will often be different, and the appropriate measure depends on the analytical context. Wealth measures of capital are more commonly available, and in some circumstances may be used as a proxy measure of capital services (as is the case in this study). Information on capital measurement is provided in (OECD, 2009).

throughput), an index of opex input prices, the quasi-fixed quantity of capital services, operating environment factors and technological change. When cost functions are estimated, it is usually desirable to jointly estimate the cost function with the implied input demand functions, which provides for more robust estimation of common parameters. However, in this case, with only one variable input, this approach is not available, and the variable cost function is estimated as a single equation.[15]

The various interaction terms in the translog specification can require many parameters to be estimated, which may be problematic when the size of the sample is not large. One means of reducing the number of parameters to be estimated is to exclude some of the quadratic and interaction terms. Given the limited size of the sample used in this study, restrictions of this kind are found to be necessary and have been imposed on capital inputs, and on most of the operating environment variables, to better identify the main effects of the model. Data limitations are discussed in section 5.2.1.

5.1.2 Method of forecasting opex productivity growth

To forecast future opex partial productivity growth we use an approach similar to that presented in Pacific Economics Group (2004), Lawrence (2007b) and Economic Insights (2012a). The starting point for this analysis is the following relationship between a GDB's actual opex, C_{OM}, and its efficient opex, C^*_{OM}:

(5.2) $$C_{OM} = C^*_{OM}.\eta$$

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**), opex quantities (**Y**), capital quantities (**K**), operating environment variables (**Z**) and time (T) as follows:

(5.3) $$C^*_{OM} = g\left(\mathbf{W},\mathbf{Y},\mathbf{K},\mathbf{Z},T\right)$$

Totally differentiating (5.3) with respect to time produces the following:

(5.4) $$\dot{C}^*_{OM} = \left(\sum_i \varepsilon_{Y_i}.\dot{Y}_i + \sum_j \varepsilon_{W_j}.\dot{W}_j + \sum_m \varepsilon_{K_m}.\dot{K}_m + \sum_n \varepsilon_{Z_n}.\dot{Z}_n\right) + \dot{g}$$

The ε coefficients are elasticities of opex cost with respect to the variable, and the dot over a variable represents the variable's growth rate. Combining equations (5.2) and (5.4) we get:

(5.5) $$\dot{C}_{OM} = \left(\sum_i \varepsilon_{Y_i}.\dot{Y}_i + \sum_j \varepsilon_{W_j}.\dot{W}_j + \sum_m \varepsilon_{K_m}.\dot{K}_m + \sum_n \varepsilon_{Z_n}.\dot{Z}_n\right) + \dot{g} + \dot{\eta}$$

The growth rate in actual opex is the sum of:

- the products of the growth rates of each output, input price, capital input and operating environment variable and the elasticity of the opex cost function with respect to that variable;

[15] The restrictions from economic theory imply that one of the factor demand functions must be omitted, and there is only one variable factor.

- the shift in the cost function over time; and
- the growth rate of the inefficiency factor.

Applying Shephard's Lemma (which states that the derivative of the efficient cost with respect to an input price is equal to the efficient quantity of that input), the elasticity of efficient cost with respect to the price of each input can be shown to be equal to the optimal cost share of that input in the minimum cost combination of inputs (SC_j^*). Equation (5.5) can be rewritten as:

(5.6) $$\dot{C}_{OM} = \sum_i \varepsilon_{Y_i}.\dot{Y}_i + \dot{W}_{OM}^* + \sum_m \varepsilon_{K_m}.\dot{K}_m + \sum_n \varepsilon_{Z_n}.\dot{Z}_n + \dot{g} + \dot{\eta}$$

where $\dot{W}_{OM}^* = \sum_j SC_j^*.\dot{W}_j$ is an index of input price growth rates with the efficient cost shares as the weights, and $SC_j^* = \varepsilon_{W_j}$ by Shephard's Lemma, as discussed.

We next define the growth rate of the elasticity weighted output index is defined as:

(5.7) $$\dot{Y}^{\varepsilon} = \sum_j \left(\varepsilon_j / \sum \varepsilon_j \right) \dot{Y}_j$$

Thus $\left(\sum_i \varepsilon_{Y_i} \right) \dot{Y}^{\varepsilon} = \sum_i \varepsilon_{Y_i}.\dot{Y}_i$, which is substituted into (5.6):

(5.8) $$\dot{C}_{OM} = \left(\sum_i \varepsilon_{Y_i} \right) \dot{Y}^{\varepsilon} + \dot{W}_{OM}^* + \sum_m \varepsilon_{K_m}.\dot{K}_m + \sum_n \varepsilon_{Z_n}.\dot{Z}_n + \dot{g} + \dot{\eta}$$

We make use of two definitions. The growth rate of opex partial productivity, $P\dot{F}P_{OM}$, is defined as:

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

where $\dot{X}_{OM}$ is the growth rate of the opex input quantity, which is equal to the difference between the rates of change of opex and the opex price index:

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

Substituting (5.10) into (5.9) and using (5.8) we have:

(5.11) $$\begin{aligned} P\dot{F}P_{OM} &= \dot{Y}^{\varepsilon} + \dot{W}_{OM} - \dot{C}_{OM} \\ &= \left\{ 1 - \left(\sum_j \varepsilon_{Yj} \right) \right\} \dot{Y}^{\varepsilon} - \sum_m \varepsilon_{K_m}.\dot{K}_m - \sum_n \varepsilon_{Z_n}.\dot{Z}_n - \dot{g} - \dot{\eta} \end{aligned}$$

Equation (5.11) provides an 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 (5.11) 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 (5.11) 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 factors. Note also that when the translog specification is used to estimate the opex cost function, and when all variables (excluding the time trend) are divided by their respective mean values prior to estimation, the estimated first order coefficients represent the elasticities required for forecasting opex growth. The combined term $-(\dot{g}+\dot{\eta})$ in equation (5.11) is estimated by the coefficient of the estimated opex function with respect to time.

The AER made the following observation regarding the methodology presented in Economic Insights (2012a):

> 'The AER considers the total cost function parameters estimated by Economic Insights using data from 11 gas distribution businesses from Australia and New Zealand represents a reasonable benchmark of opex PFP growth for the Australian gas distribution industry.' (2012a, p. 8)

With regard to Economic Insights (2009) the AER commented:

> '… it can be accepted that the report provides a supporting opinion that Jemena has obtained value for money for its past operating expenditures and, without evidence to the contrary, is likely to continue to do so.' (AER, 2010, p. 218)

5.2 Data Sources & Sample

5.2.1 Data limitations

Despite the existence of the National Gas Law and Regulations and their predecessors, the amount of reliable, publicly available GDB data below high level aggregate variables has been very limited to-date. Regulatory data have to date concentrated almost exclusively on financial variables, and where detailed operational information has been provided by regulators or GDBs, it often differs in coverage between jurisdictions and over time, and is not typically drawn together in the one location.

These limitations are being addressed by the Australian Energy Regulator (AER), which recently developed regulatory information notices (RINs) for the purpose of gathering information from electricity network businesses for benchmarking purposes (AER 2013). This will include historical data. The RINs published to-date apply to electricity transmission and distribution businesses.

Because of the data limitations, the amount of detail we can include in the operating cost function remains relatively limited. There is no available disaggregation of opex into components such as labour and materials costs or into operating and maintenance costs which is consistent across GDBs. This implies that only a single input can be used in the variable cost function. Similarly, there is only limited available information on operating environment factors. That said, this study uses a wider set of operating environment factors than previous studies of this kind. In addition to the key characteristic of customer density, this study also uses data for the geographical fragmentation or dispersion of networks operated by each GDB, and network age-related characteristics such as the proportion of mains that are made of cast iron or unprotected steel.

5.2.2 Data sources

The data used in this part of the study has been sourced from documents in the public domain to the maximum extent possible and relates to the period from 1999 onwards. Data for most of the Australian GDBs in the study are publicly available for most of this period, but 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, of the two New Zealand GDBs included in the sample, Powerco only has observations for 2004 onwards and Vector for 2006 onwards. For JGN, only historical data up to 2013 is included. For the other Australian GDBs, regulators' forecasts for years beyond 2012 or 2013 (as applicable) are also included, where available in final regulatory determinations. The database used in this study includes a total of 171 observations. This compares to 144 observations used in Economic Insights (2012a).

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;
- Asset Management Plans (AMPs), whether appended to AAI or published separately;
- Regulators' final decisions, sometimes with amendment following appeal; and
- Annual Reports from the GDB or its parent firm.

The principal public domain data sources used for the NZ GDBs are the Information Disclosure Data filings required by the *Gas (Information Disclosure) Regulations 1997*, and published AMPs and Annual Reports.

The Australian GDBs included in the database are:

- ActewAGL, Australian Capital Territory
- APT Allgas Pty Ltd (Allgas), Queensland
- ATCO Gas Australia, Western Australia
- Envestra Queensland, Queensland
- Envestra SA, South Australia
- Envestra Victoria, Victoria
- JGN, NSW
- Multinet Gas, Victoria
- SP AusNet, Victoria

The New Zealand GDBs included in the database are:

- Powerco Limited

- Vector Ltd

The dataset developed from the public domain sources relates 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 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.

While relatively recent regulatory reviews are available for most Australian States, this is not the case for NSW where the last regulatory review was undertaken by the AER in 2009. Consequently, we use data from our survey of JGN up to 2013 in preference to now relatively old public domain sources. Conversely, public domain data for the Victorian GDBs are now more up to date than the survey data used in Economic Insights (2012a) and AER final determination forecasts are available out to 2017. As a result we follow the same practice as in Economic Insights (2012a) of using public domain data for all GDBs other than the one we are producing opex productivity forecasts for, and use survey data for that GDB, in this case JGN.

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. The most important of these is adjustment of the opex of non–Victorian GDBs to exclude unaccounted for gas allowances in order to put those GDBs on a comparable basis with Victorian reporting. The AER's final determination forecasts, which have been undertaken at various times, have not been adjusted for any differences in assumptions made about carbon taxes. JGN's survey data is used in this analysis, which excludes carbon costs in 2012 and 2013.

The data used for the Australian GDBs covers only their regulated activities, and may exclude some large industrial users whose supply is not regulated. Data for unregulated activities was not included in part because the information is not generally in the public domain and in part because this might diminish the comparability between GDBs. 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 mentioned previously need to be recognised.

5.2.3 Variables used

GDB data used includes: nominal opex; the opex input price index; constant price regulatory asset value; gas throughput; customer numbers; GDB pipeline length; the length of mains that are made of cast iron or unprotected steel; and the number of city gates serving the GDB's network.

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 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) as reported in Economic Insights (2012c). We have used the ABS wage price index (WPI), Electricity, gas, water and waste services (EGWW) sector, for the labour component and a weighted average of five economy–level Producer Price Indexes for the non–labour component. For the New Zealand GDBs the opex price index is a similar weighted average of labour costs and the consumer price index. These opex price indexes were projected forward beyond 2013 based on the average annual growth rate over the five years from 2008 to 2013.

Constant price asset value was calculated using reported historical real regulatory asset base (RAB) values and regulator approved forecasts. Given the relatively one hoss shay physical depreciation characteristics of pipelines, using the constant price depreciated asset value is generally less preferred to using pipeline length as the proxy measure for the capital input quantity. Nevertheless, we use the constant price RAB as a proxy for the quantity of capital in this econometric analysis, rather than a physical proxy such as the kilometres of mains, to avoid multicollinearity problems given that mains length is used in the measurement of the important operating environment factor of customer density.

Table 5.1 summarises the variables used in the opex cost function analysis.

Table 5.1: **Summary of outputs, inputs & business environment variables**

Outputs	Inputs	Operating Environment Factors
Gas throughput (TJ) Customer numbers	Constant price opex Capital services measured by constant price asset value	Customer density (customers/km mains) Network age (proxied by the proportion of total mains length not made of cast iron or unprotected steel) Service area dispersion (proxied by the number of city gates)

Operating environment factors are exogenous influences affecting the cost efficiency of the network which are largely beyond management's control. They include the climate, geography, topography and demography of the GDB's service area. Unless the key operating environment factors are allowed for in the analysis, an inaccurate and misleading estimate of the scope for opex productivity growth and of relative efficiency levels may result because like is not being compared with like. The key operating environment factors which influence an energy distribution business' operating cost levels, and that were included in this study are:

- *Customer density* (customers per kilometre of mains): This variable was included in the Economic Insights (2012a) study. Customer density is largely a product of the degree of urban density in the GDB's reticulated areas and the rate of gas penetration in these areas. The rate of gas penetration is heavily influenced by the coldness of the winter climate which is an important factor in demand for gas for household heating purposes, although other influences such as the prices of alternative heating fuels may also be important.

- *Proportion of cast iron/unprotected steel mains*: Gas networks that are made of cast iron and unprotected steel have higher maintenance requirements because they are subject to corrosion, water ingress and relatively high rates of breakage. The network age proxy variable, the proportion of cast iron/unprotected steel mains, was included for the following reasons. Economic Insights previously expressed reservations with regard to the use of depreciated constant price asset value as a measure of capital inputs because "differences in average asset age will play a role in the resulting capital asset efficiency comparisons" (Economic Insights 2012b, p. 25). Further, it is well established that maintenance requirements may increase with the age of certain types of assets (Diewert 2009). The inclusion of a variable related to asset age is intended to control for effects of these kinds. The proportion of cast iron/unprotected steel mains is correlated with, and effectively a proxy for, the average network age (UMS 2001, p. 28). It is likely to be a more useful variable than average network age because "materials such as PE and cathodically protected steel do not generally exhibit a useful life and may be considered to have an indefinite life if well-constructed and maintained" (Multinet 2012, p. 18). The progressive replacement of cast iron/unprotected steel mains with new mains made with modern materials substitutes capital for non-capital inputs and is a source of reduction in maintenance costs over time. Failing to take into account this source of reduction in maintenance cost would confuse factor substitution with productivity change. It would place at a disadvantage those GDBs that have renewed their former cast iron/unprotected steel networks, and no longer have this as an ongoing source of reducing opex.
- *Service area dispersion:* A measure of network fragmentation, proxied by the number of city gates was also included. Some GDBs have a large number of discrete networks serving smaller cities and townships, whilst others have fewer networks serving larger urban areas. The former will not only have a smaller typical operating scale, but the greater dispersion of the area supplied may reduce the efficiency of work crews that maintain the networks and necessitate more duplication of some inputs than would be the case for a GDB serving a very compact and contiguous area. Similarly, a network that is more 'dendritic' in nature will require more mains to support enough gas flow to service spreadout pockets of consumption compared to a network that is more compact and intermeshed. Failing to allow for this operating environment difference in efficiency comparisons would place the fragmented and dendritic networks at an unreasonable disadvantage and the compact and intermeshed networks at an artificial advantage.

We also tested climate–related variables, particularly measures of the average heating degree days in each region. However, for reasons given above, we considered that customer density takes into account most of the influence of climate on gas distribution networks. That is, the rate of gas penetration in reticulated areas is correlated with the demand for gas for heating. Average gas use per household is also related to climate, but the measure of gas throughput used in this study includes commercial and industrial uses also, which are less weather sensitive. The relative importance of commercial and industrial load differs between networks, and this is an important factor in the comparative levels of throughput per customer. Climate is not a sufficiently significant factor in this sample given that most of its influence is taken into account by the customer density variable.

5.2.4 Key characteristics of included utilities

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. Table 5.2 presents summary data for the GDBs included in the sample for 2012, including outputs, inputs and key operating environment factors.

Table 5.2: **GDBs' key characteristics, 2012**

GDB	Throughput	Customers	Nominal opex	Real Reg. Asset Value
	TJ	no.	$m	$m
Envestra Vic	55,492	576,804	56.9	1,063
Multinet	56,858	669,631	56.7	1,004
SP AusNet	74,707	609,290	46.7	1,213
Envestra SA	22,256	411,199	52.5	1,047
Envestra Qld	6,030	89,098	17.9	324
Allgas Qld	9,897	87,315	17.1	436
JGN	90,877	1,147,291	95.3	2,253
ActewAGL	7,696	123,470	23.1	315
ATCO WA	28,103	640,936	55.0	880
Powerco NZ	9,067	102,696	17.8	367
Vector NZ	21,740	153,585	28.8	440

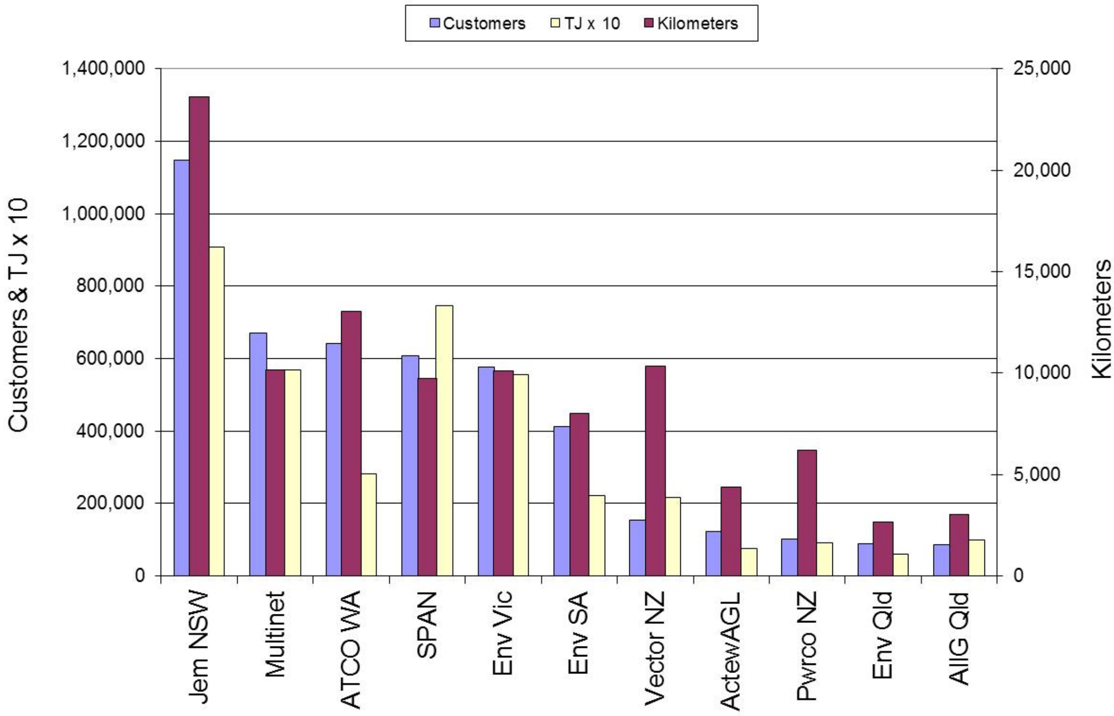
Table 5.2: **GDBs' key characteristics, 2012 (cont'd)**

GDB	Distribution mains length	Customer density	Cast iron/ unprotected steel mains	City Gates
	kms	cust./km	%	no.
Envestra Vic	10,135	56.9	3.7	56
Multinet	10,147	66.0	13.2	6
SP AusNet	9,719	62.7	8.0	38
Envestra SA	8,010	51.3	15.4	16
Envestra Qld	2,643	33.7	8.5	11
Allgas Qld	3,022	28.9	15.7	7
JGN	23,628	48.6	0.6	74
ActewAGL	4,364	28.3	0.0	2
ATCO WA	13,035	49.2	0.2	15
Powerco NZ	6,216	16.5	0.1	36
Vector NZ	10,326	14.9	0.5	63

Source: Economic Insights GDB database

Figure 5.1 shows the comparative sizes of the GDBs in the sample using three different measures of business size. JGN's NSW distribution network is by far the largest of the 11 included GDBs, with the three Victorian GDBs and ATCO in WA being the next largest in terms of customer numbers.

Figure 5.1: **Key measures of GDB size, 2012**



Source: Economic Insights gas utility database

Table 5.2 shows that the three Victorian GDBs have the highest customer density in the sample, in part due to the cool winter climate and associated high gas demand for household area heating. By contrast, the two Queensland GDBs have customer densities that are approximately half the levels of the Victorian utilities, in part due to Queensland's warm winter climate, which reduces the likelihood that households will choose to have reticulated gas supplied to their home. JGN, Envestra SA and ATCO all have customer densities that are between those of the Victorian and Queensland GDBs. In some areas that have cold winter climates, such as New Zealand and the ACT, customer density is comparatively low. This may in part be due to relatively lower urban density. Higher or lower density is largely driven by factors external to the GDB, and if the differing densities are not allowed for in the analysis, the effects of lower density on opex may be incorrectly attributed to comparative inefficiency of those GDBs. The approach of taking customer numbers as an output measure with customer density as separate operating environment variable was used by Pacific Economics Group (2004) and Economic Insights (2012a).

As shown in Table 5.2, five of the GDBs in the sample have significant amounts of cast iron and unprotected steel mains in their networks. These include Multinet and SP Ausnet in Victoria, Envestra SA, and Allgas and Envestra in Queensland. These networks are generally the oldest in the sample. The network that is the newest in the sample – ActewAGL in the ACT – has no cast iron and unprotected steel mains. JGN has only 0.6 per cent of its mains made up of cast iron and unprotected steel due to an AGL replacement program in the 1990s. Where there remains significant amounts of cast iron and unprotected steel mains, and as these mains are replaced with more modern pipeline materials over time, maintenance costs will be progressively reduced due to the substitution of capital for labour. Including this variable in the analysis enables this substitution effect to be separated from the measurement of technical change. Failure to do this would lead to the rate of opex productivity growth being overestimated both historically and in resulting forecasts for future achievable gains.

The three GDBs with the highest number of city gates are JGN, Vector NZ and Envestra Vic. These GDBs supply a large number of regional cities and towns in addition to their main city markets. The three GDBs with the smallest number of city gates are ActewAGL, Multinet and Allgas Qld. These GDBs largely supply metropolitan areas and relatively few regional cities and towns. It is useful to take into account the separate effects on opex of this spatial dimension of network configuration in order to achieve more like–with–like comparisons of fragmented and dendritic networks versus compact and intermeshed networks in efficiency level comparisons and to obtain an unbiased estimate of the rate of technical change.

5.3 Econometric Results

5.3.1 Enhancements and changes relative to Economic Insights (2012a)

In this analysis we have been able to further develop the model presented in Economic Insights (2012a). Specifically:

- The analysis benefits from a larger data sample by including additional observations now available, and recent AER approved forecast values for the Victorian GDBs. The analysis also uses the most up-to-date historical data for JGN drawn from the survey.
- Given the larger number of observations, we can now estimate opex efficiency levels directly within the operating cost function itself rather than indirectly through a total cost function system as done in Economic Insights (2012a). The total cost function method used in Economic Insights (2012a) relied on estimates of opex cost shares to derive implicit forecast opex levels and opex efficiency information. But because information on the goodness–of–fit of individual equations within an equation system is generally less reliable (Berndt, 1990, p. 468), the accuracy of the opex efficiency estimates using that method is less certain. Deriving opex efficiency information directly from the operating cost function provides more information about the goodness–of–fit, and hence confidence in the accuracy of the estimates.
- Additional operating environment factors relating to network age and the dispersion of distribution networks supplied by each GDB have been included in the model.
- Improved econometric methods have been used which enables the relative opex efficiency of GDBs to be directly measured. Two different econometric techniques are used to estimate the preferred opex cost function specification, providing for more

robust forecasting of the rate of change in opex partial productivity while also permitting estimation of comparative opex technical efficiency levels.

5.3.2 Opex cost function specification

The specification shown in equation (5.9) is, by necessity simplified when compared to the full translog specification of the variable cost function discussed in section 5.1.1. The model has two outputs, namely gas throughput and customer numbers, and second order terms for these outputs are included. The opex input price is restricted to have a coefficient of one to ensure homogeneity of degree one in input prices. The constant price asset value was used as the capital quantity proxy and a time trend as the technological change proxy. Second order terms relating to capital inputs were not included.

The model includes three operating environment variables – customer density, the proportion of mains that are not cast iron or unprotected steel (NCI) and the measure of service area dispersion (ie the number of city gates, CG) – which all enter the model in log form.

$$\begin{aligned} \text{(5.9)} \quad \ln C_{OM} = {} & \ln W_{OM} + b_0 + b_D \ln D + b_C \ln C + 0.5 b_{DD} (\ln D \ln D) + b_{DC} (\ln D \ln C) \\ & + 0.5 b_{CC} (\ln C \ln C) + b_{CPAV} \ln CPAV + b_t t + b_{NCI} \ln NCI + b_{CD} \ln CD \\ & + 0.5 b_{CDCD} (\ln CD \ln CD) + b_{CG} \ln CG \end{aligned}$$

5.3.3 Econometric estimation methods & results

Two estimation methods were used for this analysis. The first is the feasible generalised least squares (FGLS) estimator, allowing for heteroscedastic panels. This method was used to estimate the coefficients of equation (5.9), but does not provide estimates of the comparative efficiency of the GDBs. The second method is stochastic frontier analysis (SFA) with time invariant firm-specific inefficiency. These two models, taken together, aim to update the models reported in Economic Insights (2012a) but include more operating environment effects and use improved econometric estimation methods. The SFA model is used to provide estimates of the technical efficiency of each GDB in the sample. It thus advances the model reported in Economic Insights (2012a) to incorporate direct estimation of opex efficiency levels within the operating cost function.

We report, and combine, the results from both the FGLS and SFA methods because each has different assumptions regarding the nature of the stochastic disturbance term (not shown in equation (5.9)) to be assumed when estimating the model. Each has particular advantages that are appropriate to this application.

These two methods and the reasons for their use in this study can be explained as follows. Let ε_{it} represent the stochastic disturbance term included in the variable cost function, where i = 1 …n are panels (or firms) in the sample and t is the year of each observation. The FGLS estimation method used here has the advantage that the variance matrix of the disturbance terms can take the form:

(5.10)
$$E\left[\varepsilon\varepsilon'\right]=\mathbf{\Omega}=\begin{pmatrix}\sigma_1^2 I & \cdots & 0\\ \vdots & \ddots & \vdots\\ 0 & \cdots & \sigma_n^2 I\end{pmatrix}$$

for panels 1 to n, so that the random error term has zero mean across the whole sample, and in each panel of the dataset it has a different variance. This assumption is appropriate in this context because there is wide variation in the sizes of the GDBs in the sample, so the dependent variables, and some of the explanators, are of different orders of magnitude for some GDBs compared to others. So it is reasonable to expect the scale of the variances may also differ. The FGLS estimator is equivalent to maximum likelihood estimation (see: Davidson and MacKinnon 1993, s 9.5; Wooldridge 2002, s 7.6).

The SFA method used here has the advantage that the stochastic disturbance term can be decomposed into a white noise term (v_{it}) and a cross-sectional (firm-specific) strictly positive random term (u_i), which is interpreted as a measure of inefficiency. That is:

(5.11)
$$\varepsilon_{it}=v_{it}+u_i; \quad v_{it}\sim N(0,\sigma_v^2); \quad u_i \sim N^{+}(\mu,\sigma_u^2)$$

The component u_i is positive and distributed according to a truncated normal distribution. It is interpreted as a time invariant firm-specific inefficiency measure (see: Kumbhakar and Lovell 2000; Greene 2008). This method has the advantage that it can be used to estimate the coefficients of equation (5.9) while also providing estimates of the technical efficiency of each GDB in the sample.

Table 5.6: **Opex cost function regression estimates**

FGLS model[1]			SFA model[2]		
Coefficient	Estimate	t–statistic[3]	Coefficient	Estimate	t–statistic[3]
b_0	0.2368755	9.74	b_0	0.1228221	1.72
b_D	0.2491346	4.77	b_D	0.2284355	2.14
b_C	0.2160532	3.05	b_C	0.1709524	1.44
b_{DD}	0.8031134	4.12	b_{DD}	1.1013310	4.62
b_{DC}	-0.4355324	-2.59	b_{DC}	-0.9164218	-4.51
b_{CC}	-0.1410659	-0.96	b_{CC}	0.4772826	2.26
b_{CPAV}	0.3381158	5.08	b_{CPAV}	0.4747325	3.23
b_t	-0.0081894	-3.31	b_t	-0.0088088	-2.86
b_{NCI}	-0.3816269	-2.97	b_{NCI}	-0.2370862	-0.95
b_{GT}	0.0105180	0.96	b_{GT}	0.0661678	1.64
b_{CD}	-0.4070233	-4.50	b_{CD}	-0.8392710	-6.37
b_{CDCD}	-0.5964261	-3.87	b_{CDCD}	-1.3405460	-5.68

1 R^2 between observed and predicted is 0.95.
2 R^2 between observed and predicted is 0.97.
3 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.

The results of estimating these two models are shown in table 5.6. In both cases the estimated model has the same variables in the form shown in equation (5.9). Where a variable is significantly different from zero in one model (at least to a 90 per cent level of confidence), but insignificant in the other model, the variable has been retained in both models. Differences in the models are then entirely due to the different estimation methods. Taken together, these two estimated models provide a suitable representation of the opex cost drivers of GDBs, and together provide a robust basis for forecasting partial productivity. The two models provide similar estimates of opex partial productivity growth under different assumptions relating to the stochastic process. Each model has merit with neither model preferred over the other, and it is appropriate to take the average of the two sets of results for use in the opex rate of change analysis. This approach was used in previous analysis of this kind by Economic Insights (2012a, p. 23) and the same approach is followed in this report.

5.3.4 Discussion of parameter values

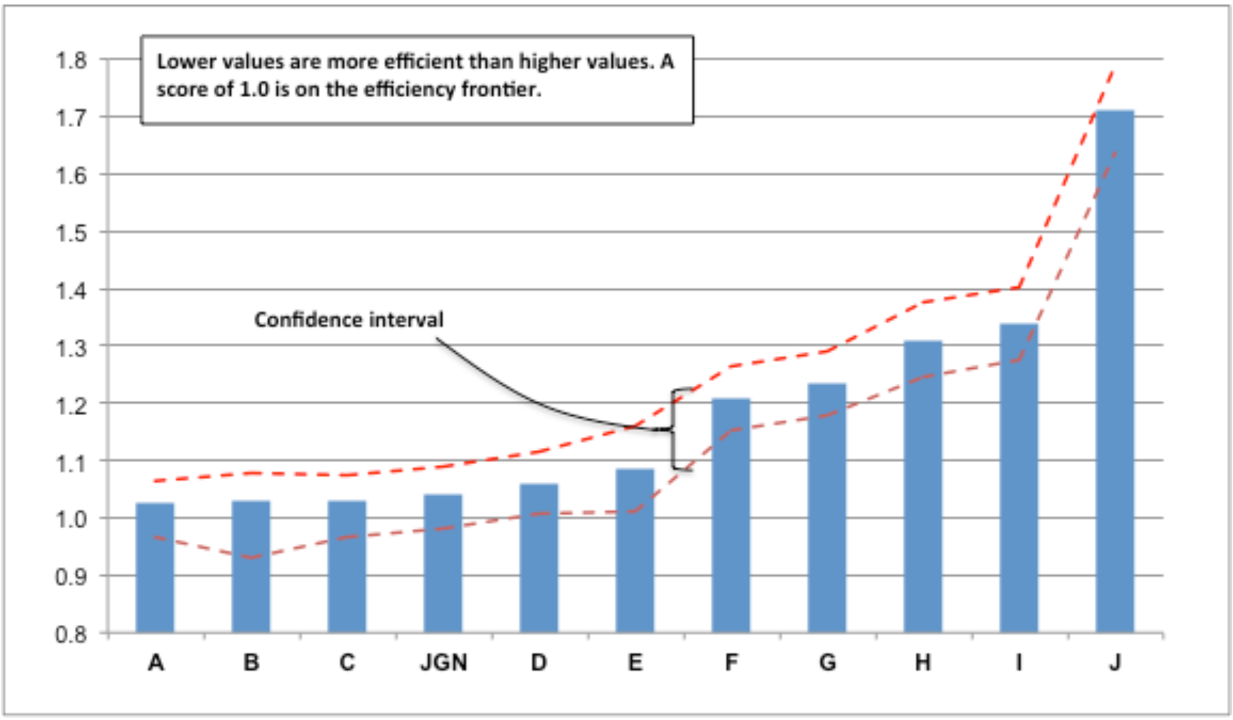
GDBs are found to have strong economies of scale in regard to opex, as indicated by the sum of the elasticities of opex with respect to gas deliveries and customer numbers ($b_D + b_C$). In the first model this is equal to: (0.249 + 0.216 =) 0.465, and in the second model it i:s (0.228 + 0.171 =) 0.399. This means a one per cent proportionate increase in outputs results in an opex increase of less than half of one per cent.

The negative values of the coefficient b_{NCI} , which is the elasticity of opex with respect to changes in the percentage of mains that are not cast iron or unprotected steel, indicates that opex decreases when cast iron mains are replaced with PE or PVC mains. The positive values of the coefficients b_{GT}, which measures the elasticity of opex with respect to changes in the fragmentation of the networks supplied by a GDB, indicates that opex will be higher for networks that are more fragmented. The negative values on the elasticity of opex with respect to changes in customer density, b_{CD}, indicates that opex decreases significantly with increased network density, all other things remaining constant. These effects are all consistent with prior expectations.

5.3.4 Estimates of opex cost efficiency

Having estimated the operating cost function model, we can now proceed to examine the comparative efficiency of each of the included GDBs with respect to opex. The stochastic frontier model produces estimates of the opex cost inefficiency of each GDB in the sample. They are shown in Figure 5.2 plotted in rank order from highest efficiency (where the inefficiency measure is close to one) to lowest efficiency (where the inefficiency measure is significantly higher than one). None of the GDBs are identified except for JGN. The other GDBs are identified only by the letters A, B, C, etc. From figure 5.2 we can see that JGN is among a group of four GDBs that are close to the opex cost efficiency frontier, after taking into account the largely exogenous operating environment effects. The 95 per cent confidence interval shown in figure 5.2 indicates that JGN's estimated opex cost efficiency was not significantly different from the other three or four GDBs that are close to the efficiency frontier. Furthermore, JGN's opex efficiency is not statistically different from the efficiency frontier level.

Figure 5.2 **Opex cost function – comparative cost inefficiency (per cent)***
All GDBs in Sample – showing 95 per cent confidence interval



Source: Economic Insights estimates

5.4 Forecasting JGN's Opex Partial Productivity

In table 5.7, the parameter estimates reported in table 5.6 are combined with JGN's 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 the method previously discussed (see section 5.1.2). In calculating the effects of changes in the included operating environment factors, it has been assumed there is no change in the number of city gates, and we have made estimates of the future rate of change of the proportion of mains that are not cast iron or unprotected steel by extrapolating past rates of change. The resulting estimates of the average opex partial productivity growth rate for JGN for the next period regulatory period are 0.90 per cent, using the FGLS model, and 1.15 per cent using the SFA model, as shown in the last row of Table 5.7. Following the approach adopted in Economic Insights (2012a), our preferred estimate of the opex partial productivity growth over the period from 2015 to 2020 is the average of these two estimates, which is 1.03 per cent per year. Technical change is the main source of improvement in opex partial productivity. The effect of economies of scale has a smaller complementary effect.

Table 5.7: **Opex cost function partial productivity forecasts – Average 2016 to 2020**

	FGLS model	SFA model	Average
1) Model's estimated cost elasticities			
Energy	0.2491*	0.2284**	
Customers	0.2161*	0.1710**	
Customer density	-0.4070	-0.8393	
Capital (constant price asset value)	0.3381	0.4747	
Technology	-0.0082	-0.0088	
Non-cast iron mains	-0.3816	-0.2371	
Network fragmentation	0.0105	0.0662	
2) JGN's forecast driver growth rates (2015-2020)			
Energy	-1.00%	-1.00%	
Customers	2.35%	2.35%	
Weighted Average Output Growth	0.56%*	0.44%**	
Customer density	1.22%	1.22%	
Capital (constant price RAB)	2.17%	2.17%	
Non-cast iron mains	0.05%	0.05%	
Network fragmentation	0.00%	0.00%	
3) PP Opex Growth Rates Forecast			
Technology (A)	0.82%	0.88%	
Returns to Scale (B)	0.30%	0.26%	
Operating environment factors (C)	0.21%	-0.01%	
PP Opex Growth Rates (=A+B–C)	*0.90%*	*1.15%*	*1.03%*

Sources: JGN forecasts and Economic Insights estimates
* The implied proportionate cost-elasticity weights in the FGLS model are 53.6% for energy and 46.4% for customers.
** The implied proportionate cost-elasticity weights in the SFA model are 57.2% for energy and 42.8% for customers.

The opex partial productivity growth rate presented in table 5.7 is an average for a five year forecast period. This forecast can be broken down into separate years, as shown in table 5.8 for both the FGLS and SFA models. It shows that a large decline in demand is forecast in 2014-15, the year before the five year period ending 2019-20. This, together with strong capital growth in the same year, is anticipated to lead to negative opex partial productivity growth in that year. Partial productivity is forecast to return to trend rates by 2016-17.

5.4 Method of Applying Opex PP Growth Rates

It remains to explain how the opex PFP results in Table 5.8 can be used to forecast real opex. Using the 'Δ' symbol to stand for 'the rate of change in' (or difference in logs), the formula for the opex rate of change can be stated as (Economic Insights, 2012d, p. 3):

(5.12) $\Delta\text{Real Opex} = \Delta\text{Real Opex Price} - \Delta\text{Opex Partial Productivity} + \Delta\text{Output Quantity}$

The rate of change in opex is equal to the rate of change in an index of opex prices less the opex partial productivity growth rate plus the rate of change in an index of output quantities.

Table 5.8: **Annual opex partial productivity forecasts, 2015–2020**

Year	*2014-15*	*2015-16*	*2016-17*	*2017-18*	*2018-19*	*2019-20*
JGN's forecast driver growth rates (2015-2020):						
Energy	-8.90%	-2.01%	-0.73%	-0.86%	-0.80%	-0.58%
Customers	2.39%	2.46%	2.53%	2.38%	2.23%	2.17%
Customer density	1.35%	1.31%	1.35%	1.27%	1.15%	1.04%
Capital (constant price RAB)	4.29%	3.56%	2.45%	2.40%	1.39%	1.03%
Non-Cast iron Mains	0.05%	0.05%	0.05%	0.05%	0.05%	0.05%
Network fragmentation	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
PP Opex Growth Rates Forecast – FGLS model						
Technology (A)	0.82%	0.82%	0.82%	0.82%	0.82%	0.82%
Returns to Scale (B)	-1.95%	0.03%	0.42%	0.34%	0.33%	0.37%
Operating environment (C)	0.88%	0.65%	0.26%	0.27%	-0.02%	-0.09%
PP Opex Growth Rates	*-2.02%*	*0.20%*	*0.98%*	*0.89%*	*1.16%*	*1.28%*
PP Opex Growth Rates Forecast – SFA model						
Technology (A)	0.88%	0.88%	0.88%	0.88%	0.88%	0.88%
Returns to Scale (B)	-2.44%	-0.06%	0.40%	0.31%	0.30%	0.36%
Operating environment (C)	0.89%	0.58%	0.02%	0.06%	-0.32%	-0.40%
PP Opex Growth Rates	*-2.45%*	*0.24%*	*1.26%*	*1.14%*	*1.50%*	*1.63%*
Avg PP Opex Growth Rate	***-2.23%***	***0.22%***	***1.12%***	***1.01%***	***1.33%***	***1.46%***

Source: JGN forecasts and Economic Insights estimates

The weights for the output index are given in the notes to table 5.7, and are derived from the estimated elasticities of cost with respect to each output shown in the same table. The FGLS and SFA models each have different estimated elasticities with respect to the two outputs, and different weights. The appropriate output index to use in equation (5.12) is the average of the two output indexes associated with the FGLS and SFA models.

Ideally, the forecast opex price index would have a broadly similar construction to the opex price index used in the variable cost function, which was described in section 5.2.1. The WPI index for the labour component of opex prices has been used in the opex price index (as with previous Economic Insights studies of GDB productivity). Note that here real opex excludes unaccounted for gas.

5.5 Summary Conclusions

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

- JGN is among the most efficient of the GDBs in terms of opex cost efficiency, when the effects of scale, customer density, network age and network fragmentation are taken into account and its opex efficiency is not statistically different from the efficient frontier level;
- JGN's forecast average annual opex partial productivity growth rate over the period 2015-16 to 2019-20 is 1.03 per cent.

6 CONCLUSIONS

This report has sought to:

- examine JGN's TFP and opex PFP performance over the last 15 years
- assess the relative efficiency of JGN's opex, and
- forecast JGN's achievable opex productivity growth over the next regulatory period given forecast output and capital input levels and important operating environment factors.

JGN's TFP grew at an average annual rate of 1.2 per cent between 1999 and 2011, but taken over the period to 2013, the average is 1.0 per cent due to productivity reductions in 2011 and 2012. JGN resumed TFP growth in 2013. JGN's TFP growth over the period 1999 to 2011 was at a similar rate to those of Multinet and Envestra SA, although Envestra Vic and SP AusNet both achieved average TFP growth rates of over 2 per cent over the same period.

The main source of TFP growth for most GDBs over this period was strong growth in opex partial productivity in the period from 1999 to 2006. JGN had the equal highest growth rate of opex partial productivity over this period. For most GDBs, this source of productivity gain was considerably more modest in the period from 2006 to 2011.

JGN has had the highest or second highest level of opex multilateral partial productivity for the last 15 years, exceeded only by SP AusNet in 2010 and 2011. JGN's opex partial productivity increased by over 80 per cent over this period. JGN has had similar capital multilateral partial productivity levels to Multinet and SP AusNet over the last decade but lower than those of Envestra Vic and Envestra SA. Looking at the overall productivity result, JGN has had similar multilateral TFP levels to SP AusNet and Multinet since around 2005.

The index number analysis thus shows JGN to have been a good performer in terms of both opex partial productivity levels and growth rates. And it has had similar TFP levels to two of the three Victorian GDBs for the last decade.

To assess JGN's opex efficiency levels and forecast its achievable opex productivity growth for the next regulatory period, we have used an operating cost function model similar to that reported in Economic Insights (2012a). The operating cost function model presented here contains several advances compared to our earlier study. In particular, two additional operating environment factors – network age and network fragmentation – are included and the larger number of observations now available has enabled us to directly estimate GDB opex efficiency levels using a stochastic frontier model.

JGN is found to be among the most efficient of the GDBs in terms of opex cost efficiency when the effects of scale, customer density, network age and network fragmentation are taken into account. Its opex efficiency is not statistically different from the efficient frontier level.

JGN's forecast average annual opex partial productivity growth rate over the period 2015-16 to 2019-20 is 1.03 per cent when returns to scale, the impact of operating environment factors and technical change are allowed for.

APPENDIX A: GDBS INCLUDED IN THE STUDY

The database used for the econometric analysis in Part C of this report includes 9 Australian GDBs and 2 New Zealand GDBs and uses public domain information to the maximum extent possible. The database used for the index analysis in Part B does not include all of these GDBs (see Table 3.1) and is based on survey information collected directly from the relevant GDBs. A brief summary of the operations of the included GDBs follows.

A.1 Australian GDBs

ActewAGL, Australian Capital Territory

ActewAGL Distribution is the distribution business supplying gas and electricity in the Australian Capital Territory (ACT), which is jointly owned by the ACT Government and SGSP (Australia) Assets Pty Ltd.[16] The total population of the ACT in 2013 was 383,000. Gas is distributed to a predominantly residential customer base with Canberra the largest market. Outside the ACT ActewAGL supplies gas to Queenbeyan and Bungendore in NSW. There are few industrial users of any significance in its supply area. 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 than a single sided system with longer cross-road service connection. For these reasons it is a low density distribution network when measured in terms of customers per kilometre of main.

In 2012 ActewAGL supplied 123,470 customers with 7,696 TJ of gas from a distribution network of around 4,364 kilometres of mains.

Allgas Energy Pty Ltd (Allgas), Queensland

Allgas is owned by Marubeni Corporation, RREEF and the APA Group. It 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 June 2011 southeast Queensland's population was around 3,178,000. More than 70 per cent of Allgas' gas demand is from around 100 large demand class customers.

In 2012 Allgas supplied 87,315 customers with 9,897 TJ of gas from a distribution network of 3,022 kilometres of mains.

[16] ActewAGL Distribution is a related entity to ACTEWAGL Retail, which is owned equally by ACTEW Corporation and AGL Energy

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, including the greater Perth Metropolitan region (including Busselton and Bunbury), Geraldton, Kalgoorlie and the Albany region, each with separate gas distribution networks (Albany is supplied with reticulated LPG).

In 2012, ATCO supplied 640,936 customers with 28,103 TJ of gas from a distribution network of 13,035 kilometres of mains.

Envestra Queensland, Queensland

Envestra Queensland is an operating division of Envestra Limited, a publicly listed gas distribution business. 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, Gladstone and Bundaberg).

The network consists of 2,643 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 2012 there were 89,098 customers consuming 6,030 TJ of gas.

Envestra SA, South Australia

Envestra SA's distribution network services: greater Adelaide; to the north-east of Adelaide, the Barossa Valley, Riverland and Mildura in Victoria; to the north, Peterborough, Port Pirie and Whyalla; and in the east and south-east regions, Murray Bridge and Mt Gambier. Adelaide's population in 2011 was 1.23 million. As with Melbourne, Adelaide's winter climate is conducive to relatively high residential gas demand for heating.

In 2012, Envestra SA supplied 411,199 customers with 22,256 TJ of gas from a distribution network of 8,010 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 greater Melbourne metropolitan area (population of 4.25 million in 2012) including the northern suburbs, the Mornington Peninsula and Pakenham/Cranbourne. Envestra Victoria also supplies the north central Victorian area (including Seymour, Wodonga, Wangaratta, Shepparton-Mooropna and Echuca among others). It also supplies rural townships and cities in the Gippsland region (including Bunyip, Drouin, Warragul, Traralgon, Morwell and Sale among others), and a number of outlying towns in East Gippsland 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 2012 there were 553,604 residential customers and 23,200 non–residential customers.

In 2012, Envestra Victoria supplied its 576,804 customers with 56,492 TJ of gas from a distribution network of 10,135 kilometres of mains.

Jemena Gas Networks, NSW

JGN was formed from the sale of Alinta Ltd in 2007, Alinta itself having acquired the gas assets of AGL Gas Networks (AGLGN) in 2006. It is now co-owned by State Grid Corporation of China and Singapore Power. The JGN network provides gas to more than 1,170,000 customers in Sydney, Newcastle, Wollongong and the Central Coast, and over 20 country centres including those within the Central Tablelands, Central West, Southern Tablelands and Riverina regions of NSW.

Jemena has the largest distribution network and customer base of the Australian GDBs. In 2012 JGN supplied 90,877 TJ of gas from a distribution network of 23,628 kilometres of mains.

Multinet Gas, Victoria

Multinet is owned by the DUET Group, an ASX-listed energy infrastructure business. 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 comparatively recent extensions of supply to townships in the Yarra Valley and South Gippsland. In 2012 there were 652,931 residential customers and 16,700 non–residential customers.

In 2010, Multinet supplied its 669,631 customers with 56,858 TJ of gas from a distribution network of 10,147 kilometres of mains. Multinet has the highest customer density per kilometre of mains of the Australasian GDBs (66 customers per km of main).

SP AusNet, Victoria

SP AusNet's Victorian gas distribution business was formerly TXU networks which was formerly Westar (Assets) Pty Ltd, and is now part of the SP AusNet Group, an ASX-listed business. The SP AusNet gas distribution business delivers gas to over 600,000 customers across a geographically diverse region spanning the western half of Victoria, including the Western part of Melbourne, from the Hume highway in metropolitan Melbourne west to the South Australian border and from the southern coast to Horsham and just north of Bendigo. Its supply area includes the major Victorian regional centres of Geelong, Ballarat and Bendigo, and many other cities and towns in western Victoria. In 2012 there were 593,218 residential customers and 16,072 non–residential customers.

In 2012, SP AusNet supplied its 609,290 customers with 74,707 TJ of gas from a distribution network of 9,719 kilometres of mains.

A.2 New Zealand GDBs

The New Zealand gas distribution industry is generally less mature than Victoria's with penetration rates still increasing relatively quickly, but comparatively low customer density at present.

Powerco Limited

Powerco is based in New Plymouth (population 53,400 in 2013) and distributes gas in the central and lower North Island regions. It is a dual gas and electricity network business. Powerco's gas networks in the central North Island region include the Taranaki (including New Plymouth), Manawatu and Horowhenua (including Palmerston North, population 83,800), and Hawkes Bay networks (including Napier-Hastings, population 125,300). In the lower North Island it supplies Wellington City (population of 203,100), Hutt Valley (estimated population 141,700) and Porirua (district population of 53,100). Powerco acquired part of UnitedNetworks' gas operations in 2002 comprising the Hawkes Bay, Wellington, Horowhenua and Manawatu networks.

In 2012, Powerco supplied its 102,696 customers with 9,067 TJ of gas from a distribution network of 6,216 kilometres of mains.

Vector Ltd

Vector Ltd operates the gas distribution network in Auckland (estimated population of 1,418,000 including North Shore City, and the urban parts of Waitakere and Manukau cities) 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. In 2012, Vector supplied 153,585 gas distribution customers with 21,740 TJ of gas from a distribution network of 10,326 kilometres of mains.

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.

APPENDIX B: PAST GDB EFFICIENCY & TFP STUDIES

There have been several studies undertaken previously of gas pipeline efficiency performance in Australasia. These include Bureau of Industry Economics (1994), IPART (1999), Pacific Economics Group (2001), Lawrence (2004a, 2004b, 2007a), Pacific Economics Group (2008), Economic Insights (2009, 2010, 2012a, 2012b, 2012c).

Bureau of Industry Economics (1994)

While now somewhat dated, the Bureau of Industry Economics (BIE 1994) international benchmarking study was the first major comparative study of gas supply performance in Australia. It compared prices and technical efficiency of 42 utilities including five Australian utilities, 23 US utilities, nine Canadian utilities, four Japanese utilities and one UK utility. Technical efficiency was calculated using the quantity only version of data envelopment analysis (DEA) using energy deliveries and customer numbers as the outputs, employee numbers, distribution kilometres of mains and transmission kilometres of mains as the inputs and the number of degree days and customer density (customers per kilometre of main) as operating environment variables.

The BIE noted that input coverage was likely to be somewhat inconsistent due to varying amounts of contracting out between utilities and the unavailability of data on operating and maintenance expenses. No account was able to be taken of differences in pipeline age and construction methods (eg cast iron versus polyethylene).

IPART (1999)

In 1999, the New South Wales Independent Pricing and Regulatory Tribunal (IPART) published a research paper titled *Benchmarking the Efficiency of Australian Gas Distributors*. Eight Australian distributors were benchmarked against a sample of 51 US local distribution companies (LDCs) using the quantity only version of data envelopment analysis. Sensitivity testing of the DEA efficiency scores against efficiency scores derived from stochastic frontier analysis (SFA) and corrected ordinary least squares (COLS) was also undertaken.

The outputs included in the study were energy deliveries (in terajoules), residential customer numbers, the number of non–residential customers and the reciprocal of unaccounted for gas. The inputs included were the length of mains in kilometres and operating and maintenance expenditure. The number of heating degree–days and the age of the network were included as operating environment variables in a second stage Tobit regression.

The Australian distributors were found to be around 27 per cent behind best practice on average. The Victorian distributor Multinet was found to achieve best practice while the least efficient of the Australian distributors was AGLGN (ACT) (the forerunner of ActewAGL) at 58 per cent behind best practice. IPART found that neither of its included operating environment variables of climate and density were statistically significant. It rationalised the climate result by stating that the higher demand for gas in the northern hemisphere is likely to be offset by higher input requirements to deal with the adverse conditions.

Pacific Economics Group (2001a, 2001b, 2001c)

In 2001 Pacific Economics Group (PEG) benchmarked the Australian gas distribution operations of three Victorian utilities – Multinet (United Energy), TXU, and Envestra Victoria (2001a, 2001b, 2001c) – against its database of US gas utilities. The variables included in the analyses were:

- Number of gas delivery customers (outputs);
- Total gas throughput (outputs);
- Operation and maintenance (O&M) expenses (inputs);
- Value of plant (inputs);
- Labour costs (inputs);
- Percentage of distribution miles in total distribution and transmission miles (operating environment);
- Percentage of distribution mains that are cast iron (operating environment);
- Percentage of electricity distribution capital in the gross value of distribution plant (operating environment); and
- Percentage of sales volume to non–industrial users (operating environment).

PEG benchmarked the O&M cost performance of the Australian gas distributors against those of 43 distributors in the United States using a translog econometric cost function. PEG uses standard regression techniques to compare the O&M actual cost for the utility in question with that predicted by the model. The model predicted O&M cost is that for an average utility after adjusting for the included operating environment conditions.

PEG found that Multinet's actual O&M cost was nearly 50 per cent below the model's point prediction making Multinet a superior performer compared to the sample of US utilities. Similarly, Envestra Victoria's and TXU Networks' actual O&M costs were 34 per cent and 28 per cent, respectively, below the model's predictions.

Lawrence (2004a)

Denis Lawrence undertook a comparative benchmarking study of Australian and New Zealand gas transmission and distribution pipeline businesses for the New Zealand Commerce Commission using data sourced from New Zealand and Australian regulatory data. The study used the multilateral TFP index method applied to 2003 data to obtain a snapshot of comparative performance. Cost efficiency comparisons were presented for 10 Australian and four New Zealand GDBs. The distribution model contained two outputs (throughput and customer numbers) and two inputs (operating and maintenance expenditure and capital measured by kilometres of main).

Undertaking proxy adjustments for both customer and energy density differences led to the productivity levels of the New Zealand GDBs being found to be around 21 per cent behind those of the Australian GDBs. The three Victorian GDBs were among the most efficient performers after allowing for operating environment differences.

Lawrence (2004b)

The Commerce Commission also engaged Denis Lawrence to undertake an analysis of the rate of TFP growth in New Zealand's gas distribution networks. Changes in the structure of the New Zealand distribution industry in recent years, particularly the splitting up of UnitedNetworks' gas distribution operations between Powerco and Vector, made it difficult to obtain consistent data through time. Only data for NGC Distribution (which has subsequently been taken over by Vector) was available for any length of time on a consistent basis.

The distribution TFP model again contained two outputs (throughput and customer numbers) and two inputs (operating and maintenance expenditure and capital measured by kilometres of main). For the 7 year period from 1997 to 2003 NGC Distribution's TFP increased at a relatively high trend annual rate of 2.8 per cent. For the 12 year period from 1997 to 2008 (ie including forecast data from 2004 onwards) the trend annual rate of TFP increase was still relatively high at 2.5 per cent. Based on forecast strong increases in NGC Distribution's customer density, it was expected, all else equal, that the New Zealand GDBs would enjoy relatively high TFP growth.

Lawrence (2007a)

The three Victorian GDBs commissioned Denis Lawrence to examine the total factor productivity (TFP) performance of the Victorian gas distribution industry. The study concentrated on performance in the post privatisation period from 1998 to 2006 and also presented forecasts of TFP performance for the period 2007 to 2012 based on the GDBs' forecasts of expected changes in their outputs and inputs over this period.

The study contained a number of advances for gas distribution TFP measurement. In conjunction with the GDBs' engineers Lawrence developed a measure of system capacity to supplement the standard output measures of throughput and customer numbers. He also included 7 capital input components and presented a range of sensitivity analyses of alternative output and input specifications to assess the influence of specification changes on the results.

The first major finding of this study was that the Victorian gas distribution industry had exhibited strong TFP growth over the 9 years following privatisation. TFP grew at an average annual rate of 2.7 per cent. Envestra and Multinet achieved average annual TFP growth rates of around 3 per cent while SP AusNet achieved around 2.3 per cent.

Most of the high TFP growth rate had been achieved by reductions in GDB operating and maintenance expenditure (opex) which fell by 4 per cent annually in constant price terms. All three GDBs achieved average annual opex partial productivity growth rates in excess of 6 per cent for the previous 9 years. Capital partial productivity growth, on the other hand, had been relatively flat as the GDBs continued expanding their pipeline networks and replacing low pressure mains with high pressure mains.

The second key finding of the study was that GDB productivity growth was expected to flatten over the 6 years from 2006 onwards based on forecasts of GDB outputs and inputs. The combination of the convergence effect (whereby productivity growth becomes constrained by the rate of technological change in the industry once all identifiable inefficiencies are removed) and anticipated changes to the safety and compliance requirements facing GDBs were expected to reduce annual TFP growth to around 0.1 per cent going forward. The scope to further reduce opex was expected to be limited and opex partial productivity growth was forecast to reverse and decline by around 0.3 per cent per annum.

Lawrence (2007a) also examined productivity levels as well as growth rates and found that the three GDBs all started from a similar productivity level in 1998. The similar starting productivity levels were not surprising given that the three GDBs all came out of the one predecessor organisation and all operated in suburban Melbourne.

Pacific Economics Group (2008)

PEG (2008) calculated the TFP trend for Victoria's GDBs using a less detailed model than Lawrence (2007a) with three outputs and two inputs. The sample period was 1998 to 2007. PEG estimated that TFP for Victoria's gas distribution industry grew at an average annual rate of 2.9 per cent over the 1998 to 2007 period. Output quantity grew at an average rate of 1.1 per cent per annum while input quantity was reported to have declined at 1.8 per cent per annum over the same period.

Economic Insights (2009)

Economic Insights (2009) extended the Lawrence (2007a) TFP study of the three Victorian GDBs to include data for JGN's NSW distribution system. Given JGN's inclusion of relatively more transmission–equivalent trunk and primary pipelines in its distribution business given its geographic coverage, a number of adjustments were made to the functional coverage of JGN's data to ensure more like–with–like comparisons. The results of this study indicated that overall JGN was a relatively efficient performer compared to the three Victorian GDBs.

Economic Insights (2010)

Economic Insights (2010) further extended the Economic Insights (2009) TFP study of the three Victorian GDBs and JGN's NSW distribution system to include data for Envestra SA and Envestra Qld. The results of this study indicated that Envestra SA performs relatively well by almost matching the performance of the larger included GDBs. Taking the differences in network density and size into account, the results of this study indicated that Envestra SA is likely to be a relatively efficient performer.

Economic Insights (2012a)

SP AusNet commissioned Economic Insights to assess the efficiency of its gas distribution business (GDB) within a statistical framework taking opex and capital input trade–offs and business conditions into account. The study also forecast SP AusNet's future GDB opex partial productivity growth rate.

Econometric estimates of total cost function and operating cost function parameters were developed using data for 9 Australian GDBs and 2 New Zealand GDBs. The estimated total cost function parameters were used to form predicted total costs and opex, which were compared with actual total costs and opex in assessing overall and opex efficiency respectively. The estimated operating cost function parameters were combined with forecasts of output and capital input levels to form forecasts of future opex partial productivity growth.

In the total cost function efficiency analysis, customer density and energy density were found to be significant operating environment factors that influenced GDB total costs. SP AusNet was found to be the best overall cost efficiency performer compared to its peers when scale, customer density and energy density effects. It also had the best opex cost efficiency, with actual opex cost being 38.4 per cent less than the model's prediction in 2010.

Two opex cost function models were estimated. One model predicted that technological change would lead to a 0.6 per cent increase in annual forecast opex partial productivity growth for both SP AusNet and Multinet (a close peer). The other model predicted that partial opex productivity would increase at an annual rate of 1.1 per cent for SP AusNet and 0.9 per cent for Multinet. These results were averaged to yield a forecast opex partial productivity growth rate of 0.8 per cent for both SP AusNet and Multinet.

Economic Insights (2012b)

Economic Insights was engaged by the three Victorian gas distribution businesses (GDBs) – Envestra Victoria, Multinet and SP AusNet – to compare their efficiency performance of over the period 1999–2010 within a group of 11 Australian GDBs and 3 New Zealand GDBs. This report uses a range of partial productivity performance indicators to compare the opex and capital input efficiency performance of these businesses with one another. It also assessed the efficiency of each GDB's performance by comparing their cost outcomes.

The study noted that while partial productivity indicators are relatively easy to construct and understand, care needs to be exercised in interpreting the partial performance indicator results. To gain an indication of overall relative performance, the partial indicators need to be considered together and jointly with key operating environment indicators. Using this approach, the Victorian GDBs were found to have performed well on most indicators. Opex efficiency was been particularly strong considering that the Victorian GDBs had older systems and higher proportions of cast iron and other low pressure mains.

Some of the indicator growth rates observed in the first half of the period in the immediate aftermath of reform and ownership changes were found to have slowed in the second half of the period as cost reductions become progressively harder to achieve after these initial gains are made. Future growth rates of key indicators were expected to reflect the generally lower average growth rates of the more recent period due to a 'convergence' effect.

Economic Insights (2012c)

The three Victorian gas distribution businesses (GDBs) commissioned Economic Insights to examine their total factor productivity (TFP) and partial factor productivity (PFP) performance, and to compare their productivity levels with JGN, Envestra SA and Envestra Qld using multilateral index analysis.

The Victorian gas distribution industry as a whole has exhibited relatively continuous TFP growth over the 13 years covered in the study, with the annual TFP growth rate averaging 1.7 per cent for the 10 years to 2011. However, the rate of TFP growth slowed in the latter part of this period. TFP growth was been driven largely by significant reductions in opex. The three

Victorian utilities showed quite different TFP trends with average annual TFP growth rates of 2.2 per cent for Envestra Vic, 0.8 per cent for Multinet and 2.4 per cent for SP AusNet, over the 10 years ending 2011.

The multilateral TFP analysis suggested that the three Victorian GDBs together with JGN had comparable rates of TFP growth in the period up to 2009, with average annual TFP growth rates in the range 1.8 to 2.4 per cent. The smaller Envestra SA a lower TFP growth rate of 1.4 per cent, still very reasonable. Turning to productivity levels, JGN and SP AusNet achieved the highest opex partial productivity levels in 2009, followed by Multinet and Envestra Victoria. In terms of capital multilateral partial productivity levels, Envestra Victoria is the best performer followed by Envestra SA and then Multinet, SP AusNet and JGN which all had similar capital productivity performance. The overall conclusion from the multilateral productivity index analysis was that the Victorian GDBs were operating efficiently.

ATTACHMENT A: TERMS OF REFERENCE

Expert Terms of Reference – productivity study

Jemena Gas Networks
2015-20 Access Arrangement Review

AA15-570-0041

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Contents

1 Background

Jemena Gas Networks (NSW) Ltd (**JGN**) is the principal gas distribution service provider in New South Wales. JGN owns more than 25,000 kilometres of natural gas distribution system, delivering approximately 100 petajoules of natural gas per annum to over one million homes, businesses and large industrial consumers across NSW.

JGN is currently preparing its revised Access Arrangement (**AA**) proposal with supporting information for the consideration of the Australian Energy Regulator (**AER**). The revised AA will cover the period 1 July 2015 to 30 June 2020 (July to June financial years). JGN must submit its revised AA proposal to the AER by 30 June 2014.

When considering JGN's revised AA proposal, the AER must have regard to the National Gas Objective, which is:

> "to promote efficient investment in, and efficient operation and use of, natural gas services for the long term interests of consumers of natural gas with respect to price, quality, safety, reliability and security of supply of natural gas."

The AER may also take into account the pricing principles in section 24(2) of the National Gas Law, and must do so when considering whether to approve a reference tariff:

> A service provider should be provided with a reasonable opportunity to recover at least the efficient costs the service provider incurs in—
>
> a) providing reference services; and
>
> b) complying with a regulatory obligation or requirement or making a regulatory payment.

Rule 72 of the National Gas Rules provides that, amongst other things, the supporting information to be submitted with a full AA proposal (**AA Information**) must include forecasts of both conforming capital and operating expenditure over the AA period, and the basis for these forecasts.

Some of the key rules that JGN must comply with in submitting its revised AA proposal are set out below.

Rule 74 of the National Gas Rules:

(1) Information in the nature of a forecast or estimate must be supported by a statement of the basis of the forecast or estimate.

(2) 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.

Rule 79 of the National Gas Rules:

(1) Conforming capital expenditure is capital expenditure that conforms with the following criteria:

(a) the capital expenditure must be such as would be incurred by a prudent service provider acting efficiently, in accordance with accepted good industry practice, to achieve the lowest sustainable cost of providing services;

(b) the capital expenditure must be justifiable on the ground stated in subrule (2).

(2) Capital expenditure is justifiable if:

(a) the overall economic value of the expenditure is positive; or

(b) the present value of the expected incremental revenue to be generated as a result of the expenditure exceeds the present value of the capital expenditure; or

(c) the capital expenditure is necessary:

(i) to maintain and improve the safety of services; or

(ii) to maintain the integrity of services; or

(iii) to comply with a regulatory obligation or requirement; or

(iv) to maintain the service provider's capacity to meet levels of demand for services existing at the time the capital expenditure is incurred (as distinct from projected demand that is dependent on an expansion of pipeline capacity); or

(d) the capital expenditure is an aggregate amount divisible into 2 parts, one referable to incremental services and the other referable to a purpose referred to in paragraph (c), and the former is justifiable under paragraph (b) and the latter under paragraph (c).

Rule 91(1) of the National Gas Rules:

Operating expenditure must be such as would be incurred by a prudent service provider acting efficiently, in accordance with accepted good industry practice, to achieve the lowest sustainable cost of delivering pipeline services.

Accordingly, JGN seeks the independent opinion of Economic Insights Pty Ltd, as a suitably qualified expert (**Expert**) on efficiency measurement and benchmarking in the gas distribution sector, as outlined below. This opinion will assist JGN to develop and justify the expenditure forecasts to be included in its revised AA proposal.

2 Scope of Work

The Expert is to provide an expert report detailing:

a) its analysis of time series and multilateral total factor productivity (**TFP**) estimates and partial factor productivity (**PFP**) estimates, where that analysis is to be suitable for comparing JGN's productivity level and productivity growth rate performance with the Victorian, South Australian and Queensland gas distribution businesses (**GDBs**) for which similar analysis has previously been undertaken; and

b) its estimate of the opex cost function and forecast opex partial productivity growth rate for JGN, in a form that is suitable for incorporation into the rate of change approach for forecasting opex in JGN's revised AA proposal.

For clarity, this scope of work entails:

a) updating the analysis that Economic Insights undertook for JGN in 2009 as reported in Economic Insights, *The Productivity Performance of Jemena Gas Networks' NSW Gas Distribution System*, 18 August 2009[1];

b) applying an analysis similar to that reported in Economic Insights, *Econometric Estimates of the Victorian Gas Distribution Businesses' Efficiency and Future Productivity Growth*, 28 March 2012 [2], to JGN

and providing a report to JGN on those analyses (see "Deliverables" below).

The engagement does not include strategic advice on JGN's revised AA proposal, or any related step change issues.

3 Information to be considered

The Expert is expected to draw upon the following information:

- historical and forecast cost, input and output data provided by JGN;
- subject to the agreement of the relevant GDBs, the data set that informed Economic Insights, *Econometric Estimates of the Victorian Gas Distribution Businesses' Efficiency and Future Productivity Growth*, 28 March 2012 [3];
- relevant published research literature;
- relevant government decisions on energy policy and policy implementation;

[1] Report submitted to the AER by JGN on 25 August 2009.

[2] Report submitted to the AER by SP AusNet on 30 March 2012.

[3] Report submitted to the AER by SP AusNet on 30 March 2012.

- factors such as the scale, topography and configuration of the JGN network, that may contribute to or explain observed differences between the results obtained for JGN and for other GDBs in the data set on which the analysis is based;
- recent regulatory reviews for gas that have considered efficiency measures within the context of establishing cost forecasts; and
- such other information that, in the Expert's opinion, should be taken into account to address the scope of work set out in Section 2.

4 Deliverables

At the completion of its review the Expert will provide an independent expert report which addresses the scope of work set out in Section 2 and:

- is of a professional standard suitable for submission to the AER;
- includes an executive summary which highlights key aspects of the Expert's work and conclusions;
- includes detailed reasons for the Expert's opinions;
- fully documents the methodology used and discusses the results obtained;
- lists the facts, matters and assumptions on which the Expert's opinions are based and the source of those facts, matters and assumptions, and lists all reference material and information on which the expert has relied;
- lists any limitations, incomplete matters or qualifications to the Expert's opinions;
- identifies and summarises the experience and qualifications of, and includes a curriculum vitae for, each person who assisted in preparing the report or in carrying out any research or test for the purposes of the report;
- summarises JGN's instructions and attaches these terms of reference; and
- is prepared in accordance with the Federal Court Guidelines for Expert Witnesses set out in Attachment 1[4] and includes an acknowledgement that the Expert has read the guidelines.

The Expert is required to present its draft findings and report to JGN for discussion prior to finalising them.

Use of the report

JGN expects to submit the Expert's report to the AER as part of JGN's revised AA proposal for the period from 1 July 2015 to 30 June 2020. The AER may provide the report to its own advisers. The report must be expressed so that it may be relied upon by both JGN and the AER.

[4] Available at: http://www.fedcourt.gov.au/how/prac_direction.html.

The AER may ask questions in respect of the report and the Expert will be required to assist JGN in answering those questions. In addition, the AER may choose to interview the Expert and, if so, the Expert will be required to participate in any such interview.

The Expert must be available to assist JGN in connection with the work defined in the scope of work (Section 2), until such time as JGN has responded to the AER's draft decision on JGN's revised AA proposal.

Compliance with the code of conduct for expert witnesses

Attachment 1 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**).

The Expert is required to be familiar with the Code of Conduct and comply with it at all times in the course of the engagement by JGN. In particular, the expert report prepared for JGN 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.

In particular, the report should contain particulars of the timing, study or experience by which the Expert has acquired specialised knowledge. The report should also 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 a declaration that:

> "[the expert] has made all the inquires 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."

As noted previously, JGN requires a copy of these terms of reference to be attached to the Expert's report, as well as copies of the curriculum vitae of each of the report's authors.

5 Timetable

The Expert will deliver its required output to JGN as follows:

- analysis of time series and multilateral TFP estimates and PFP estimates; estimate of the opex cost function and forecast opex partial productivity growth rate; and draft written report, by 7 March 2014; and
- final written report by 25 April 2014.

6 Terms of Engagement

The terms on which the Expert will be engaged to provide the requested advice shall be as set out in JGN's standard form of consultancy agreement, a copy of which is included as Attachment 2.

ATTACHMENT B: CURRICULUM VITAE

Michael Cunningham

Position	Associate
Business address:	28 Albert St, Brunswick East, VIC 3057
Business telephone number:	+61 3 9380 4700
Mobile:	0412 255 131
Email address	michael@economicinsights.com.au

Qualifications

Master of Commercial Law, Melbourne University

Master of Commerce (Hons), Melbourne University

Bachelor of Economics, Monash University

Key Skills and Experience

Michael Cunningham has recently become an Associate of Economic Insights following more than a decade as a senior regulatory manager with the Essential Services Commission of Victoria. Michael has extensive experience in the regulation of energy, water and transport networks and in detailed productivity analysis.

Michael recently developed Victoria's minimum feed-in tariffs for 2014, and conducted research into Victoria's energy retail market, including methods for estimating retailer margins, and research into emerging regulatory issues such as household electricity control products. He produced the ESC's analysis of the productivity of the Victorian water industry in 2012, and on secondment to the Victorian Competition and Efficiency Commission in 2011, for the Inquiry into a State-Based Reform Agenda, he was lead author of its Productivity Information Paper (Dec 2011).

Michael has led many key ESC reviews, including:

- Review of the Rail Access Regime 2009-10
- Reviews of Victorian Ports Regulation 2009 & 2004
- Reviews of Grain Handling Access Regime 2009, 2006 & 2002
- Taxi Fare Review 2007-08
- Review of Port Planning 2007
- Implementing the Victorian rail access regime 2005 & rail access arrangement approvals 2006 & 2009

- Review of the Supply of Bottled LPG in Victoria 2002.

Prior to joining the ESC, Michael was a commercial advisor at Gascor Pty Ltd for the re-determination of the natural gas price under Victoria's (then) principal gas supply contract for Gippsland gas. From 1997 to 1999, he was an Associate Analyst at Credit Suisse First Boston Australian Equities, carrying out financial analysis of Australia listed infrastructure businesses and utilities. For more than 10 years Michael was employed by Gas & Fuel Corporation Victoria (GFCV) and was responsible for developing forecasting models, operations research, project evaluation, developing management performance reporting systems and tariff design.

As Manager, Resource Strategy, he participated in contract negotiations, and carried out key analysis, relating to the supply of LNG (for the Dandenong storage facility), and participated in the development of gas transmission prices. From 1994 to 1997, he was seconded to the Gas Industry Reform Unit (GIRU) in Victoria's Treasury department and assisted with the negotiation and settlement of the Resource Rent Tax dispute between GFCV and Esso-BHP (approximately $1 billion in claims). He was a member of the negotiating team that settled a new 13-year gas supply agreement to supply 95% of Victoria's natural gas. In addition to being a member of the negotiating team, he was responsible for carrying out all of the forecasting and risk analysis of key contractual terms such as take-or-pay, maximum day quantity, quantity renomination options etc.

Recent Publications

- Journal article: 'Productivity Benchmarking the Australian Water Utilities' *Economic Papers* (June 2013)
- Conference paper: Cunningham M B & Harb, D 'Multifactor productivity at the sub-national level in Australia', 41st Australian Conference of Economists 2012
- Submissions:
  - 'Submission to MCE consultation on the separation of electricity transmission and distribution' (Nov 2011)
  - 'Submission to AEMC consultation on AER rule change request' (Dec 2011)
  - 'Submission to PC Consultation on Electricity Network Regulation' (Apr 2012)
  - 'Processes for stakeholder negotiation for electricity regulation', submission to PC (Nov 2012)
  - 'Submission to Productivity Commission Review of the National Access Regime' (Feb 2013).

ATTACHMENT C: DECLARATION

I, Michael Bradbury Cunningham, Associate 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.

Michael Bradbury Cunningham

14 April 2014

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2013-2017 Gas Access Arrangement Review –

Access Arrangement Information

Appendix 6B:

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

Submitted 30 March 2012

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

Report prepared for
SP AusNet

28 March 2012

Denis Lawrence and John Kain

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CONTENTS

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.

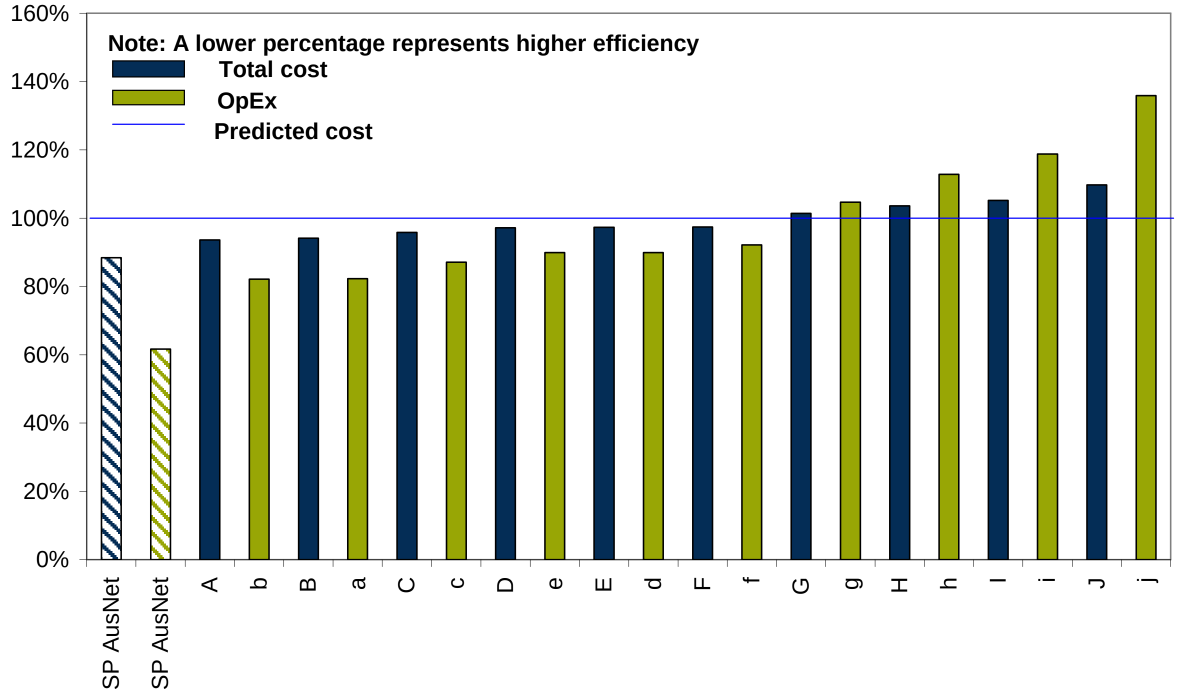
Key findings – efficiency

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.

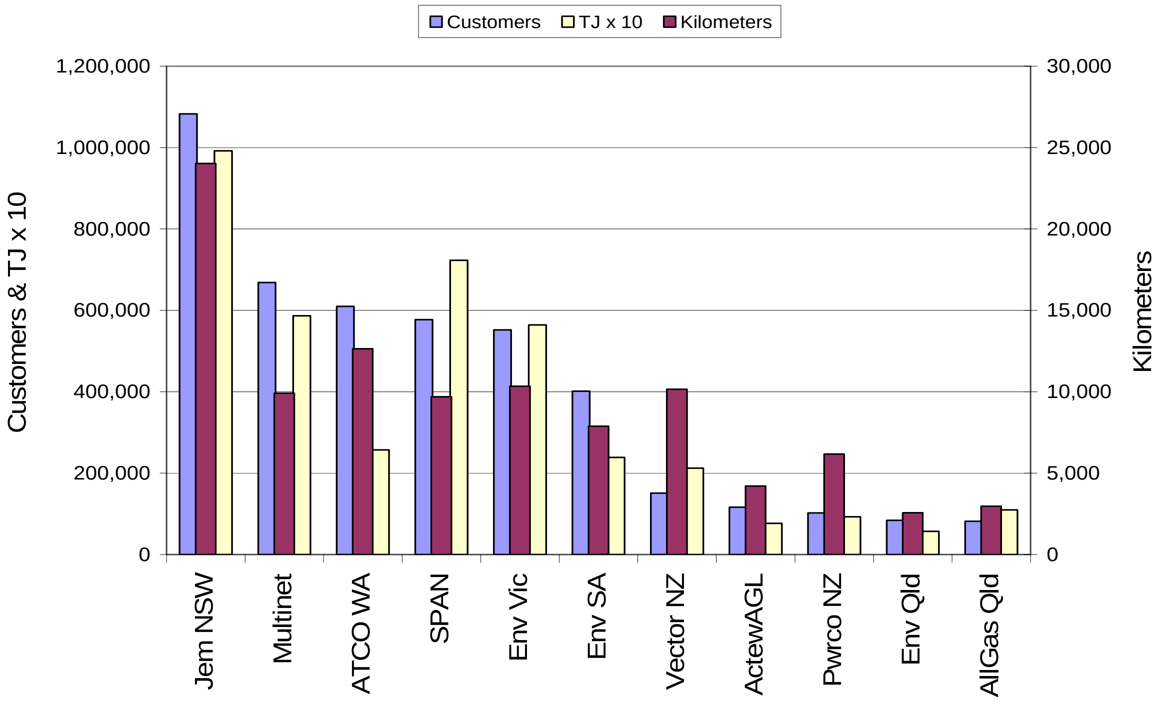
Capital input costs are calculated as 12.5 per cent of the Regulatory Asset Base (RAB) for each GDB. Economic Insights (2009b) showed that this method provided a very close approximation to the sum of the return on and return of capital calculated using a standard regulatory post–tax revenue model. This 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**

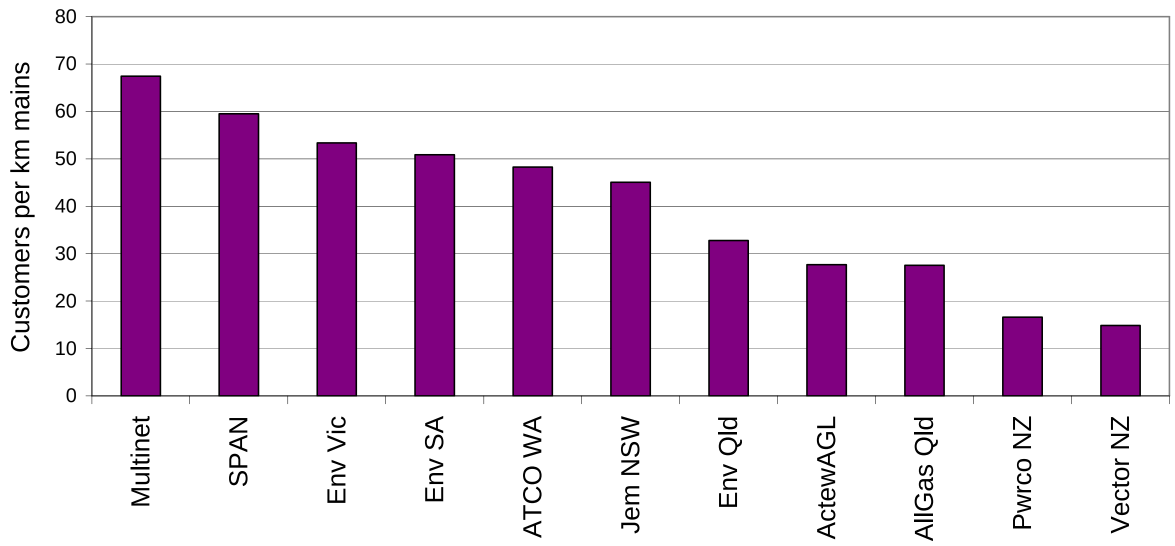


Source: Economic Insights gas utility database

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.

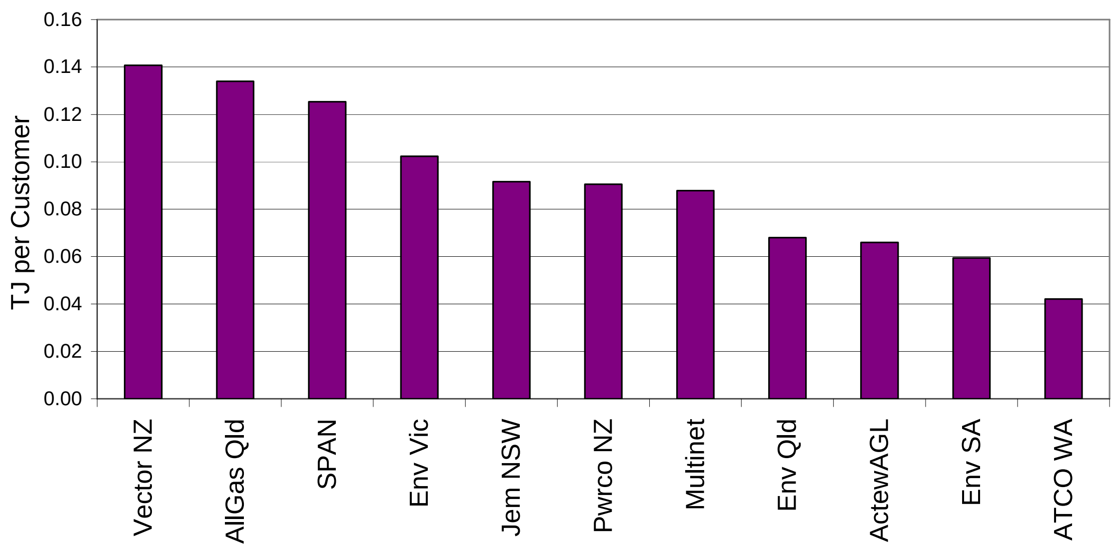
The two key operating environment characteristics which influence energy distribution business productivity levels and costs are customer density (customers per kilometre of mains) and energy density (throughput per customer). A GDB with lower customer density will require more pipeline length to reach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

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

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.

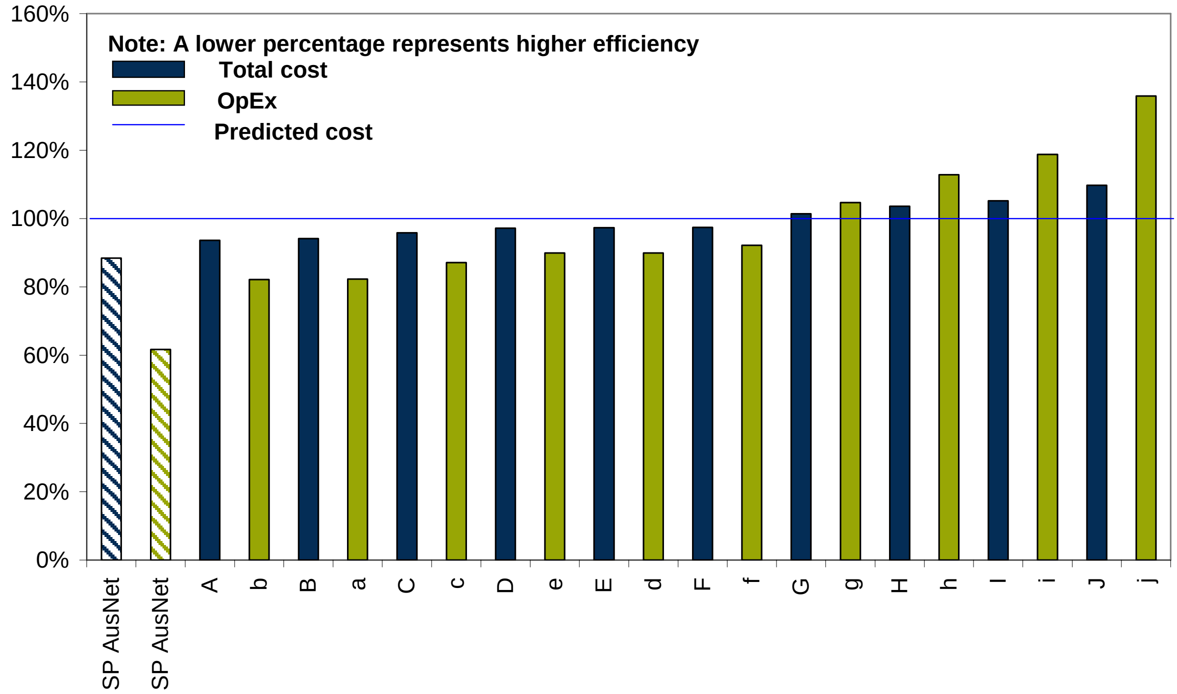
Table 1: **Cost function regression estimates**[1]

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:

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

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:

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

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

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:

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

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:

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

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

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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

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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
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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.

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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

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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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