Response to Pacific Economics Group on Meyrick Opex Rate of Change and Productivity Reports

Prepared for
Envestra, Multinet and SP AusNet

15 October 2007

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AUSTRALIAN CAPITAL TERRITORY NEW SOUTH WALES VICTORIA

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EXECUTIVE SUMMARY

In March 2007 Meyrick and Associates prepared two reports for the three Victorian gas distribution businesses (GDBs) – Envestra, Multinet and SP AusNet. One covered gas distribution productivity performance and the other covered the appropriate operations and maintenance expenditure (opex) 'rate of change' formula and parameters to apply in the Gas Access Arrangement Review (GAAR) for 2008 to 2012 (see Meyrick 2007a,b). The Essential Services Commission (ESC) subsequently engaged Pacific Economics Group (PEG) to review the two Meyrick reports on productivity and the opex rate of change (PEG 2007a). This report responds to PEG (2007a).

The rate of change formula aims to index real opex for the starting year of the regulatory period forward through the remainder of the regulatory period taking account of changes in the three key opex drivers (input prices, ongoing productivity gains, and output growth) and the consumer price index (CPI). Meyrick (2007a) proposed the following mathematical formula for implementing the opex rate of change:

(1) ΔReal Opex = ΔOpex Price – ΔOpex Partial Productivity + ΔOutput Quantity – ΔCPI

where the 'Δ' symbol stands for 'the proportional change in'. We recommended basing the opex price growth on the 5.7 per cent labour price increase forecast by BIS Shrapnel (2007) and extrapolation of the 2.6 per cent non–labour opex price reported in PEG (2006). This produced an opex price forecast of 4.52 per cent. We recommended an opex partial productivity growth forecast of 0.8 per cent based on the projections in Meyrick (2007b) and BIS Shrapnel (2007), the results of previous energy distribution productivity studies across a range of jurisdictions and Australian regulatory precedent.

While PEG (2007a) agreed with the formula we recommended, they claimed that the growth rates we had recommended for use in the formula were not 'best' estimates arrived at 'on a reasonable basis' as required by the Gas Code. PEG instead proposed alternative growth rates. PEG advocated greater reliance on the Access Economics (2007) labour price forecast of 4.24 per cent and the results of their own cost function estimation producing an opex partial productivity forecast of 2.75 per cent.

The Meyrick (2007a) and PEG (2007a) growth rate recommendations for use in the rate of change formula are listed in table A along with the revised rates recommended in this report.

In this report we demonstrate that the PEG criticisms of the Meyrick estimates are not valid and the alternative estimates proposed by PEG do not pass most of the evaluation criteria PEG proposed. In particular, we show that the alternative opex partial productivity growth forecasts proposed by PEG have a number of major flaws and are not suitable for use in regulatory decisions.

Table A: **Opex rate of change recommendations**

	Meyrick (2007a)	PEG (2007a)	**This report**
Industry opex rate of change calculation			
Labour price growth [A]	5.70%	4.48%	6.54%
Labour share [B]	0.62	0.62	0.62
Non–labour opex price growth [C]	2.60%	2.60%	2.67%
Opex price growth [D] = [B*A + (1 – B)*C]	4.52%	3.77%	5.07%
Opex partial productivity growth [E]	0.80%	2.75%	0.80%
Output growth [F]	1.77%	1.93%	1.77%
CPI [G]	2.83%	3.00%	2.58%
Rate of Change [H] = [D – E + F – G]	2.66%	–0.05%	3.46%
Envestra opex rate of change calculation			
Labour price growth [A]	5.70%	4.48%	6.54%
Labour share [B]	0.62	0.62	0.62
Non–labour opex price growth [C]	2.60%	2.60%	2.67%
Opex price growth [D] = [B*A + (1 – B)*C]	4.52%	3.77%	5.07%
Opex partial productivity growth [E]	0.80%	2.45%	0.80%
Output growth [F]	2.44%	2.26%	2.44%
CPI [G]	2.83%	3.00%	2.58%
Rate of Change [H] = [D – E + F – G]	3.33%	0.58%	4.13%
Multinet opex rate of change calculation			
Labour price growth [A]	5.70%	4.48%	6.54%
Labour share [B]	0.62	0.62	0.62
Non–labour opex price growth [C]	2.60%	2.60%	2.67%
Opex price growth [D] = [B*A + (1 – B)*C]	4.52%	3.77%	5.07%
Opex partial productivity growth [E]	0.80%	2.78%	0.80%
Output growth [F]	0.83%	1.09%	0.83%
CPI [G]	2.83%	3.00%	2.58%
Rate of Change [H] = [D – E + F – G]	1.72%	–0.92%	2.52%
SP AusNet opex rate of change calculation			
Labour price growth [A]	5.70%	4.48%	6.54%
Labour share [B]	0.62	0.62	0.62
Non–labour opex price growth [C]	2.60%	2.60%	2.67%
Opex price growth [D] = [B*A + (1 – B)*C]	4.52%	3.77%	5.07%
Opex partial productivity growth [E]	0.80%	3.05%	0.80%
Output growth [F]	2.12%	2.42%	2.12%
CPI [G]	2.83%	3.00%	2.58%
Rate of Change [H] = [D – E + F – G]	3.01%	0.14%	3.81%

Sources: Meyrick (2007a), PEG (2007a) and Meyrick analysis

Opex price forecasts

We find no case for favouring the Access Economics (2007) labour price forecasts over those of BIS Shrapnel (2007) (as advocated by PEG 2007a) for the following reasons:

- based on available evidence on the gender composition of the GDB workforce and likely competition for GDB staff from a range of related sectors, BIS Shrapnel's use of the male AWOTE is unlikely to cause significant bias;
- available evidence indicates that BIS Shrapnel's use of national average forecasts is likely to somewhat understate rather than overstate EGW labour price increases in Victoria;
- the argument that the timing of network upgrades and maintenance can be varied to take advantage of the timing of input price changes ignores the impact of rapidly increasing peak energy demands in most Australian states, the impending 'bow wave' of replacement investment and the increasing demand for high levels of energy infrastructure reliability – all of which mean there is little scope to change the timing of expenditure;
- export infrastructure 'bottlenecks' that have limited Australia's ability to increase mining exports will take some time to clear and there is likely to then be a substantial increase in mining operations employment as increased mining output is exported;
- the scope for increases in the supply of skilled staff in the medium term are limited and the argument that university graduates and migrants can fill the shortfall ignores the timing lags involved and the level of transactions costs that have to be overcome.

On the basis of new information that has been released and endorsed by the AER since both the Meyrick (2007a) and PEG (2007a) reports were released, we have revised our recommended opex price growth forecast. The Econtech (2007) report recently released by the AER supersedes the earlier Access Economics reports for the AER, addresses conditions in Victoria specifically and performs best on nearly all the evaluation criteria proposed by PEG. It indicates that the BIS Shrapnel (2007) labour price forecasts used in Meyrick (2007a) were somewhat conservative. The AER (2007, p.141) concludes that 'the independent forecasts provided by Econtech suggest that the forecasts provided by BIS Shrapnel … are not excessive'. It vindicates our earlier decision to not place any weight on the Access Economics (2006) forecasts. In light of this new information and an assessment of the three sets of forecasts currently available against the criteria proposed by PEG, we now recommend using the Econtech labour price forecast of 6.54 per cent.

We have reviewed and updated the group of Producer Price Indexes used by PEG (2006) to measure the price of non–labour opex inputs. As a result we have more closely targeted the Producer Price Indexes used to deflate non–labour opex. The effect of this improved targeting and two year updating has led to only a minor change in the recommended non–labour opex price.

The overall opex price forecast we recommend using is 5.07 per cent. This is 0.55 per cent above our earlier forecast and 1.30 per cent above the PEG (2007a) forecast.

Opex partial productivity forecasts

On the basis of the analysis presented in this report in response to PEG (2007a), we find no case for rejecting the Meyrick (2007a) recommendation to use a 0.8 per cent opex partial productivity forecast in the rate of change formula for the following reasons:

- there is no evidence that the Victorian GDBs have 'overshot' cost reductions nor that their experience is substantially different to that of the Victorian electricity DBs;
- it is important to take account of information supplied by the GDBs themselves as one of the sources of information to form the opex productivity forecast rather than relying principally on cost 'driver' information derived from northern hemisphere businesses;
- the BIS Shrapnel forecast for EGW sector labour productivity is consistent with information in the National Accounts on the gas industry and the economy as a whole, all of which points to the need for caution in forecasting future opex productivity growth;
- information and regulatory precedents from electricity distribution is very relevant for considering gas distribution productivity growth rates given the similarities between the industries – a point recognised by PEG (2007a, p.43); and,
- when considered in an appropriate timeframe, the latest PEG productivity research on US GDBs supports the recommended opex productivity forecast of 0.8 per cent.

We show that the alternative econometric opex partial productivity growth forecasts proposed by PEG have a number of major flaws and are not suitable for use in regulatory decisions. We find that the recommendations are not likely to be 'best' estimates arrived at 'on a reasonable basis' as required by the Gas Code for the following reasons:

- the estimated capital quantity coefficients are of the wrong sign implying that, if everything else is held constant, additional capital inputs will *increase* opex costs as more capital is added which is counter to required regularity conditions and reasonable expectations;
- parameter estimates are 'mixed and matched' between disparate models which means there is no coherent quantitative basis for the resulting forecasts;
- econometric cost function estimation results will be sensitive to the functional form and stochastic specification chosen;
- the translog functional form used is not well suited to the inclusion of multiple outputs;
- the cost driver relationships estimated using a northern hemisphere database cannot be assumed to apply to Australian operating environment conditions, particularly given that the Australian observations are not included in the estimation process;

- the use of the Meyrick (2007d,e) Australia/New Zealand database is inconsistent with the criticisms made of this database in PEG (2007b);
- no system capacity output is included in the regressions which will almost surely bias the results as one of a GDB's main functions is not captured in the included outputs;
- the non–labour opex price index used is unlikely to reflect prices GDBs face for these inputs;
- forecast capital quantities used for the Victorian GDBs appear to be inaccurate; and,
- using GDB–specific partial productivity forecasts is contrary to the principles of incentive regulation.

We retain our earlier opex partial productivity forecast as it is the best currently available and was arrived at on a reasonable basis.

Output growth forecast

The PEG (2007a) preferred output growth forecast is based on a less complete specification than the Meyrick (2007a) specification as the former does not include the important system capacity output whereas the latter does. We retain the output forecasts presented in Meyrick (2007a,b) as the best estimates arrived at on a reasonable basis currently available.

CPI forecast

Finally, we have revised our estimate of the CPI. We now recommend using the forecast in Econtech (2007) to be consistent with the recommended labour price growth forecasts. We note that the figure proposed by the ESC is at the high end of the range of available forecasts and much higher than the figure produced by Access Economics (2007) which was used by PEG (2007a) as its primary source of labour price forecasts. If the ESC wished to use a different inflation rate in the rate of change formula to the one we have recommended then it would be necessary to make a corresponding adjustment to the Econtech labour price growth forecast to maintain internal consistency.

Opex rate of change recommendation

After reviewing and assessing all the information now available, our recommended real opex rate of change for the Victorian gas distribution industry as a whole is 3.46 per cent. This is 0.8 per cent higher than that recommended in Meyrick (2007a) due to the higher labour price forecast and lower inflation rate forecast in Econtech (2007). When differences in output growth are allowed for, the recommended rates of change for the GDBs are 4.13 per cent for Envestra, 2.52 per cent for Multinet and 3.81 per cent for SP AusNet.

1 INTRODUCTION

In March 2007 Meyrick and Associates ('Meyrick') prepared two reports for the three Victorian gas distribution businesses (GDBs) – Envestra, Multinet and SP AusNet – on gas distribution productivity performance and the appropriate operations and maintenance expenditure (opex) 'rate of change' formula and parameters to apply in the Gas Access Arrangement Review (GAAR) for 2008 to 2012 (see Meyrick 2007a,b). The Essential Services Commission (ESC) subsequently engaged Pacific Economics Group (PEG) to review the Meyrick reports on productivity and the opex rate of change (PEG 2007a)[1]. This report responds to the PEG (2007a) report on issues related to the opex rate of change.

The rate of change formula aims to index real opex for the starting year of the regulatory period forward through the remainder of the regulatory period taking account of changes in the three key opex drivers (input prices, ongoing productivity gains, and output growth) and the consumer price index (CPI). Conceptually, if all else remains unchanged, an increase in real opex input prices will lead to an increase in real opex requirements. Similarly, ongoing improvements in the partial productivity of opex will reduce opex requirements going forward, all else unchanged, while output growth will lead to an increase in opex requirements, all else unchanged.

Meyrick (2007a) proposed the following mathematical formula for implementing the opex rate of change:

(1) ΔReal Opex = ΔOpex Price – ΔOpex Partial Productivity + ΔOutput Quantity – ΔCPI

where the 'Δ' symbol stands for 'the proportional change in'. Based on a review of available evidence Meyrick (2007a) proposed using the following parameter values in the rate of change formula for the gas distribution industry as a whole:

(2) ΔReal Opex = ΔPrice Opex – ΔOpex Partial Productivity + ΔOutput Quantity – ΔCPI
= 4.52% – 0.80% + 1.77% – 2.83%
= 2.66%

PEG (2007a) agrees with the rate of change formula proposed by Meyrick but has proposed using alternative parameter values in the implementation of the formula as follows:

(3) ΔReal Opex = ΔPrice Opex – ΔOpex Partial Productivity + ΔOutput Quantity – ΔCPI
= 3.77% – 2.75% + 1.93% – 3.00%
= –0.05%

[1] Meyrick also prepared three benchmarking reports for Multinet (see Meyrick 2007c,d,e) which the ESC engaged PEG to review (PEG 2007b).

While there are only minor differences between Meyrick and PEG on the output growth and CPI parameters reflecting different forecasts used by the ESC compared to those of the GDBs, there are major differences between the opex price and opex partial productivity parameters proposed by Meyrick and PEG. PEG (2007a) claimed that the Meyrick proposals did not satisfy two Gas Code requirements based on a number of 'evaluation criteria' developed by PEG and so PEG proposed using alternative methodologies and values.

Meyrick rejects PEG's assessment and proposed alternative values. PEG (2007a) contains a number of important contradictions and the values proposed by PEG fail to satisfy many of their own evaluation criteria. The PEG opex partial productivity estimates also do not satisfy key aspects of evaluation criteria Meyrick has previously used to assess quantitative studies used in regulatory reviews.

In the following section of the report we review the relevant Gas Code requirements and alternative evaluation criteria. We also respond to some specific issues raised in PEG (2007a) on the application of the opex rate of change formula at different stages of industry evolution. In sections 3 to 7 we respond to the PEG (2007a) analyses of labour prices, non–labour opex prices, opex partial productivity trends, output growth and the consumer price index, respectively, before drawing conclusions in section 8.

2 GAS CODE AND EVALUATION CRITERIA

2.1 Best estimates

Section 8.2(e) of the Gas Code mandates that "any forecasts required in setting the Reference Tariff represent best estimates arrived at on a reasonable basis" but, as PEG (2007a, p.6) notes, does not establish any more specific criteria for evaluating forecasts. The PEG report puts forward several evaluation criteria separately addressing the 'best estimates' and 'reasonable basis' aspects that it claims 'operationalise' this part of the Gas Code.

With regard to identifying best estimates, PEG suggests the following criteria:

- accuracy of the data employed;
- data sources reflect relevant business conditions that affect GDBs;
- the use of rigorous empirical techniques;
- robustness;
- historical consistency;
- no "cherry picking" of available data;
- internal consistency and no "double counting" of changes; and,
- reflects long-run behaviour.

With regard to assessing whether estimates have been arrived at on a reasonable basis, PEG suggests the following criteria:

- objective process and information;
- consistent with economic theory;
- feasibility;
- low forecast errors;
- weighting of alternative forecasts;
- transparent;
- verifiable; and,
- regulatory precedent.

It should be emphasised firstly that these criteria are simply ones proposed by PEG. They have no official status with regard to the Gas Code. While Meyrick agrees with many of these criteria, we do not agree with the PEG (2007a) report's assessment of the Meyrick (2007a) labour price and opex partial productivity estimates against these criteria as will be explained in the following sections. Furthermore, we will demonstrate that the alternative PEG (2007a) parameter estimates do not satisfy many of these criteria, particularly key ones relating to internal consistency, no cherry picking, consistency with economic theory, transparency and regulatory precedent.

We also note that PEG (2007a) attempts to 'operationalise' its criteria by simply conducting head–counts of now many criteria are satisfied and, in some cases, weighting alternative estimates according to how many criteria they are judged to be superior on. This process implicitly places equal weight on all included criteria. Even if one accepts the listed criteria as being exhaustive, there is no logical basis for justifying equal weights across the range of criteria and attempting to justify estimates on this basis is simply an example of spurious accuracy.

2.2 Meyrick criteria

There are several basic criteria that quantitative studies that are satisfactory for use in regulatory deliberations must satisfy. In previous reports assessing the quality and accuracy of quantitative studies undertaken by regulators and their consultants, we have used the following set of evaluation criteria:

1. the data used must be accurate, consistent and comparable. Failure to understand the operations of all included utilities and to ensure that data are being captured for the same functions will invalidate the results. This applies particularly to items such as 'overheads' and applies more broadly to regulatory and accounting requirements and standards and

the range of tasks performed by distributors. All data must be individually tracked back and verified against primary sources.

2. efficiency comparisons and conclusions must be made using a model that is explicit, clearly specified, robust and, most importantly, replicable. Only by using an explicit model that can be scrutinised and reproduced by interested parties can objective assessments of efficiency differences be made and their veracity assessed.
3. the model needs to be holistic with all major outputs and inputs included. If some important outputs are excluded from the analysis then this will disadvantage those utilities which provide that output efficiently while providing an artificial advantage to those utilities who provide the output less efficiently or not at all. Similarly, excluding key inputs from the analysis will artificially advantage those utilities that are intensive users of those inputs.
4. all outputs and inputs must be adequately specified. Unless accurate and robust measures of key outputs and inputs are used the study is likely to produce misleading results. It is particularly important in comparisons of opex efficiency to allow for differences in levels of reliability and service quality provided. Capital inputs are difficult to measure and account must be taken of differences in the resource intensiveness and quality of different capital inputs. This will, in turn, impact differences in opex requirements.
5. differences in the operating environment must be adequately and explicitly allowed for. It is essential that quantitative studies compare like with like situations either by limiting comparisons to very similar utilities or explicitly modelling the impact of operating differences in a rigorous quantitative framework. Whether including utilities from the one jurisdiction or across several jurisdictions, it is essential to ensure data comparability, that like functions are being covered and that an explicit model is used.
6. the sample of utilities included needs to include a number of utilities similar to the ones being reviewed. It is not possible to accurately assess the efficiency of two utilities whose characteristics are, for instance, at the two end points of the sample used.
7. stakeholders must be adequately consulted to ensure the data used are accurate and modelling results are realistic. Failure to ‘sanity check’ data and results with stakeholders can lead to infeasible constraints being placed on regulated firms.
8. the modelling must be transparent and the data must be fully accessible. If all participants in the process are to have confidence in the quality of the analysis then the model and the data used in the study for all the included utilities must be available to participants to permit complete checking, verification and the carrying out of sensitivity analyses. The electricity lines business review undertaken by the New Zealand Commerce Commission

in 2003 sets the benchmark for transparency of modelling with all data and computer files being made publicly available and is an ideal that other Australasian regulators should emulate (at least for affected parties if there are potential data confidentiality issues).

9. given the asymmetric risks involved with placing unrealistic constraints on infrastructure providers which may lead to failure or suspension of the service, model construction and recommendations based on modelling results need to be conservative.

We will assess the PEG (2007a) econometric models that form the basis of their alternative opex partial productivity trends against these criteria and demonstrate that several key criteria are not satisfied.

2.2 Sustainable costs

Section 8.37 of the Gas Code is also relevant to the allowed opex path as it states that "a Reference Tariff may provide for the recovery of all Non Capital Costs (or forecast Non Capital Costs, as relevant) except for any such costs that would not be incurred by a prudent Service Provider, acting efficiently, in accordance with accepted and good industry practice, and to achieve the lowest sustainable cost of delivering the Reference Service." Again, there is no explicit guidance on how these concepts should be operationalised.

PEG (2007a) contains a lengthy discussion of a notion of 'cost overshooting' and posits that if cost reductions have 'overshot' then there will be a period of ensuing lower, or even negative, productivity growth until the firm returns to a sustainable position. This discussion appears to have emanated from taking a statement made in Meyrick (2007a) out of context. In our response to an information request from PEG in May 2007, we indicated that there was no evidence that this has occurred in the case of the GDBs and we were not implying that it had. But this has not been acknowledged by PEG (2007a) which uses the quote out of context in support of its notion. We have further requested PEG to provide any evidence it has that cost 'overshooting' has occurred in our information request dated 4 September 2007 but the PEG response of 18 September 2007 did not answer this question.

In section 5.1.1 we address the PEG arguments regarding 'cost overshooting' in detail. We conclude that there is no evidence of cost overshooting by the GDBs and that, contrary to PEG's contention, the experiences of the Victorian electricity DBs and GDBs have been broadly consistent. The PEG notion of 'cost overshooting' is, thus, of no assistance in operationalising this section of the Gas Code in this instance.

3 LABOUR PRICE INDEX

Meyrick (2007a) used the Electricity, gas and water (EGW) sector opex labour price index forecasts of 5.7 per cent annual increases contained in BIS Shrapnel (2007) in preference to forecasts prepared by Access Economics (2006) for the Australian Energy Regulator (AER). The Access Economics forecasts predicted lower annual labour price increases of 4.5 per cent. PEG (2007a) claimed that the Access Economics (2006) forecasts were superior in many respects and noted that a new Access Economics (2007) report had been released by the AER after completion of the Meyrick (2007a) report. PEG (2007a) proceeded to place nearly all the weight in its preferred labour price index forecasts for use in the opex rate of change formula on the Access Economics (2007) series.

In this section we assess the PEG (2007a) arguments in favour of Access Economics (2007). We also review a new report by Econtech (2007) prepared for and endorsed by the AER which supersedes the earlier Access Economics reports for the AER and which was released after the PEG (2007a) report. The Econtech report addressed Victorian conditions specifically and found that the BIS Shrapnel forecasts were conservative. Econtech (2007) forecasts annual labour price increases of 6.5 per cent for the Victorian EGW sector for the calendar years 2008–2012. We then revisit the PEG (2007a) 'evaluation criteria'.

3.1 Critique of the PEG (2007a) analysis

Meyrick (2007a) argued for using the BIS Shrapnel (2007) forecast on the grounds that it used a better measure of labour prices (AWOTE or average weekly ordinary time earnings) and provided a better treatment of skill shortages that have been evident in the EGW sector in recent years, competition for labour from the mining and construction sectors and the impact of increasing infrastructure maintenance programs and ongoing industry restructuring. On the other hand, Meyrick (2007a) thought that the Access Economics (2006) forecast appeared to significantly underestimate likely wage pressures and labour market conditions in the EGW sector and underestimate the major phase of network infrastructure upgrades, refurbishment and maintenance now underway.

While agreeing that AWOTE was a better measure of labour prices for the purpose at hand than the Labour Price Index used by Access Economics, PEG (2007a) criticised the BIS Shrapnel report on a number of grounds including:

- the AWOTE used only covered male workers;
- the use of a national average may not reflect conditions in Victoria;
- cyclical impacts were not adequately covered; and,
- there was inadequate allowance for supply–side responses.

3.1.1 Gender composition of GDB workforce

PEG argued that wage pressures for male workers may be greater than those for female workers due to the concentration of male employment in engineering and operational trades that face the greatest competition from the booming mining and construction sectors. They argued that female workers, on the other hand, are concentrated in the office and service–oriented parts of the GDBs that faced less competition for resources. Information recently released by the Department of Employment and Workplace Relations (DEWR 2007) indicates that over 77 per cent of employment in the gas supply industry in 2006 was made up of male workers and there had been little change in this ratio in the last 5 years. Additional information provided to Meyrick by Envestra indicated that its 2007 workforce gender split was 80 per cent male, indicating that the concentration of male workers in the distribution component of the gas supply industry is likely to be even higher than that for the industry as a whole.

We also note that while the booming mining and construction sectors most likely provide the strongest source of competition for male workers, there is also strong competition for customer service staff from the entry of new players in the energy retail sector and increased competition through product differentiation. This will place upward pressure on the wage rates required to hold office and customer service staff (which PEG (2007a, p.25) notes are likely to be predominantly female) in the distribution sector. There is also likely to be greatest scope for productivity improvements in office and customer service functions due to the relatively higher use of computers leading to higher wage rate pressures.

Based on available evidence on the gender composition of the GDB workforce and likely competition for GDB staff from a range of related sectors, not just mining and construction, we conclude that BIS Shrapnel's use of the male AWOTE is unlikely to cause significant bias and thus reject PEG's criticism.

3.1.2 Victorian versus national wage forecasts

PEG (2007a) also criticises the BIS Shrapnel study for using national average forecasts rather than ones specifically for Victoria. PEG argue this could be material as competition for labour from the booming mining and construction sectors will be concentrated in Western Australia and Queensland and, because labour is not as mobile as trade in goods, using the projected labour price inflation for Australia's EGW sector could overstate the labour price inflation for Victoria's GDBs. However, this ignores information available in the Access Economics (2007) report favoured by PEG which shows that Victoria had the third highest rate of increase in the composite energy wage index and Victoria was slightly above the national average. Econtech (2007) also forecasts EGW labour prices to increase slightly more

in Victoria than in Australia as a whole over the 2008–2012 period (by 6.5 per cent versus 6.4 per cent).

Available evidence, therefore, indicates that using national average forecasts is likely to somewhat understate rather than overstate EGW labour price increases in Victoria and, thus, we reject PEG's criticism.

3.1.3 Cyclical effects and the mining boom

PEG (2007a) argues that a reason to favour the Access Economics (2006, 2007) forecasts is that they contain more detailed cyclical impacts. PEG argues that the timing of network upgrades, maintenance and other activities can be varied to take advantage of, among other things, the timing of input price changes based on work attributed to the US Electric Power Research Institute. However, this ignores the impact of rapidly increasing peak demands in most Australian states from the increased penetration of domestic airconditioning, the aging of much of Australia's distribution infrastructure and the likely impact of an impending 'bow wave' of replacement investment and the increasing demand for high levels of energy infrastructure reliability. For instance, Econtech (2007, p.34) note:

> 'Another distinguishing feature of this industry is that electricity, gas and water are considered essential services for business and consumers. As such, their supply must be reliable and activities within the industry are less responsive to increases in input costs. In other words, maintenance and supply activities in the electricity, gas and water industry cannot be delayed or cancelled when input prices such as wages increase in the short run. This means that businesses in this industry have a greater imperative to attract and maintain skilled workers and are more likely to absorb wage increases in order to maintain labour supply.'

Synergies Economic Consulting (2007, p.35) has also questioned the cyclical nature of the forecasts reported in Access Economics (2006):

> '… the wages demand model formulated by Access Economics, we believe, overstates the role and speed of excess demand pressures (cyclical factors) and understates the role of institutional barriers and wage agreements. As a result we believe their model overstated the role of cyclical factors in wages growth in the Utilities industry pre 2008 and also overstates their role in easing wages growth post 2008.
>
> This error in the conceptual aspects of their modelling leads them in to making the unlikely claim that wages growth in the Utilities sector (with its high proportion of skilled and semi-skilled workers) will lag behind the All industries rate of wages growth for a 4 year (at least) period. We can find no example where such behaviour has occurred in the Australian economy.'

Another area of dispute between the studies is the likely impact of the mining boom. PEG (2007a, pp.32–3) notes that Access Economics (2007) cautions that the current construction surge associated with the mining boom simply represents 'catch up' associated with past failure to invest in mining capacity and related infrastructure and the move from the investment to production phase in mining will shortly lead to a slowing in demand for labour from the mining and construction industries. Access Economics (2007, p.8) also sees mineral prices 'sliding' as mining supply increases from both Australia and its international competitors. It is important to note, however, that the export infrastructure 'bottlenecks' that have limited Australia's ability to increase mining exports will take some time to clear. This inability to increase mining exports in the short run combined with substantial investment in increased mine and infrastructure capacity has been responsible for the observed substantial fall in mining sector productivity in recent years (ABS 2007a). Once these bottlenecks are cleared, the demand for labour from construction activities will decline but there likely to be a substantial increase in mining operations employment as increased mining output is exported. This view is supported by Econtech (2007, p.25):

> 'Strong output growth is likely to continue over the forecast period, as demand from China is showing no signs of slowing, with the Chinese economy recording its fourth consecutive year of double digit growth. … Despite a likely fall in investment growth, overall investment levels are expected to remain high by historical standards. … Employment levels are also expected to remain relatively high by historical standards, and employment growth will remain strong as firm's ramp up production in response to continued export demand ... This is quite different to Access Economics view.'

One of Australia's leading labour market research organisations, the National Institute for Labour Studies, has also highlighted the ongoing impacts of the mining boom on labour market shortages:

> 'By 2015, the minerals sector will need to employ 70,000 more employees than it currently employs to achieve predicted increases in output. The largest shortages are projected to be in the non-professional occupational classifications with the greatest absolute increases being in tradespersons (26,983 additional employees required) and semi-skilled employees (22,059 additional employees required). Projections of economy-wide employment (an indicator of the potential for supply response) in these non-professional occupational categories indicate that they are likely to be the slowest growing, indicating that the minerals industry will need to attract a greater share of people in these occupational categories. However, the challenge of attracting people to skills shortage professional areas such as mining engineering and metallurgical engineering is also strategically critical. … The output projections used indicate the

> fastest growth between 2006 and 2010. There is therefore the potential for a rapid onset of significant labour shortages. Further, these shortages will continue to worsen as the growth rate of projected labour demand remains above the capacity of the labour market to respond.' (National Institute for Labour Studies 2006, p.2)

We conclude that the combination of ongoing strong demand for skilled labour in the energy distribution industries and the ongoing competition for the same skill sets from the mining and construction industries will lead to no amelioration of the upward pressure on energy sector wage rates in the medium term. We, therefore, reject the argument that there will be a cyclical downturn in the sector's wage pressures.

3.1.4 Supply–side responses

PEG (2007a, p.33) also notes that Access Economics place greater weight on supply side responses to labour shortages. According to PEG 'these responses include greater numbers of mining engineers coming out of Australian universities and greater migration within and to Australia to areas where labor demand is greatest'. What Access Economics (2007, p.ii) actually said on the first of these was 'Australian universities are working hard to lift the number of mining engineers' which is somewhat less positive than PEG's reporting. While these responses have some 'textbook theory' appeal, they ignore the timing lags involved and the levels of transactions costs that have to be overcome.

Econtech (2007, p.41) note some of the difficulties involved in training new professionals and bringing them into the workforce to ease skill shortages:

> 'To address the current skill shortages in these industries, a number of measures have been introduced to actively increase the supply of engineers. For instance the Australian Group of Technical Universities has started a program to encourage students to study engineering. This program is expected to provide an extra 3,300 engineers over the next four years. However the shortage in engineers ranges from new graduates to experienced senior managers. As such, while the new program could provide additional engineers, it will take some years before these new engineering graduates are experienced enough to also fill the more senior level shortages. This means that the wage pressures for experienced engineers are unlikely to ease in the near future.'

Wage pressures for experienced staff are likely to be exacerbated by the age profile of employees in the EGW sector. DEWR (2007) reports that both the gas supply industry and the EGW sector in total have an older than average workforce relative to the economy as a whole with a median age of 42 years. More than 40 per cent of the sector's workforce was aged 45 years and over in 2006, with around 27 per cent of workers aged 45 to 54 years. In the ten years to 2006, the number of workers aged 55 to 64 years more than doubled. DEWR

(2007, p.7) notes that EGW sector 'has not experienced a large influx of workers in the younger age groups (16 to 19 years and 20 to 24 years), thus making it more vulnerable to workforce ageing'.

Econtech (2007, p.41) goes on to describe the limitations on the scope for migrants to ease the skills shortage:

> '… many migrants who enter under the independent permanent migration stream may find it difficult to gain employment in the Australian labour market as an engineer. According to Engineers Australia [(2006)], there are several reasons for these difficulties. These include:
>
> - scepticism by employers about the strength and value of the person's qualification;
> - lack of Australian work experience and unfamiliarity with Australian standards and regulations and understanding the work culture; and
> - ability of the prospective employee to present relevant/local experience.'

We conclude that the scope for increases in the supply of skilled staff in the medium term are limited and the argument that university graduates and migrants can fill the shortfall ignores the timing lags involved and the levels of transactions costs that have to be overcome.

3.1.5 Other issues

PEG (2007a, p.32) also claims that 'AE (2007) represents a substantial methodological upgrade over their earlier report'. However, an examination of Access Economics (2007) shows that the changes made have not been major. The AER terms of reference required Access Economics to include a 'detailed description of the methodology used to develop the forecasts, and assumptions used in the modelling' so some additional descriptive material has been added. Access Economics (2007, p.62) notes that the main difference relative to their earlier report are small differences in wage forecasts for 2011 to 2014 reflecting 'the implementation of our new macroeconomic model, which has a more detailed flowthrough of the impact of capital investment on productivity levels in the economy'. Econtech (2007, p.13) noted that the 'differences between the first and second report by Access Economics largely reflect updates to the latest macroeconomic data'. Econtech (2007, p.ii) also observed:

> 'One key issue in assessing the labour cost forecasts in the earlier studies is the lack of clear and detailed methodology in each report. While the data sources are identified, the methodology used to convert these data sources into the detailed labour cost forecasts for Victoria is unclear. Therefore, it is difficult to fully assess or evaluate the labour costs forecasts presented in these reports.'

It is, thus, not clear that Access Economics (2007) represents the 'substantial methodological upgrade' that PEG claims it to be.

PEG (2007, p.32) also claimed that Access Economics (2007) indicated that 'ABS data show that utilities wages have grown by about 1.2% annually in real terms between December 2003 and December 2006'. However, what Access Economics (2007, p.i) said was 'ABS statistics indicate that mining wages rose 15.3% from December 2003 to December 2006, utilities wages by 15.8% and construction wages 15.9% – whereas total wages rose by 12.1% over the same period'. That is, the ABS data indicate that wages in the utilities sector increased by around 1.2 per cent per annum more than average wages in the economy as a whole, not that they increased by 1.2 per cent per annum in real terms.

3.1.6 Conclusions

On the basis of the analysis presented in this section and the information that has become available since the Meyrick (2007a) report was prepared and, in a key instance since the PEG (2007a) report was prepared, we find no case for favouring the Access Economics forecasts over those of BIS Shrapnel as advocated by PEG for the following reasons:

- based on available evidence on the gender composition of the GDB workforce and likely competition for GDB staff from a range of related sectors, BIS Shrapnel's use of the male AWOTE is unlikely to cause significant bias;
- available evidence (including that from the Access Economics report) indicates that BIS Shrapnel's use of national average forecasts is likely to somewhat understate rather than overstate EGW labour price increases in Victoria;
- the argument that the timing of network upgrades and maintenance can be varied to take advantage of the timing of input price changes ignores the impact of rapidly increasing peak energy demands in most Australian states, the impending 'bow wave' of replacement investment and the increasing demand for high levels of energy infrastructure reliability;
- export infrastructure 'bottlenecks' that have limited Australia's ability to increase mining exports will take some time to clear and there is likely to then be a substantial increase in mining operations employment as increased mining output is exported;
- the scope for increases in the supply of skilled staff in the medium term are limited and the argument that university graduates and migrants can fill the shortfall ignores the timing lags involved and the levels of transactions costs that have to be overcome.

Before revisiting the 'evaluation criteria' for best and reasonable estimates put forward by PEG, we will next review the Econtech report.

3.2 The Econtech (2007) report

The AER commissioned Econtech to review the BIS Shrapnel (2007) forecasts submitted by SP AusNet as input to the Victorian electricity transmission determination for 2008–09 to 2013–14. The Econtech (2007) report was, thus, conducted for a review concentrating specifically on conditions in Victoria, unlike the earlier Access Economics (2007) report which was prepared in the context of the prior review of Powerlink in Queensland. The AER (2007, p.8) notes Econtech's qualifications as follows:

> 'Econtech Pty Ltd was engaged to provide an independent economic assessment of SP AusNet's proposed wage growth escalators for capex and opex. Econtech is a leading independent economic consultancy specialising in economic modelling, forecasting and policy analysis. Econtech has an international reputation for modelling with clients including the governments of Australia, New Zealand, Singapore, Hong Kong, Vietnam and Malaysia.'

Econtech (2007) uses the ABS's average weekly earnings (AWE) measures of labour prices. Because the ABS only publishes these measures at the national level, Econtech uses the unpublished ABS state by industry AWE data. The measures used appear to be for all employees. Econtech then uses a Labour Cost Model (LCM) developed for the study to forecast Victorian EGW sector labour prices. The results from the LCM are fully consistent with the large scale Murphy Model 2 macroeconomic model used by Econtech. The structure of the LCM is outlined in Econtech (2007) and the model equations and coefficients were provided in a series of spreadsheets accompanying the report to the AER.

Econtech (2007, p.vii) notes its main result and the reasons behind the result as follows:

> 'In comparison to BIS, Econtech expects higher growth in labour costs over the period 2008 to 2014. Econtech's forecast is consistent with the historic pattern of wages growth in the utility sector exceeding the average for all industries, at both the Victorian and national levels.
>
> The main driver of this continued strong utility wages growth into the future is that of skill shortages and the competition the industry faces from industries such as the construction industry and the mining industry for the same type of skilled workers. With the mining and construction boom expected to last for another couple of years, this will continue to boost wages in these industries. In turn, wages for the utility sector will also need to increase, so as to continue to attract skilled workers.'

Econtech (2007, p.34) goes on to observe:

> 'The utilities sector in particular has been hit hard by the skills shortage, given the nature of demand for its output as well as the fact that it is forced to compete for workers with both the construction and mining industries. … [T]he boom in the energy intensive mining and construction industries has supported strong demand for energy across the Australian economy. Even though the demand for Victorian energy was not strongly effected by the mining boom (Victoria is isolated from Western Australia and did not export electricity to Queensland in 2005/06), the overall effect across the Australian economy was to increase the demand for electrical and gas related trades, putting upwards pressure on wages.'

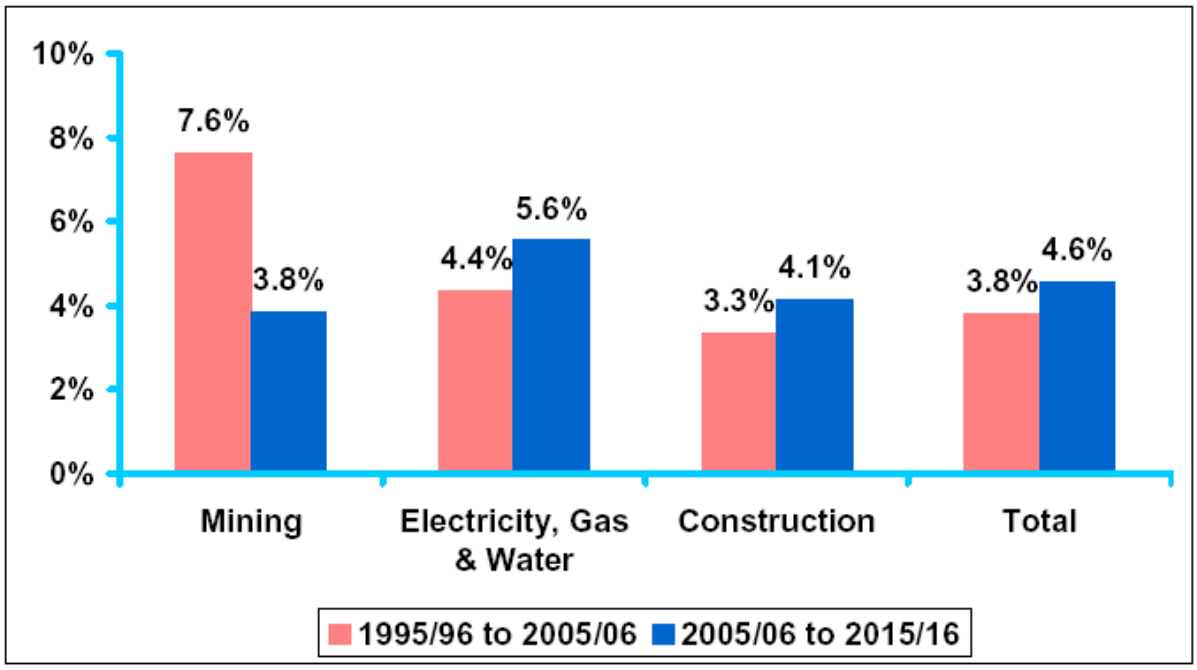
The AER (2007, p.138) also notes:

> 'Econtech makes the following observations in relation to the electricity industry generally, and in Victoria:
>
> - The electricity, gas and water industry has exhibited above average wage growth over the last 20 years when compared to wage growth over the economy as a whole.
> - Productivity movements in the electricity, gas and water industry have not been conducive to wage increases in recent times, and have in fact been negative since 2000-01 whilst wage growth has been relatively strong. The drive for increases in productivity in the industry is expected to lead to a fall in the number of lower-skilled workers, and a higher average wage.
> - The utilities sector has been particularly hard hit by the skills shortage, given the demand for its output and competition for labour with the mining and construction industries. This has had an inflationary effect on wages as employers are forced to offer higher wages in order to retain staff.'

As noted in the preceding section, Econtech disagrees with the analysis in Access Economics (2006, 2007) which indicates that the impacts of the mining and construction booms on EGW labour price increases are relatively transitory. Econtech also observes that the compound labour price growth rate for the EGW sector has been historically higher than for both the Construction sector and Victoria as a whole. Econtech expects this trend to continue with EGW wage growth forecast to average an annual rate of 5.6 per cent over the 10 years to 2015–16. The Econtech forecast of EGW sector labour prices for the calendar years 2008 to 2012, the period of the next Victorian Gas Access Arrangement (GAA), is 6.54 per cent. In comparison, after experiencing strong labour price growth over the last ten years, Econtech forecasts growth in wages in the Mining sector to return to more modest levels over the next 10 years, as the mining boom eases (see figure 1).

Econtech (2007, p.45) concludes that 'while BIS does not provide a wage forecast for the Victorian utility sector, its national and overall utility wage profiles are fairly consistent with Econtech'.

Figure 1: **Ten Year Compound Labour Cost Growth Rates in Victoria**



Source: Econtech (2007, p.39)

The AER (2007, p.141) concludes:

> 'While there is some difference between the two, the independent forecasts provided by Econtech suggest that the forecasts provided by BIS Shrapnel, and relied on by SP AusNet, are not excessive. … On the basis of the independent advice provided by Econtech and the BIS Shrapnel report provided by SP AusNet, the AER accepts that SP AusNet's proposed real labour growth escalator of 2.8%, based on the nominal rate of 5.7%, is a realistic expectation of increases in the cost of labour in SP AusNet's forthcoming regulatory control period.'

The Econtech (2007) report and its recent endorsement by the AER vindicate the earlier Meyrick (2007a) decision to place all its weight on the BIS Shrapnel (2007) forecasts as the best and most reasonable estimates (at the time) for forecast labour price increases for the Victorian GDBs during the next GAA period.

3.3 Assessment using the PEG evaluation criteria

As noted in section 2.1, the evaluation criteria for best estimates prepared on a reasonable basis put forward in PEG (2007a) have no standing under the Gas Code and Meyrick disagrees with the way PEG has attempted to operationalise the proposed criteria. However, for completeness, in this section we review PEG's application of the criteria and update it in light on information that has become available since both the Meyrick (2007a) and PEG (2007a) reports were prepared.

We look first at the PEG (2007a) 'best estimate' criteria.

Accuracy of the data employed

PEG (2007a) claimed that the BIS Shrapnel forecasts were deficient in that they related to male employees only whereas the Access Economics forecasts related to all employees. PEG thus favoured Access Economics on this criterion. However, PEG conceded elsewhere that BIS Shrapnel's use of the AWOTE measure would give a more accurate indication of actual labour price pressures facing the GDBs than the Labour Price Index measure used by Access. This is because AWOTE takes account of workforce compositional changes whereas the Labour Price Index takes a constant basket of positions.

As shown in section 3.1, BIS Shrapnel's use of male employees only is unlikely to introduce significance bias into their forecasts given that around 80 per cent of GDB employment is male and there is also competition for office and customer service staff (likely to be where most female employees are located) from other energy supply entities, particularly those in the energy retail component. BIS Shrapnel (2007, p.2) also note that they use male employee AWOTE to obtain a more consistent series through time. In light of these considerations and taking the superior accuracy of the AWOTE measure into account, we reject PEG's assessment using this criterion.

To provide a full assessment using all information now available we also need to include the Econtech (2007) report. It uses the AWOTE measure based on ABS data specifically for Victoria. It also appears to use data for all employees rather than just male employees. The Econtech forecasts would, thus, be favoured based on this criterion over both the BIS Shrapnel and Access forecasts.

Data sources reflect relevant business conditions that affect GDBs

PEG argued that the Access forecasts were to be favoured over the BIS Shrapnel forecasts on this criterion as they presented estimates for Victoria whereas the BIS Shrapnel forecasts were for the national level. In section 3.1 we have demonstrated that the Victorian forecasts of Access are slightly higher than their national forecasts and Econtech finds a similar result.

The national forecasts, thus, appear to be a very good proxy for Victorian–specific forecasts. We, therefore, believe PEG's decision to favour Access on this criterion is not supported by available evidence.

While the Access forecasts contain results for all states, they were prepared in the context of the AER's review of Powerlink in Queensland and did not focus specifically on business conditions in Victoria. The Econtech forecasts, however, were prepared for the AER in the context of the review of electricity transmission in Victoria. They, thus, focus very much on business conditions in Victoria specifically and most of the results presented are for Victoria. They have been endorsed by the AER as providing an accurate picture of EGW wage pressures in Victoria. On the basis of this criterion, therefore, the Econtech forecasts are superior.

The use of rigorous empirical techniques

PEG favours Access on this criterion because it claims Access cover a wider range of considerations in forming their forecasts. However, in section 3.1 we have noted that Access' methodology is not transparent and a number of respected analysts have criticised the degree of cyclicality in their forecasts and the overly optimistic nature of their claimed supply side responses which appear to place inadequate weight on timing lags and transactions costs. We cannot, therefore, support PEG's assessment on this criterion.

The Econtech forecasts, on the other hand, use a very transparent Labour Cost Model based on the most detailed data available and which is fully integrated with a widely used macroeconomic model. The equations and coefficients in the model were made available to the AER. The model has been endorsed by the AER as reflecting EGW labour market conditions in Victoria. We, therefore, favour the Econtech forecast on this criterion.

Robustness

PEG favours the Access forecasts on this criterion because the Access analysis is 'more detailed and persuasive'. However, as noted above and in section 3.1, the Access analysis is not transparent and a number of respected analysts have criticised the cyclicality of the results and overly optimistic supply conditions put forward. We cannot, therefore, agree with PEG that the Access forecasts are more persuasive.

The Econtech forecasts are based on the most detailed data available and the full details of the model have been made available allowing scope for sensitivity analyses to be undertaken. The results are consistent with historical experience and the report provides plausible descriptions of interaction mechanisms and supply constraints. We, therefore, favour the Econtech forecast on this criterion.

Historical consistency

PEG favoured neither the BIS Shrapnel nor Access forecasts on this criterion. We agree it is hard to apply this criterion to either of these studies. However, as noted above, the Econtech forecasts are demonstrated to be consistent with historical experience over the last decade (for example, see figure 1 above). We, therefore, favour the Econtech forecast on this criterion.

No "cherry picking" of available data

PEG did not identify any 'cherry picking' in either of the BIS Shrapnel or Access studies and so favoured neither on this criterion. We agree with this assessment. We also cannot identify any cherry picking in the Econtech study and so no study is favoured on this criterion.

Internal consistency and no "double counting" of changes

PEG did not identify any double counting in either of the BIS Shrapnel or Access studies and so favoured neither on this criterion. We agree with this assessment. We also cannot identify any double counting in the Econtech study and so no study is favoured on this criterion.

Reflects long–run behaviour

PEG favours Access on this criterion because it claims Access has a better treatment of cyclical and non–cyclical factors and transitory 'catch up' factors. However, as noted above and in section 3.1, Access' methodology is not transparent and a number of respected analysts have criticised the degree of cyclicality in their forecasts and the overly optimistic nature of their claimed supply side responses which appear to place inadequate weight on timing lags and transactions costs. They also place inadequate weight on the implications of the aging of the GDB workforce. Their observations regarding the 'catch up' nature of recent infrastructure investment ignore the impending need to renew significant parts of the energy distribution networks and the need to expand capacity to meet rapidly increasing peak demands. They also appear to underestimate the extent of labour required to produce increased mineral exports which have, till now, been stymied by bottlenecks at both the mine and infrastructure levels and are at odds with analysis by the National Institute of Labour Studies. We cannot, therefore, support PEG's assessment on this criterion.

The Econtech forecasts, on the other hand, are consistent with observed historical experience while at the same time allowing for the impacts of the different stages of the mining boom. They are fully integrated with one of Australia's leading macroeconomic models and, therefore, incorporate long–run adjustment mechanisms. We, therefore, favour the Econtech forecast on this criterion.

We turn now to the PEG (2007a) 'reasonable basis' criteria.

Objective process and information

PEG indicated it had no information on whether the process used by either the BIS Shrapnel or Access studies was 'objective, impartial and free from bias' and so favoured neither on this criterion. We agree with this assessment. While it is also difficult to assess the Econtech study against this criterion we note that Econtech's release of its model details and spreadsheets to the AER means that it is the most transparent and, therefore, most likely to be unbiased. However, in the absence of more information we agree that this criterion cannot be used to differentiate the studies with sufficient confidence.

Consistent with economic theory

PEG favoured the BIS Shrapnel study on this criterion because of its use of the AWOTE labour price measure which better reflects the labour cost pressures the GDBs actually face. We agree with this assessment. However, as noted above, the Econtech study uses more detailed state–specific AWOTE data rather than published national level data and appears to cover all employees. The Econtech Labour Cost Model is also fully integrated with a leading macroeconomic model and, thus, is soundly grounded in economic theory. We, therefore, favour the Econtech forecasts on this criterion.

Feasibility

PEG believed that both the BIS Shrapnel and Access forecasts 'can be feasibly implemented' and so favoured neither on this criterion. We agree with this assessment. The Econtech forecasts can also 'be feasibly implemented'.

Low forecast errors

PEG favoured neither BIS Shrapnel nor Access Economics on this criterion as it had inadequate information on which to assess the previous forecasting track records of the firms. We agree with this assessment.

Weighting of alternative forecasts

PEG thought this criterion was not relevant to the exercise at hand. We concur.

Transparent

PEG favoured Access Economics on this criterion as it thought the bases for the Access forecasts were 'more clearly presented' than was the case for BIS Shrapnel. However, as documented above, a number of analysts have noted that there is the lack of a clear and detailed explanation of the methodology used in the Access report and the method used to convert data sources into the detailed labour cost forecasts for Victoria is unclear. It is, therefore, difficult to fully assess or evaluate the labour costs forecasts presented, let alone

replicate them. We cannot, therefore, agree with PEG that the Access forecasts are more transparent.

As noted above, the Econtech report contains a detailed description of the processes used in its Labour Cost Model and the spreadsheets supporting the model were made available to the AER. This is closer to the desirable level of transparency noted in the Meyrick criteria for good regulatory study practice listed in section 2.2. We, therefore, favour the Econtech forecasts on this criterion.

Verifiable

PEG favoured neither BIS Shrapnel nor Access Economics on this criterion as it had inadequate information to verify the forecasts. We agree with this assessment. Econtech, on the other hand, provided their Labour Cost Model spreadsheets to the AER and so their forecasts are verifiable. Hence, we favour the Econtech forecasts on this criterion.

Regulatory precedent

PEG favoured neither BIS Shrapnel nor Access Economics on this criterion as it was not aware that either set of forecasts had been used in regulatory determinations. Since the time of the PEG report, however, the AER has released its Draft Determination on electricity transmission in Victoria where it commissioned Econtech to review the BIS Shrapnel forecasts which had been submitted by SP AusNet. The Econtech forecasts indicate that the BIS Shrapnel forecasts were somewhat on the conservative side. As noted in section 3.2, the AER accepted that the BIS Shrapnel forecasts are 'a realistic expectation of increases in the cost of labour in SP AusNet's forthcoming regulatory control period'. Therefore, based on developments since the PEG report, we have to reject PEG's finding that neither the BIS Shrapnel nor Access Economics forecasts have been used in regulatory determinations as the BIS Shrapnel forecasts have subsequently been accepted and used by the AER.

Conclusion

Based on the above assessment of the three sets of labour price forecasts now available, we find that the Econtech forecasts are unambiguously favoured on 6 of the 8 PEG criteria for 'best estimates' while the remaining two criteria cannot distinguish between the forecasts. On PEG's 8 criteria for whether forecasts have been arrived at on 'a reasonable basis', we find that none of the studies can be favoured on four of the criteria, three of the criteria unambiguously favour the Econtech forecasts and the remaining one jointly favours BIS Shrapnel and Econtech. Application of these criteria, thus, overwhelmingly favours acceptance of the Econtech forecasts. Since the Econtech forecasts indicate that the BIS Shrapnel forecasts for EGW labour price increases in Victoria over the period 2008 to 2012 are somewhat conservative, this vindicates the earlier Meyrick (2007a) decision to place all

its weight on the BIS Shrapnel (2007) forecasts as the best and most reasonable estimates (at the time). We, thus, reject the PEG (2007a) analysis and contention that most of the weight should be placed on the Access Economics (2007) forecasts.

Making use of the full amount of information now available and applying the evaluation criteria put forward by PEG (2007a), we conclude that the most appropriate labour price forecasts to use in the rate of change formula are those developed by Econtech (2007). These forecasts have been specifically developed in the context of the Victorian EGW sector and have been endorsed by the AER subsequent to the earlier Access Economics reports. They score well on all the criteria proposed by PEG where the forecasts can be distinguished. We, thus, recommend using a forecast nominal labour price increase of 6.54 per cent per annum in application of the rate of change formula for the calendar years 2008 to 2012.

4 NON–LABOUR OPEX PRICE INDEX

For the growth rate of non–labour opex prices, Meyrick (2007a) recommended using an extrapolation of the weighted average of Producer Price Indexes (PPIs) used by PEG (2006a) in their latest update of TFP for Victoria's electricity DBs. The indexes reported in PEG (2006a) allowed a 5 year annual average growth rate to be calculated using the years 2001 to 2005. This produced an average growth rate of 2.61 per cent. PEG (2007a) concurred with this approach and agreed this was a best estimate prepared on a reasonable basis.

Given that we are now three quarters of the way through 2007 and two years have passed since the time period covered in PEG (2006a), it is appropriate to review the latest PPIs published by the ABS to check that the 2.61 per cent growth rate is still an accurate reflection of recent experience. We also take advantage of doing this review to check the appropriateness of the PPIs used in PEG (2006a) as being a reasonable representation of the coverage of tasks in the main opex categories they report.

Table 1: **PEG (2006a) ABS Producer Price Indexes, growth to June 2003–2007**

June Qtr to June Qtr	Business services	Computer services	Secretarial services	Accounting & legal services	Advertising services
2003	3.52%	2.49%	3.57%	3.13%	6.40%
2004	3.22%	0.43%	1.33%	7.09%	-3.16%
2005	1.94%	-0.69%	0.61%	2.92%	3.82%
2006	3.73%	2.17%	1.22%	5.44%	4.98%
2007	4.31%	1.45%	1.37%	4.28%	3.51%
Average	3.34%	1.17%	1.62%	4.57%	3.11%
Weight	51.19%	21.49%	16.71%	7.96%	2.65%
Weighted average	2.68%				

Sources: ABS (2007b) and PEG (2006a)

In table 1 we report the latest ABS PPI data for the 5 years to June 2007. We report changes from June quarter to June quarter to maximise the use of the most recent available information. Using the same composition of PPIs and weights as reported in PEG (2006a), we find the 5 year weighted average price change to June 2007 has increased to 2.68 per cent from the 2.61 per cent figure to 2005 reported in PEG (2006a). We conclude that the 2.6 per cent figure recommended in Meyrick (2006a) is still a reasonable approximation but should be updated to 2.68 per cent as it does not utilise the most recent available information.

Table 2: **Allocation of Producer Price Indexes to opex components**

Opex component	PEG (2006a) PPI	Meyrick PPI recommendation
Meter data services	Computer services	Data processing services & Information storage & retrieval
Billing & revenue collection	Computer services	Data processing services & Information storage & retrieval
Advertising/marketing	Advertising services	Advertising services & Market research services
Customer service	Secretarial services	Secretarial services
Regulatory	Legal and accounting services	Legal and Accounting services
SCADA maintenance	Computer services	Computer maintenance
Other	Business services	Business services

Sources: ABS (2007b) and PEG (2006a)

We have also reviewed the allocation of PPIs to the non–labour opex components used in PEG (2006a). The allocation used by PEG is reported in table 2. We agree with PEG on the allocation of the Secretarial services PPI to Customer service opex, the Legal and accounting services PPI to Regulatory opex and the Business services PPI to Other opex. These opex components account for around 75 per cent of the weight in the overall PEG non–labour opex price index. However, a review of the PPIs used for Meter data services opex, Billing and revenue collection opex, Advertising/marketing opex and SCADA maintenance opex indicates that they are not the best proxies for these components.

For Meter data services and Billing and revenue collection PEG (2006a) used the Computer services PPI. The Computer services PPI is, however, a higher level PPI that aggregates 4 lower level PPIs. The lower level PPIs are those for Data processing services, Information storage & retrieval, Computer maintenance and Computer consultancy. The first two of these are likely to closely reflect activities contained in both Meter data services and Billing and revenue collection. However, neither Computer maintenance nor Computer consultancy services are likely to be closely linked to Meter data services and Billing and revenue collection. Therefore, taking a weighted average of the PPIs for Data processing services and Information storage and retrieval is likely to more closely match these opex activities. Since

we do not have disaggregated data on these opex components, we assume that data processing services and information storage and retrieval activities are both equally important. We, therefore, take a simple average of the Data processing services and Information storage and retrieval PPIs to represent the prices of these opex components.

For Advertising/marketing opex PEG (2006a) used only the Advertising services PPI. This effectively neglects the marketing component. The ABS prepares a Market research services PPI which is at the same level of aggregation as the Advertising services PPI. To more accurately represent this opex component we propose taking a weighted average of the PPIs for Advertising services and Market research services. Since we again do not have disaggregated data on these opex components, we assume that advertising services and market research services activities are both equally important and, therefore, take a simple average of two PPIs.

And for SCADA maintenance PEG (2006a) uses the Computer services PPI. As noted above, this is a higher level index and only one of its four component indexes, namely Computer maintenance, appears directly relevant to SCADA maintenance. We, therefore, propose using the PPI for Computer maintenance for this opex component.

Table 3: **Meyrick ABS Producer Price Indexes, growth to June 2003–2007**

June Qtr to June Qtr	Data Proces'g services	Info & retriev. services	Business services	Secret-arial services	Acc'nt. & legal services	Advert-ising services	Market. research services	Comp'r maint. services
2003	2.20%	1.30%	3.52%	3.57%	3.13%	6.40%	3.96%	-2.41%
2004	2.51%	1.39%	3.22%	1.33%	7.09%	-3.16%	4.32%	-1.58%
2005	0.52%	1.89%	1.94%	0.61%	2.92%	3.82%	3.17%	3.91%
2006	5.13%	-1.34%	3.73%	1.22%	5.44%	4.98%	7.79%	-4.24%
2007	0.99%	-2.30%	4.31%	1.37%	4.28%	3.51%	3.28%	6.14%
Average	2.27%	0.19%	3.34%	1.62%	4.57%	3.11%	4.50%	0.36%
Weight	8.90%	8.90%	51.30%	16.72%	7.88%	3.11%	1.28%	3.74%
Weighted average	2.67%							

Sources: ABS (2007b) and PEG (2006a)

The revised PPIs, their 5 yearly growths and updated weights derived from the PEG (2006a) opex component values are presented in table 3. The weighted average growth rate for this non–labour opex price index is 2.67 per cent which is little different to the more aggregated figure of 2.68 per cent reported in table 1 using the PEG (2006a) specification.

We conclude that the appropriate non–labour opex price growth rate to use in the rate of change formula is 2.67 per cent based on the latest ABS data and an allocation of PPIs that more closely matches relevant opex tasks.

5 OPEX PARTIAL PRODUCTIVITY TRENDS

Meyrick (2007a) recommended using an annual opex partial productivity growth rate of 0.8 per cent in the rate of change formula. The use of this figure was supported by four pieces of concurring evidence:

- forecasts of future Victorian GDB opex partial productivity growth derived from the detailed Meyrick TFP database presented in Meyrick (2007b);
- forecasts made by BIS Shrapnel (2007) of labour productivity in the EGW sector;
- regulatory precedents from other Australian energy distribution decisions; and
- productivity growth rates observed in North American energy distribution studies.

PEG (2007a) disputed the evidence advanced by Meyrick in support of a 0.8 per cent partial productivity growth rate and, instead, undertook an econometric modelling exercise and recommended a much higher growth rate of 2.75 per cent.

In this section we review the arguments advanced by PEG for rejecting the Meyrick recommendation and critique the PEG econometric model. The PEG analysis is found to contain a number of internal contradictions and the PEG modelling is found to not meet key parameter requirements and to be based on inaccurate forecast data. A key aspect of PEG's modelling is also found to be not consistent with good modelling practice. We then present additional evidence based on analysis of US gas distribution data supporting a lower productivity growth rate before assessing the Meyrick and PEG recommendations against alternative evaluation criteria.

5.1 Critique of the PEG (2007a) analysis

5.1.1 Meyrick forecasts

A large part of PEG's argument for rejecting the Meyrick (2007b) opex partial productivity forecasts appears to be based on PEG's embrace of a notion of 'cost overshooting'. Meyrick (2007a, p.9) mentioned the possibility of cost overshooting as one of several possible explanators of the often observed initial productivity 'burst' immediately following privatisation where cost cutting might be excessive as new business management takes time to learn what sustainable levels of input use are required in the longer term. However, this is not the situation faced by the Victorian GDBs which have now been privatised for nearly a decade.

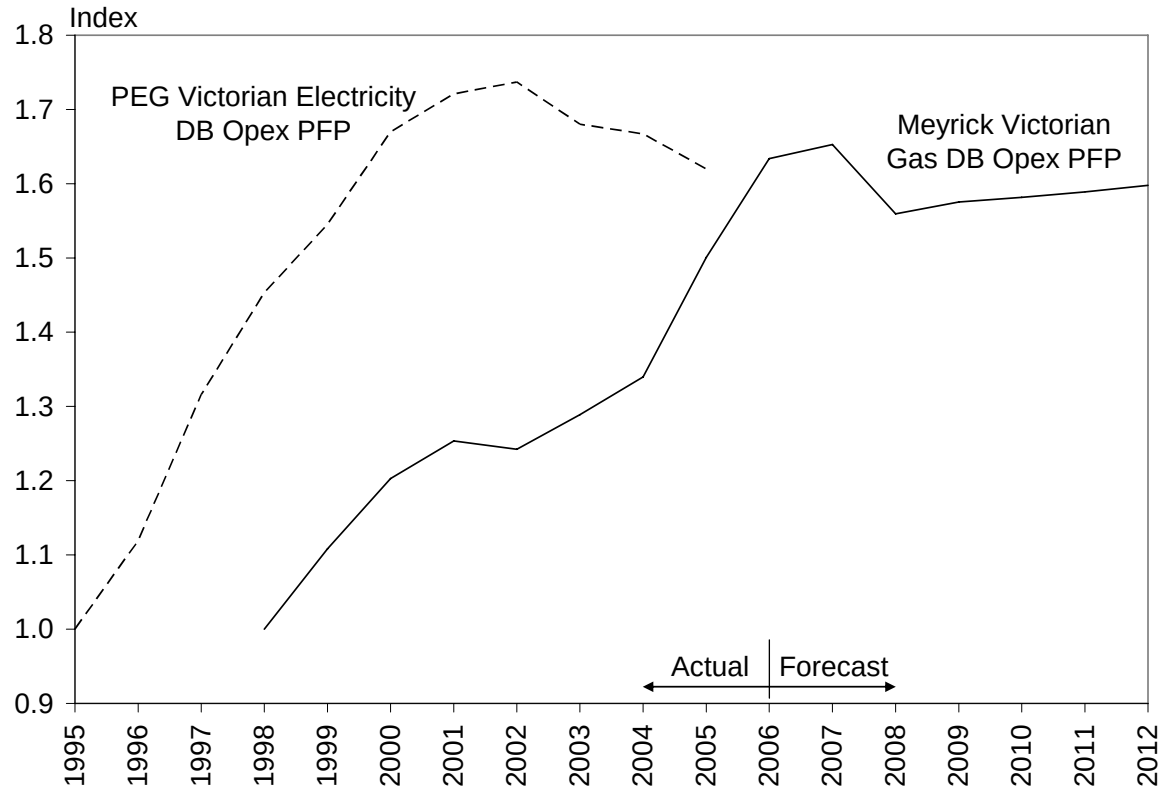
The point that Meyrick (2007a) was making was that high productivity growth rates immediately following periods of reform do not provide a good guide to sustainable future productivity growth rates. Our primary argument was that new ownership is able to implement easy 'catch–up' gains to remove the worst inefficiencies quickly. However, over

time the GDBs move closer to the best practice frontier and their productivity growth will become constrained by the movement of the frontier. This is the so–called 'convergence' effect. Since the movement of the frontier is primarily determined by the rate of technological change in the industry and, being an industry using a very mature technology which is changing relatively slowly compared to other industries in the economy, we would expect the frontier for gas distribution to be moving relatively slowly over time. Hence, once GDBs reach the frontier, we would expect the scope for productivity growth after that to be relatively limited.

We also observed that new ownership may take time to become fully familiar with the characteristics of the business and so there may be some 'overshooting' during initial cost–cutting. This should not be confused with inefficiency. Rather, it simply reflects the fact that no players in the industry during the immediate post–reform period – firms, consumers or regulators – will have perfect knowledge and there will inevitably be a period of learning by doing to determine what is sustainable in the longer term. However, we are now looking at a situation a decade after privatisation so it is very unlikely these conditions apply.

PEG reports apparent differences between the Victorian electricity DB and GDB experience in support of its claim of cost overshooting by the GDBs. PEG (2007a, p.41) notes 'the experience of the power distribution DBs during their first eight years after their privatisation was very different [to that of the GDBs]'. PEG argues that the electricity DBs' opex partial productivity growth tapered off whereas that of the GDBs has remained at high levels and, hence, there has been cost overshooting by the GDBs. However, this ignores the comparison of actual electricity DB experience (as calculated by PEG 2006a) and actual and forecast GDB experience as reported by Meyrick (2007a, p.11) in figure 2 (reproduced below). Remembering that the GDB privatisations took place three years after the electricity DB privatisations, the actual and forecast opex partial productivity experience of the GDBs is remarkably similar to that of the electricity DBs' actual experience. Both increase by around 70 per cent in the 7 to 9 years following privatisation before decreasing slightly. In the case of the GDBs the forecast decrease in 2008 is due to the scope changes required of the GDBs in that year which increase input use but are not picked up in our measured outputs. After that, GDB opex partial productivity is forecast to increase by around 0.4 per cent per annum during the period of the next GAA, ie 2008 through to 2012. The opex partial productivity of the electricity DBs, on the other hand, has continued to trend down based on the available data. Therefore, if it is accepted that there has not been cost overshooting in electricity distribution, it is untenable to argue that there has been in gas distribution in Victoria.

Figure 2: **Gas and electricity distribution opex partial productivity indexes for Victoria, 1995–2012**



Source: Meyrick and Associates (2007a, p.11)

PEG (2007a, p.44–5) stated:

> 'PEG nevertheless believes there is a significant probability that cost overshooting has occurred in Victoria's gas distribution industry. This explanation is consistent with the GDBs' observed pattern of opex PFP gains and the statements of the GDBs' own consultants.'

As illustrated above, the GDBs' actual and forecast opex partial productivity performance is broadly similar to that of the electricity DBs and does not provide support for the occurrence of cost overshooting. With regard to the last statement in this quote, in its response dated 8 May 2007 to an information request from PEG, Meyrick stated the following:

> 'In case PEG is in any doubt, we are not saying that current forecasts indicate some degree of 'overshooting' has necessarily occurred in the Victorian gas distribution industry. The industry's opex partial productivity increases in every year except 2008 and the decline in 2008 is due to additional safety and compliance requirements being placed on the GDBs' at that time. The industry's reliability and service quality performance has also remained at very high levels. What we are saying is that there are a

> number of reasons why past productivity growth rates may not reflect sustainable future productivity growth which is what needs to be built into the rate of change formula.'

In an information request to PEG dated 4 September 2007, Meyrick asked PEG to provide 'a detailed explanation of the objective, quantitative basis' for its conjecture of cost overshooting by the GDBs. In its reply dated 18 September 2007 PEG provided no additional information. We cannot, therefore, accept PEG's conjecture.

Meyrick (2007a, p.9) also raised another issue which needs to be considered in the context of forecasting productivity trends. We noted that an unsustainably low level of input use 'may also result from privatisation occurring at a time of surplus capacity in the industry and, as that capacity is fully utilised or as assets near the end of their useful lives, input use will have to increase to allow higher levels of maintenance and asset refurbishment'. This phenomenon has been recognised in a number of recent Australian regulatory decisions, most notably IPART's 2004 electricity distribution decision. But PEG (2007a) has ignored this important issue.

PEG (2007a) also does not acknowledge the role of the convergence effect described above whereby productivity levels will eventually be constrained by the rate of movement of the efficient frontier. PEG appears to argue that scale economies and the scope for opex/capital input substitution mean that high rates of opex partial productivity growth may be sustainable for long periods, even where the rate of technological change in the industry is relatively slow and inefficiencies have been largely removed. However, in an industry that has been privatised and subject to incentive regulation for 10 years we would expect the composition of input use to be relatively stable. The scope to achieve further economies of scale is also likely to be limited given that the Victorian GDBs are, with the exception of the NSW network, the largest in Australasia and penetration rates are already high due to Victoria's cooler winter climate and early introduction of natural gas. This means that the slower rate of technological change is likely to be the predominant constraint on future opex partial productivity growth if inefficiencies have been removed. Earlier studies by PEG (2001a,b,c) have found that the three Victorian GDBs were relatively efficient performers compared to US GDBs – a result confirmed and updated by Meyrick (2007c) – so inefficiency is unlikely to be a significant issue.

Apart from the scope changes the GDBs will be required to bear from 2008 onwards, there are a number of important reasons why future GDB opex productivity growth is likely to be much less than the rapid rates observed up to 2006. These include:

- the move from two to one man crews – having achieved this, the gain cannot be repeated by moving to half man crews;

- optimisation in maintenance regimes have significantly reduced the need for opex resources but opex requirements can now not be further reduced at anywhere near this rate;
- reduced visits to regulator sites due to SCADA have led to rapid productivity gains that can now not be repeated;
- risk based leakage surveys have allowed far better targeting of opex;
- optimised inspection regimes have significantly reduced the need for opex resources but opex requirements can now not be further reduced quickly; and,
- synergies from consolidating contractors (such as for meter reading) to achieve scope economies between gas and electricity distribution activities cannot be repeated.

These practical constraints have to be taken into account in assessing any opex productivity forecast. They indicate that the convergence effect is a far more plausible effect on likely future opex partial productivity growth than PEG's cost overshooting conjecture.

PEG (2007a, p.44) argues against relying on information supplied by the GDBs in calculating opex productivity forecasts as this is likely to be 'self–referential' and not objective. While we accept that regulators will not want to rely entirely on information supplied by the businesses, it also needs to be recognised that the businesses are the ones who know most about their own operations and the scope for ongoing productivity improvements. Failure to place weight on information supplied by the businesses, or to even consult with the businesses, runs the risk that unrealistically high opex productivity growth rates will be incorporated – particularly where models based on overseas characteristics and conditions are relied upon. It is precisely for this reason that Meyrick (2007a) based its recommended opex productivity forecast on a combination of information supplied by the businesses, sectoral information, precedents in other jurisdictions and the results of a range of other studies. It is also why the Meyrick criteria for assessing quantitative studies used in regulatory decisions listed in section 2.3 require stakeholders to be consulted on modelling inputs and results and, given the asymmetric risks involved, why conservative decisions on modelling recommendations are necessary.

Taking the above considerations into account, Meyrick rejects the PEG (2007a) failure to accept the Meyrick (2007b) productivity forecasts as one of the relevant pieces of information on which to base the opex partial productivity forecast in the rate of change formula.

5.1.2 Technical issues

Before moving on to examine PEG's criticisms of the other components on which the Meyrick opex productivity recommendation was based, we turn to some technical criticisms

made by PEG (2007a). Firstly, PEG argue that the opex price deflator used by Meyrick (2007b) should have not been based on the PEG (2006a) opex price deflator which incorporates the Labour Price Index measure rather than the faster growing AWOTE measure. PEG (2007a, p.40) argues that this is likely to have biased the Meyrick opex partial productivity estimates downwards. What is relevant to the rate of change calculation, however and as agreed by PEG (2007a), is the likely achievable opex partial productivity going forward rather than the historic rate of opex productivity growth. The Meyrick (2007b) productivity projections were based on the constant price data on expected future opex requirements supplied by the three GDBs. Since each of the GDBs had used different opex price indexes reflecting their own conditions when supplying the forecast data, the price effects were removed, the constant price series retained and then a new forecast opex value was formed using the constant price series and the common opex price index derived from PEG (2006a). Since the opex productivity projections are driven by the constant price opex series (and forecast output quantities), this means that the opex productivity forecasts were not affected by the bias PEG claims in the price index based on its earlier study.

PEG (2007a, p.37–9) notes that, despite a number of areas of debate between Meyrick and PEG on the appropriate specification of outputs and inputs to be used in distribution productivity studies, there is likely to be more agreement on opex productivity specifications than total factor productivity specifications. This is because some of the areas of debate relate to capital inputs. While this is partly true, some differences remain on the appropriate specification of the output measure which may affect opex partial productivity calculations. However, the specification of an appropriate capital input quantity variable remains an important issue in the PEG (2007a) study's econometric results. Meyrick (2005a,b) has discussed the problems with using deflated asset value measures in productivity studies in the energy distribution industries and how it is likely to bias capital input measures downwards and, hence, productivity measures upwards. This will be examined in the context of the current PEG study in the following section.

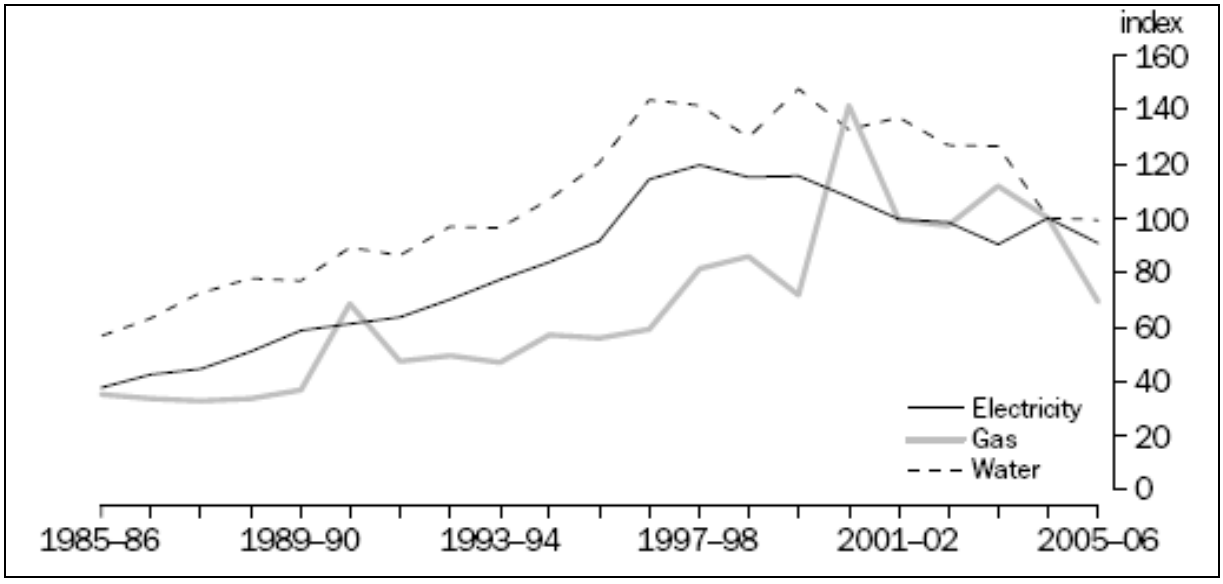
Finally, PEG (2007a, p.38) contains a lengthy discussion of the appropriate weights to use in constructing output indexes for productivity measurement. PEG's position appears to be that it agrees with Meyrick that output cost share based weights are appropriate for the exercise at hand but it retains its view that revenue–based share weights are appropriate for price cap calculations. We do not intend to debate this issue here but record our ongoing concerns with using revenue–based output weights in the energy distribution industry. We also note that the discussion in PEG (2007a, p.49) regarding the mismatch between US GDB's cost structures and rate design and the trend to 'decoupling' (breaking the link between GDB revenue and deliveries) highlights the problems with using revenue weights.

5.1.3 BIS Shrapnel and National Accounts based estimates

PEG (2007a) attempts to dismiss the relevance of the BIS Shrapnel (2007) forecast of annual labour productivity growth of 0.8 per cent on the grounds that it only applies to labour and not all of opex, applies to the EGW sector and not gas specifically and BIS Shrapnel's historic labour productivity estimates show steady decline whereas the Meyrick (2007b) opex partial productivity estimates show growth over the last several years.

Since labour accounts for around 62 per cent of opex based on PEG (2006a) and data supplied to Meyrick by the GDBs, labour productivity will be an important driver of opex productivity. It is, thus, not satisfactory to dismiss labour productivity information as not being relevant. PEG also claims that the results of North American studies show that labour productivity and materials and services productivity can move in opposite directions. However, no evidence is presented that this has been the case in Victoria. Given that the Victorian GDBs have been privatised and subject to incentive regulation for over a decade, they can be expected to be operating at high levels of efficiency and it is, thus, unlikely that the labour and non–labour components of opex would be moving in disparate directions.

Figure 3: **ABS Electricity, Gas and Water industry labour productivity indexes**



Source: ABS (2007a, p.41)

Evidence discounting PEG's contention that the gas industry's experience may have been different to that of the broader EGW sector has recently been released in ABS (2007a). This shows that the labour productivity of each of the three components of the EGW sector have followed a similar pattern over the last several years, with labour productivity generally declining. While the gas industry's labour productivity has been more volatile than that of the electricity and water industries, it has also declined since the turn of the century, consistent

with the BIS Shrapnel EGW series. ABS (2007a, p.41) notes 'the recent fall in productivity for the Gas industry was due to a large increase in hours worked relative to the change in value added.' This result supports BIS Shrapnel's cautious forecasts of labour productivity growth over the next 5 years. The labour productivity series for the three industries are shown in figure 3.

Meyrick has discussed this finding with the ABS[2] over a long period. The ABS indicate they have checked the relevant calculations and data sources and staunchly defend their results. Since gas distribution is an important component of the gas supply industry, this finding from Australia's national statistical office cannot simply be ignored when considering what opex partial productivity growth forecast is appropriate for the Victorian GDBs. It points to the need for the ESC to adopt a cautious, rather than aggressive, estimate of opex partial productivity for use in the rate of change formula.

It is also instructive to examine the ABS National Accounts estimates of labour productivity growth for the economy as a whole. Based on data in ABS (2007c), the economy–wide rate of labour productivity growth over the period from June 2003 to June 2007 was an annual rate of 1.3 per cent. As discussed earlier in this section, the gas distribution industry is characterised by the use of mature technology which is changing only slowly compared to the average for the economy and, for the Victorian GDBs, scale and input substitution are unlikely to be major contributors to the shift in the efficient frontier. Assuming the Victorian GDBs are operating efficiently – a reasonable assumption after 10 years of privatisation and incentive regulation and consistent with the findings of quantitative benchmarking studies – then the economy–wide rate of labour productivity growth is likely to form the upper bound for reasonable forecasts of GDB labour productivity growth and GDB productivity performance is likely to be less than this. The Meyrick (2007a,b) opex productivity forecasts are consistent with this while the PEG (2007a) forecasts are not.

Given the available evidence from National Accounts sources, we do not agree with the PEG (2007a) dismissal of the relevance of the BIS Shrapnel forecast.

5.1.4 Regulatory precedents

Meyrick (2007a, p.12) stated that support for expected opex partial productivity improvements in the order of around 1 per cent per annum can also be found in the energy distribution decisions of other Australian regulators, including those in Queensland, Tasmania and the ACT. This is despite the DBs in those states being less advanced in the reform process than the Victorian GDBs. PEG (2007a) dismisses this evidence as not being relevant on the grounds that the examples cited relate to electricity distribution rather than

[2] Denis Lawrence is a member of the ABS Productivity Measurement Reference Group.

gas distribution. PEG also make this argument with regard to electricity distribution evidence from North America.

The functions of the gas and electricity distribution industries are, however, quite similar as are their cost structures. Both are capital intensive, have long–lived assets, have low marginal costs associated with additional throughput and the focus of their opex is on maintaining these assets to ensure delivery of reliable energy supplies. Furthermore, the histories of these industries in Australia in terms of the reform process has been very similar – gas has simply lagged electricity by a few years as noted earlier. Just how similar the experience of these two industries has been is highlighted in figure 2 above.

Indeed, PEG (2007a, p.43) itself recognises how similar one would expect the productivity performance of gas and electricity distribution businesses to be:

> 'A third possibility is that the long-run opex PFP trend is greater for the GDBs than the power distributors. While this is also possible, it seems a highly unlikely explanation for differences in the industry's patterns of PFP gains. There is little reason to believe that the acceleration in GDBs' opex PFP over the 2002-2006 period reflects differences in the industry's, long-run sustainable behavior.'

This is clearly inconsistent with PEG's subsequent claim that electricity distribution opex partial productivity information is of no relevance to forecasting likely GDB performance and does, in fact, support the use of electricity distribution information as well as gas distribution information in Meyrick (2007a). Given the similarities between the industries and that there have been relatively few gas distribution productivity studies and regulatory reviews undertaken compared to those for electricity distribution, it would be negligent not to draw on the available electricity distribution information.

5.1.5 North American studies

Meyrick (2007a) quoted productivity growth rates from a number of North American energy distribution productivity studies and regulatory decisions that supported the case for an opex productivity forecast of less than 1 per cent. PEG (2007a) claims that the rates quoted are not accurate and, again, attempts to dismiss the relevance of information from the more numerous electricity distribution studies. As discussed above, electricity distribution productivity studies provide an important and very relevant source of information. Consequently, Meyrick (2007a) quoted the PEG (2004) study of US electricity distribution productivity performance which shows an average annual TFP growth of 0.7 per cent and an average annual opex partial productivity growth rate of 0.8 per cent based on a sample of 75 US electricity DBs[3]. We believe this study is relevant in arriving at a forecast of Victorian

[3] A typographical error led to this study being described as being of GDBs in the text of Meyrick (2007a).

GDB opex partial productivity. Although PEG (2007a, p.47) chooses to argue against the relevance of electricity DB information in this instance, as noted above, this is contrary to the argument made on page 43 of the PEG report.

PEG (2007a, p.48) notes that Meyrick did not use the latest PEG research on US gas distribution prepared for the Ontario Energy Board in Lowry (2007a,b). These papers present information on opex partial productivities whereas the earlier PEG (2006b) material used in Meyrick (2007a) only presented TFP results. Seeing that Lowry (2007a,b) were both released after Meyrick (2007a), it is not surprising that we were not able to use this material. However, an examination of the PEG Lowry reports is very instructive.

PEG (2007a, p.48) claims that the latest Lowry report shows that the opex partial productivity trend rate of growth for US GDBs is between 2.14 and 2.23 per cent while TFP growth was between 1.28 and 1.37 per cent (depending on which capital measure was used). These results are actually for the 11 year period from 1994 to 2004 (Lowry 2007b, p.30). Within this period, however, there are two very distinct patterns of productivity growth with a break point around 1999. In the period 1994 to 1999 opex partial productivity growth grew strongly at an average annual rate of around 3.6 per cent while TFP grew at around 2 per cent. Since 1999, however, productivity growth has been much more modest. From 1999 to 2004 opex partial productivity growth grew at an average annual rate of between 0.7 and 0.8 per cent while TFP grew at between 0.5 and 0.7 per cent. This slowing down in productivity growth occurs primarily as a result of a reversal of the trend in input use from a decline to an increase and also a slow down in output growth. It is the more recent period since 1999 which is directly comparable with the time period of current GDB operation in Victoria. Including results from the last century distorts assessment of the likely opex partial productivity improvements achievable in the next GAA.

Thus, rather than contradicting the opex partial productivity forecasts in Meyrick (2007a), when examined in a comparable timeframe the latest PEG research on US GDB productivity performance actually reinforces the forecast rate of 0.8 per cent we recommended. We will present new, independent evidence in section 5.3 which corroborates this result.

5.1.6 Conclusion

On the basis of the analysis presented in this section in response to PEG (2007a), we find no case for rejecting the Meyrick (2007a) recommendation to use a 0.8 per cent opex partial productivity forecast in the rate of change formula for the following reasons:

- there is no evidence that the Victorian GDBs have 'overshot' cost reductions nor that their experience is substantially different to that of the Victorian electricity DBs;

- it is important to take account of information supplied by the GDBs themselves as one of the sources of information to form the opex productivity forecast rather than relying principally on cost 'driver' information derived from northern hemisphere businesses;
- the BIS Shrapnel forecast for EGW sector labour productivity is consistent with information in the National Accounts on the gas industry and the economy as a whole, all of which points to the need for caution in forecasting future opex productivity growth;
- information and regulatory precedents from electricity distribution is very relevant for considering gas distribution productivity growth rates given the similarities between the industries – a point recognised by PEG (2007a, p.43); and,
- when considered in an appropriate timeframe, the latest PEG productivity research on US GDBs supports the recommended opex productivity forecast of 0.8 per cent.

We next review the econometric study carried out by PEG (2007a).

5.2 Critique of the PEG (2007a) econometric models

PEG (2007a) reports results from two opex cost function estimation exercises and uses these results to obtain econometric parameter values for the various elasticities that appear in the opex partial productivity 'decomposition' formula reported as equation (11) in Meyrick (2007a). PEG then combines these parameters with forecast changes in key variables for the Victorian GDBs to derive opex productivity forecasts which it argues are 'best' estimates prepared on a 'reasonable basis'. However, in this section, we will indicate that there are some very significant problems with these two regression models and PEG's application of the results.

5.2.1 Methodology

PEG (2007a, p.53) acknowledges that 'the use of decomposition techniques is a novel method for generating PFP projections' but goes on to argue that 'there is ample precedent and support for the general approach in Victoria'. PEG quote their earlier electricity DB study (PEG 2004b) in support of the latter statement and also imply support for the general rate of change approach equates to support for their methodology. However, it is not correct to assume that support for the rate of change approach translates to support for the calculation of productivity forecasts using econometric estimation. There are a number of reasons why index number methods are to be preferred for estimating productivity. These include:

- cost function results are dependent on functional form assumptions whereas (superlative) index number methods are basically nonparametric and, hence, more robust;

- the more output and input data are disaggregated, the less feasible it is to implement the cost function methodology whereas this is not a restriction on the use of index numbers; and,
- seemingly minor differences in the stochastic specification of the errors in the cost function method can lead to substantial differences in the results.

It should also be noted that the decomposition application in PEG (2004b) was a minor part of the report and the report has not been used as the basis for any regulatory decisions.

PEG (2007a) uses the now relatively old translog functional form. Guilkey, et al (1983) is quoted as evidence that the translog is 'the most reliable of several alternatives' (PEG 2007a, p.75). However, this ignores the significant developments that have occurred in the development of functional forms over the last 25 years. A particular problem has emerged with the use of the translog function in joint cost function and inputs requirement function estimation. In order to successfully model technologies in a panel data context (as used by PEG 2007a), the functional form generally has to allow for the possibility of firm specific first order parameters along with common second order parameters for the function being estimated. This requirement creates problems when using the translog functional form because, when the second order parameters are dropped from this functional form, the function collapses to a Cobb–Douglas functional form which is a suitable functional form only in very restrictive contexts; namely, situations where there are many inputs but only one output. Experience has shown that the estimated second order parameters in panel data set applications of the translog function are often small in magnitude and so the translog does not provide a good approximation to joint cost functions where there is more than one output. The second order parameters in both the PEG (2007a) models are generally small and so this will be a problem. This issue is explained in more detail in appendix A in the context of the input requirements function – the analysis also applies to joint cost function applications.

5.2.2 Databases used

The first PEG (2007a) opex cost model is based on data for US GDBs while the second model is based mainly on data from the Meyrick (2007d) Australia and New Zealand (ANZ) GDB database. PEG's choice of these two databases appears to be at odds with statements PEG make elsewhere about the relevance of US data for Australia and the efficacy of the ANZ database.

PEG (2007a, p.49) presents a lengthy discussion of how the conditions facing US GDBs are different to those in Victoria. A major difference advanced by PEG is the declining average consumption per household in the US. PEG notes that it believes that 'North American and Victorian GDBs are not likely to be at comparable stages of maturity'. PEG (2001a) argued

that a diversity of operating conditions would actually help improve the accuracy of econometric parameter estimates and so using US data to predict costs would be better than using data from a more homogenous sample. However, this argument places inadequate weight on the underlying differences in operating conditions between countries and means that using parameter estimates derived from a sample of northern hemisphere companies to forecast for a completely different country 'out of sample' is unlikely to produce good estimates.

Meyrick (2004, p.3) has previously drawn attention to this problem in the context of regulatory proceedings in New Zealand and the same applies to US/Australian comparisons:

> 'equally or more important [than scale differences] is the fact that the key operating environment differences between the US and NZ are not included. These are climatic differences, the presence of perma–frost in much of the US, differences in industrial usage, population density and lifestyle influences to name but a few. The main lifestyle difference is the North American practice of keeping homes heated to summer temperature levels in the winter compared to Australasian practice of heating homes more moderately. …
>
> In practice, econometric models have proven relatively unsuccessful at distinguishing the effects of these key operating environment differences due to statistical difficulties (lack of variation in key variables, multicollinearity, etc). While these factors will be of low importance when comparing NZ and Australia which have relatively similar operating environments, they will be of critical importance in comparing NZ and the US distributors.'

PEG (2007b) criticises the Meyrick (2007d,e) ANZ database at some length. PEG argues that the database's necessary reliance on regulators' allowed costs rather than actual observed costs for many of the included observations render it unsuitable as incentive regulation will lead to GDBs achieving lower ex–post actual costs than regulators' ex–ante allowed costs. PEG (2007b) thus rejects the ANZ database as being suitable for benchmarking applications. PEG (2007a, p.63), however, claims that the database is suitable for use in establishing opex cost and partial productivity 'drivers'. These arguments are not logically consistent as, if the PEG (2007b) contention regarding costs being overestimated in the database is true, then the underlying relationship between key variables derived from the database would also be inaccurate.

5.2.3 Model specification

The PEG (2007a, p.56) econometric models include two variables as outputs:

> 'As noted above, economic theory suggests that quantities of work performed by utilities should be included in our cost model as business condition variables. There are two output quantity variables in our model: the number of retail customers and total throughput.'

The important output variable of system capacity or length of the pipeline grid in standard efficiency units is missing from this list of outputs. Meyrick (2007b) explains how the provision of system capacity is one of the key functions of a GDB. Failure to include this dimension of output can significantly bias the results. If changes in system capacity follow a different pattern to changes in throughput and customer numbers then the model will not accurately reflect cost 'drivers'. If there is a high correlation between system capacity and one of these variables in the US then the estimated parameters will be biased and their use to forecast costs for another country where the same correlation may not apply will be inappropriate. This omission alone, thus, means that any econometric results obtained from this model will be biased.

PEG (2007a, pp.56–57) makes the following observation:

> 'Cost theory also suggests that the prices paid for production inputs are relevant business condition variables. In this model, we have specified input price variables for capital, labor and other O&M inputs. We expect cost to be higher as the values of these price variables increase.'

The problem here is that input prices for capital should not be included as an explanatory price in the opex cost function regression since the quantity of capital services used by the GDB is used as an exogenous variable and the value of capital services should be excluded from opex cost. Fortunately, this description of the model appears to be at odds with what was actually estimated and the capital price was not included in the regressions.

PEG (2007a) assumes that the prices for non–labour opex inputs are the same in a given year for all companies and are measured by growth in the GDP–PI. Thus, the national GDP producer price index is taken to be a proxy for non–labour opex prices. This is not a good approximation to trends in materials and business services prices for GDBs since the aggregate producer price index is an index of the prices of all outputs produced by the economy and it is not particularly relevant for the materials and service prices that a GDB faces. By contrast, Meyrick (2007c) used the intermediate input price index for utilities which will more closely reflects prices faced by GDBs.

The opex cost function model used by PEG (2007a) has the following main explanatory variables: two outputs (number of customers and volume of throughput), two input price variables (the price of labour and the price of non–labour opex inputs), the quantity of capital

used by the GDB and a time trend which should capture at least some elements of technical progress for the GDB. PEG also includes the following 4 'business condition' variables which are used as additional explanatory variables in the opex cost function regression models:

- the percentage of throughput deliveries to commercial and residential customers which is expected to have a positive coefficient;
- the percentage of distribution main not made of cast iron or bare steel which is expected to have a negative coefficient;
- the number of electric customers which is expected to have a negative coefficient; and,
- total miles of distribution main which is expected to have a positive coefficient.

5.2.4 US model results

PEG (2007a, pp.60–61) reports the results of the opex cost function regression for US GDBs. The estimated business condition coefficients satisfy PEG's a priori sign expectations and the estimated time trend coefficient is –0.015, which corresponds to a rate of technical progress for US GDBs of 1.5 per cent. However, the main problem with the results (and it is a major problem) is that the estimated coefficient that corresponds to the capital quantity variable, KQ, is 0.057 which is positive instead of being negative. Thus, taken at face value, if a gas distributor increases its capital input, holding constant input prices, outputs and operating cost environmental variables, then opex cost will increase instead of decrease, which is contrary to economic theory[4]. This incorrect sign in the PEG results is a major violation of the monotonicity conditions implied by economic theory and casts major doubt on the validity of the results. PEG (2007a, p.25) earlier noted the role of the opex/capital interaction term as follows:

> 'All else equal, capital–labor substitution will reduce the amount of labor employed and boost opex PFP. This input substitution is reflected in the capital interaction term in the PFP decomposition equation …'

But what the PEG US GDB opex cost function regression says is that if capital is increased, all else equal, opex costs will also increase.

The problem with the PEG econometric model is likely to be one of multicollinearity[5]. The included variables KQ (capital quantity) and M (mains length 'business condition') are bound to be somewhat collinear with each other and with the omitted system capacity output

[4] The only explanation for a positive partial derivative of opex cost with respect to an increase in capital input would be if additional capital inputs caused congestion so that production would *fall* (instead of increase) as capital inputs increased. Congestion costs are extremely unlikely in this context.
[5] A high degree of correlation between included (and excluded) explanatory variables reducing the precision of the model.

variable. Hence, the econometric estimates obtained for these parameters are unlikely to be estimated with any degree of precision. The solution to this multicollinearity problem would be to move away from estimating an opex cost function and instead estimate a total cost function, preferably including all output dimensions, but not using the translog functional form which has further problems in this context as identified above.

In its information request to PEG of 4 September 2007 Meyrick asked PEG if it had tested for the required theoretical monotonicity and concavity conditions. In its reply of 18 September 2007, PEG indicated that the monotonicity and concavity conditions were satisfied for all observations. However, having a negative sign on the capital quantity coefficient is also an important required monotonicity regularity condition and it is not satisfied in this model.

Apart from this major issue, there are also a number of issues with PEG's application of the model. The US elasticity estimates were applied to forecast output and business condition variables for the Victorian GDBs. As noted above, it is unlikely that the US elasticity estimates are a useful proxy for the underlying cost drivers for the Victorian GDBs given the differences in a wide range of key operating environment conditions. This could in fact be tested empirically by running a regression that combines the US and Victorian data and then testing for equality of coefficients for the two groups of firms. In any case, in equation (8) of PEG (2007a, p.62), the (wrong sign) estimated coefficient for capital input in opex cost, 0.057, is used to escalate the growth in capital input of the Victorian GDBs, which is entirely inappropriate. As will be discussed further below, the variables used by PEG to forecast Victorian capital quantities also appear to be seriously flawed, making this application of the model even less appropriate.

Given these major problems with the estimation and application of the PEG (2007a) US opex cost function model, the resulting forecast of opex partial productivity growth of 2.53 per cent cannot be considered to be a 'best' estimate arrived at 'on a reasonable basis' as required by the Gas Code.

5.2.5 ANZ model results

PEG (2007a, p.67) reports the results of the ANZ opex cost function regression. In this case, the problems with the model are again major. The same problem that emerged from the US regression estimates is present with the estimated parameter coefficient for the quantity of capital services, KQ, being 0.693 (with a highly significant t statistic of 16.6) which again is the wrong sign for this parameter. Thus, taken at face value, if a gas distributor increases its capital input by 1 per cent, holding constant input prices, outputs and operating cost environmental variables, then opex cost will increase by approximately 0.7 per cent instead

of decreasing as expected. This model also appears to be plagued by multicollinearity and does not satisfy required regularity conditions.

A further problem with the ANZ model is that the trend coefficient for the regression was –0.060, which implies that the average rate of technical progress for Australian and New Zealand GDBs over the sample period was about 6 per cent per year, which is quite different from the 1.5 per cent rate obtained for US GDBs. PEG (2007a) recognises the implausibility of this parameter for forecast purposes and also the problem with the capital coefficient.

PEG (2007a, p.69) proceeds to 'mix and match' the corresponding time trend and capital quantity parameters from the US model with the remaining parameters from the ANZ model. There is no rigorous basis for such mixing and matching of parameters from two totally separate models. It runs counter to the tenets of good modelling practice and simply makes the resulting forecasts internally inconsistent and lacking in any coherent quantitative basis. And the major problem with the US estimates, namely the positive coefficient on the capital quantity, is retained. In the Meyrick information request to PEG dated 4 September 2007 we asked PEG to explain why it thought such mixing and matching of parameter estimates was consistent with good modelling practice and whether PEG could provide any examples of where such a 'hybrid' approach has been used in other regulatory proceedings. PEG did not provide an answer to this question. While indeed being 'novel', the solution put forward for this problem is, unfortunately, unsatisfactory.

Given these major problems with the estimation and application of the PEG (2007a) ANZ opex cost function model, the resulting forecast of opex partial productivity growth of 2.97 per cent cannot be considered to be a 'best' estimate arrived at 'on a reasonable basis' as required by the Gas Code.

5.2.6 Forecast variables used

As well as having a major problem with the sign of the capital quantity coefficient in both their opex cost function models, there is also a major problem with the forecast values PEG (2007a) uses for the Victorian GDB capital quantities. These are shown as decreasing by 2.18 per cent and 0.87 per cent annually for Multinet and SP AusNet, respectively, and increasing by only 0.56 per cent for Envestra. These are reported to be the inflation adjusted depreciated asset values (although a spreadsheet provided in response to the Meyrick information request labelled the series used as 'value of capital').

Meyrick (2005a,b) has discussed at length likely biases introduced to productivity measures and econometric studies of energy network firms where the constant price depreciated asset value is used as a proxy for capital quantity. This is because the nature of the major assets in electricity and gas distribution are such that they exhibit a physical depreciation profile more

akin to that of the 'one hoss hay' model than that of the declining balance or straight–line depreciation profiles implicitly being used when the constant price asset value is used as a proxy. That is, provided the assets are properly maintained, they will continue to provide the same physical carrying capacity year in, year out until they are replaced. In these circumstances the best proxy of the capital input quantity will be a physical measure of the asset capacity. Where the constant price depreciated asset value approach is used it will tend to underestimate the change in capital quantity over time and hence overestimate productivity growth.

Meyrick (2007b) formed a measure of capital input quantity using disaggregated data for 7 capital components. Six of these components used physical measures of the relevant asset and the seventh, the small residual other capital component, used a depreciated asset value proxy. These disaggregated capital quantities measures were then aggregated into a total capital input quantity using depreciated asset value shares as weights in the indexing procedure. This measure will thus provide a more accurate proxy for capital input quantity. PEG (2007a, p.40) acknowledges that the Meyrick (2007b) productivity estimates are 'defensible and generally accurate'. The annual changes in this variable forecast over the next GAA were increases of 2.59 per cent for SP AusNet, 1.60 per cent for Envestra and 1.24 per cent for Multinet. These changes are very different to the forecast values used by PEG (2007a). Using the corresponding constant price asset value series from Meyrick (2007b) to that described as being used by PEG (2007a), the forecast annual changes are increases of 2.26 per cent for SP AusNet, 0.87 per cent for Envestra and 0.54 per cent for Multinet. These are, again, quite different to the forecast capital quantity changes used by PEG (2007a). The use of negative forecasts by PEG (2007a) for SP AusNet and Multinet are, thus, at odds with available evidence on GDB capital inputs and this further compounds the problem caused by the incorrect sign on the PEG opex cost function capital quantity coefficient as it contributes to an overstatement of PEG (2007a) forecast opex productivity growth for these GDBs.

5.2.7 Incentive issues

A fundamental principle of incentive regulation is that productivity targets should be set using industry average performance rather than firm–specific performance wherever possible and provided there is not a large disparity in operating environments within the industry. This way firms cannot directly influence the target set and their actions will not have a close link to future targets that will be set. Instead, firms have an incentive to outperform the industry average. PEG (2007a) recommends using forecasts specifically tailored for each of the three Victorian GDBs to their individual forecast output and business conditions. Given that the three Victorian GDBs all operate in the Melbourne metropolitan area and all face broadly similar operating environment conditions and histories – indeed they were formerly all part of

the one organisation – there does not appear to be any case for tailoring the forecasts in this way. Any benefits would be small compared to likely forecast errors and the costs are that potentially perverse incentives are created for the GDBs to alter their current behaviour to influence the future targets that would be set using the same approach in future GAARs.

5.2.8 Conclusions

This review of the PEG (2007a) econometric opex partial productivity forecast recommendations finds that the recommendations are not likely to be 'best' estimates arrived at 'on a reasonable basis' as required by the Gas Code for the following reasons:

- the estimated capital quantity coefficients are of the wrong sign implying that additional capital inputs are 'anti–productive' instead of being productive in the sense that opex costs will *increase* as more capital is added, holding constant outputs and variable input prices, which is counter to required regularity conditions and reasonable expectations;
- parameter estimates are 'mixed and matched' between disparate models which means there is no coherent quantitative basis for the resulting forecasts;
- forecast capital quantities used for the Victorian GDBs appear to be inaccurate;
- econometric cost function estimation results will be sensitive to the functional form and stochastic specification chosen;
- the translog functional form used is not well suited to the inclusion of multiple outputs;
- the cost driver relationships estimated using a northern hemisphere database cannot be assumed to apply to Australian operating environment conditions, particularly given that the Australian observations are not included in the estimation process;
- the use of the Meyrick (2007d,e) Australia/New Zealand database is inconsistent with the criticisms made of this database in PEG (2007b);
- no system capacity output is included in the regressions which will almost surely bias the results;
- the non–labour opex price index used is unlikely to reflect prices GDBs face for these inputs; and,
- using GDB–specific partial productivity forecasts is contrary to the principles of incentive regulation.

5.3 US opex partial productivity performance

In section 5.1 we indicated that examination of the latest PEG US GDB productivity research contained in Lowry (2007a,b) reveals that average annual growth of opex partial productivity has been between 0.7 and 0.8 per cent since 1999. This study used a sample of 36 US GDBs. Meyrick (2007c) constructed a database of around 70 US GDBs based on the Platts (2007) Energy Advantage subscription data set although, at the time, there was insufficient

information available to separate the cost of gas purchases from other opex costs. PEG (2007b) indicated that the cost of gas purchases data are available from an alternative Platts product and this has now been accessed by Meyrick. A new US database has now been constructed based on this expanded and updated information and is used here to form partial productivity indexes for the US sample.

Platts is a division of the McGraw–Hill group of companies which specialises in supplying energy industry data and associated services. The Platts data on individual gas businesses are assembled form a range of official sources including Federal Energy Regulatory Commission (FERC) Form 2 filings, Energy Information Administration (EIA) form 176 filings and Annual Reports to the individual state Public Utility Commissions.

There are a large number of firms in the US involved in the gas supply industry with a wide range of functional coverage. Some firms specialise in interstate transmission of gas while others provide a range of vertically integrated services from gas production through to end delivery to consumers. The original database contained around 1,250 firms identified as gas utilities involved in gas deliveries to customers but most were excluded at the first stage of data review because they were not involved in gas distribution or, if they were involved in gas distribution, they had less than 10,000 customers. This left a sample of just over 200 utilities for each of the 10 years. Following PEG (2004a, p.16) we then undertook a second stage of data review where additional firms were excluded because data were incomplete or did not appear to be plausible. This process led to a sample size of just over 50 GDBs and 415 observations. Data covered the period 1998 to 2005 but the panel was not balanced in that the number of included GDBs reduced from 2001 onwards. To check that the reduction in the number of included firms in the latter years did not bias the results we also formed a balanced panel subset of the data that included 18 GDBs with data continuously available from 1998 to 2004. The balanced panel thus included 162 observations.

A total output index is formed using two outputs: throughput measured in millions of cubic feet and customer numbers. The Platts Energy Advantage database does not contain data on pipeline length or type so, unfortunately, no system capacity output can be included. The weights used to aggregate the two outputs are 25 per cent on throughput and 75 per cent on customer numbers derived from the cost function estimation reported in Meyrick (2007b).

The opex cost used in the analysis includes distribution activities only and excludes all distribution capital costs and all retail related costs. It includes all directly employed labour costs, contracted services and materials and consumables costs associated with operating and maintaining the distribution network. The US data excludes administrative and general costs, and customer service costs including the costs of meter reading.

The opex price index for US GDBs is a weighted average of labour costs and the costs of purchased intermediate input services for utilities. The weights were 35 per cent for labour costs and 65 per cent for intermediate inputs. The weights were based on average weights for the period 1998–2005 for inputs used by utilities from the US Bureau of Economic Analysis KLEMS database (BEA 2007a, b). The labour cost data series was based on total compensation for all employees in the electricity, gas and sanitary services sector (Bureau of Labor Statistics 2002, 2004, 2006). The price index for other operating expenditure was based on the price index for utilities' purchased services from the KLEMS database (BEA 2007b).

The opex partial productivity index is formed by dividing the output index by the constant price opex series. The opex partial productivity average annual growth rate for the larger unbalanced panel database for the period 1998 to 2005 was 0.68 per cent while the corresponding growth rate for the smaller balanced panel database for the period 1998 to 2004 was 0.24 per cent. These growth rates are close to the growth rates obtained by Lowry (2007a,b) over a similar period. This result, thus, provides further evidence that the opex partial productivity average annual growth rate achieved by US GDBs in recent years has been less than 1 per cent.

5.4 Assessment against evaluation criteria

In section 5.1 we assessed the PEG (2007a) criticisms of the Meyrick (2007a) opex partial productivity recommendation and the claim that the Meyrick forecast of 0.8 per cent did not represent a best estimate arrived at on a reasonable basis as required by the Gas Code. The analysis rejected the PEG claims as there is no evidence that the Victorian GDBs have 'overshot' cost reductions nor that their experience is substantially different to that of the Victorian electricity DBs. It was also noted that it is important to take account of information supplied by the GDBs themselves as *one* of the sources of information used to form the opex productivity forecast rather than relying principally on cost 'driver' information derived from northern hemisphere businesses. The BIS Shrapnel forecast for EGW sector labour productivity was found to be consistent with information in the National Accounts on the gas industry and the economy as a whole, all of which points to the need for caution in forecasting future opex productivity growth. Information and regulatory precedents from electricity distribution were found to be very relevant for considering gas distribution productivity growth rates given the similarities between the industries – a point recognised by PEG (2007a, p.43). And, when considered in an appropriate timeframe, the latest PEG productivity research on US GDBs contained in Lowry (2007a,b) supports the recommended opex productivity forecast of 0.8 per cent.

In section 5.2 we assessed the PEG (2007a) econometric models and found that they contain a number of major weaknesses relating to key parameter estimates, methodology and data used. We now assess the PEG (2007a) opex productivity recommendation against PEG's own evaluation criteria and also the Meyrick criteria outlined in section 2.2. We focus specifically on those criteria we believe the PEG (2007a) opex productivity recommendations do not satisfy. With regard to identifying best estimates, we believe the PEG productivity recommendations do not satisfy the following criteria:

- accuracy of the data employed

The PEG (2007a) study does not employ plausible data with regard to forecasts of the Victorian GDBs' capital quantities. The PEG data show marked decreases in forecast capital quantity for two of the three GDBs whereas all measures of forecast capital quantities in the Meyrick (2007b) TFP study show capital quantity increases going forward. PEG (2007a, p.40) has endorsed the Meyrick (2007b) TFP study as 'defensible and generally accurate'.

- data sources reflect relevant business conditions that affect GDBs

Although PEG (2007a) includes 5 business condition variables, the underlying cost driver relationships are estimated solely for US GDBs (in one case and partly in the other case) and there is no guarantee these relationships will apply to Victorian conditions. In fact, the excluded climatic and lifestyle operating environment differences mean that using the US results to forecast 'out of sample' will not be appropriate. PEG (2007a) also argues that the US and Victorian GDBs cannot be compared because they are at different stages of maturity. Using US parameters to forecast Victorian productivity growth would, therefore, be inappropriate.

- the use of rigorous empirical techniques

Cost function estimation is sensitive to the functional form used and stochastic specification adopted. In addition, the translog functional form is not well suited to estimating a joint cost function on panel data. A key monotonicity requirement is not satisfied by the estimated models. Thus, while the approach adopted has grounding in economic theory, it does not provide rigorous empirical estimates in this application.

- robustness

Again, cost function estimation is sensitive to the functional form used and stochastic specification adopted. In addition, the translog functional form is not well suited to estimating a joint cost function on panel data and a key monotonicity requirement is not satisfied. The empirical estimates are not robust.

- historical consistency

There is inadequate information to assess the PEG (2007a) models against this criterion.

- no "cherry picking" of available data

The PEG (2007a) practice of 'mixing and matching' coefficients between the estimated US and ANZ models represents a form of 'cherry picking' that leads to estimates that have no coherent quantitative basis.

- internal consistency and no "double counting" of changes

PEG (2007a,b) contain a number of internal inconsistencies regarding arguments surrounding the appropriateness of different comparisons and databases. PEG (2007a) cautions against comparing the US and Australian GDBs because of underlying differences in stages of maturity but goes on to apply relationships estimated using US data to the Victorian GDBs. PEG (2007b) criticises the Meyrick ANZ database for using regulator allowed costs for those observations where no records of actual costs are publicly available but PEG (2007a) uses the database to calculate forecast productivity trends. If, as PEG (2007b) argues, actual costs will be less than regulator allowed costs then use of the database to calculate productivity trends would be inappropriate.

- reflects long–run behaviour

There is inadequate information to assess the PEG (2007a) models against this criterion.

Of the 8 PEG (2007a) criteria for assessing 'best' estimates, the PEG (2007a) opex productivity forecasts do not meet 6 of these criteria and there is inadequate information to asses them against the remaining two criteria. We conclude, therefore, that the PEG opex productivity recommendations cannot be considered 'best' estimates as required by the Gas Code.

With regard to assessing whether estimates have been arrived at on a reasonable basis, we believe the PEG (2007a) productivity recommendations do not satisfy the following criteria:

- consistent with economic theory

A key monotonicity regularity condition is not satisfied in either PEG opex cost function model due to the sign of the capital quantity coefficients being positive instead of negative. There is also no justifiable basis for 'mixing and matching' parameter estimates from two disparate models which leads to the resulting forecasts having no coherent basis. The results cannot, therefore, be considered to be consistent with economic theory.

- weighting of alternative forecasts;

PEG (2007a) provides no justification for its decision to equally weight its US and 'adjusted' ANZ forecasts. The weighting therefore appears to be arbitrary. Meyrick asked PEG to explain this basis in its information request to PEG of 4 September 2007. PEG's response of 18 September 2007 did not answer this question. Given the problems with both models outlined above, relying on these two results to the exclusion of other available information appears inappropriate.

- regulatory precedent

We are not aware of regulatory (or other) precedents that have relied on 'hybrid' model results where parameters from two disparate models are 'mixed and matched'. Meyrick asked PEG to provide examples of regulatory precedents in its information request to PEG of 4 September 2007. PEG's response of 18 September 2007 did not answer this question. There do not appear to be any regulatory precedents.

The PEG (2007a) opex productivity forecasts do not meet 3 key criteria that PEG (2007a) put forward for estimates to be arrived at on 'a reasonable basis'. We conclude, therefore, that the PEG opex productivity recommendations cannot be considered estimates that have been arrived at on 'a reasonable basis' as required by the Gas Code.

We turn now to the Meyrick criteria for assessing quantitative studies used in regulatory proceedings outlined in section 2.2. There is overlap between some of these criteria and the PEG (2007a) criteria discussed above so discussion is not repeated at length in the following. We believe the PEG (2007a) productivity recommendations do not satisfy the following criteria:

- the data used must be accurate, consistent and comparable

As noted above, the capital quantity forecasts used for the Victorian GDBs do not appear accurate. And the comparability of the US and Victorian GDBs is uncertain.

- efficiency comparisons and conclusions must be made using a model that is explicit, clearly specified, robust and, most importantly, replicable

As noted above, the methodology used is not likely to be robust due to the sensitivity of estimates to the functional form and stochastic specification used. In this instance, the fact that neither model satisfies a key monotonicity regularity condition means the estimates are not robust. Furthermore, the 'mixing and matching' of parameter estimates from two disparate models means that the resulting forecasts do not have a coherent quantitative basis.

- the model needs to be holistic with all major outputs and inputs included

The fact that one of the major distribution outputs – provision of system capacity – is not included is likely to bias the results.

- all outputs and inputs must be adequately specified

The capital quantity variable used is the deflated depreciated asset value which is not reflective of the annual capital input from the key network assets. The change in the capital input quantity will be underestimated using this approach because a distribution pipeline installed a decade or two ago will, in reality, be providing the same annual quantity of input as one installed today. The US database also appears to use historic cost based asset values rather than current cost estimates which will further distance them from the annual capital input quantity. The use of the GDP–PI for the non–labour opex price in the US model will also not be a good proxy for the non–labour opex price faced by US GDBs.

- differences in the operating environment must be adequately and explicitly allowed for

As noted above, while the models contain several business condition variables, the underlying cost driver relationships are estimated solely for US GDBs (in one case and partly in the other case) and there is no guarantee these relationships will apply to Victorian conditions.

- the sample of utilities included needs to include a number of utilities similar to the ones being reviewed

The US model is only estimated for US GDBs. It does not include any of the Victorian GDBs. Given the wide range of differences in operating environments between the US and Victorian GDBs, it will be inappropriate to use the US based parameters to forecast 'out of sample' results for the Victorian GDBs.

- stakeholders must be adequately consulted to ensure the data used are accurate and modelling results are realistic

There has been no consultation with the Victorian GDBs prior to the release of PEG (2007a).

- given the asymmetric risks involved with placing unrealistic constraints on infrastructure providers which may lead to failure or suspension of the service, model construction and recommendations based on modelling results need to be conservative

The recommendations from the PEG (2007a) models lead to considerably higher opex partial productivity forecasts than those obtained in recent years by US GDBs which might be taken as representative of productivity growth rates obtained by best practice distribution businesses. They are also considerably higher than corresponding electricity distribution opex productivity results, including those used both explicitly and implicitly in recent Victorian and other Australian regulatory decisions. In addition, they are considerably higher than relevant evidence available from the National Accounts. The recommendations cannot, therefore, be considered to be conservative.

The PEG (2007a) opex productivity forecasts do not meet 8 of the 9 criteria set out in section 2.2 above that Meyrick has previously used to assess quantitative studies used by regulators. We conclude, therefore, that it would not be appropriate for the ESC to use the PEG (2007a) opex partial productivity recommendations in setting the rate of change formula for the GAAR.

6 OUTPUT INDEX GROWTH

Meyrick (2007a) used the gas distribution total output index presented in Meyrick (2007b) as its preferred output index for inclusion in the opex rate of change formula. This is a chained Fisher index of three output components – throughput, customer numbers and system capacity – using the GDBs' forecasts for the period 2008 to 2012. The system capacity measure used is the volume of gas held within the 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 weights used to form the overall index are derived from the cost function reported in Meyrick and Associates (2007b). The weights are based on output cost shares for throughput of 13 per cent, for customer numbers of 49 per cent and for system capacity of 38 per cent.

PEG (2007a, p.23) viewed the Meyrick output index as 'a best estimate determined on a reasonable basis for the output quantity trend'. However, PEG (2007a) went on to recommend a different output index based only on throughput and customer number forecasts using the ESC's then current forecasts for these variables. PEG argued that this would be more consistent with other data used by the ESC in the GAAR and also with the data used in PEG's opex partial productivity forecasts.

In practice, the Meyrick (2007a,b) output growth forecasts and those preferred by PEG (2007a) are relatively close with the PEG average annual growth forecasts being 0.30 per cent and 0.26 per cent higher than the corresponding Meyrick forecasts for SP AusNet and Multinet, respectively. The PEG average annual growth forecast for Envestra is 0.18 per cent lower than the corresponding Meyrick forecast.

The PEG (2007a) preferred output growth forecast is based on a less complete specification than the Meyrick (2007a) specification as the former does not include the important system capacity output whereas the latter does. The ESC's throughput and customer number forecasts are yet to be tested in the review process by the GDBs and so their current status is uncertain. In the preceding section we demonstrated that the PEG (2007a) opex productivity forecasts do not represent best estimates arrived at on a reasonable basis so the need to retain

consistency with the PEG opex productivity forecasts is not relevant. Rather, the output growth forecasts included in Meyrick (2007a) are consistent with the opex partial productivity forecasts presented in Meyrick (2007b). Since these opex partial productivity forecasts are one of the four pieces of evidence used to support the Meyrick (2007a) opex partial productivity forecast – and we have demonstrated in section 5.1 that the PEG (2007a) criticisms of this forecast are not valid – it is more important to use the same output forecast as that derived from Meyrick (2007b) to maintain consistency. Consequently, we believe the best estimates arrived at on a reasonable basis are the output forecasts presented in Meyrick (2007a,b).

7 CONSUMER PRICE INDEX

Meyrick (2007a) recommended using a CPI growth rate of 2.83 per cent in the rate of change formula. This was the inflation rate predicted by BIS Shrapnel (2007) for the years 2008 to 2012 and was used to be consistent with the forecast labour price growth used which was based on the BIS forecasts. PEG (2007a) recommended using an inflation rate forecast of 3 per cent as this was what the ESC was using in its draft determination.

The ESC inflation rate forecast is at the high end of the forecast spectrum. In particular, it is considerably higher than the 2.4 per cent inflation rate forecast used by Access Economics (2007, p.22)). PEG (2007a) prefers the labour price growth rate advanced by Access Economics (2007) which, at 4.48 per cent, is considerably lower than the nominal labour price growth of 5.7 per cent forecast by BIS Shrapnel (2007). The use of a labour price forecast at the low end of the spectrum and an inflation rate forecast at the high end of the spectrum by PEG (2007a) is likely to lead to a significant understatement of real labour price pressures facing the GDBs.

In section 3 of this report we demonstrated that the recent labour price forecasts prepared by Econtech (2007) for the AER in the review of SP AusNet's electricity transmission business perform best against the evaluation criteria advanced by PEG (2007a) for best estimates prepared on a reasonable basis. We also demonstrated how the Access Economics forecasts did not perform well on these criteria. The Econtech forecasts were somewhat higher than the BIS Shrapnel forecasts, vindicating the Meyrick (2007a) decision to rely on the BIS Shrapnel forecasts. Since the Econtech (2007) labour price forecasts perform best on nearly all of the PEG criteria, we are now using the Econtech forecasts (which have been released since both Meyrick (2007a) and PEG (2007a) were prepared) for labour price growth. To be consistent we should, therefore, also use the Econtech (2007) CPI forecast for the same period. Econtech (2007, p.20) is forecasting CPI growth of 2.53 per cent for the calendar years 2008 to 2012. We, therefore, believe that the Econtech inflation forecasts are the best forecasts to

use in this context. We have already demonstrated that the Econtech report has been prepared on a reasonable basis.

Econtech (2007, p.24) notes the following with regard to expected inflation:

> 'The strong outlook in wages is expected to exert some upward inflationary pressures. However, the AUD is expected to stay above 80 US cents, reducing inflationary pressures in the short term.

The Australian dollar is currently sitting at 90 US cents.

If the ESC wished to use a different inflation rate in the rate of change formula then it would be necessary to make a corresponding adjustment to the Econtech labour price growth forecast to maintain internal consistency. This is because the Econtech nominal labour price forecast is based on a model that produces an inflation forecast of 2.53 per cent. Using an inflation rate different to this without making a corresponding adjustment to the nominal labour price growth rate used would constitute a form of 'cherry picking'.

8 CONCLUSIONS

In this report we have reviewed the PEG (2007a) response to Meyrick (2007a) where we recommended an appropriate rate of change formula for use in the GAAR and the appropriate growth rates to use in the formula. While PEG (2007a) agreed with the formula we recommended, they claimed that the growth rates we had recommended for use in the formula were not 'best' estimates arrived at 'on a reasonable basis' as required by the Gas Code. PEG instead proposed alternative growth rates based, in part, on its own work. In this report we have demonstrated that the PEG criticisms of the Meyrick estimates are not valid and the alternative estimates proposed by PEG do not pass most of the evaluation criteria PEG proposed. In particular, we have shown that the alternative opex partial productivity growth forecasts proposed by PEG have a number of major flaws and are not suitable for use in regulatory decisions.

The Meyrick (2007a) and PEG (2007a) growth rate recommendations for use in the rate of change formula are listed in table 4 along with the revised rates recommended in this report.

On the basis of new information that has been released and endorsed by the AER since both the Meyrick (2007a) and PEG (2007a) reports were released, we have revised our recommended opex price growth forecast. The Econtech (2007) report recently released by the AER and addressing conditions in Victoria specifically performs best on nearly all the evaluation criteria proposed by PEG. It indicates that the BIS Shrapnel (2007) labour price forecasts used in Meyrick (2007a) were somewhat conservative. It vindicates our earlier decision to not place any weight on the Access Economics (2006) forecasts. In light of this

Table 4: **Opex rate of change recommendations**

	Meyrick (2007a)	PEG (2007a)	**This report**
Industry opex rate of change calculation			
Labour price growth [A]	5.70%	4.48%	6.54%
Labour share [B]	0.62	0.62	0.62
Non–labour opex price growth [C]	2.60%	2.60%	2.67%
Opex price growth [D] = [B*A + (1 – B)*C]	4.52%	3.77%	5.07%
Opex partial productivity growth [E]	0.80%	2.75%	0.80%
Output growth [F]	1.77%	1.93%	1.77%
CPI [G]	2.83%	3.00%	2.58%
Rate of Change [H] = [D – E + F – G]	2.66%	–0.05%	3.46%
Envestra opex rate of change calculation			
Labour price growth [A]	5.70%	4.48%	6.54%
Labour share [B]	0.62	0.62	0.62
Non–labour opex price growth [C]	2.60%	2.60%	2.67%
Opex price growth [D] = [B*A + (1 – B)*C]	4.52%	3.77%	5.07%
Opex partial productivity growth [E]	0.80%	2.45%	0.80%
Output growth [F]	2.44%	2.26%	2.44%
CPI [G]	2.83%	3.00%	2.58%
Rate of Change [H] = [D – E + F – G]	3.33%	0.58%	4.13%
Multinet opex rate of change calculation			
Labour price growth [A]	5.70%	4.48%	6.54%
Labour share [B]	0.62	0.62	0.62
Non–labour opex price growth [C]	2.60%	2.60%	2.67%
Opex price growth [D] = [B*A + (1 – B)*C]	4.52%	3.77%	5.07%
Opex partial productivity growth [E]	0.80%	2.78%	0.80%
Output growth [F]	0.83%	1.09%	0.83%
CPI [G]	2.83%	3.00%	2.58%
Rate of Change [H] = [D – E + F – G]	1.72%	–0.92%	2.52%
SP AusNet opex rate of change calculation			
Labour price growth [A]	5.70%	4.48%	6.54%
Labour share [B]	0.62	0.62	0.62
Non–labour opex price growth [C]	2.60%	2.60%	2.67%
Opex price growth [D] = [B*A + (1 – B)*C]	4.52%	3.77%	5.07%
Opex partial productivity growth [E]	0.80%	3.05%	0.80%
Output growth [F]	2.12%	2.42%	2.12%
CPI [G]	2.83%	3.00%	2.58%
Rate of Change [H] = [D – E + F – G]	3.01%	0.14%	3.81%

Sources: Meyrick (2007a), PEG (2007a) and Meyrick analysis

new information we now recommend using the Econtech labour price forecast. We have also updated and more closely targeted the Producer Price Indexes used to deflate non–labour opex. The overall opex price forecast we recommend using is 5.07 per cent. This is 0.55 per cent above our earlier forecast and 1.30 per cent above the PEG (2007a) forecast.

A thorough review of the analysis and modelling contained in PEG (2007a) provides no reason to change our earlier opex partial productivity forecast. The criticisms made by PEG of our earlier forecasts have been demonstrated to not be valid and the alternative forecasts advanced by PEG do not meet a key required regularity condition. They are also based on 'mixed and matched' parameter estimates from disparate models which have no coherent quantitative basis. The latest PEG research on US GDB productivity growth actually supports our recommendation when viewed in a comparable timeframe. The PEG recommendation to use business–specific opex partial productivity forecasts is also not consistent with the principles of incentive regulation in this situation.

We have retained the Meyrick (2007b) output growth forecasts as the alternative growth forecasts put forward by the ESC have yet to be tested by the GDBs in the review process and the Meyrick (2007b) forecasts are consistent with data used elsewhere in Meyrick (2007a).

Finally, we have revised our estimate of the CPI. We now recommend using the forecast in Econtech (2007) to be consistent with the recommended labour price growth forecasts. We note that the figure proposed by the ESC is at the high end of the range of available forecasts and much higher than the figure produced by Access Economics (2007) which was used by PEG (2007a) as its primary source of labour price forecasts. If the ESC wished to use a different inflation rate in the rate of change formula to the one we have recommended then it would be necessary to make a corresponding adjustment to the Econtech labour price growth forecast to maintain internal consistency.

After reviewing and assessing all the information now available, our recommended real opex rate of change for the Victorian gas distribution industry as a whole is 3.46 per cent. This is 0.8 per cent higher than that recommended in Meyrick (2007a) due to the higher labour price forecast and lower inflation rate forecast in Econtech (2007). When differences in output growth are allowed for, the recommended rates of change for the GDBs are 4.13 per cent for Envestra, 2.52 per cent for Multinet and 3.81 per cent for SP AusNet.

APPENDIX A: PROBLEMS WITH THE TRANSLOG FUNCTIONAL FORM IN THE REGULATORY CONTEXT[6]

In order to successfully model technologies in a panel data context, the functional form generally has to allow for the possibility of firm specific first order parameters along with *common* second order parameters for the function being estimated. This requirement creates problems when using the translog functional form because when the second order parameters are dropped from this functional form, the function collapses to a Cobb-Douglas functional form which is a suitable functional form only in very restrictive contexts; namely, situations where there are many inputs but only one output. In the regulatory context, we generally have two or more outputs and as we shall see below, this creates problems for the use of the Cobb-Douglas functional form.

Consider a situation where it is necessary to estimate a factor requirements function f:

(1) $x = f(y_1,y_2,k)$

where x is the minimum amount of variable input (or aggregate opex input) needed to produce the two outputs, y_1 and y_2, given that the firm also has available the positive amount of capital k at its disposal. In order for f to be a well behaved function in this context, it is necessary that f be increasing in its first two variables, y_1 and y_2, (so that increases in either output necessitate increased variable inputs) and decreasing in the capital variable, k, so that an increase in capital services availability enables the firm to produce the same outputs with less variable input.

If the firm chooses variable input x and capital services input k in order to minimize total cost for any given period, then the firm will solve the following cost minimization problem:

(2) $\min_{x,k} \{wx + p_k k ; x = f(y_1,y_2,k)\} = \min_{k} \{wf(y_1,y_2,k) + p_k k\}$

where $w > 0$ is the price of the opex input and $p_k > 0$ is the price of capital services.

If f is twice continuously differentiable at the point $k^* > 0$ which solves the cost minimization problem (2), then the following first and second order necessary conditions for a minimum at k^* must be satisfied:

(3) $\partial f(y_1,y_2,k^*)/\partial k = -p_k/w < 0$;

(4) $\partial^2 f(y_1,y_2,k^*)/\partial k^2 \geq 0$.

If we define the optimal variable input as $x^* > 0$, then:

(5) $x^* = f(y_1,y_2,k^*)$.

[6] This appendix reproduces a note prepared by Prof Erwin Diewert, University of British Columbia.

Note that the first order condition (3) can be rewritten in elasticity form as follows:

(6) $\partial \ln f(y_1,y_2,k^*)/\partial \ln k = -p_k k^*/w x^* = - s_k/s_x$

where s_k and s_x are the *shares of capital services and opex expenditures in total cost*; i.e., these cost shares are defined as follows:

(7) $s_k \equiv p_k k^*/[p_k k^* + w x^*]$; $s_x \equiv w x^*/[p_k k^* + w x^*]$.

We now consider putting some restrictions on the factor requirements function f that are useful specializations of the general case. In particular, we consider restrictions on f that will allow the resulting technology set to become a well behaved constant returns to scale, convex technology. Although these restrictions are not required in the regulatory context, it seems useful to have a flexible enough functional form so that if the technology sets of the regulated firm happen to be well behaved, we can successfully estimate these technologies.

In order for the firm's technology set to be convex, it is necessary and sufficient that the factor requirements function, $f(y_1,y_2,k)$, be a convex function. If f is twice continuously differentiable over its domain of definition, then necessary and sufficient conditions for convexity of f over the interior of its domain of definition are that its matrix of second order partial derivatives be positive semidefinite at each point of this domain of definition. Thus for a convex technology, in particular, the following second order partial derivatives must be nonnegative:

(8) $\partial^2 f(y_1,y_2,k)/\partial y_1^2 \geq 0$;

(9) $\partial^2 f(y_1,y_2,k)/\partial y_2^2 \geq 0$;

(10) $\partial^2 f(y_1,y_2,k)/\partial k^2 \geq 0$.

If we also ask that f be consistent with a constant returns to scale technology, then f must satisfy the following property for all points in its domain of definition:

(11) $f(\lambda y_1,\lambda y_2,\lambda k) = \lambda f(y_1,y_2,k)$ for all $\lambda > 0$.

If f is differentiable, then differentiating both sides of (11) with respect to λ and then evaluating the resulting partial derivatives at λ equals 1 leads to the following equation:

(12) $f(y_1,y_2,k) = y_1 \partial f(y_1,y_2,k)/\partial y_1 + y_2 \partial f(y_1,y_2,k)/\partial y_2 + k \partial f(y_1,y_2,k)/\partial k$.

The above equation is equivalent to the following restriction on the *elasticities of the factor requirements function with respect to the two outputs and capital*:

(13) $\partial \ln f(y_1,y_2,k)/\partial \ln y_1 + \partial \ln f(y_1,y_2,k)/\partial \ln y_2 + \partial \ln f(y_1,y_2,k)/\partial \ln k = 1$.

We now turn to the properties of the translog functional form in the special case where all second order terms are zero. In this case, the factor requirements function f is defined as

follows:

(14) $f(y_1,y_2,k) \equiv \alpha\, y_1^{\beta}\, y_2^{\gamma}\, k^{\delta}$

where α, β, γ and δ are unknown parameters. We will assume that α is positive.

Differentiating f with respect to its arguments leads to the following first order partial derivatives:

(15) $\partial f(y_1,y_2,k)/\partial y_1 = \beta\alpha\, y_1^{\beta-1}\, y_2^{\gamma}\, k^{\delta}$;

(16) $\partial f(y_1,y_2,k)/\partial y_2 = \gamma\alpha\, y_1^{\beta}\, y_2^{\gamma-1}\, k^{\delta}$;

(17) $\partial f(y_1,y_2,k)/\partial k = \delta\alpha\, y_1^{\beta}\, y_2^{\gamma}\, k^{\delta-1}$.

The first order monotonicity restrictions on f and the derivatives listed in (15)-(17) imply the following restrictions on the parameters:

(18) $\beta > 0$;

(19) $\gamma > 0$;

(20) $\delta < 0$.

If we assume that the firm has a convex technology set, then the necessary conditions (8)-(10) imply the following further restrictions on the parameters:

(21) $\beta(\beta-1) \geq 0$;

(22) $\gamma(\gamma-1) \geq 0$;

(23) $\delta(\delta-1) \geq 0$.

Using (15)-(17), it can be shown that β, γ and δ are equal to the input requirement function elasticities $\partial \ln f(y_1,y_2,k)/\partial \ln y_1$, $\partial \ln f(y_1,y_2,k)/\partial \ln y_2$ and $\partial \ln f(y_1,y_2,k)/\partial \ln k$ respectively. Thus the inequalities (18)-(23) imply the following restrictions on these elasticities:

(24) $\partial \ln f(y_1,y_2,k)/\partial \ln y_1 = \beta \geq 1$;

(25) $\partial \ln f(y_1,y_2,k)/\partial \ln y_2 = \gamma \geq 1$;

(26) $\partial \ln f(y_1,y_2,k)/\partial \ln k = \delta \leq 0$.

The restriction (26) is not at all restrictive but the restrictions (24) and (25) are very restrictive. If the second order terms in the translog functional form are zero, then the restrictions (24)-(26) tell us that the input requirement function elasticities are all constant and the elasticities $\partial \ln f(y_1,y_2,k)/\partial \ln y_1$ and $\partial \ln f(y_1,y_2,k)/\partial \ln y_2$ *must both be greater than one if the technology set is convex*.

If in addition to the convexity restriction, we also impose the constant returns to scale

restriction (11), then using (13) and (24)-(26), we can deduce the following restriction on the elasticity $\partial \ln f(y_1,y_2,k)/\partial \ln k$:

(27) $\partial \ln f(y_1,y_2,k)/\partial \ln k = \delta \leq -1$.

Thus if the technology is *regular* (which we define to be one that is convex and exhibits constant returns to scale) and if we represent this technology by a translog functional form that has all second order terms equal to zero, then the three input requirement function elasticities must be constant and in addition, *they must all be equal to or greater than one in magnitude*. This is a severe restriction on the applicability of this translog model since elasticities for large aggregates tend to be less than one in magnitude rather than being greater than one.

The restriction (27) can be combined with equation (6) above to give us the following further restriction on the elasticity parameter δ:

(28) $\partial \ln f(y_1,y_2,k)/\partial \ln k = \delta = -s_k/s_x \leq -1$ or

(29) $s_k \geq s_x$.

Thus in order for a Cobb-Douglas factor requirements function to satisfy the appropriate conditions for regularity, the share of capital services in total cost must be equal to or greater than the share of operating expense costs in total cost. This last condition will not be satisfied for many data sets.

All of the above applies to a special case of the translog functional form where the second order terms are all zero. If we allow the second order terms to be present in the functional form, then the above analysis does not follow. However, experience has shown that the estimated second order parameters in panel data set applications of the translog function are often small in magnitude and so the above arguments will follow in an approximate fashion.

Similar problems apply to the translog joint cost function.

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