The Total Factor Productivity Performance of Victoria's Gas Distribution Industry

Report prepared for
Envestra Victoria, Multinet and SP AusNet

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EXECUTIVE SUMMARY

The three Victorian gas distribution businesses (GDBs) – Envestra Victoria, Multinet and SP AusNet – have commissioned Economic Insights to examine their total factor productivity (TFP) and partial factor productivity (PFP) performance. Economic Insights has also been requested to include updated data for the Victorian GDBs in the comparison of productivity levels of the Victorian distribution networks, the New South Wales GDB Jemena Gas Networks (JGN), Envestra's South Australian network (Envestra SA) and Envestra's Queensland network (Envestra Qld) reported in Economic Insights (2010a).

The primary data sources for this study are information supplied by Envestra Victoria, Multinet and SP AusNet in response to common detailed data surveys and earlier similar surveys of JGN, Envestra SA and Envestra Qld. The current detailed data surveys of the three Victorian GDBs update earlier surveys undertaken by Lawrence (2007) but also extend the amount of information collected to provide a comprehensive coverage of billed outputs.

The survey data has been subjected to an extensive checking and, where necessary, clarification process to ensure compatibility over time and between included GDBs. The surveys covered key output and input value, price and quantity information for the period 1999 to 2011 in the case of Victoria, for the period 1999 to 2009 in the case of JGN and for the period 1999 to 2010 in the case of Envestra SA and Envestra Qld.

The TFP measure used includes three outputs (throughput, customer numbers and system capacity) and 8 inputs (opex, lengths of transmission pipelines, high pressure pipelines, medium pressure pipelines, low pressure pipelines and services, meters, and other capital). For productivity level comparisons transmission pipelines and associated opex are excluded.

The Victorian gas distribution industry as a whole has exhibited relatively steady TFP growth over the past 13 years. The average annual growth rate was 1.7 per cent for the last 10 years although this has slowed to 0.7 per cent for the last 5 years. This TFP growth has been driven largely by significant reductions in opex. However, the pattern of both TFP growth and opex partial productivity growth has been very different across the three GDBs.

Envestra Victoria and Multinet had productivity growth 'spurts' from 1999 onwards before their productivity growth flattened off from 2006 onwards. SP AusNet's network (owned by TXU until mid 2004), on the other hand, had relatively constant TFP from 1999 to 2004 before starting its productivity growth spurt in 2005. Productivity growth for all three GDBs was negative in 2011.

Envestra Victoria's opex partial productivity grew strongly between 2001 and 2005 but has flattened off since then leading to the high average annual growth rate of 5.3 per cent over the last 10 years but a much lower 0.8 per cent over the last 5 years. Annual growth in the partial productivity of capital has been somewhat positive over the last 10 years at 0.1 per cent and 0.3 per cent over the last 5 years.

Envestra Victoria's TFP index (which is effectively a weighted average of the two partial productivity indexes) exhibits relatively strong growth up to 2005 but much more modest growth since then. The average annual growth rate was 2.2 per cent for the last 10 years but this has slowed to 0.5 per cent for the last 5 years.

Despite ongoing large reductions in opex usage, Multinet's relatively low rate of output growth given the more mature inner city area it services has constrained its productivity performance over the last 13 years. Its opex partial productivity grew strongly between 1999 and 2002 and again between 2007 and 2009 but growth was more modest between 2002 and 2007 and has flattened off since 2009. This has led to average annual growth rates of 2.8 per cent over the last 10 years and 1.6 per cent over the last 5 years. Annual growth in the partial productivity of capital has been somewhat negative over the last 10 years at –0.2 per cent and more negative over the last 5 years at –1.5 per cent.

Multinet's TFP index exhibits relatively strong growth up to 2003 but much more modest growth since then. The average annual growth rate was 0.8 per cent the last 10 years but this has reversed to –0.5 per cent for the last 5 years, driven in part by a fall in output in 2011.

SP AusNet embarked on major opex usage reforms somewhat later than the other two GDBs. The other two GDBs exhibited rapid reductions in opex usage from 1999 onwards before opex usage levelled off around 2005. SP AusNet's rapid reductions in opex usage only commenced in 2004 but have slowed over the last year. SP AusNet's reduction in opex usage over the second half of the period at around 40 per cent was somewhat larger than those achieved by the other two GDBs over the first half of the period of around 25 to 35 per cent.

SP AusNet made significant savings in the network operations component of opex as it extracted synergies from the operation of the 3 networks it owns and operates. Many of these synergies were generated by the combined network operations centre it operates. However, once these synergies have been fully extracted there can be expected to be a flattening out of network operations costs and this was observed in 2011.

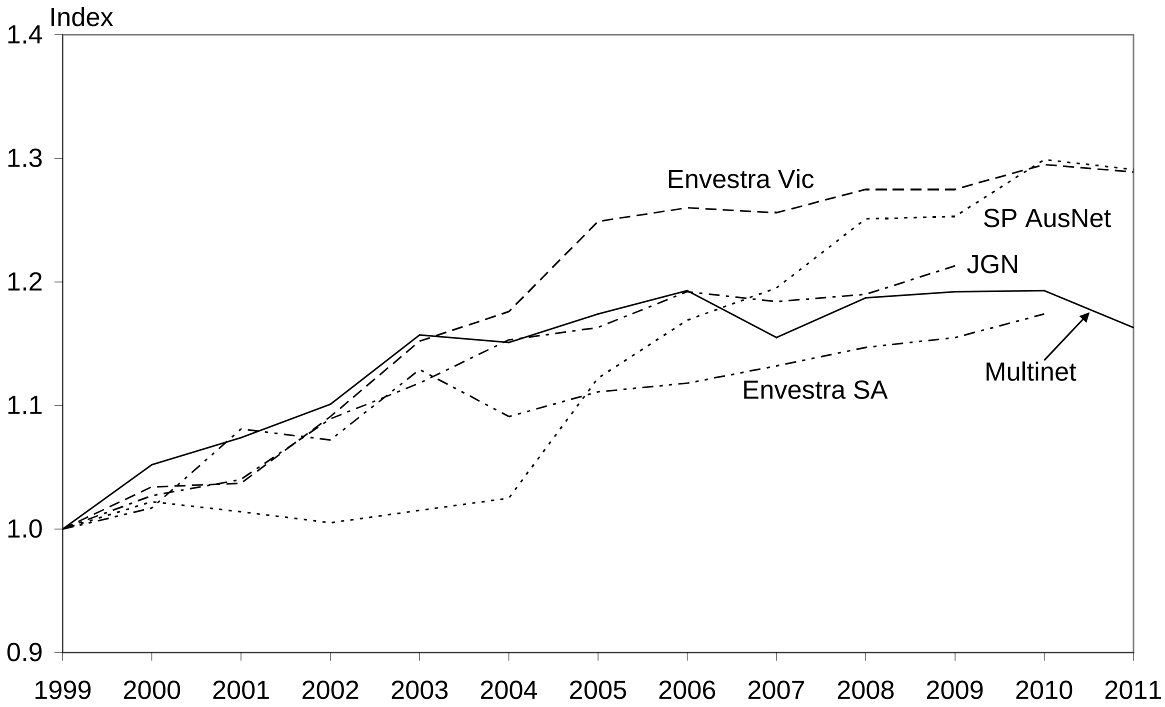
SP AusNet's opex partial productivity was relatively flat between 1999 and 2004 but it has more than doubled in the period since 2004. This has led to the high average annual growth rates of 7.8 per cent over the last 10 years and 8.4 per cent over the last 5 years. Annual growth in the partial productivity of capital, on the other hand, has been somewhat negative over both the last 10 years and the last 5 years at around –0.1 per cent.

SP AusNet's TFP index was relatively flat up to 2004 but has grown strongly since then. The average annual growth rate was 2.4 per cent over the last 10 years but this has slowed somewhat to 2.0 per cent for the last 5 years.

Comparing the three Victorian GDBs', JGN's and Envestra SA's TFP indexes (figure A), Envestra Victoria and SP AusNet had the highest TFP growth for the period up to 2009 (the latest year for which data are available for all the included GDBs) with average annual growth rates of 2.4 per cent and 2.3 per cent, respectively. They were followed by JGN and Multinet with average annual TFP growth rates of 1.9 per cent and 1.8 per cent, respectively. The smaller Envestra SA had the lowest TFP growth rate at a still very reasonable 1.4 per cent.

TFP growth slowed markedly for 4 of the included GDBs in the more recent 5 year period from 2005 to 2009, with SP AusNet being the exception. Envestra Victoria's average annual TFP growth fell to 1.6 per cent, Envestra SA's fell to 1.1 per cent, JGN's fell to 1.0 per cent and Multinet's fell to 0.7 per cent over the 5 years to 2009. TFP growth was negative for all three Victorian GDBs in 2011 reflecting increases in input usage and, in the case of Multinet, a reduction in output.

Figure A: **Victorian GDB, JGN, and Envestra SA TFP indexes, 1999–2011**



Source: Economic Insights GDB database

In this study we have collected accurate billed quantity and matching revenue data as part of the updated and expanded survey of the Victorian GDBs. We have examined the impacts of using an alternative output specification – the billed outputs approach – and an alternative input specification which uses exogenous instead of endogenous capital user costs as weights in forming the total input quantity. In both cases the results are relatively invariant to these sensitivity tests. The billed outputs approach introduces more volatility into the output quantity index which can affect productivity growth rates if taken over a short period and with years of atypical climatic conditions at one or both ends of the period. However, the underlying trends in total output and TFP growth are broadly similar under the two approaches.

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.

In summary, the Victorian GDBs operate at the highest TFP levels in the sample and at or near the highest opex partial productivity levels. Envestra Victoria has the highest capital partial productivity level while Multinet and SP AusNet exhibit around average capital partial productivity performance. The overall conclusion from the multilateral productivity index analysis is that the Victorian GDBs are operating efficiently.

1 INTRODUCTION

The three Victorian gas distribution businesses (GDBs) – Envestra Victoria, Multinet and SP AusNet – have commissioned Economic Insights Pty Ltd (‘Economic Insights’) to examine their total factor productivity (TFP) and partial factor productivity (PFP) performance. Economic Insights has also been requested to include updated data for the Victorian GDBs in the comparison of productivity levels of the Victorian distribution networks, the New South Wales GDB Jemena Gas Networks (JGN), Envestra’s South Australian network (Envestra SA) and Envestra’s Queensland network (Envestra Qld) reported in Economic Insights (2010a).

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.

Industry level TFP performance plays a key role in setting prices in a competitive market. It is, hence, of interest to regulators where the aim of regulation is typically to mimic the outcome of a competitive market in an industry operating under natural monopoly conditions. Information from TFP studies can be one ingredient in the setting of 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.

The study concentrates on performance in the period from 1999 to 2011. It is also the first study to collect comprehensive productivity data on so–called ‘billed’ outputs and TFP growth results for Victoria using a billed outputs basis are compared with those from the more ‘functional’ outputs specification used in previous studies. Results are also presented for an input specification similar to that used in the Economics Insights (2010b) model constructed for the Australian Energy Market Commission (AEMC).

This report extends and updates similar work reported by the authors in Lawrence (2007). A separate stream of work reported in Economic Insights (2012a) drawing mainly on public domain data sources presents the results of partial productivity indicator comparisons covering operating expenditure (opex), capital expenditure (capex) and capital asset value performance across 14 Australasian GDBs. Economic Insights (2012b) then forms econometric estimates of cost function parameters using this database. These estimates are used to assess efficiency taking opex and capital input trade–offs and business conditions into account within a statistical framework and to forecast future opex partial productivity growth rates. The comprehensive total factor productivity measures of the historic productivity performance of the three Victorian GDBs and three other Australian GDBs using detailed survey–based data presented in this report complement the partial productivity indicators and econometric estimates presented in Economic Insights (2012a,b).

The following parts of this section of the report list the terms of reference for the report and Economic Insights' productivity experience and the qualifications of the consultants involved. In section 2 of the report we outline the basics of TFP, why it is of interest to regulators and briefly summarise earlier GDB efficiency and productivity reports. We then discuss a number of key measurement issues affecting outputs, inputs and the indexing method in section 3 before describing the specifications and data used in section 4. Productivity growth results for the three Victorian GDBs are then presented in section 5 and multilateral TFP results comparing the three Victorian GDBs productivity levels with those of JGN, Envestra SA and Envestra Qld are presented in section 6. We then draw conclusions in section 7.

1.1 Terms of reference

The terms of reference provided to Economic Insights by the three Victorian GDBs required the preparation of an expert report which quantifies:

a) the total factor productivity and partial factor productivity growth of the GDBs' gas distribution networks; and

b) how the Victorian GDBs' total factor productivity and partial factor productivity levels compare with those of Envestra's South Australian and Queensland networks and the Jemena New South Wales gas distribution network.

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 ABOUT TFP

2.1 What is TFP?

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.

In practice, 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 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.

2.2 Why is TFP of interest to regulators?[1]

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 including the Expert Panel on Access Pricing (2006) and AEMC (2011) have also advocated consideration of 'productivity based' approaches to regulation whereby X factors are set using information on industry productivity trends. In this section we review the underlying rationale behind using TFP measures in setting price caps.

The principal objective of CPI–X regulation is to mimic the outcomes that would be achieved in a competitive market. Competitive markets normally have a number of desirable properties. The process of competition leads to industry output prices reflecting industry unit costs, including a normal rate of return on the market value of assets after allowing for the

[1] This section draws on Lawrence (2003b).

risk. Because no individual firm can influence overall industry unit costs, each firm has a strong incentive to maximise its productivity performance to achieve lower unit costs than the rest of the industry. This will allow it to keep the benefit of new, more efficient processes that it may develop until such times as they are generally adopted by the industry. This process leads to the industry operating as efficiently as possible at any point in time and the benefits of productivity improvements being passed on to consumers relatively quickly.

Because infrastructure industries such as the provision of gas distribution networks are often natural monopolies, competition is normally limited and incentives to minimise costs and provide the cheapest and best possible quality service to users are not strong. The use of CPI–X regulation in such industries attempts to strengthen the incentive to operate efficiently by imposing similar pressures on the network operator to the process of competition. The change in output prices is 'capped' as follows:

(1) $$P^1/P^0 = W^1/W^0 - X \pm Z$$

where the superscripts represent different time periods, P is the maximum allowed output price, W is a price index taken to approximate changes in the industry's input prices, X is the estimated productivity change for the industry and Z represents relevant changes in external circumstances beyond managers' control which the regulator may wish to allow for. There are several alternative ways of choosing the index W to reflect industry input prices. Perhaps the best way of doing this is to use a specially constructed index which weights together the prices of inputs by their shares in industry costs. However, this price information is often not readily or objectively available, particularly in regulatory regimes that have yet to fully mature. A commonly used alternative is to choose a generally available price index such as the consumer price index or GDP deflator.

The framework that underlies the CPI–X approach can be illustrated as follows. We start with the index number definition of TFP growth:

(2) $$\begin{aligned} TFP^1/TFP^0 &\equiv [Y^1/Y^0]/[X^1/X^0] \\ &= \{[R^1/R^0]/[P^1/P^0]\}/\{[C^1/C^0]/[W^1/W^0]\} \\ &= \{[M^1/M^0][W^1/W^0]\}/[P^1/P^0] \end{aligned}$$

where R^t (C^t) is revenue (cost) in period t, M^t is the period t markup and $R^t = M^t C^t$. As a normal return on assets (after allowing for risk) is included in the definition of costs, a firm earning normal returns will have a markup factor of one while a firm earning excess returns will have a markup of greater than one. Rearranging the above equation gives:

(3) $$P^1/P^0 = \{[M^1/M^0][W^1/W^0]\}/ [TFP^1/TFP^0]$$

where W^1/W^0 is the firm's input price index (which includes intermediate inputs). Equation (3) is approximately equal to:

(4) $$\Delta P = \Delta M + \Delta W - \Delta TFP.$$

where Δ is taken to represent the proportional change in a variable. Thus, the admissible rate of output price increase ΔP is equal to the rate of increase of input prices ΔW less the rate of TFP growth ΔTFP provided the regulator wants to keep the monopolistic markup constant (so that ΔM = 0). Equation (3) or its approximation (4) is the key equation for setting up an incentive regulation framework: the term W^1/W^0 would be an input price index of the target firm's peers and the term ΔTFP would be the average projected TFP growth rate for the target firm's peers. The markup growth term could be set equal to zero under normal circumstances but if the target firm was making an inadequate return on capital due to factors beyond its control, this term could be set equal to a positive number. On the other hand, if the target firm was making monopoly profits or excessive returns, then this term could be set negative. This effectively sets a 'glide path' to bring firms closer to earning a normal or average rate of return.

The next issue to be considered in operationalising (4) is the choice of the price index to reflect changes in the industry's input prices, W. The most common choice for this index is the consumer price index (CPI). But this is actually an index of output prices for the economy rather than input prices. Normally we can expect the economy's input price growth to exceed its output price growth by the extent of economy–wide TFP growth (since labour and capital ultimately get the benefits from productivity growth). We assume that the markup factors for the economy as a whole are one so that the counterpart to equation (2) applied to the entire economy becomes:

(5) $$P_E^1/P_E^0 = [W_E^1/W_E^0]/\ \Delta TFP_E.$$

Substituting the rate of change of the CPI for the economy–wide output price index on the left hand side of (5) and rearranging terms leads to the following identity:

(6) $$1 = [CPI^1/CPI^0]\ \Delta TFP_E/[W_E^1/W_E^0].$$

Substituting the right hand side of (6) into (2) produces the following equation:

(7) $$\begin{aligned} P^1/P^0 &= \{[CPI^1/CPI^0]\Delta TFP_E\ /[W_E^1/W_E^0]\}\{[M^1/M^0][W^1/W^0]\}/\ \Delta TFP \\ &= [CPI^1/CPI^0][\Delta TFP_E\ /\Delta TFP]\{[W^1/W^0]/[\ W_E^1/W_E^0]\}[M^1/M^0]. \end{aligned}$$

Approximating the terms in (7) by finite percentage changes leads to the following:

(8) $$\Delta P = \Delta CPI + \Delta M + [\Delta W - \Delta W_E] - [\Delta TFP - \Delta TFP_E]$$

so that the X factor is defined as:

(9) $$X \equiv [\Delta TFP - \Delta TFP_E] - [\Delta W - \Delta W_E] - \Delta M.$$

What equation (9) tells us is that the X factor can effectively be decomposed into three terms. The first differential term takes the difference between the industry's TFP growth and that for the economy as a whole while the second differential term takes the difference between the firm's input prices and those for the economy as whole. Thus, taking just the first two terms, if the regulated industry has the same TFP growth as the economy as a whole and the same rate of input price increase as the economy as a whole then the X factor in this case is zero. If the regulated industry has a higher TFP growth than the economy then X is positive, all else equal, and the rate of allowed price increase for the industry will be less than the CPI. Conversely, if the regulated industry has a higher rate of input price increase than the economy as a whole then X will be negative, all else equal, and the rate of allowed price increase will be higher than the CPI. As noted above, the markup growth term could be set equal to zero under normal circumstances but if the target firm was making excessive returns, then this term could be set negative (leading to a higher X factor).

Normally, firms that are at the forefront of industry performance have high productivity levels but low productivity growth rates. This is because they have removed almost all unnecessary slack from their operations and are only able to increase productivity at the rate of technological change for the industry. Conversely, firms that are not operating at high levels of efficiency should be able to achieve higher productivity growth rates as they catch up. As all firms become efficient (eg in response to incentive regulation) then productivity growth rates will converge to the long run rate of technological change in the industry.

This process of 'convergence' to the long rate of technological change in the industry also has important implications for the interpretation of measures of historical TFP growth at the industry level for regulatory purposes. In most infrastructure industries we normally see a period of high productivity growth when the reform process is started and easy 'catch–up' gains are made. As performance moves closer to best practice, industry productivity growth usually slows down as marginal improvements become harder to achieve.

The rate of technological change in distribution businesses is likely to be relatively slow given the mature and stable nature of the technology used. Extreme caution is thus required in drawing inferences about attainable future productivity growth from studies of historical performance following reform. For regulatory purposes we thus need to extend the analysis beyond TFP growth rates to place the analysis in a broader perspective, particularly comparing productivity levels to industry best practice. We also examine the Victorian GDBs' TFP levels relative to those of JGN, Envestra SA and Envestra Qld to provide information on where they stand in terms of relative efficiency.

Economic Insights (2009a,b) has recently extended the X factor framework presented in equation (9) above to allow for the importance of sunk costs and the regulatory principle of financial capital maintenance. The extended framework involves using approved amortisation charges as the weight for capital input quantities in calculating TFP and in forming the input price differential. Since this report draws on the data used in Economic Insights (2010a) for JGN, Envestra SA and Envestra Qld, the same approach to productivity measurement adopted in Economic Insights (2010a) and the earlier Lawrence (2007) is adopted here to allow comparisons to be made. However, for this project we have also collected data from the Victorian GDBs that allows the newer framework of Economic Insights (2009a,b, 2010b) to be applied for the Victorian GDBs and results of using this framework are compared with the traditional approach in section 5.

2.3 Past gas distribution efficiency and TFP studies

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

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 (2001)

In 2001 Pacific Economics Group (PEG) benchmarked the Australian gas distribution operations of three Victorian utilities – Multinet (United Energy), TXU, and Envestra Victoria (PEG 2001a,b,c) – 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 a still relatively high 2.5 per cent.

While being New Zealand's third largest GDB with around 56,000 customers, NGC Distribution was only around one tenth the size of the Victorian GDBs. The New Zealand gas distribution industry is generally less mature than Victoria's with penetration rates still increasing relatively quickly. For instance, NGC Distribution's customer density increased from 18.5 customers per kilometre in 1997 to 20.4 customers per kilometre in 2003. It was forecast to increase further to 22 customers per kilometre by 2008. All else equal, this could be expected to lead to the New Zealand GDBs having relatively high TFP growth.

Lawrence (2007)

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 (2007) 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 (2007) 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 (2009c)

Economic Insights (2009c) extended the Lawrence (2007) 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 (2010a)

Economic Insights (2010a) further extended the Economic Insights (2009c) 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.

3 MEASUREMENT ISSUES

To measure productivity performance we require data on the price and quantity of each output and input and data on key operating environment conditions. We require quantity data 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 the share of each output in total revenue or, alternatively, from output cost shares and for inputs from the share of each input in total costs. To derive the revenue and cost shares we require information on the value of each output and input, ie its price times its quantity. Hence, we require either the price and quantity of each output and input or, alternatively, their values and quantities, or their values and prices. 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.

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).

In common with other network infrastructure industries, measuring the performance of gas pipelines presents a number of challenges. In this section we examine a number of measurement issues including how to define GDB outputs and inputs and the likely impact of operating environment conditions.

3.1 Measuring GDB outputs

Early energy supply productivity studies simply measured output by system throughput. However, this simple measure ignores important aspects of the functions pipelines perform. In Lawrence (2003a), to capture the multiple dimensions of electricity distribution business output we measured distribution output using three 'functional' output quantities: throughput, system line capacity and connection numbers. Output cost shares were derived from an econometric cost function. A broadly similar measure was developed in Lawrence (2007) in consultation with the Victorian GDBs' engineers.

Pacific Economics Group (2004, 2006) also included three output quantities in their electricity distribution business TFP study but as proxies for 'billed' outputs (ie the quantities the businesses actually billed customers for): throughput, customer numbers and non–coincident peak demand. This measure of peak demand was used as a proxy for the quantity component of demand–based charges.

There has been some debate about whether just 'billed' outputs (ie outputs explicitly charged for) should be included in the TFP measure for regulatory purposes or whether 'functional' outputs which include both billed outputs and 'unbilled' outputs (ie outputs of value to the user – such as system reliability and redundancy – but which are not explicitly charged for) should be included. Because network industries are natural monopolies the price of billed outputs will typically not equal their marginal cost (as would be the case in a competitive industry). Furthermore, some key output dimensions that would be charged for in competitive industries may not be charged for at all in networks. Economic Insights (2009a) has recently shown that all network outputs – both billed and unbilled – should ideally be included in the productivity measure and that each output should be weighted by the difference between its price and marginal cost in deriving the X factor. However, marginal costs are not readily observable and their estimation would currently require the use of econometric methods.

In section 5 of this report we undertake the first detailed comparison between TFP results obtained using the simplified functional outputs approach used in our earlier studies and results from the billed outputs approach. Earlier attempts to implement the billed outputs approach have used proxy quantity measures and/or data on revenue from one year only. In this study we have collected accurate billed quantity and matching revenue data as part of the updated survey of the Victorian GDBs.

3.2 Measuring GDB inputs

Previous studies of pipeline productivity have typically used two or three input categories. For instance, BIE (1994) used labour numbers, kilometres of distribution main and kilometres of transmission main. No allowance was made for materials and services inputs due to lack of data at that time. IPART (1999) used operating expenditure and kilometres of main as its two inputs. Differences in the levels of contracting out between utilities made obtaining labour data problematic either due to its unavailability or lack of comparability. PEG (2001) used a three input specification with labour, other operating expenditure and capital inputs. As labour data is not available for most Australian GDBs and the extent of contracting out makes such a measure problematic, in this study labour inputs are subsumed within operating expenditure which is a more appropriate treatment where levels of contracting out are high.

There are a number of different approaches to measuring both the quantity and cost of capital inputs. The quantity of capital inputs can be measured either directly in quantity terms (eg using pipeline length measures) or indirectly using a constant dollar measure of the value of assets. Similarly, the annual cost of using capital inputs can be measured either directly by allowing for the regulatory depreciation rate, a rate reflecting the opportunity cost of capital tied up in the regulatory asset base (RAB) and the important regulatory principle of financial capital maintenance (FCM) or indirectly as the residual of revenue less operating costs.

Some analysts have argued that measuring the quantity of capital by the deflated asset value method provides a better estimate of total input as it better reflects the quality of capital and can include all capital items, not just pipelines. There are two potential problems with this approach. Firstly, asset valuation data are less likely to be accurate over time compared to physical asset data. The second problem with basing capital quantities on constant price asset value measures is that they usually incorporate some variant of the straight line approach to measuring depreciation. Gas pipeline assets tend to be long lived and produce a relatively constant flow of services over their lifetime. Consequently, their true depreciation profile is more likely to reflect the 'one hoss shay' assumption than that of a straight line approach. That is, they produce the same service each year of their life and until the end of their specified life rather than producing a reducing quantity of service every year. In these circumstances it may be better to proxy the quantity of capital input by the physical quantity of the principal assets.

The direct approach to measuring capital costs involves calculating the return of and return on capital in analogous fashion to that used in the building blocks approach. This is similar to the approved amortisation approach derived in Economic Insights (2009a) when the effects of sunk costs and financial capital maintenance are fully allowed. The indirect approach of allocating a residual or ex post cost to capital of the difference between revenue and operating costs has been favoured by some regulatory agencies such as the US Federal Communications Commission (1997). Given that the implicit rates of return in the Economic Insights GDB database are relatively stable and of broadly similar magnitude, one would expect the differences between these approaches to not be major in this instance. We examine the impact of using these alternative approaches in section 5.

3.3 Normalisation for operating environment conditions

Operating environment conditions can have a significant impact on distribution costs and productivity and in many cases are beyond the control of managers. Consequently, to ensure reasonably like–with–like comparisons it is desirable to 'normalise' for at least the most important operating environment differences. Likely candidates for normalisation include energy density (energy delivered per customer), customer density (customers per kilometre of main), customer mix, the proportion of cast iron pipes and climatic and geographic conditions.

Energy density and customer density are generally found to be the two most important operating environment variables in energy distribution normalisation studies (see Lawrence 2003a). 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 pipeline length than a less energy dense GDB would require to reach more customers to deliver the same total volume. A GDB with lower customer density will require more pipeline length to reach its customers than will a GDB with higher customer density but the same consumption per customer making the lower density distributor appear less efficient unless the differing densities are allowed for.

Energy distribution studies adopting the functional outputs approach usually incorporate density variables by ensuring that the three main output components – throughput, system capacity and customers – are all explicitly included. This means that distribution businesses that have low customer density, for instance, receive credit for their longer line lengths whereas this would not be the case if output was measured by only one output such as throughput.

3.4 TFP indexing methods

A TFP index is generally defined as the ratio of an index of output growth divided by an index of input growth. 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. 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.

Mathematically, the TFP index is given by:

(10) $TFP = \Delta Q / \Delta I$

where ΔQ is the proportional change in the quantity of total output between the current period and the base period and ΔI is the corresponding proportional change in the quantity of total inputs.

To operationalise this concept we need a way to combine changes in diverse outputs and inputs into measures of change in total outputs and total inputs. Different index number methods take this weighted average change in different ways.

Diewert (1993) reviewed alternate index number formulations to determine which index was best suited to TFP calculations. Alternative index number methods were evaluated by assessing their performance relative to a number of axiomatic tests. These included:

- 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;
- 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;
- 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,

- 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.

The four most popular index formulations were evaluated against these tests. The indexes evaluated included:

- the Laspeyres base period weight index;
- the Paasche current period weight index;
- the Fisher ideal index which is the square root of the product of the Paasche and Laspeyres index; and
- the Törnqvist index which has been used extensively in previous TFP work, including that of PEG (2004, 2006).

When evaluated against the tests listed above, only the Fisher ideal index passed all four tests. The Laspeyres and Paasche index fail the time reversal test while the Törnqvist index fails the constant basket test.

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. In this study the Fisher ideal index was therefore chosen as the preferred index formulation. It is also increasingly the index of choice of leading national statistical agencies.

Mathematically, the Fisher ideal output index is given by:

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

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:

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

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

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 *j*th input for the base observation.

The Fisher ideal TFP index is then given by:

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

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:

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

In this study we generally use the cost function method developed in Lawrence (2003a) and applied to GDB data in Lawrence (2007) 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 A. However, we also apply the billed outputs approach for the Victorian GDBs where actual revenue shares are used to derive the prices used in the indexing procedure.

4 DATA USED

The primary data sources for this study are information supplied by Envestra Victoria, Multinet and SP AusNet in response to common detailed data surveys and earlier similar surveys of JGN, Envestra SA and Envestra Qld. The current detailed data surveys of the three Victorian GDBs update earlier surveys undertaken by Lawrence (2007) but also extend the amount of information collected to provide a comprehensive coverage of billed outputs. The survey data has subjected to an extensive checking and, where necessary, clarification process to ensure compatibility over time and between included GDBs. The surveys covered key output and input value, price and quantity information for the period 1999 to 2011 in the case of Victoria (as provided in October 2011), for the period 1999 to 2009 in the case of JGN and for the period 1999 to 2010 in the case of Envestra SA and Envestra Qld.

The data supplied were consistent with the GDBs' Regulatory Accounts but the focus was on ensuring data reflected 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.

Asset values reflect the initial capital base allowed by the respective regulators in 1998 with subsequent roll–forward recognising indexation, regulatory depreciation of the initial capital base and subsequent additions, and capital expenditure using a simplified version of the AER's (2008b) roll forward model.

Because an important part of this study is comparisons across the included GDBs, a number of adjustments have been made to the functional coverage of JGN's data to ensure more like–with–like comparisons. In particular, very few transmission pipelines are present within the Victorian GDBs', Envestra SA's and Envestra Qld's operations whereas JGN operates significant amounts of trunk and primary mains which operate at very high pressures (above 1050 kPa) with characteristics normally associated with transmission or sub-transmission. To ensure comparability, trunk and primary mains for JGN (and associated opex) are excluded for JGN and transmission mains are excluded for Victoria, Envestra SA and Envestra Qld in the comparison of productivity levels (section 6). These items are, however, included where productivity growth comparisons are made (section 5).

In all cases, government levies and unaccounted for gas are excluded from opex to put it on 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.

4.1 Output definitions

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 Tariff V domestic and non–domestic customers and Tariff D, Tariff L and Tariff M customers for Victoria and equivalent categories for JGN, Envestra SA and Envestra Qld.

Billed Throughput (Victoria only): The quantity of the GDB's throughput is measured by the number of terajoules of gas supplied to Tariff V domestic and non–domestic customers.

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

Billed Customers (Victoria only): Connection dependent and customer service activities that are explicitly charged for are proxied by the GDB's number of Tariff V domestic and non–domestic customers.

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 studies (see, for example, Lawrence 2003a) 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 (2007) 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. 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, 525 kPa for high pressure, 70 kPa for medium pressure and 3.5 kPa for low pressure pipelines for JGN, 302 kPa for high pressure, 35 kPa for medium pressure and 1.2 kPa for low pressure pipelines for Envestra SA and 487 kPa for high pressure, 60 kPa for medium pressure and 1.2 kPa for low pressure pipelines for Envestra Qld.

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.

Billed Demand (Victoria only): The quantity of the GDB's demand charge–based output is proxied by the sum of GDB's maximum hourly quantities for Tariffs D, L and M.

Output weights

To aggregate a diverse range of outputs into an aggregate output index using indexing procedures, we have to allocate a weight to each output. For the functional output case we use the estimated output cost shares derived from the econometric cost function outlined in appendix A used in Lawrence (2007) 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 (2003a). 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.

Total GDB revenue is the sum of revenue from Tariff V domestic and non–domestic customers and Tariff D customers for the Victorian GDBs and equivalent categories for JGN, Envestra SA and Envestra Qld.

In the Victorian billed output case we collected annual data on revenue by charge type for Tariff V, D, L and M customers. Direct revenue weights for each GDB for each year are then formed from this data.

4.3 Input definitions

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)[2]. 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. 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 the Victorian GDBs, Envestra SA and Envestra Qld is proxied by their transmission pipeline length while that for JGN is proxied by the sum of its trunk and primary mains length.

[2] 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.

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.

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 meters.

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.

Capital constant price and nominal values

Asset values reflect the initial capital base allowed by the respective regulators in 1998 with subsequent roll–forward recognising indexation, regulatory depreciation of the initial capital base and subsequent additions, and capital expenditure using a simplified version of the AER's (2008b) roll forward model.

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 Lawrence (2007), the implicit gross rate of return for the three Victorian GDBs was relatively stable over the period up to 2006 and also across the three GDBs so there is likely be little difference in TFP estimates formed using this approach and the exogenous user cost method. The JGN, Envestra SA and Envestra Qld implicit gross rates of return are also relatively stable over the period to 2009. 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.

For the expanded work on the Victorian GDBs we use the exogenous approach with the annual user cost of capital comprising the return of capital, the return on capital and a benchmark tax liability. We use a similar process to that used in the Economic Insights (2010b) model constructed for the AEMC which uses a simplified version of the AER's (2008a) post–tax revenue model. This process is used for each of the capital components. Input shares for opex and each of the capital components are their shares in the GDB's annual revenue requirement for that year.

4.4 Key characteristics of the included GDBs

The key characteristics of the three Victorian GDBs, JGN, Envestra SA, Envestra Qld and are presented in table 4.1 for 2009, the latest year of common coverage in the database. In terms of throughput Envestra Victoria and Multinet are just over half the size of JGN, just over double the size of Envestra SA and just over nine times the size of Envestra Qld. SP AusNet is around three quarters the size of JGN based on throughput and nearly three times the size of Envestra SA. In terms of customer numbers Envestra Victoria and SP AusNet are around 55 per cent the size of JGN while SP AusNet is around 65 per cent JGN's size. Envestra SA is around 70 per cent the size of Envestra Victoria and SP AusNet on the basis of customer numbers while Envestra Qld is only around 15 per cent their size. The three Victorian GDBs have around 40 per cent the distribution pipeline length of JGN but 45 per cent longer length than Envestra SA and around four times the length of Envestra Qld.

Table 4.1: **Included GDBs' key characteristics, 2009**

GDB	Throughput	Customers	System capacity	Distribution mains length	Energy density	Customer density
	TJ	No	Sm3	kms	GJ/customer	customers/km
Envestra Vic	54,064	538,088	136,020	10,172	100	53
Multinet	56,596	663,330	123,522	9,867	85	67
SP AusNet	72,570	559,502	120,931	9,496	130	59
JGN	98,152	1,048,315	362,480	23,703	94	44
Envestra SA	25,122	388,169	87,082	6,905	65	56
Envestra Qld	5,722	81,771	27,100	2,342	70	35

Source: Economic Insights GDB database

As noted in section 3.3, the two key operating environment characteristics which influence energy distribution business productivity levels are energy density (throughput per customer) and customer density (customers per kilometre of mains). SP AusNet has the highest energy density in the sample and the second highest customer density. Multinet, on the other hand, has the highest customer density but only the fourth highest energy density. Multinet's high customer density reflects its coverage of Melbourne's densely populated inner southeast. Envestra Victoria has the second highest energy density but only the fourth highest customer density.

To summarise, Table 4.1 shows that the three Victorian GDBs have relatively high overall energy densities and customer densities among the included GDBs. Together with their medium sizes, this could be expected to give them something of an advantage when comparing productivity levels. JGN, on the other hand is much larger than the other included GDBs and has relatively good overall energy density but it has relatively low customer density. Envestra SA has a size disadvantage and relatively low overall energy density but it has customer density similar to those of the Victorian GDBs. Envestra Qld, on the other hand, is likely to be at a significant disadvantage relative to the other included GDBs in comparisons of productivity levels as it is by far the smallest, has low overall energy density, and by far the lowest customer density.

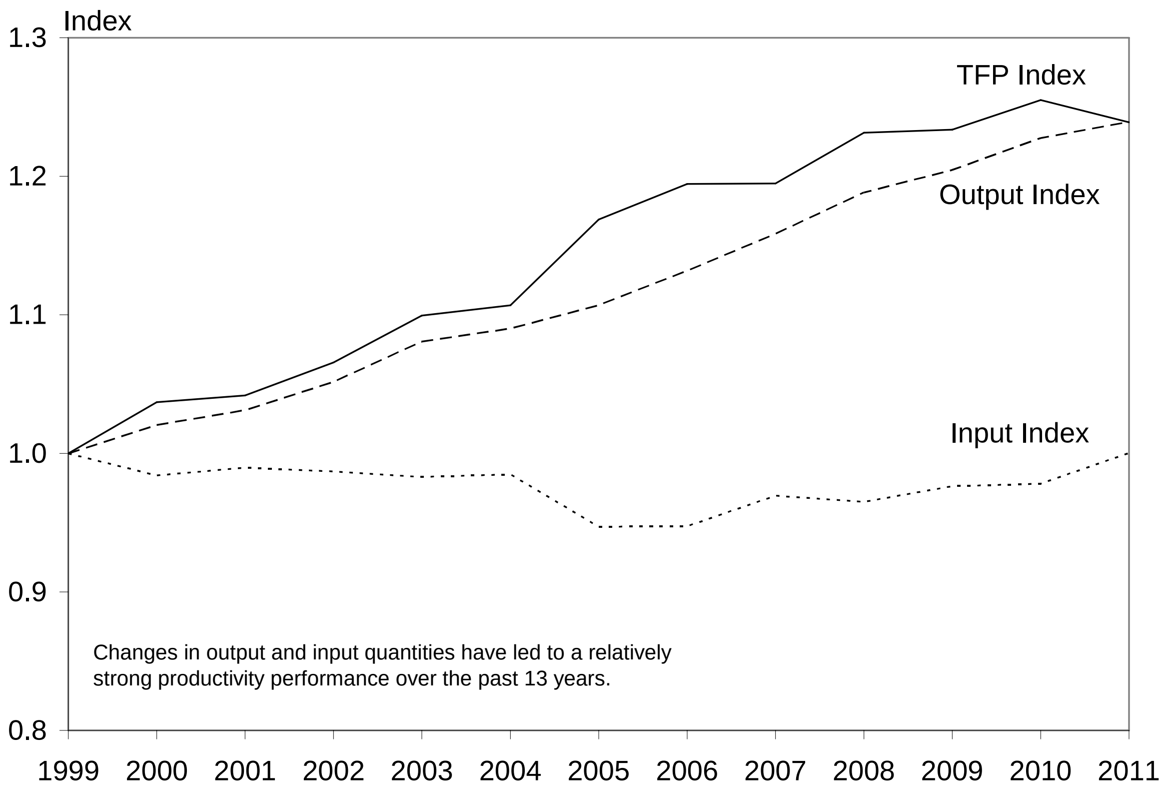
5 PRODUCTIVITY GROWTH RESULTS

In this section we first report the TFP performance of the Victorian gas distribution industry as a whole over the period 1999 to 2011 in section 5.1 before examining the TFP performance of each of the three Victorian GDBs over the same period in sections 5.2 to 5.3. We then compare the productivity growth rates of the three Victorian GDBs with productivity growth rates of the other three GDBs included in the detailed productivity database in section 5.4. To maintain comparability with data available for the other included GDBs we use the same specification as used in Economic Insights (2009c, 2010a). In section 5.5 we report Victorian GDB results using the billed outputs specification drawing on data collected for the first time in this study. In section 5.6 we report results using the billed outputs and exogenous capital user costs specification along the lines of Economic Insights (2010b).

5.1 Victorian gas distribution industry results, 1999 to 2011

In this section we present the key productivity results for the Victorian gas distribution industry for the 13 year period to 2011. Results are presented using the specification outlined in section 4 of three outputs (throughput, customer numbers and system capacity) and 8 inputs (opex, lengths of transmission pipelines, high pressure pipelines, medium pressure pipelines, low pressure pipelines and services, meters, and other capital).

Figure 5.1: **Victorian gas distribution output, input and TFP indexes, 1999–2011**



Source: Economic Insights GDB database

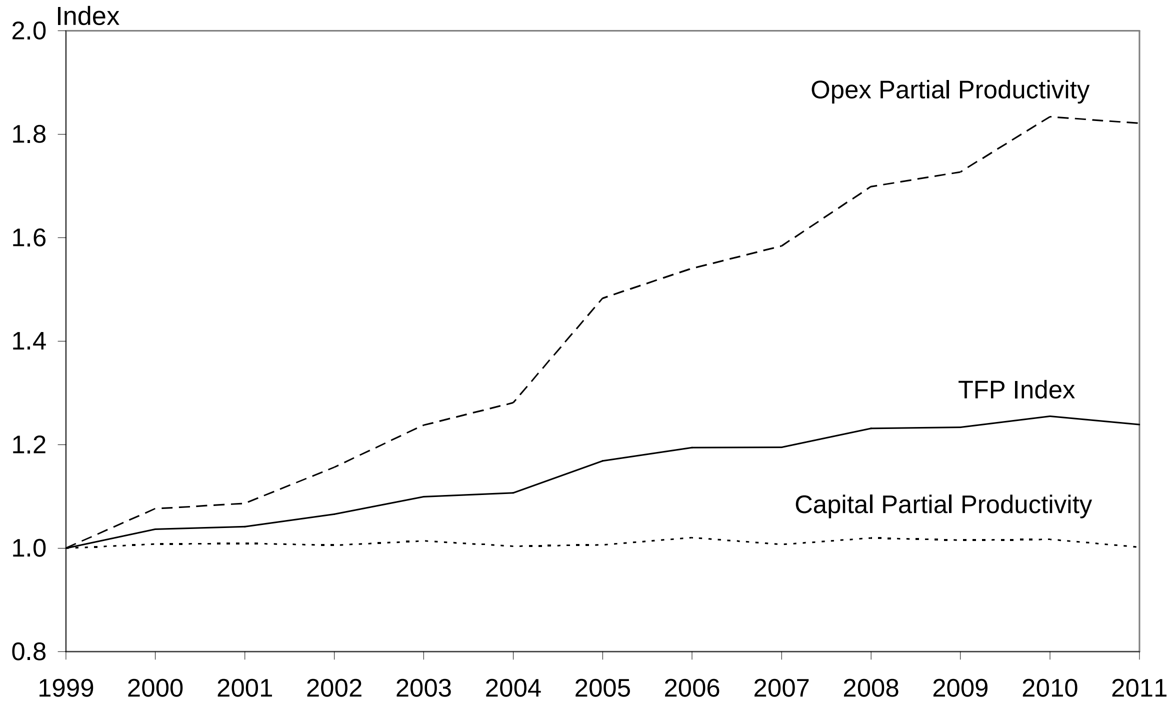
The output, input and TFP indexes for the Victorian gas distribution industry are presented in figure 5.1 and table 5.1.

Table 5.1: **Victorian gas distribution productivity indexes, 1999–2010**

Year	Output	Input	Opex	Capital	Opex PP	Capital PP	TFP
1999	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2000	1.021	0.984	0.948	1.012	1.076	1.008	1.037
2001	1.031	0.990	0.949	1.021	1.087	1.010	1.042
2002	1.052	0.987	0.910	1.046	1.156	1.006	1.066
2003	1.081	0.983	0.873	1.066	1.238	1.014	1.099
2004	1.090	0.985	0.851	1.086	1.281	1.004	1.107
2005	1.107	0.947	0.746	1.100	1.483	1.006	1.169
2006	1.132	0.947	0.734	1.109	1.541	1.021	1.195
2007	1.158	0.970	0.731	1.150	1.584	1.007	1.195
2008	1.188	0.965	0.699	1.165	1.699	1.020	1.231
2009	1.205	0.976	0.697	1.186	1.727	1.016	1.234
2010	1.228	0.978	0.669	1.207	1.834	1.017	1.255
2011	1.239	1.000	0.680	1.237	1.821	1.002	1.239
Average Annual Change							
2002–2011	1.84%	0.11%	–3.33%	1.92%	5.17%	–0.08%	1.73%
2007–2011	1.82%	1.09%	–1.53%	2.19%	3.34%	–0.37%	0.73%

Source: Calculations using Economic Insights GDB database

Figure 5.2: **Victorian gas distribution partial productivity indexes, 1999–2011**



Source: Economic Insights GDB database

The increase in the output quantity index over the last 13 years has been relatively steady with an average annual growth rate of 1.8 per cent over both the last 10 years and the last 5 years. The total quantity of inputs fell by just over 5 per cent between 1999 and 2005 before increasing by a similar amount between 2006 and 2011. Overall input use had an average annual growth rate of only 0.1 per cent over the last 10 years but this was higher at 1.1 per cent over the last 5 years.

The pattern of input quantity growth has differed markedly between opex and capital. Opex quantity fell markedly between 1999 and 2008 with a 30 per cent reduction on 1999 levels by 2008. Since 2008 opex usage has flattened out. The average annual rate of reduction was 3.3 per cent for the last 10 years but 1.5 per cent for the last 5 years and only 0.1 per cent for the last 3 years. Capital input usage, on the other hand, has continued to increase over the period with average annual growth rates of 1.9 per cent over the last 10 years and 2.2 per cent over the last 5 years.

These changes in output and input quantities have led to a relatively strong productivity performance over the last 13 years, driven largely by significant reductions in opex. From figure 5.2 and table 5.1 we see that the partial productivity of opex has grown strongly at the high annual rate of 5.2 per cent over the last 10 years and a still strong rate of 3.3 per cent over the last 5 years. However, we will see in the following sections that the pattern of opex partial productivity growth has been very different across the three GDBs. Annual growth in the partial productivity of capital has been slightly negative over the last 10 years at –0.1 per cent and –0.4 per cent over the last 5 years.

The TFP index (which is effectively a weighted average of the two partial productivity indexes) exhibits relatively steady growth over the past 13 years. The average annual growth rate was 1.7 per cent the last 10 years although this has slowed to 0.7 per cent for the last 5 years.

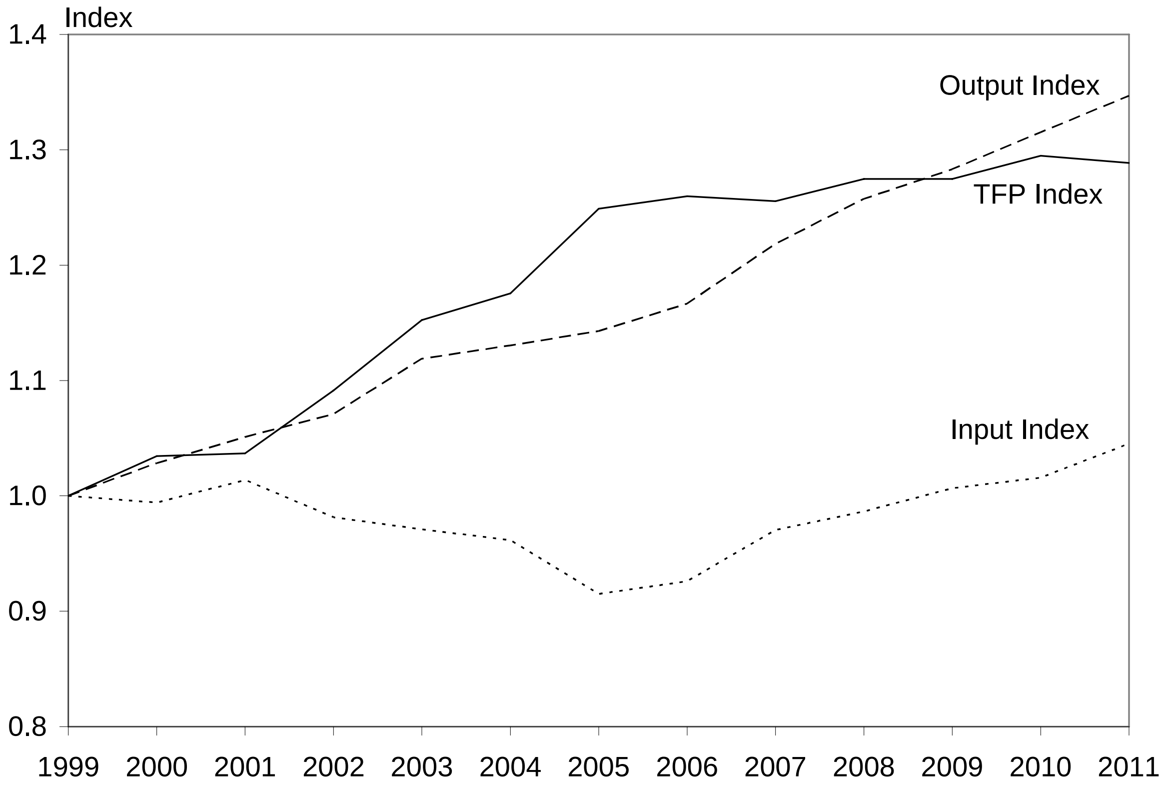
5.2 Envestra Victoria productivity growth, 1999 to 2011

In this section we present the key productivity results for Envestra Victoria's gas distribution system for the 13 year period to 2011. The output, input and TFP indexes for Envestra Victoria are presented in figure 5.3 and table 5.2.

The increase in the output quantity index over the last 13 years has been relatively steady with average annual growth rates of 2.5 per cent over the last 10 years and of 2.9 per cent over the last 5 years. The total quantity of inputs fell by around 4 per cent between 1999 and 2006 before increasing after that to end up around 5 per cent above its 1999 level in 2011. Overall input use had an average annual growth rate of only 0.3 per cent over the last 10 years but this was considerably higher at 2.4 per cent over the last 5 years.

The pattern of input quantity growth has differed markedly between opex and capital. Opex quantity fell by one third between 1999 and 2005. Since 2005 opex usage has increased by 14 per cent. The average annual rate of reduction was 2.8 per cent for the last 10 years but there was an average annual increase of 2.1 per cent for the last 5 years. Capital input usage, on the other hand, has continued to increase over the period with average annual growth rates of 2.4 per cent over the last 10 years and 2.6 per cent over the last 5 years.

Figure 5.3: **Envestra Victoria output, input and TFP indexes, 1999–2011**



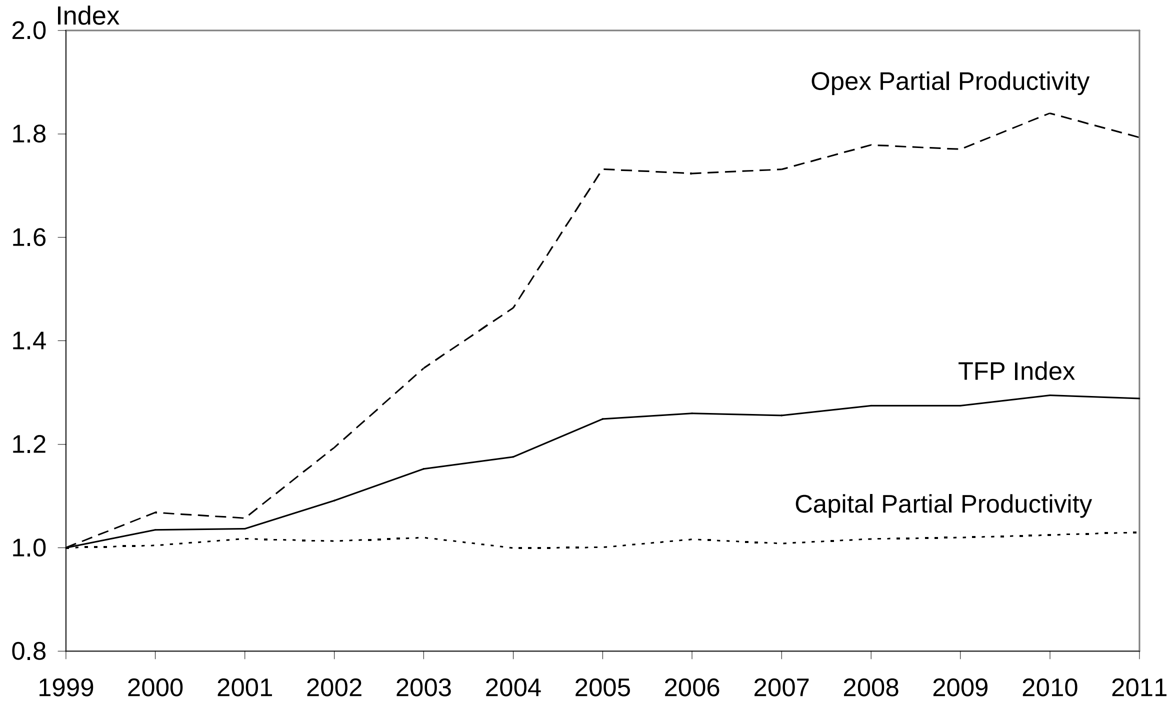
Source: Economic Insights GDB database

Table 5.2: **Envestra Victoria productivity indexes, 1999–2010**

Year	Output	Input	Opex	Capital	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							
2002–2011	2.48%	0.31%	-2.80%	2.36%	5.28%	0.12%	2.17%
2007–2011	2.87%	2.42%	2.08%	2.60%	0.79%	0.27%	0.45%

Source: Calculations using Economic Insights GDB database

Figure 5.4: **Envestra Victoria partial productivity indexes, 1999–2011**



Source: Economic Insights GDB database

These changes in output and input quantities have led to a relatively strong productivity performance over the last 13 years on average, driven largely by significant reductions in opex. From figure 5.4 and table 5.2 we see that the partial productivity of opex grew strongly between 2001 and 2005 but has flattened off since then leading to the high average annual growth rate of 5.3 per cent over the last 10 years but a much lower 0.8 per cent over the last 5 years. Annual growth in the partial productivity of capital has been somewhat positive over the last 10 years at 0.1 per cent and 0.3 per cent over the last 5 years.

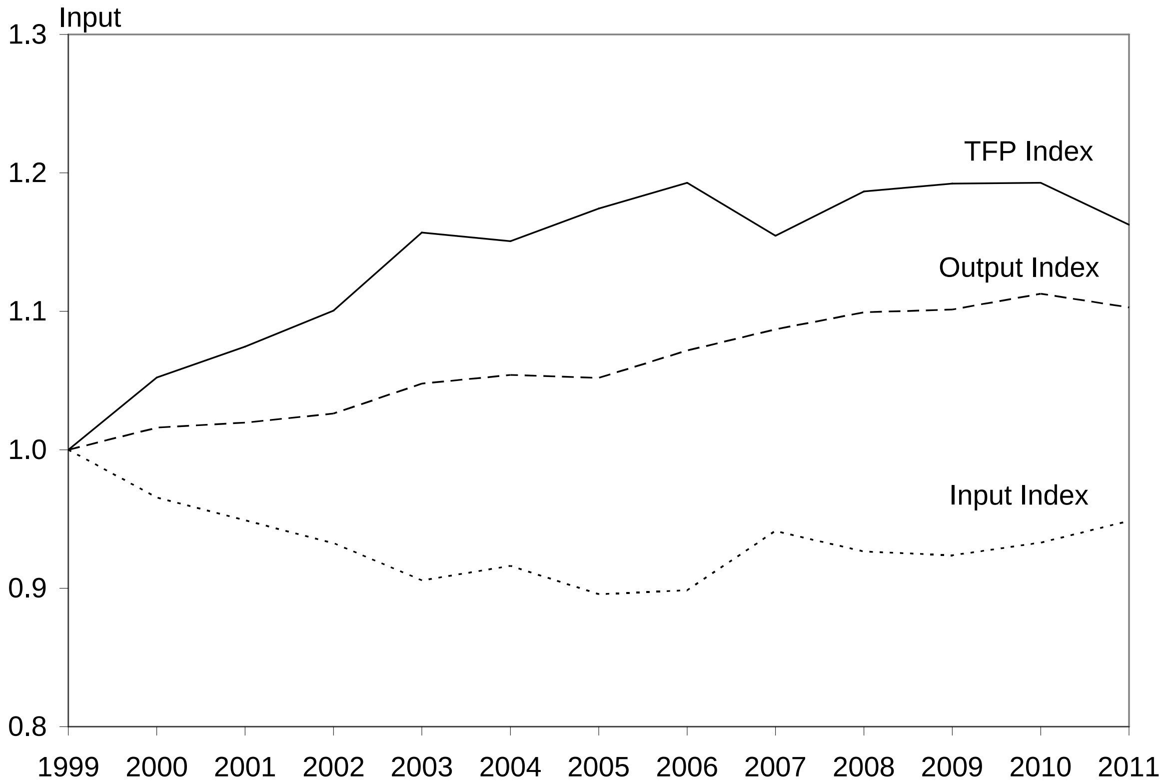
The TFP index (which is effectively a weighted average of the two partial productivity indexes) exhibits relatively strong growth up to 2005 but much more modest growth since then. The average annual growth rate was 2.2 per cent the last 10 years but this has slowed to 0.5 per cent for the last 5 years.

5.3 Multinet productivity growth, 1999 to 2011

In this section we present the key productivity results for Multinet's gas distribution system for the 13 year period to 2011. The output, input and TFP indexes for Multinet are presented in figure 5.5 and table 5.3.

The increase in the output quantity index over the last 13 years has been relatively steady but much more modest than for Envestra Victoria with average annual growth rates of 0.8 per cent over the last 10 years and of 0.6 per cent over the last 5 years. The total quantity of inputs fell by around 10 per cent between 1999 and 2005 before increasing after that to end

Figure 5.5: **Multinet output, input and TFP indexes, 1999–2011**



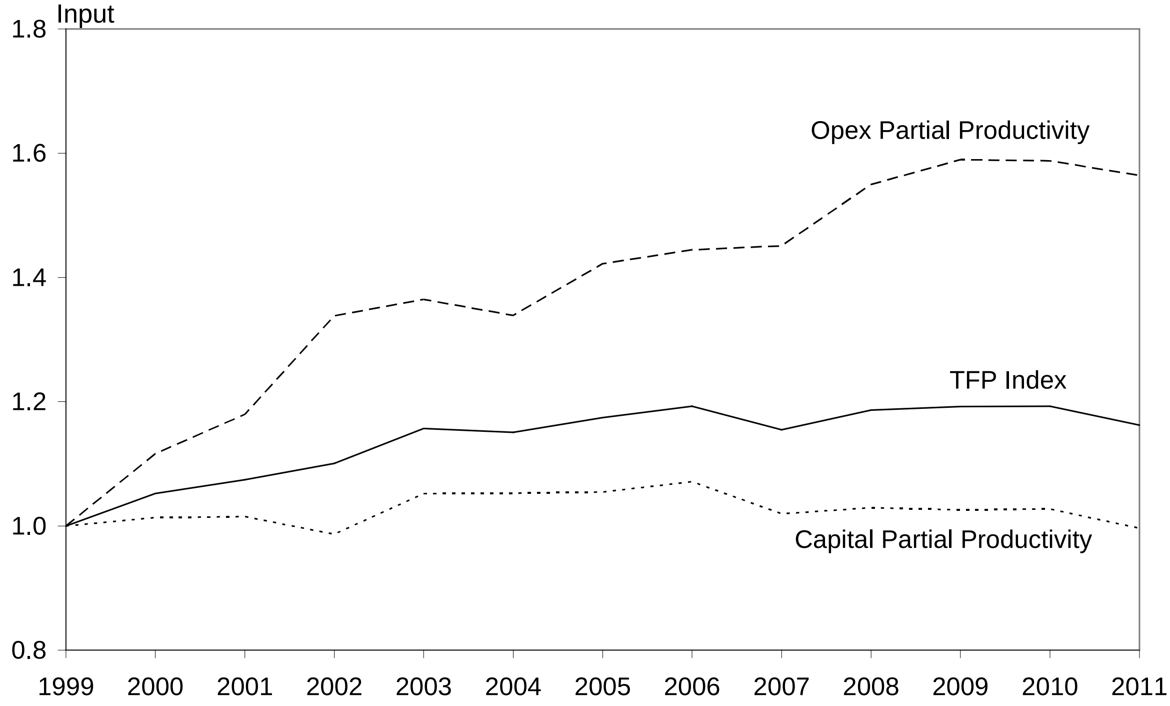
Source: Economic Insights GDB database

Table 5.3: **Multinet productivity indexes, 1999–2010**

Year	Output	Input	Opex	Capital	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							
2002–2011	0.78%	0.00%	–2.04%	0.97%	2.82%	–0.18%	0.79%
2007–2011	0.57%	1.09%	–1.02%	2.02%	1.60%	–1.45%	–0.52%

Source: Calculations using Economic Insights GDB database

Figure 5.6: **Multinet partial productivity indexes, 1999–2011**



Source: Economic Insights GDB database

up around 5 per cent below its 1999 level in 2011. Overall input use had average annual growth rates of zero per cent over the last 10 years and 1.1 per cent over the last 5 years.

The pattern of input quantity growth has again differed markedly between opex and capital. Opex quantity fell by around 30 per cent between 1999 and 2009. Since 2009 opex usage has increased marginally. The average annual rate of reduction was 2.0 per cent for the last 10 years but this reduced to an annual decrease of 1.0 per cent for the last 5 years. Capital input usage, on the other hand, was relatively flat from 1999 to 2006 but has increased by over 10 per cent since then. The average annual growth rates in the capital input quantity have been 1.0 per cent over the last 10 years and 2.0 per cent over the last 5 years.

Despite ongoing large reductions in opex usage, Multinet's relatively low rate of output growth given the more mature inner city area it services has constrained its productivity performance over the last 13 years. From figure 5.6 and table 5.3 we see that the partial productivity of opex grew strongly between 1999 and 2002 and again between 2007 and 2009 but growth was more modest between 2002 and 2007 and has flattened off since 2009. This has led to average annual growth rates of 2.8 per cent over the last 10 years and 1.6 per cent over the last 5 years. Annual growth in the partial productivity of capital has been somewhat negative over the last 10 years at –0.2 per cent and more negative over the last 5 years –1.5 per cent with the increase in capital quantity since 2006.

The TFP index (which is effectively a weighted average of the two partial productivity indexes) exhibits relatively strong growth up to 2003 but much more modest growth since then. The average annual growth rate was 0.8 per cent the last 10 years but this has reversed to a decrease of –0.5 per cent for the last 5 years, driven in part by a fall in output in 2011.

5.4 SP AusNet productivity growth, 1999 to 2011

In this section we present the key productivity results for SP AusNet's gas distribution system for the 13 year period to 2011. The output, input and TFP indexes for SP AusNet are presented in figure 5.7 and table 5.4.

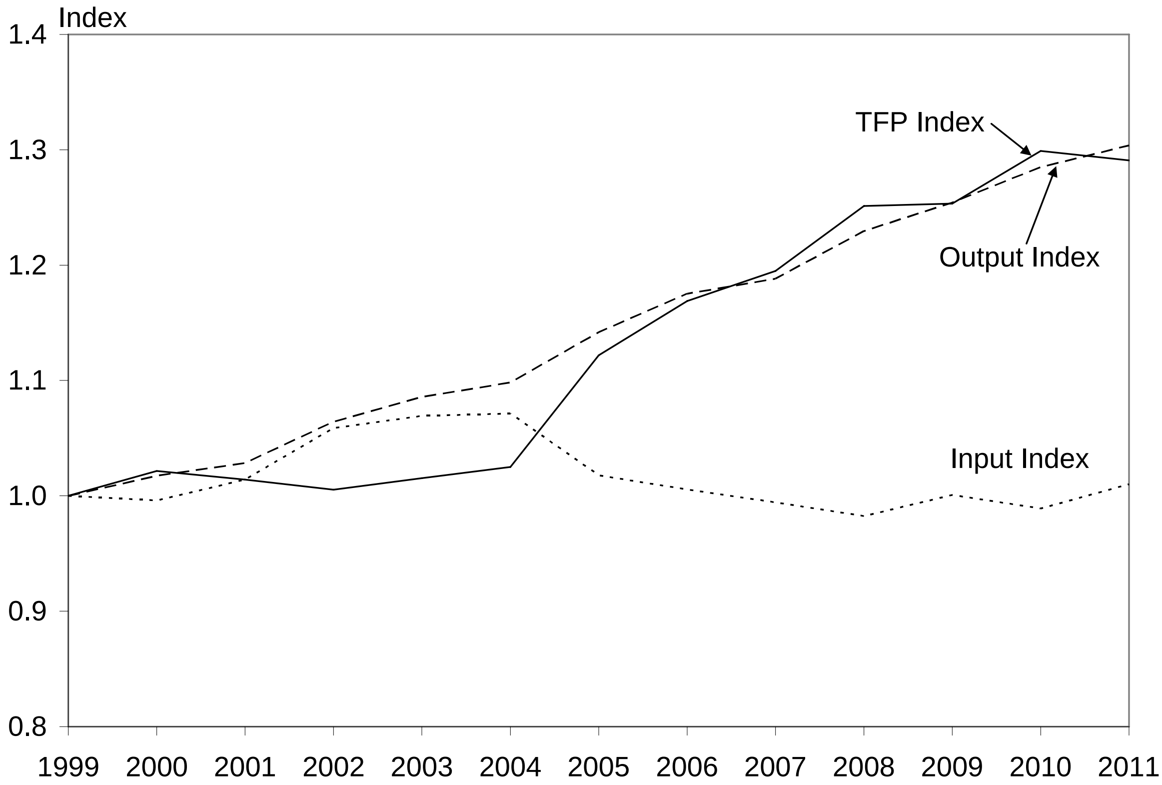
The increase in the output quantity index over the last 13 years has been relatively steady with average annual growth rates of 2.4 per cent over the last 10 years and of 2.1 per cent over the last 5 years. These growth rates are similar to Envestra Victoria's for the 10 year period but lower for the last 5 years. They are considerably higher than Multinet's output growth rates. SP AusNet's total input quantity movements have been quite different to those of the other two GDBs. Total input quantity increased by 7 per cent between 1999 and 2004 before falling back to around its 1999 level over the next two years and staying around that level through to 2011. Overall input use had a slightly negative average annual growth rate over the last 10 years and an annual increase of only 0.1 per cent over the last 5 years.

The pattern of input quantity growth has again differed markedly between opex and capital for SP AusNet. However, SP AusNet's pattern of opex usage has been very different to that of the other two GDBs. Whereas Envestra Victoria's and Multinet's opex both fell sharply during the first half of the period and then levelled off, SP AusNet's opex quantity stayed relatively flat on average between 1999 and 2004 before then falling by over 40 per cent during the second half of the period. The average annual rate of reduction was a very high 5.5 per cent for the last 10 years and 6.3 per cent for the last 5 years, although opex usage flattened out in the last year of the period. Capital input usage, on the other hand, has continued to increase over the period with average annual growth rates of 2.5 per cent over the last 10 years and 2.2 per cent over the last 5 years.

SP AusNet thus appears to have embarked on major opex usage reforms somewhat later than the other two GDBs. The other two GDBs exhibited rapid reductions in opex usage from 1999 onwards before opex usage levelled off around 2005. SP AusNet's rapid reductions in opex usage only commenced in 2004 but have levelled off over the last year. SP AusNet's reduction in opex usage over the second half of the period at around 40 per cent was somewhat larger than those achieved by the other two GDBs over the first half of the period of around 25 to 35 per cent. SP AusNet made significant savings in the network operations component of opex as it extracted synergies from the operation of the 3 networks it owns and operates. Many of these synergies were generated by the combined network operations centre it operates. However, once these synergies have been fully extracted there can be expected to be a flattening out of network operations costs and this was observed in 2011. Information technology investments have also allowed efficiencies in network operations to be achieved.

Offsetting some of the reduction in network operations costs over the second half of the period, however, has been an increase in maintenance costs, particularly from 2009 onwards. These cost increases are expected to continue, but may be mitigated by the pipe replacement program. The key driver of much of this cost increase has been unplanned work associated with reacting to water ingress and reported gas leaks associated with the deterioration of the aging network.

Figure 5.7: **SP AusNet output, input and TFP indexes, 1999–2011**



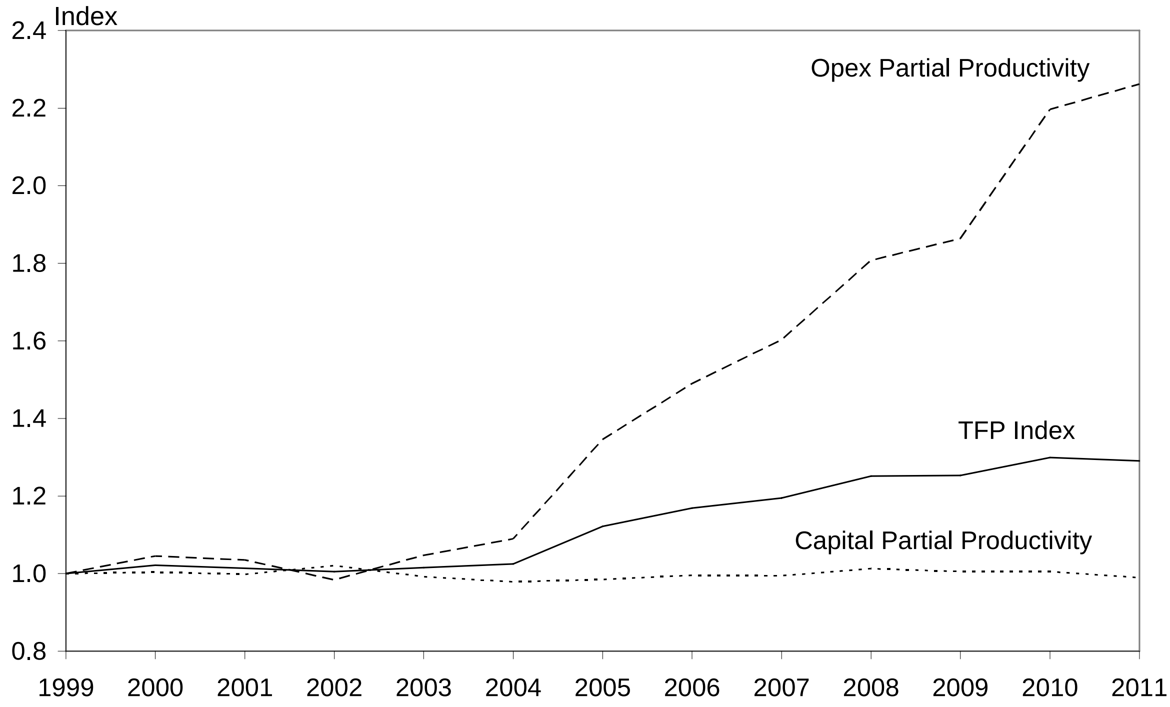
Source: Economic Insights GDB database

Table 5.4: **SP AusNet productivity indexes, 1999–2010**

Year	Output	Input	Opex	Capital	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							
2002–2011	2.37%	–0.04%	–5.45%	2.46%	7.82%	–0.09%	2.41%
2007–2011	2.07%	0.09%	–6.28%	2.19%	8.36%	–0.12%	1.98%

Source: Calculations using Economic Insights GDB database

Figure 5.8: **SP AusNet partial productivity indexes, 1999–2011**



Source: Economic Insights GDB database

These changes in output and input quantities have led to a relatively flat productivity performance up to 2004 but strong productivity growth in the second half of the period, driven largely by significant reductions in opex. From figure 5.8 and table 5.4 we see that the partial productivity of opex was relatively flat between 1999 and 2004 but it has more than doubled in the period since 2004. This has led to the high average annual growth rate of 7.8 per cent over the last 10 years and 8.4 per cent over the last 5 years. Annual growth in the partial productivity of capital, on the other hand, has been somewhat negative over both the last 10 years and the last 5 years at around –0.1 per cent.

The TFP index (which is effectively a weighted average of the two partial productivity indexes) was also relatively flat up to 2004 but has grown strongly since then. The average annual growth rate was 2.4 per cent for the last 10 years but this has slowed somewhat to 2.0 per cent for the last 5 years.

5.5 Comparison with JGN and Envestra SA productivity growth

This section compares the three Victorian GDBs' productivity growth rates with those of JGN and Envestra SA reported in Economic Insights (2010a)[3]. The historic output, input and productivity indexes and growth rates for JGN are presented in table 5.5 while the historic output, input and productivity indexes and growth rates for Envestra SA are presented in table 5.6. Note that the historic JGN data only goes to 2009 while that for Envestra SA goes to 2010, reflecting the times when the earlier studies were undertaken.

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

Table 5.5: **JGN gas distribution productivity indexes, 1999–2009**

Year	Output	Input	Opex	Capital	PP Opex	PP Capital	TFP
1999	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2000	1.032	1.005	0.938	1.040	1.100	0.992	1.027
2001	1.054	1.013	0.915	1.067	1.151	0.988	1.040
2002	1.079	0.991	0.820	1.090	1.316	0.990	1.089
2003	1.101	0.985	0.773	1.109	1.424	0.993	1.118
2004	1.120	0.971	0.719	1.121	1.558	0.999	1.153
2005	1.136	0.977	0.697	1.142	1.629	0.995	1.163
2006	1.150	0.964	0.645	1.156	1.782	0.994	1.192
2007	1.169	0.987	0.655	1.186	1.785	0.985	1.184
2008	1.188	0.998	0.652	1.207	1.822	0.984	1.190
2009	1.205	0.993	0.610	1.229	1.975	0.980	1.213
Average Annual Change							
1999–2009	1.87%	–0.07%	–4.94%	2.06%	6.81%	–0.20%	1.93%

Source: Economic Insights (2010a, p.29)

Table 5.6: **Envestra SA gas distribution productivity indexes, 1999–2010**

Year	Output	Input	Opex	Capital	PP Opex	PP Capital	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%

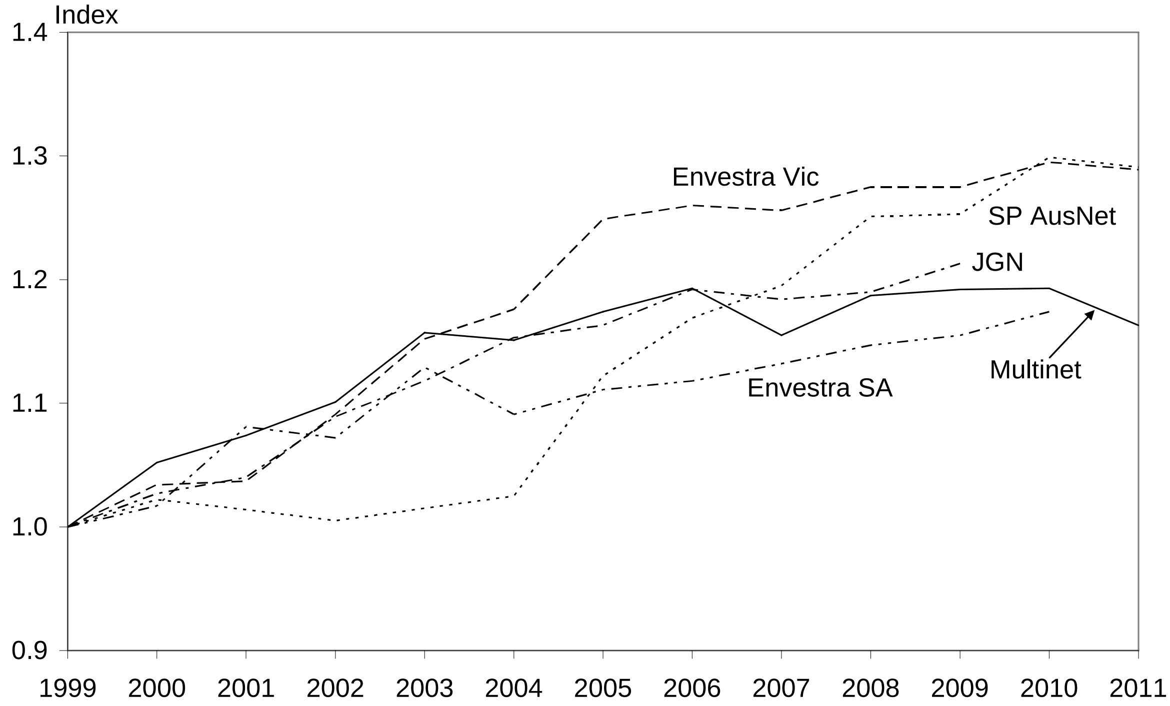
Source: Economic Insights (2010a, p.25)

The three Victorian GDBs', Envestra SA's and Envestra Qld's TFP indexes are plotted in figure 5.9 for the period starting in 1999. Envestra Victoria and SP AusNet had the highest TFP growth for the period up to 2009 (the latest year for which data are available for all the included GDBs) with average annual growth rates of 2.4 per cent and 2.3 per cent, respectively. They were followed by JGN and Multinet with average annual TFP growth rates of 1.9 per cent and 1.8 per cent, respectively. The smaller Envestra SA had the lowest TFP growth rate at a still very reasonable 1.4 per cent.

TFP growth slowed markedly for 4 of the included GDBs in the more recent 5 year period from 2005 to 2009, with SP AusNet being the exception. Envestra Victoria's average annual

TFP growth fell to 1.6 per cent, Envestra SA's fell to 1.1 per cent, JGN's fell to 1.0 per cent and Multinet's fell to 0.7 per cent over the 5 years to 2009. Reflecting its relatively later start in the process of reform in opex usage, SP AusNet's average annual TFP growth rate increased to 4.0 per cent for this period. TFP growth was, however, negative for all three Victorian GDBs in 2011 reflecting increases in input usage and, in the case of Multinet, a reduction in output.

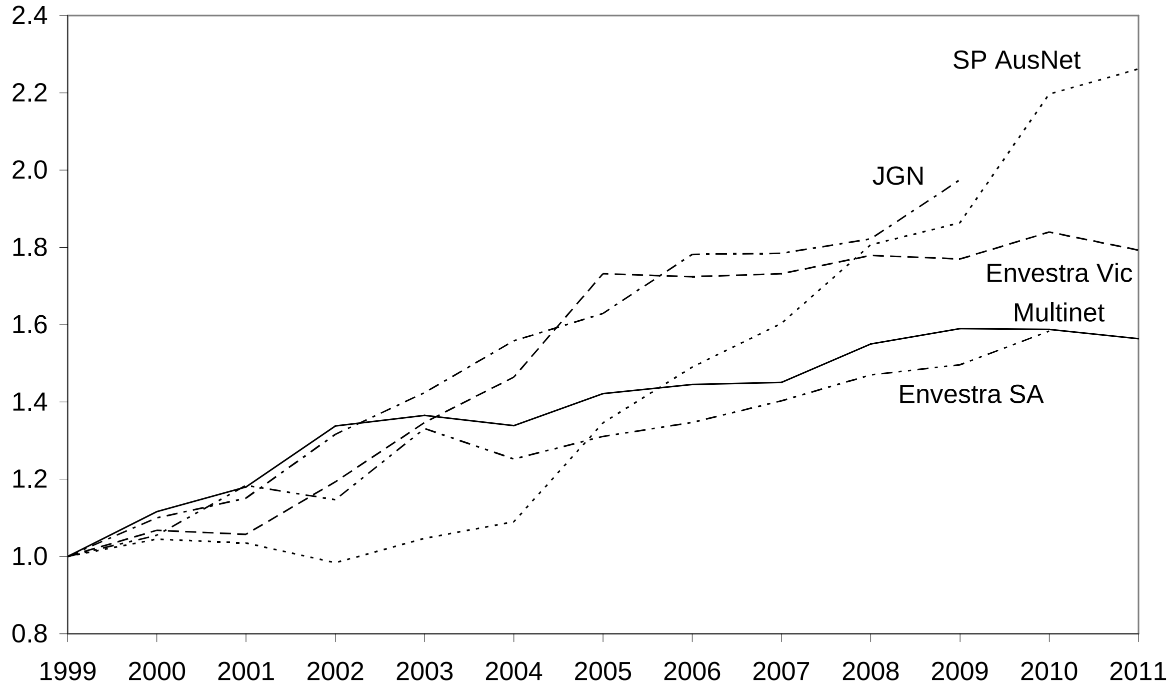
Figure 5.9: **Victorian GDB, JGN, and Envestra SA TFP indexes, 1999–2011**



Source: Economic Insights GDB database

The three Victorian GDBs', Envestra SA's and Envestra Qld's opex partial productivity indexes are plotted in figure 5.10 starting from 1999. All 5 included GDBs have exhibited strong opex partial productivity growth over this period although it has slowed over the second half of the period for all except SP AusNet. For the period from 1999 to 2009 (the latest year of common data) JGN, SP AusNet and Envestra Victoria had the highest opex partial productivity growth with average annual rates of 6.8 per cent, 6.2 per cent and 5.7 per cent, respectively. Multinet and Envestra SA had slightly lower opex partial productivity growth rates of 4.6 per cent and 4.0 per cent, respectively. For the last 5 years of the period to 2009, SP AusNet's average annual opex partial productivity growth rate increased to a very high 10.7 per cent while those of the other 4 GDBs decreased to between 3.6 per cent and 4.7 per cent. There was a further deceleration in opex partial productivity growth for the three Victorian GDBs for the most recent three year period from 2009 to 2011 with Envestra Victoria's and Multinet's average annual growth rates both falling to 0.3 per cent while SP AusNet's average annual growth rate reduced to 7.5 per cent. For the latest year for which data are available the Envestra Victoria, Multinet and SP AusNet annual opex partial productivity growth rates have further fallen to –2.5 per cent, –1.5 per cent and 3.0 per cent, respectively.

Figure 5.10: **Victorian GDB, JGN, and Envestra SA PFP opex indexes, 1999–2011**



Source: Economic Insights GDB database

Over the period from 1999 to 2009 all 5 of the included GDBs had similar capital partial productivity growth with average annual growth rates in the range of –0.2 per cent to 0.3 per cent. The range increased only slightly to –0.5 per cent to 0.5 per cent over the 5 years to 2009.

In summary, all of the 5 included GDBs have exhibited relatively strong TFP growth since 1999, driven mainly by strong opex partial productivity growth. In most cases opex partial productivity growth was considerably higher in the first half of the period and has progressively reduced over the second half of the period. SP AusNet started the opex usage reform process later and so has exhibited higher productivity growth in the second half of the period than the first but its productivity growth has also tapered off in recent years as available cost savings have progressively been implemented.

5.6 TFP results using billed outputs and exogenous capital user costs

As noted in section 3, there has been some debate about whether only 'billed' outputs (ie outputs explicitly charged for) should be included in the TFP measure for regulatory purposes or whether 'functional' outputs which include both billed outputs and 'unbilled' outputs (ie outputs of value to the user – such as system reliability and redundancy – but which are not explicitly charged for) should be included.

Economic Insights (2009a) has recently shown that all network outputs – both billed and unbilled – should ideally be included in the productivity measure and that each output should be weighted by the difference between its price and marginal cost in deriving the X factor. This is a somewhat more complex weighting process than the simplified output cost shares approach used to date. However, marginal costs are not readily observable and their estimation would currently require the use of econometric methods. Economic Insights (2009a) also showed that, provided billed outputs are included as a subset of functional outputs, then the results obtained using the two approaches will be broadly similar.

Up until now, attempts to implement the billed outputs approach have used proxy quantity measures and/or data on revenue from one year only. In this study we have collected accurate billed quantity and matching revenue data as part of the updated and expanded survey of the Victorian GDBs. In this section we commence by comparing output quantity index and TFP results using the detailed billed outputs approach with the simplified functional output–based results presented so far. The availability of the billed outputs data is currently limited to Victoria so only Victorian results are presented here.

Victorian GDBs charge according to 5 broad tariff categories. Tariff V Domestic and Tariff V Non–domestic apply to smaller consumers and charges comprise a variable component based on throughput and a fixed per customer component. Tariffs D, L and M apply to large industrial users and charges are imposed on the basis of the individual customer's maximum hourly demand for the period in question. There are no variable or fixed charges for these customers.

We have collected data on three billed output quantities and associated revenues: throughput for Tariff V customers (variable charges), the number of Tariff V customers (fixed charges) and the sum of (non–coincident) maximum hourly demands for all Tariff D, L and M customers (demand–based charges). These three billed outputs compare with total throughput, total customer numbers and system capacity used as the three output components so far in this report. The differences are thus Tariff V throughput versus total throughput, Tariff V customer numbers versus total customers and the sum of maximum hourly demands for all Tariff D, L and M customers versus system capacity.

The other important difference between the billed output results presented in this section and the results presented up till now in this report is the output weights used in forming the total output quantity index. The output cost share based results presented up till now allocate weights of 13 per cent to throughput, 49 per cent to customer numbers and 38 per cent to system capacity based on the results of the cost function analysis presented in Lawrence (2007). The actual revenue shares of the Victorian GDBs are very different to these output cost shares. The revenue shares for variable (throughput) charges range from 77 per cent to 92 per cent in the sample. The revenue shares for fixed (customer) charges range from 10 per cent to 22 per cent and the revenue shares for demand–based charges range from 1 per cent to 5 per cent. The billed output approach thus places much greater weight on the throughput quantity which is generally the most volatile of the three billed output quantities.

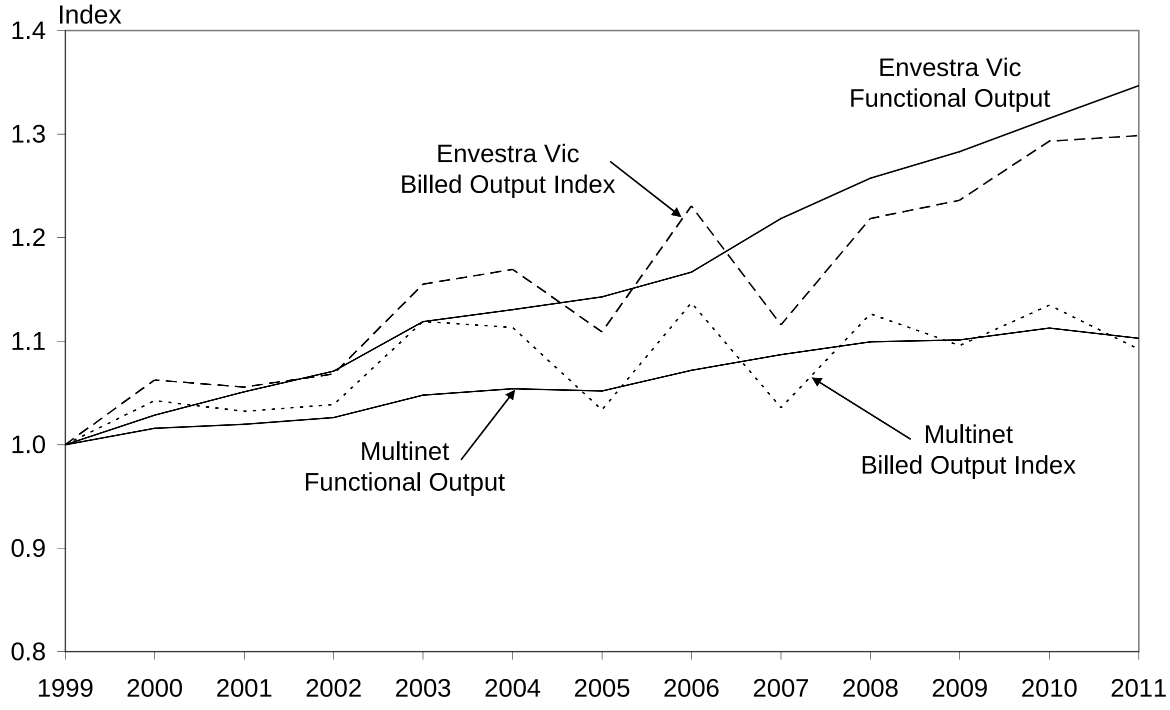
In table 5.7 we present the billed output quantity and TFP indexes for each of the three Victorian GDBs. The TFP indexes are calculated using the same input specification as used in this report up until now to maximise comparability. Because the same input quantity indexes are used as previously, differences in the output quantity indexes will translate directly to corresponding differences between the functional output–based and billed output–based TFP indexes.

Table 5.7: **Victorian GDB billed output and associated TFP indexes, 1999–2011**

	Envestra Victoria		Multinet		SP AusNet	
Year	Output	TFP	Output	TFP	Output	TFP
1999	1.000	1.000	1.000	1.000	1.000	1.000
2000	1.062	1.069	1.042	1.080	1.022	1.026
2001	1.056	1.041	1.032	1.088	1.018	1.003
2002	1.068	1.089	1.039	1.114	1.057	0.999
2003	1.155	1.189	1.119	1.236	1.156	1.081
2004	1.169	1.216	1.113	1.215	1.169	1.091
2005	1.109	1.212	1.034	1.154	1.093	1.073
2006	1.231	1.329	1.137	1.266	1.228	1.221
2007	1.116	1.150	1.036	1.100	1.151	1.158
2008	1.219	1.235	1.126	1.216	1.276	1.299
2009	1.236	1.228	1.096	1.186	1.264	1.263
2010	1.293	1.273	1.135	1.216	1.328	1.342
2011	1.299	1.242	1.092	1.151	1.343	1.329
Average Annual Change						
2002–2011	2.07%	1.77%	0.56%	0.57%	2.77%	2.81%
2007–2011	1.08%	–1.34%	–0.80%	–1.89%	1.79%	1.70%

Source: Calculations using Economic Insights GDB database

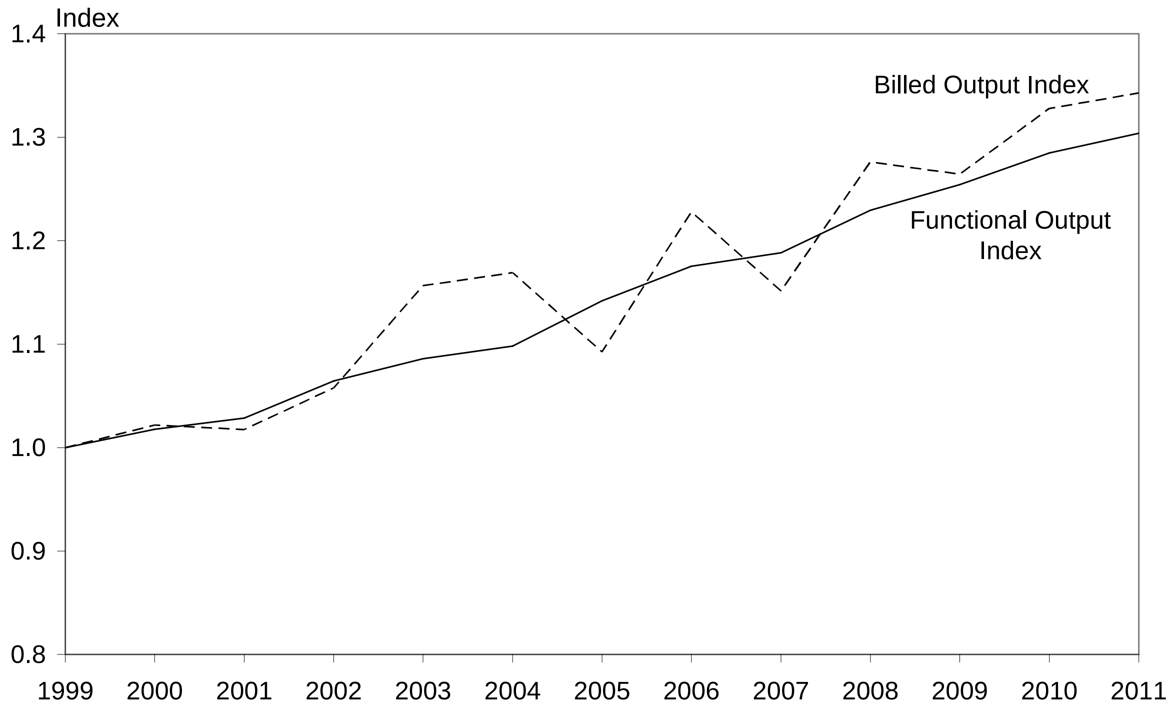
Figure 5.11: **Envestra Victoria and Multinet billed output indexes, 1999–2011**



Source: Economic Insights GDB database

The functional output indexes and the billed output indexes for Envestra Victoria and Multinet are plotted and compared in figure 5.11 while those for SP AusNet are presented in figure 5.12.

Figure 5.12: **SP AusNet billed and functional output indexes, 1999–2011**



Source: Economic Insights GDB database

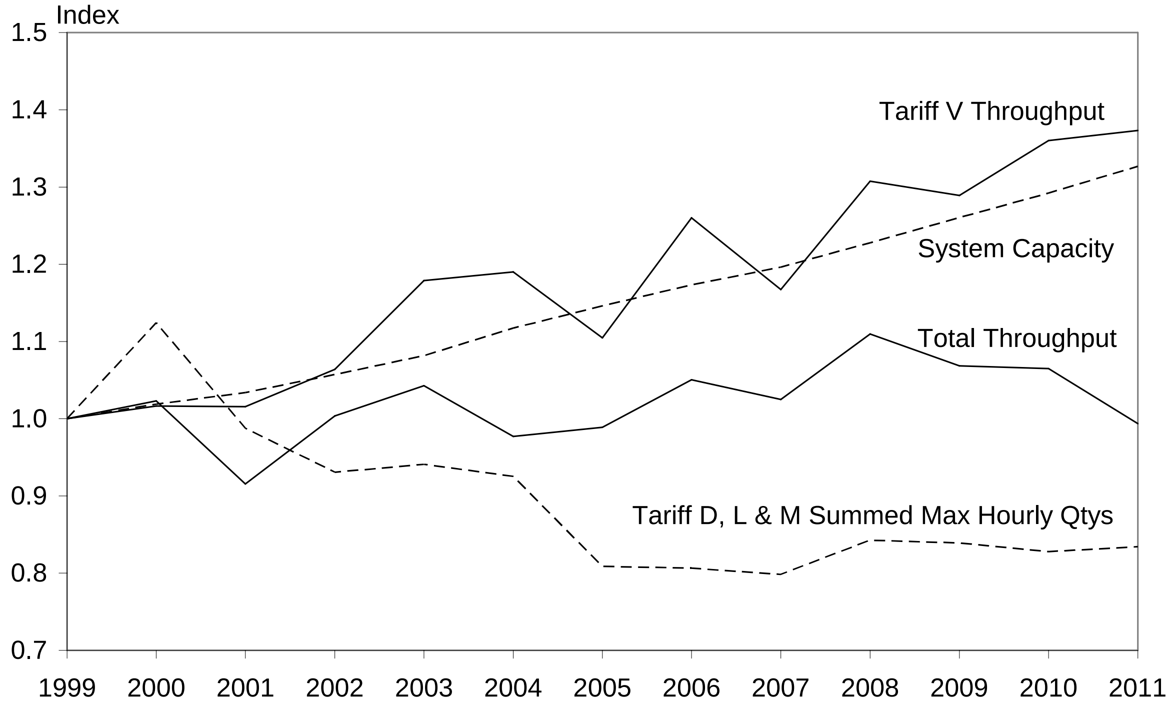
For all three GDBs the billed outputs index tracks the functional outputs index quite closely although the billed outputs index is considerably more volatile reflecting the greater impact of climatic differences (and corresponding differences in the consumption of gas for heating) across years. For longer time periods starting and ending in years with relatively average climatic conditions, the average annual growth rates of the billed and functional output indexes – and the corresponding TFP indexes – are relatively similar. However, for periods starting or ending in years with abnormal climatic conditions there will be a more significant difference in average growth rates[4]. This particularly applies to relatively short periods and is illustrated by the results for the last 5 years where the calculated average annual growth rates for all three GDBs' billed outputs and TFP indexes are pulled down by the large fall in throughput occurring in 2007 as climatic conditions went from colder than normal in 2006 to warmer than normal in 2007.

While the billed total output and functional total output quantity indexes move in a similar overall fashion, the components of the respective indexes move in quite different ways. Of the three components in each, the customer numbers components are close to identical. While the functional output specification uses total customer numbers and the billed output specification uses Tariff V customer numbers (reflecting that part of the customer base

[4] This particularly applies to the commonly–used logarithmic endpoint to endpoint method for calculating growth rates used in this report.

subject to fixed charges), the numbers of customers on demand–based charges is so small compared to total customer numbers that including or excluding them makes only a trivial difference to the customer number–based output component. However, there are significant differences in trends between the throughput components and the system capacity/demand–based component quantity trends.

Figure 5.13: **SP AusNet component output indexes, 1999–2011**



Source: Economic Insights GDB database

In figure 5.13 we plot the throughput and system capacity/demand–based component quantity indexes for SP AusNet. Similar patterns are observed for the other two GDBs. The Tariff V throughput quantity index has continued to increase over time while the total throughput quantity index has been relatively flat overall. All else equal this would lead to the throughput component in the billed output specification contributing much more to output growth – particularly given its very high weight – compared to the functional output throughput component. However, offsetting this has been relative movements in the system capacity/demand–based quantities. The system capacity index has continued to increase steadily over the 13 year period while the summed maximum hourly quantities of demand–based customers has actually declined leading to a wide gap developing between these two indexes. Since the demand–based quantity index receives a relatively small weight in the billed output specification, this tends to offset the high weight given to the smaller gap between the throughput component growth rates.

The other change in specification emerging from the detailed theoretical development work in Economic Insights (2009a) and implemented in the Economic Insights (2010b) model for the AEMC is the use of exogenous user costs which explicitly recognise the important regulatory requirement of financial capital maintenance. To model this we use a similar process to that used in Economic Insights (2010b) which uses a simplified version of the AER's (2008a) post–tax revenue model.

Table 5.8: **Victorian gas distribution indexes using endogenous and exogenous capital user costs, 1999–2011**

	Capital Quantity		Total Input		TFP	
Year	Endogenous	Exogenous	Endogenous	Exogenous	Endogenous	Exogenous
1999	1.000	1.000	1.000	1.000	1.000	1.000
2000	1.012	0.998	0.984	0.977	1.037	1.044
2001	1.021	0.990	0.990	0.973	1.042	1.059
2002	1.046	1.031	0.987	0.980	1.066	1.073
2003	1.066	1.050	0.983	0.974	1.099	1.109
2004	1.086	1.069	0.985	0.976	1.107	1.117
2005	1.100	1.082	0.947	0.940	1.169	1.178
2006	1.109	1.088	0.947	0.938	1.195	1.206
2007	1.150	1.113	0.970	0.951	1.195	1.218
2008	1.165	1.121	0.965	0.942	1.231	1.262
2009	1.186	1.143	0.976	0.954	1.234	1.263
2010	1.207	1.168	0.978	0.957	1.255	1.283
2011	1.237	1.221	1.000	0.992	1.239	1.249
Average Annual Change						
2002–2011	1.92%	2.09%	0.11%	0.19%	1.73%	1.65%
2007–2011	2.19%	2.30%	1.09%	1.11%	0.73%	0.70%

Source: Calculations using Economic Insights GDB database

The results of using the exogenous capital user cost weights to aggregate capital inputs into an aggregate capital quantity and then to aggregate the opex and capital aggregates into the total input quantity are presented in table 5.8. They are compared with the corresponding indexes obtained using the endogenous used in earlier work. As foreshadowed in section 3.2, the differences between using the exogenous and endogenous user cost approaches are relatively minor in this case. This is because the implicit rates of return for the Victorian GDBs in the Economic Insights GDB database are relatively stable and of broadly similar magnitude, reflecting the fact that the Victorian GDBs have now been regulated for a relatively long period.

To summarise, in this section we have examined the impacts of using an alternative output specification – the billed outputs approach – and an alternative input specification which uses exogenous instead of endogenous capital user costs as weights in forming the total input quantity. In both cases the results are relatively invariant to these sensitivity tests. The billed outputs approach introduces more volatility into the output quantity index which can affect productivity growth rates if taken over a short period and with years of atypical climatic conditions at one or both ends of the period. However, the underlying trends in total output and TFP growth are broadly similar under the two approaches.

6 PRODUCTIVITY LEVEL RESULTS

6.1 Multilateral TFP indexes

Traditional measures of TFP such as those discussed in section 5 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:

$$\text{(15)} \qquad \log (TFP_m/TFP_n) = \sum_i (R_{im}+R_i^*) (\log Y_{im} - \log Y_i^*)/2 - \sum_i (R_{in}+R_i^*) (\log Y_{in} - \log Y_i^*)/2 - \sum_j (S_{jm}+S_j^*) (\log X_{jm} - \log X_j^*)/2 + \sum_j (S_{jn}+S_j^*) (\log X_{jn} - \log X_j^*)/2$$

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 the main application reported in the following section 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.

The formula in (15) 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 (15) 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*.

6.2 Victorian GDB productivity levels comparisons

We commence by comparing the productivity levels of the three Victorian GDBs given the coverage of activities reported so far in this report. It will be necessary to make changes to coverage in the next section to allow comparability of activities across states.

Table 6.1: **Victorian GDB multilateral output, input and TFP indexes, 1999–2011**

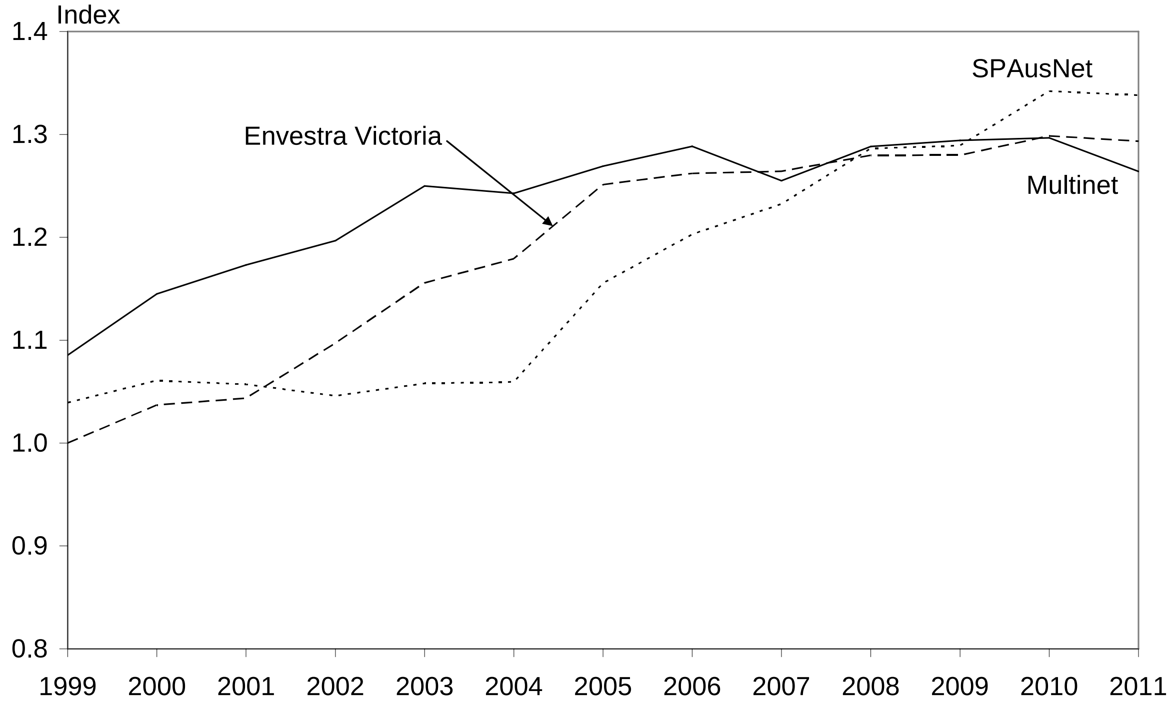
	Outputs			Inputs			TFP		
	Env Vic	Multinet	SP AN	Env Vic	Multinet	SP AN	Env Vic	Multinet	SP AN
1999	1.000	1.251	1.036	1.000	1.153	0.997	1.000	1.085	1.039
2000	1.028	1.271	1.054	0.992	1.110	0.993	1.037	1.145	1.061
2001	1.051	1.276	1.065	1.007	1.088	1.008	1.044	1.173	1.057
2002	1.071	1.284	1.102	0.976	1.073	1.054	1.097	1.197	1.046
2003	1.119	1.311	1.125	0.968	1.049	1.063	1.156	1.250	1.058
2004	1.130	1.319	1.138	0.959	1.061	1.074	1.179	1.243	1.059
2005	1.143	1.316	1.183	0.913	1.037	1.024	1.251	1.269	1.155
2006	1.167	1.341	1.218	0.924	1.041	1.012	1.262	1.288	1.203
2007	1.218	1.360	1.231	0.964	1.084	0.999	1.264	1.255	1.232
2008	1.257	1.376	1.274	0.983	1.068	0.990	1.280	1.288	1.286
2009	1.283	1.378	1.299	1.003	1.065	1.008	1.280	1.294	1.289
2010	1.315	1.393	1.331	1.013	1.074	0.992	1.299	1.297	1.342
2011	1.347	1.380	1.351	1.041	1.092	1.009	1.293	1.264	1.338

Source: Calculations using Economic Insights GDB database

Multilateral output, input and TFP indexes are presented in table 6.1 while multilateral TFP is plotted in figure 6.1. The indexes are presented relative to Envestra Victoria in 1999 having a value of one. Although Multinet started off producing 25 per cent more output than the other two GDBs in 1999, by 2011 there was little difference in the output levels of the three GDBs reflecting Multinet's slower output growth rate compared to the other two GDBs. There was similarly a narrowing in the spread of input levels over the period.

Moving to multilateral TFP, the spread of TFP levels was at its greatest around 2003 and 2004 as Envestra Victoria's and Multinet's TFP grew relatively rapidly up to that time while SP AusNet's TFP remained relatively flat. After 2004 SP AusNet's TFP grew rapidly while TFP growth for Envestra Victoria and Multinet levelled off. This led to a convergence of TFP levels in 2008 and 2009.

Figure 6.1: **Victorian GDB multilateral TFP indexes, 1999–2011**



Source: Economic Insights GDB database

In 2010 SP AusNet's TFP again increased leading to it opening up a small gap relative to the other two GDBs. However, the multilateral TFP levels for Envestra Victoria and SP AusNet fell marginally in 2011 while that for Multinet fell by 2.5 per cent, driven in large part by a fall in output.

The multilateral TFP results for Victoria show that the three Victorian GDBs have achieved good productivity growth over the last 13 years and have converged to broadly similar TFP levels. The pattern of productivity growth has differed across the three GDBs with Envestra Victoria and Multinet having had productivity growth 'spurts' from 1999 onwards before flattening off and SP AusNet having started its productivity growth spurt later around 2005. Productivity growth for all three GDBs was flat or negative in 2011.

6.3 Australian GDB productivity levels comparisons

As noted in section 4, 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 spreadout territory it serves. To ensure comparability, trunk and primary mains for JGN (and associated opex) 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. Government levies and unaccounted for gas are also excluded from all the included GDBs' opex to put them on a comparable functional basis. It should be noted that because transmission inputs are excluded from the Victorian GDB data used in this section, Victorian GDB relativities differ somewhat from those reported in the last section. In particular, because Envestra

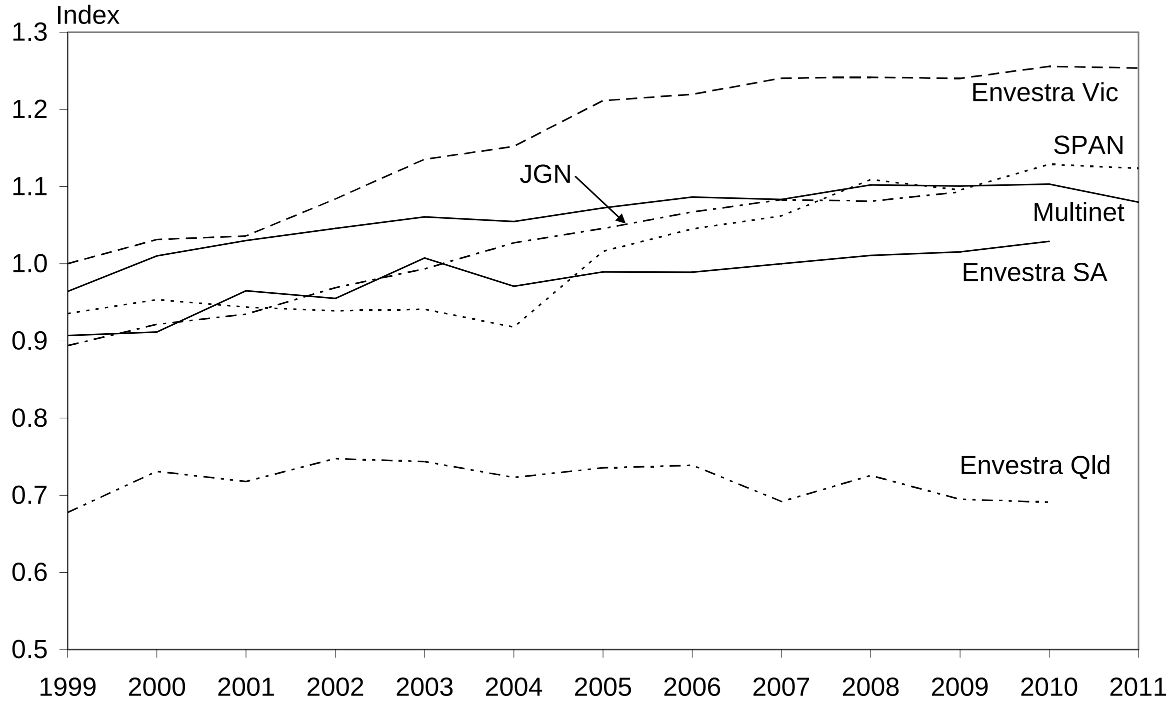
Victoria has the most transmission–equivalent mains, it improves its relative standing when transmission mains are excluded.

Table 6.2: **Australian GDB multilateral TFP indexes, 1999–2011**

	Envestra Vic	Multinet	SP AusNet	JGN	Envestra SA	Envestra Qld
1999	1.000	0.964	0.936	0.894	0.907	0.677
2000	1.031	1.010	0.953	0.921	0.911	0.731
2001	1.036	1.030	0.944	0.935	0.965	0.718
2002	1.084	1.046	0.939	0.969	0.955	0.747
2003	1.135	1.061	0.941	0.993	1.007	0.744
2004	1.152	1.055	0.918	1.027	0.971	0.723
2005	1.211	1.072	1.016	1.046	0.989	0.736
2006	1.220	1.086	1.045	1.067	0.989	0.739
2007	1.240	1.083	1.062	1.083	1.000	0.692
2008	1.242	1.102	1.109	1.081	1.011	0.726
2009	1.240	1.101	1.096	1.093	1.015	0.695
2010	1.256	1.103	1.129		1.029	0.691
2011	1.254	1.080	1.124			

Source: Calculations using Economic Insights GDB database

Figure 6.2: **Australian GDB multilateral TFP indexes, 1999–2011**

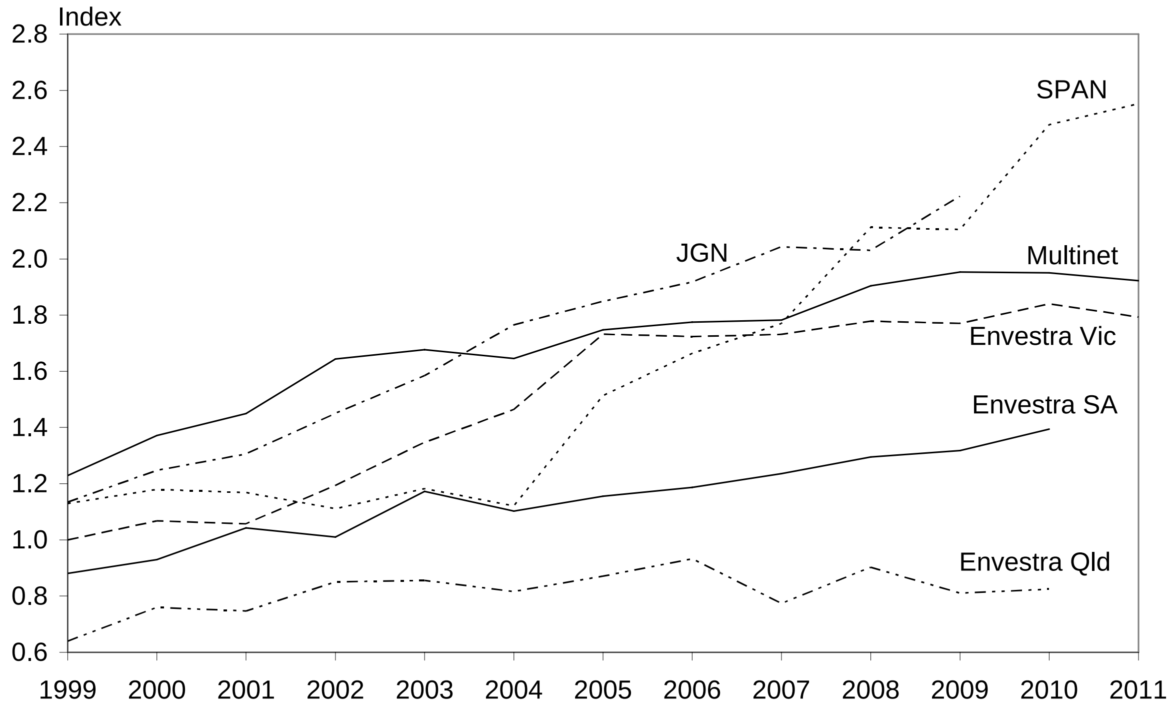


Source: Economic Insights GDB database

The multilateral TFP indexes are presented in table 6.2 and figure 6.2. The indexes are presented relative to Envestra Victoria in 1999 having a value of one. The MTFP results indicate that the three Victorian GDBs had the highest overall productivity levels in 2009, the latest year for which data are available for all the included GDBs. When transmission–

equivalent inputs are excluded, Envestra Victoria has had the highest TFP level of the five included GDBs by a 12.6 per cent margin in 2009. It also had the highest TFP level for all of the 13 year period. In 2009 Multinet and SP AusNet were second and third placed and were followed closely by the much larger JGN. By 2011 SP AusNet's TFP level had moved ahead of Multinet's by 4 per cent. Envestra SA achieved good productivity levels in 2009 despite having the lowest overall energy density and a domestic energy density that is comparable to JGN's but less than 40 per cent those of the three Victorian GDBs.

Figure 6.3: **Australian GDB multilateral opex PFP indexes, 1999–2011**



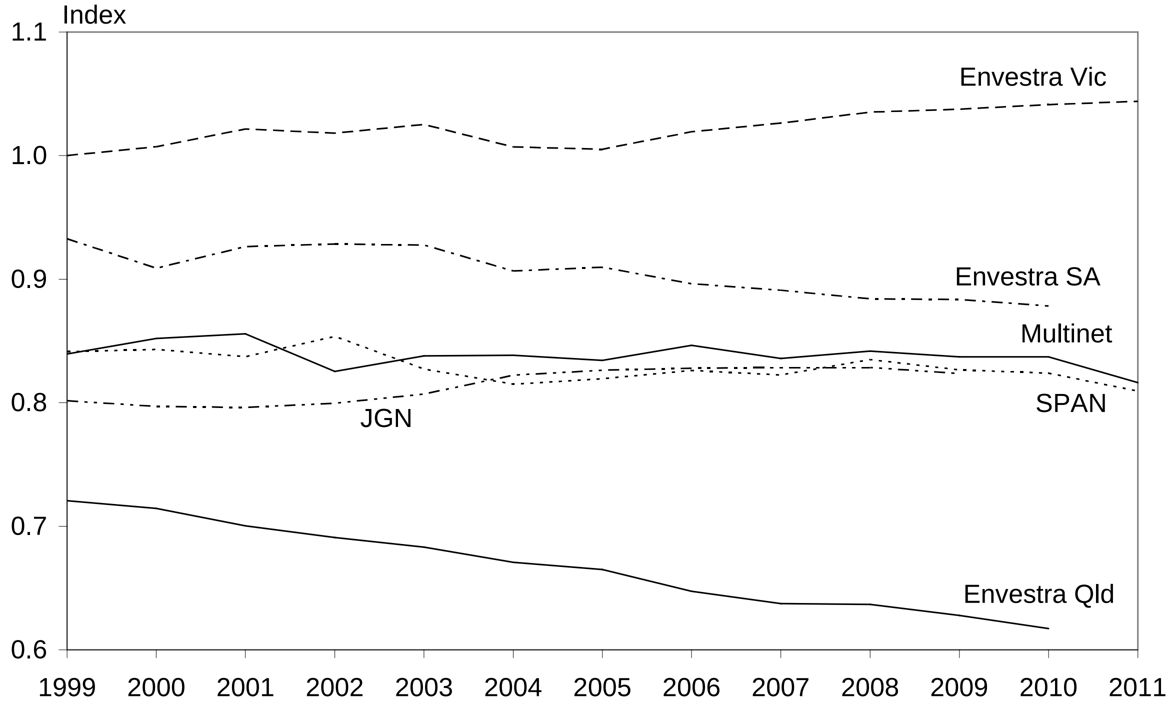
Source: Economic Insights GDB database

Table 6.3: **Australian GDB multilateral opex PFP indexes, 1999–2011**

	Envestra Vic	Multinet	SP AusNet	JGN	Envestra SA	Envestra Qld
1999	1.000	1.229	1.129	1.134	0.881	0.640
2000	1.068	1.371	1.180	1.247	0.930	0.760
2001	1.057	1.449	1.169	1.306	1.042	0.747
2002	1.193	1.644	1.111	1.450	1.011	0.851
2003	1.347	1.677	1.183	1.585	1.172	0.855
2004	1.464	1.645	1.121	1.765	1.103	0.817
2005	1.732	1.747	1.513	1.849	1.155	0.871
2006	1.724	1.775	1.664	1.918	1.187	0.933
2007	1.732	1.783	1.770	2.043	1.236	0.774
2008	1.779	1.904	2.112	2.031	1.295	0.902
2009	1.770	1.953	2.105	2.223	1.318	0.811
2010	1.840	1.951	2.478		1.394	0.825
2011	1.793	1.922	2.552			

Source: Calculations using Economic Insights GDB database

Figure 6.4: **Australian GDB multilateral capital PFP indexes, 1999–2011**



Source: Economic Insights GDB database

Table 6.4: **Australian GDB multilateral capital PFP indexes, 1999–2011**

	Envestra Vic	Multinet	SP AusNet	JGN	Envestra SA	Envestra Qld
1999	1.000	0.839	0.841	0.802	0.933	0.721
2000	1.007	0.852	0.843	0.797	0.909	0.714
2001	1.022	0.856	0.837	0.796	0.926	0.700
2002	1.018	0.825	0.854	0.800	0.928	0.691
2003	1.025	0.838	0.827	0.807	0.928	0.683
2004	1.007	0.838	0.815	0.822	0.907	0.671
2005	1.005	0.834	0.819	0.826	0.910	0.665
2006	1.019	0.846	0.826	0.828	0.896	0.647
2007	1.026	0.836	0.823	0.829	0.891	0.637
2008	1.035	0.842	0.835	0.829	0.884	0.637
2009	1.038	0.837	0.827	0.824	0.884	0.628
2010	1.041	0.837	0.824		0.878	0.617
2011	1.044	0.816	0.809			

Source: Calculations using Economic Insights GDB database

Opex and overall capital multilateral partial productivity indexes are presented in tables 6.3 and 6.4 and in figures 6.3 and 6.4, respectively. JGN and SP AusNet achieved the highest opex partial productivity levels in 2009, followed closely by Multinet and Envestra Victoria. Envestra SA's small size, its higher proportion of cast iron pipes, its low and declining overall energy density and relatively low domestic energy density affected its ability to match the opex partial productivity levels of the larger GDBs. Similarly, Envestra Qld has the lowest opex partial productivity level in nearly all years but it faces very different operating environment conditions compared to the other included GDBs which put it at an inherent disadvantage in comparisons of this type.

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. Envestra Qld again had the lowest capital partial productivity levels given its very different operating environment conditions compared to the other included GDBs which put it at an inherent disadvantage.

In summary, the Victorian GDBs operate at the highest TFP levels in the sample and at or near the highest opex partial productivity levels. Envestra Victoria has the highest capital partial productivity level while Multinet and SP AusNet exhibit around average capital partial productivity performance. The overall conclusion from the multilateral productivity index analysis is that the Victorian GDBs are operating efficiently.

7 CONCLUSIONS

The Victorian gas distribution industry as a whole has exhibited relatively steady TFP growth over the past 13 years. The average annual growth rate was 1.7 per cent over the last 10 years although this has slowed to 0.7 per cent for the last 5 years. This TFP growth has been driven largely by significant reductions in opex. However, the pattern of both TFP growth and opex partial productivity growth has been very different across the three GDBs.

Envestra Victoria and Multinet had productivity growth ‘spurts’ from 1999 onwards before their productivity growth flattened off from 2006 onwards. SP AusNet, on the other hand, had relatively constant TFP from 1999 to 2004 before starting its productivity growth spurt in 2005. Productivity growth for all three GDBs was flat or negative in 2011.

Envestra Victoria’s opex partial productivity grew strongly between 2001 and 2005 but has flattened off since then leading to the high average annual growth rate of 5.3 per cent over the last 10 years but a much lower 0.8 per cent over the last 5 years. Annual growth in the partial productivity of capital has been somewhat positive over the last 10 years at 0.1 per cent and 0.3 per cent over the last 5 years.

Envestra Victoria’s TFP index (which is effectively a weighted average of the two partial productivity indexes) exhibits relatively strong growth up to 2005 but much more modest growth since then. The average annual growth rate was 2.2 per cent the last 10 years but this has slowed to 0.5 per cent for the last 5 years.

Despite ongoing large reductions in opex usage, Multinet’s relatively low rate of output growth given the more mature inner city area it services has constrained its productivity performance over the last 13 years. Its opex partial productivity grew strongly between 1999 and 2002 and again between 2007 and 2009 but growth was more modest between 2002 and 2007 and has flattened off since 2009. This has led to average annual growth rates of 2.8 per cent over the last 10 years and 1.6 per cent over the last 5 years. Annual growth in the partial productivity of capital has been somewhat negative over the last 10 years at –0.2 per cent and more negative over the last 5 years –1.5 per cent.

Multinet’s TFP index exhibits relatively strong growth up to 2003 but much more modest growth since then. The average annual growth rate was 0.8 per cent the last 10 years but this has reversed to –0.5 per cent for the last 5 years, driven in part by a fall in output in 2011.

SP AusNet embarked on major opex usage reforms somewhat later than the other two GDBs. The other two GDBs exhibited rapid reductions in opex usage from 1999 onwards before opex usage levelled off around 2005. SP AusNet’s rapid reductions in opex usage only commenced in 2004 but have slowed markedly over the last year. SP AusNet’s reduction in opex usage over the second half of the period at around 40 per cent was somewhat larger than those achieved by the other two GDBs over the first half of the period of around 25 to 35 per cent.

SP AusNet made significant savings in the network operations component of opex as it extracted synergies from the operation of the 3 networks it owns and operates. Many of these synergies were generated by the combined network operations centre it operates. However, once these synergies have been fully extracted there can be expected to be a flattening out of network operations costs and this was observed in 2011.

SP AusNet's opex partial productivity was relatively flat between 1999 and 2004 but it has more than doubled in the period since 2004. This has led to the high average annual growth rates of 7.8 per cent over the last 10 years and 8.4 per cent over the last 5 years. Annual growth in the partial productivity of capital, on the other hand, has been somewhat negative over both the last 10 years and the last 5 years at around –0.1 per cent.

SP AusNet's TFP index was relatively flat up to 2004 but has grown strongly since then. The average annual growth rate was 2.4 per cent over the last 10 years but this has slowed somewhat to 2.0 per cent for the last 5 years.

Comparing the three Victorian GDBs', JGN's and Envestra SA's TFP indexes, Envestra Victoria and SP AusNet had the highest TFP growth for the period up to 2009 (the latest year for which data are available for all the included GDBs) with average annual growth rates of 2.4 per cent and 2.3 per cent, respectively. They were followed by JGN and Multinet with average annual TFP growth rates of 1.9 per cent and 1.8 per cent, respectively. The smaller Envestra SA had the lowest TFP growth rate at a still very reasonable 1.4 per cent.

TFP growth slowed markedly for 4 of the included GDBs in the more recent 5 year period from 2005 to 2009, with SP AusNet being the exception. Envestra Victoria's average annual TFP growth fell to 1.6 per cent, Envestra SA's fell to 1.1 per cent, JGN's fell to 1.0 per cent and Multinet's fell to 0.7 per cent over the 5 years to 2009. TFP growth was negative for all three Victorian GDBs in 2011 reflecting increases in input usage and, in the case of Multinet, a reduction in output.

In this study we have collected accurate billed quantity and matching revenue data as part of the updated and expanded survey of the Victorian GDBs. We have examined the impacts of using an alternative output specification – the billed outputs approach – and an alternative input specification which uses exogenous instead of endogenous capital user costs as weights in forming the total input quantity. In both cases the results are relatively invariant to these sensitivity tests. The billed outputs approach introduces more volatility into the output quantity index which can affect productivity growth rates if taken over a short period and with years of atypical climatic conditions at one or both ends of the period. However, the underlying trends in total output and TFP growth are broadly similar under the two approaches.

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 Victorian GDBs operate at the highest TFP levels in the sample and at or near the highest opex partial productivity levels. Envestra Victoria has the highest capital partial productivity level while Multinet and SP AusNet exhibit around average capital partial productivity performance. The overall conclusion from the multilateral productivity index analysis is that the Victorian GDBs are operating efficiently.

APPENDIX A: DERIVING OUTPUT COST SHARE WEIGHTS

This study uses the output cost share weights derived in Lawrence (2007) using a multi–output Leontief cost function. This functional form essentially assumes that GDBs use inputs in fixed proportions for each output and is given by:

(A1) $$C(y^t, w^t, t) = \sum_{i=1}^{M} w_i^t \left[\sum_{j=1}^{N} (a_{ij})^2 \, y_j^t \, (1 + b_i t)\right]$$

where there are M inputs and N outputs, w_i is an input price, y_j is an output and t is a time trend representing technological change. The input/output coefficients a_{ij} are squared to ensure the non–negativity requirement is satisfied, ie increasing the quantity of any output cannot be achieved by reducing an input quantity. This requires the use of non–linear regression methods. To conserve degrees of freedom a common rate of technological change for each input across the three outputs was imposed but this can be either positive or negative.

The estimating equations were the M input demand equations:

(A2) $$x_i^t = \sum_{j=1}^{N} (a_{ij})^2 \, y_j^t \, (1 + b_i t)$$

where the i's represent the M inputs, the j's the N outputs and t is a time trend representing the nine years, 1998 to 2006.

The input demand equations were estimated separately for each of the three GDBs using the non–linear regression facility in Shazam (White 1997) and data for the years 1998 to 2006. Given the limited number of observations and the absence of cross equation restrictions, each input demand equation is estimated separately.

Lawrence (2007) then derived the output cost shares for each output and each observation as follows:

(A3) $$h_j^t = \left\{\sum_{i=1}^{M} w_i^t \left[(a_{ij})^2 \, y_j^t \, (1 + b_i t)\right]\right\} / \left\{\sum_{i=1}^{M} w_i^t \left[\sum_{j=1}^{N} (a_{ij})^2 \, y_j^t \, (1 + b_i t)\right]\right\}.$$

Lawrence (2007) then formed a weighted average of the estimated output cost shares for each observation to form an overall estimated output cost share where the weight for each observation, b, is given by:

(A4) $$s_b^t = C(b, y_b^t, w_b^t, t) / \sum_{b,t} C(b, y_b^t, w_b^t, t).$$

ATTACHMENT A: LETTER OF RETAINER

JOHNSON WINTER & SLATTERY
LAWYERS

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23 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: Envestra, Multinet and SP AusNet

We act for Envestra Limited (**Envestra**), Multinet Gas (DB No. 1) Pty Ltd and Multinet Gas (DB No. 2) Pty Ltd (together, **Multinet**) and SPI Networks (Gas) Pty Ltd (**SP AusNet**) in relation to the AER's review of each of Envestra's, Multinet's and SP AusNet's Access Arrangements for Victoria.

Envestra, Multinet and SP AusNet (**the Distributors**) wish to jointly engage you to prepare expert reports in connection with the AER's review of the Victorian Access Arrangements.

This letter sets out the matters which the Distributors wish you to address in your reports and the requirements with which the reports must comply.

Terms of Reference

The terms and conditions upon which each of the Distributors provides access to their respective networks are subject to five yearly reviews by the AER.

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

The Distributors wish to engage you to prepare two expert reports, which reports are described below.

TFP and PFP Report

The Distributors wish to engage you to prepare an expert report which assesses:

(a) the total factor productivity and partial factor productivity of the Distributors' networks; and

(b) how this compares against the levels of total factor productivity and partial factor productivity for Envestra's South Australian and Queensland networks and the Jemena New South Wales gas distribution network.

Cost Benchmarking

The Distributors wish to engage you to prepare an expert report which considers, using partial productivity indicators, the efficiency of each Distributor's performance by comparing their cost outcomes against the cost outcomes achieved by other equivalent Australian and New Zealand gas distribution network operators.

In preparing those aspects of your reports 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 reports will be included by each of the Distributors in their respective access arrangement revision proposals for their Victorian networks for the access arrangement period from 1 January 2013 to 31 December 2017. The reports may be provided by the AER to its own advisers. The reports must be expressed so that they may be relied upon both by the Distributors and by the AER.

The AER may ask queries in respect of the reports and you will be required to assist each of the Distributors 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 reports will be reviewed by the Distributors' legal advisers and will be used by them to provide legal advice to the Distributors as to their respective rights and obligations under the National Gas Law and National Gas Rules. You will be required to work with these legal advisers and the Distributors' personnel to assist them to prepare the Distributors' respective access arrangement revision proposals and submissions in response to the draft and final decisions made by the AER.

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

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

Time Frame

Each of the Distributors' access arrangement revision proposals is due by 30 March 2012. We request that you provide your reports to us or to each of the Distributors by 28 March 2012 so that the Distributors may finalise their 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 the Distributors.

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

Your reports 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 reports 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."*

The Distributors may request the principal author of the reports to sign a statutory declaration to the effect that the Code of Conduct has been complied with. This is to ensure that the reports carry maximum weight and probative value and will be suitable to rely upon in any subsequent court proceedings.

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

Terms of Engagement

Your contract for the provision of the reports will be directly with the Distributors. You should forward to each of the Distributors 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 each of the Distributors to confirm your acceptance of the engagement by the Distributors.

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 26 March 2012

ATTACHMENT B: CURRICULA VITAE

Dr Denis Lawrence

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

Qualifications

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

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

Key Skills and Experience

For the past 20 years Dr Denis Lawrence has played a leading role in the regulation, benchmarking and performance measurement of infrastructure enterprises. He has advised Australian and overseas regulators and utilities on a wide range of quantitative and strategic issues in the energy, telecommunications, post and transport sectors. Denis has been a consultant on energy regulation since 1996. Recent key energy network projects include:

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

undertaken for the Essential Services Commission (2005).

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

Selected Publications

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John Kain

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

Qualifications

BSc, Sydney University

BE (1st Class Hons), Sydney University

Key Skills and Experience

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

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

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

ATTACHMENT C: DECLARATION

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

D.A. Lawrence

Denis Anthony Lawrence

26 March 2012

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