43 Grove Park, Camberwell, London SE5 8LG
United Kingdom
Phone +44 (0) 20 7733 6587 Fax +44 (0) 20 7771 9239
Email info@Horton4.co.uk

Horton 4 Consulting

Opex Rate of Change and Productivity: Comments on Pacific Economic Group's Response to Meyrick and Associates' reports

An opinion by Geoffrey Horton

26 October 2007

Opex Rate of Change and Productivity: Comments on Pacific Economic Group's Response to Meyrick and Associates' reports

An opinion by Geoffrey Horton

CONTENTS **Page**

1 Experience and qualifications

I am Geoffrey Robert Horton, an independent consultant specialising in advice on economic regulation to regulatory bodies and regulated companies. I hold an MA degree in Philosophy, Politics, and Economics from Oxford University and an MSc in the Economics of Public Policy from London University.

I have worked as an economist or regulator for over thirty years. The first half of my career was spent mainly as a macroeconomist at the United Kingdom Treasury, in consultancy or as a university lecturer, during which time I conducted a significant amount of econometric research and was responsible for UK, European and world economic forecasts. Since 1988, I have been involved in economic regulation, particularly in the energy industry.

As Senior Economic Adviser in the UK Department of Energy from 1988-90, I was responsible for all economic advice on electricity, coal, and the environment and played a leading role in the redesign and reorganisation of the electricity industry before the new companies were vested and subsequently floated.

From 1990 to 1995, as Director of Regulation and Business Affairs at the British Office of Electricity Regulation, I was responsible to Professor Littlechild for all aspects of the price controls, issues of price discrimination, and advice on economics and accounting. In that role I conducted reviews of the price control licence conditions for the National Grid Company, the public electricity supply businesses, and the public electricity supplier distribution businesses.

From 1992 to 1995, I was simultaneously Director General of Electricity Supply for Northern Ireland. This is an independent statutory appointment, entirely separate from the Office of Electricity Regulation in Great Britain, with responsibility for the regulation of the electricity industry in Northern Ireland. From 1995 to 1998 I was Director of Consumer Affairs at the UK Office of Fair Trading, responsible for the half of the office discharging the Director General's consumer protection responsibilities.

Since 1998, as a consultant in regulatory economics, I have worked on many topics, including matters relating to price control and efficiency in electricity, railways, gas, banking, postal services, water, bus transport and pharmaceuticals. I have advised regulators or regulated companies in England & Wales, the Republic of Ireland, the United States, New Zealand, Oman, Turkey, Russia, Singapore, Thailand, Ukraine, Australia, India, the Philippines, Brazil, Scotland, Northern Ireland, Guernsey and, through UK Trade and Investment, China, Taiwan, Saudi Arabia and Abu Dhabi.

I have worked extensively on operating cost efficiency, for example in "The Efficiency Growth Assumption for Railtrack in the 2001-6 Price Control Period", a Horton 4 Consulting paper published by the UK Office of the Rail Regulator in July 2000.

2 Summary

As part of its calculation of the allowed price to be charged by gas distribution businesses (GDBs) in Victoria the Essential Services Commission (ESC) makes an assumption about the future rate of increase in their operating costs.

I have been asked by SP Ausnet and Alinta (for Multinet) to undertake a review and critique of the July 2007 report produced by Pacific Economics Group (PEG) on this topic and to comment on the overall level of productivity improvement calculated by PEG.

The assumption is a forecast that PEG has built up from disaggregated components. It is not always the case that forecasting at a greater degree of disaggregation produces greater accuracy. In fact, the reverse can be the case. Decision on the appropriate level of aggregation is complex. I have not attempted to establish an optimal level of disaggregation in this case but have borne the inter-relationship between the variables in mind when discussing their individual forecasts and have also included (in section 6) consideration of an aggregate projection.

Factor prices

PEG has forecast the CPI, wages and other factor prices independently. This produces an inconsistent result and a real wage forecast that is lower than that of either of the two forecasts on which it purports to be based.

The relationship between the price of an individual factor of production and the general price level in the economy (as represented by an index such as the CPI) is so intimate that they can only be considered in combination. PEG's forecasts are inconsistent in that they are derived from different sources. The wage inflation forecast is a weighting of Access Economics (AE) of five sixths and BIS Shrapnel (BIS) one sixth whereas the CPI forecast is adopted to be consistent with other ESC assumptions. It is highly likely that, had the CPI forecast been 3% in either the AE or the BIS forecast, the wage inflation forecast would have been different, probably by much the same amount as the difference in the CPI forecast.

I also find PEG's derivation of the weights to apply to the forecasts unconvincing. It does not seem to me that there is a real distinction between the two sets of criteria. The criteria are overlapping and are not of equal importance. At least one, weighting of alternative forecasts, is a conclusion from the use of more fundamental principles rather than an independent criterion in its own right. The need to apply so many criteria independently makes an overall judgement difficult to achieve. The considerations cited by PEG in evaluating AE and BIS against each of the six criteria by which it rates them differently suggest that it does not distinguish sharply between the criteria.

My own view is that, even assuming PEG's claims to be correct, a more even weighting of the forecasts is justified. Any weighting should be applied to real wage movements and not nominal wages.

Neither Meyrick nor PEG provides a reason for the forecast of the rate of change of the price index of non-labour costs to differ from that of the CPI.

Output

The difference between the output growth projections made by PEG (1.77%) and Meyrick (1.93%) is well within the margin of error of the forecast. I am not familiar with the method used by ESC but it is usual to specify price control formulae such that they are robust to differences between the output projection used in reviewing the formula and the out-turn. I therefore make no further comment on the output projections other than to say that the relevant definition of output to forecast is an appropriately weighted sum of cost drivers – probably quantity distributed, customer numbers and network length.

Productivity

I do not consider PEG's cost model to be a reliable basis on which to estimate productivity growth and am also not convinced that PEG's deductions follow from the model's evidence.

PEG has estimated a cost model on both US and Australia/New Zealand data to enable it to estimate factors determining productivity growth. There is a substantial difference between the two sets of results. Either the US and ANZ gas distribution industries do not have the same cost function, which is possible but surprising and in which case the US results would not be relevant to ESC's decision, or these substantial differences suggest that the functions are uncertain and that the estimated results need to be treated with considerable caution. Either conclusion implies that they are not a reliable basis on which to calculate productivity growth.

Other features of the estimated equations suggest caution. The coefficient on the log of wages squared in the US equation is surprising. Another disturbing feature is that the capital stock coefficient is positive, highly significantly so in the case of the ANZ data. The differences in the time trend coefficients (productivity growth of 1.5% a year in the US, 6% a year in ANZ) may reflect in part the additional recent improvements after privatisation in Australia and New Zealand but the coefficients may also be affected by the uncertainty in the other coefficients and the lack of dynamic specification.

PEG used three elements from the estimated equations to project PFP growth:

- The 1.5% US time trend coefficient is taken by PEG to be representative of *technical change* in a mature industry. However, like all coefficients and particularly given that other coefficients are suspect, it is uncertain. There is the possibility that the coefficient has been affected by the lack of dynamic specification. Moreover, the use of what is hypothesised to be a steady state trend presupposes that there has been no efficiency overshooting. PEG's arguments against making an adjustment for overshooting are invalid and involve bad regulatory practice.

- The use of the ANZ coefficients in calculating the *scale effect* is unsound because their estimates are likely to have been influenced by the implausibly high and incorrectly signed coefficient on the capital stock. Moreover, km of pipe should be considered as a further scale variable. The sum of the coefficients on the three scale variables in PEG's US equation is 0.91. It seems to me reasonable to assume a gain to productivity of something between 5% and 15% of the rate of output growth.

- PEG's assessment of the impact of *business conditions* rightly ignores the impact estimated for the ABNZ capital stock. The other significant factor is

that of the change in the proportion of iron and steel pipes. I have no confidence in the estimated coefficient but am not in a position to assess the true effect. An engineering assessment of the impact may be more useful than an econometric one. However, if, as seems to be the case from PEG's figures, the overall capital stock is not rising even though mains are being replaced, it may be unreasonable to attribute a gain in productivity to a rise in one part of the stock without attributing a corresponding fall to the implicit decrease in the rest of the stock. The business conditions impact would then be ignored.

Taking these tentative conclusions - that the technical progress effect might be rather below the estimated trend rate because of the possibility of both dynamic specification effects and overshooting, that there may be a modest scale effect and that there is no capital substitution – it is unreasonable to hypothesise that PFP growth is likely to be of the size estimated by PEG rather than at a similar rate to that of real input prices. That is the long term expectation from economic theory and would result in opex growing at much the same rate as the sum of the growth rates of output and the CPI.

An aggregate approach

A similar conclusion emerges from a more general approach. The growth of operating expenditure productivity (output relative to real operating expenditure) in an industry will differ from zero insofar as its TFP growth differs from that in the economy as a whole (which is embodied in the CPI), as the relative price of its inputs changes and as a result of capital substitution.

I consider that recent work by the UK energy regulator confirms my previously published view that there is no reason to expect normal energy distribution TFP growth to differ from that in the economy as a whole. PEG's tables 6 and 7 show capital input decreasing in both SP Ausnet and Multinet and increasing less rapidly than output in Envestra Victoria so there is no capital substitution effect. There is no clear view of relative input prices but, even if they do fall slightly, this may be offset by slow capital growth. Therefore, as with the disaggregated assessment, consideration at an aggregate level does not suggest that operating expenditure productivity will rise but that operating costs (deflated by the CPI) are likely to increase with output.

PEG should have checked the implications of its disaggregated results, which I consider to be based on inconsistent price forecasts and unreliable cost modelling, for these aggregate concepts. Had it done so, it would have found it hard to justify its implicit conclusion of CPI-2 for unit operating costs.

Guidelines

I have read the Federal Court Guidelines for Expert Witnesses and have made all inquiries I believe are desirable and appropriate in the light of the remit given to me and limits of scope described in the report.

3 Remit

3.1 Question addressed

As part of its calculation of the allowed price to be charged by gas distribution businesses (GDBs) in Victoria the Essential Services Commission (ESC) makes an assumption about the future rate of increase in their operating costs.

I have been asked by SP Ausnet and Alinta (for Multinet) to undertake a review and critique of the July 2007 report produced by Pacific Economics Group (PEG) on this topic and to comment on the overall level of productivity improvement calculated by PEG.

PEG's paper was a response to a March 2007 paper by Meyrick and Associates (Meyrick) although it was far longer than that paper and introduced significant new work. Both Meyrick and PEG separated the real rate of change of opex into four components – operating cost inflation, opex productivity, output growth and CPI inflation. The table below shows their conclusions for the average GDB.

% change per annum	**Operating cost inflation**	**Opex productivity**	**Output growth**	**CPI inflation**	**Real opex growth**
PEG	3.77	2.75	1.93	3	-0.05
Meyrick	4.52	0.8	1.77	2.83	2.66

Table 1. Views of opex change components 2008-12

The difference in view lies mainly in two respects:

- PEG considers that real opex price inflation will be three quarters of a percent a year (with real earnings rising 1.5% a year) whereas Meyrick expects a rise of nearly one and three quarters percent a year (real earnings 2.9%);

- PEG expects partial opex productivity growth of 2.75% pa whereas Meyrick anticipates 0.8%.

In CPI-X terms, PEG projects opex per unit at CPI-2 whereas Meyrick has CPI+0.9.

3.2 Principles to be applied

PEG sets out sixteen criteria for evaluating the forecast of the opex rate of change – eight relating to the "best estimate" and eight to whether the estimate has been obtained "on a reasonable basis".

It does not seem to me that there is a real distinction between the two sets of criteria. Criteria 2 (relevance of comparators), 6 (no cherry-picking) and 7 (no double-counting), which are part of the "best estimate" set, seem actually to be requirements that the estimate has been made on a reasonable basis whereas, among the "reasonable basis" set, 2 (consistency with economic theory), 3 (feasibility) and 4 (low forecast errors) seem to be requirements of the

best estimate. Before the outcome is known, the criteria of what is the best forecast are, in the main, that it has been made on the most reasonable basis.

The criteria are not of equal importance and at least one, weighting of alternative forecasts, is a conclusion from the use of more fundamental principles rather than an independent criterion in its own right. The need to apply so many criteria independently makes an overall judgement difficult to achieve.

In considering the forecasts I seek to employ criteria that can be separated into the following four categories:

- Economic: Do the relationships that produce the forecasts accord with economic theory in their specification and in their parameter values?

- Data: Are the data used to estimate the relationship relevant to the situation of the GDBs in the next regulatory period? Are there other relevant data?

- Econometric: Have appropriate procedures of estimation been used? Is the chosen relationship superior to other explanations in its ability to explain the estimation data set? Is it stable over different time periods and data sets?

- Regulatory: Is the process of making the forecast transparent and consistent with regulatory practice? Does it otherwise impinge on the regulatory process, for example by being based on variables that can be influenced by regulated companies?

3.3 Disaggregation

Before considering the forecasts in detail it is worth pausing to consider the best basis for making a forecast. It is not always the case that forecasting at a greater degree of disaggregation produces greater accuracy. In fact, the reverse can be the case.

- Disaggregated data tend to be poorer since they come from smaller samples and often suffer from definitional problems with classifications of data that are uncertain or vary over time.

- There may be trade offs or other factors relating the disaggregated forecast variables, for example between wages and employment, such that the aggregate variable, in this example the salary bill, may be more stable than its components. In this case the forecasts of productivity growth, factor prices (especially wages) and the CPI are clearly inter-related and should not be made separately.

- Forecasting at a disaggregated level involves a dilution of effort as more variables need to be modelled and forecast.

- Errors in forecasting individual components may be correlated, e.g. by optimism bias, with an effect that is magnified when they are combined.

The common argument for disaggregation is that it enables a closer representation of the "true" model whereas aggregate functions suffer from the problems identified by Fisher[1], i.e. that they cannot strictly be aggregated in a single mathematical function. However, any feasible level of disaggregation is likely to encounter the problems identified by Fisher and will rely on functions that approximate to the aggregate manifestation of individual behaviours. Decision on the appropriate level of aggregation is complex. Horizontal aggregation of similar activities is normal. In general, forecasters tend to forecast manufacturing or total output as an aggregate and constrain their disaggregated industry forecasts to sum to the total rather than derive the total from the components.[2]. Similarly, consumers' expenditure is normally forecast in aggregate, or at most disaggregated into durables and non-durables, rather than by adding the components.

Hubrich[3] found that, for many forecast methods, forecasting aggregate euro area year-on-year inflation directly results in higher forecast accuracy than doing so at the individual country level and Hendry and Hubrich[4] made progress in identifying the circumstances in which the use of disaggregated information is of assistance.

I have not attempted to establish an optimal level of disaggregation in this case but have borne the inter-relationship between the variables in mind when discussing their individual forecasts and have also included (in section 6) consideration of an aggregate projection.

[1] E.g. in Fisher (1969)
[2] There are exceptions. Cambridge Econometrics has made a point of aggregating UK forecasts from individual industry forecasts and there is a strong case for separately forecasting output that is little related to the economy in general such as offshore oil production.
[3] Hubrich 2005
[4] Hendry and Hubrich 2007

4 Cost inflation relative to the RPI

There is a relationship between the growth of productivity of a factor of production and its price. Higher productivity increases the demand for and so the price of a factor. A higher factor price reduces demand and increases its marginal and average productivity. Nevertheless, it is possible to discuss each separately rather than only as a simultaneous system. The relationship between the price of an individual factor of production and the general price level in the economy (as represented by an index such as the CPI), on the other hand, is so intimate that they can only be considered in combination.

4.1 Wages

Meyrick's forecasts for the CPI and wage inflation are consistent in that they were taken from the same source (BIS Shrapnel). The forecast for other input price inflation was taken to be the same as that experienced in recent years when CPI inflation was slightly lower. This projection is therefore inconsistent but the inconsistency is identified in the report and the forecast described as therefore being conservative.

PEG's forecasts are inconsistent in that they are derived from a number of sources. The wage inflation forecast is a weighting of Access Economics (AE) of five sixths and BIS Shrapnel (BIS) one sixth whereas the CPI forecast is adopted to be consistent with other ESC assumptions. This was 3%, which is higher than the 2.83% of the BIS projections. The AE forecast for CPI inflation from 2007-08 to 2010-11 averaged 2.4%. Charts in a second AE forecast, published after Meyrick's report and relied on by PEG, seem to imply that a similar CPI inflation assumption is retained in that report.

I am not familiar with the models used by either BIS or AE but good economic models normally have a simultaneous relationship between wages and prices or, at most, a relationship lagged one year. A simultaneous relationship might stem from rational expectations, where those setting wages correctly forecast prices on average and vice versa. It is therefore highly likely that, had the CPI forecast been 3% in either forecast, the wage inflation forecast would have been different, probably by much the same amount as the difference in the CPI forecast. AE's second report suggests that this is indeed the case saying, *"Wages respond with a lag to changes in underlying CPI, with the long run real wage tied to CPI and labour productivity growth"* and *"Since wages increase by more than labour productivity, this raises nominal unit labour costs, which in turn raises underlying CPI. Wages in turn respond to changes in underlying CPI. Over time wage inflation will equal price inflation (plus changes in productivity growth)."*[5] The real wage growth forecast by AE for the Victorian utility sector is over 1.8% pa and it is this, rather than the nominal forecast, which should be considered.

Meyrick forecasts real wage growth at 2.9% a year, PEG 1.5%. The PEG real wage forecast is therefore lower than that of either of the two forecasts on which it purports to be based.

[5] Access Energy 2007, Appendix 5 p59-60.

PEG says that the Meyrick approach is deficient and favours the AE nominal (but not real) wage forecast because it says:

- It is in principle wrong to ignore additional forecasts and concentrate only on one;
- The AE forecast is for employees in each state;
- The BIS forecast is for males only;
- The AE forecast pays more attention to cyclical factors and, particularly in the later forecast, makes a number of detailed points explaining and justifying its forecast;
- Meyrick has confused the separate concepts of wage growth and productivity.

This leads PEG to conclude that AE is superior in six of its sixteen criteria (*accuracy of data* in covering both male and female employees, *appropriateness of data to business conditions* in that they relate to the state of Victoria, *use of rigorous techniques* in that it considers a wider range of factors, *robustness* in that it provides a more detailed explanation of wage changes, *reflecting long run behaviour* in that it discusses and allows for short term factors, and *transparency* through the clarity of the AE presentation) whereas BIS is superior in one (*consistency with economic theory* in that the earnings index it uses is more reflective of changes in total earnings). However it says that it finds AE superior on five criteria and accordingly uses the ratio 5:1 to weight the forecasts of nominal wage growth.

Some of the basic points made by PEG are valid.

- In selecting a single forecast one is in effect substituting one's own judgement for that of the forecasters considered. Both Meyrick and PEG do this to some extent with the former placing 100% weight on BIS and the latter 83% on its interpretation of AE, PEG providing a justification for doing so based on the criteria that it set out. I am not familiar with the models underlying the forecasts and so am not in a position to make such a judgement myself.
- If there is a reasonable expectation that labour conditions will differ from state to state this should be taken into account.
- The more the index being forecast is that for relevant earnings in the industry in question the better. The BIS index excludes women; the AE index is of a basket of jobs rather than overall average earnings. It is not clear whether the exclusion of women biases the results. That will depend on whether female earnings are expected to grow at a different rate or whether they are at a different level and the proportion of women is expected to change. However, it seems to be agreed that the AE index growth is biased downwards because it excludes the impact of "grade creep" as jobs are reclassified and average earnings rise faster than a fixed weight basket index.

- If the AE model is better specified, captures the impact of cyclical factors better and the effect of those cyclical factors is to temporarily boost earnings now, that would be a reason to prefer that forecast. However, I am not familiar with the specification of either forecaster's models and they are not considered in any significant detail in the Meyrick and PEG reports.

PEG seems to me to be wrong in criticising Meyrick for saying that AE "*appears to overestimate the scope for ongoing high levels of national productivity growth as a mitigating influence on wages growth.*" There is a perfectly plausible mechanism whereby higher *national* productivity growth reduces CPI growth and earnings growth (although not real earnings growth). PEG appears to confuse this with the separate effect whereby industry productivity growth reduces the impact of industry wage growth on prices. However, industry productivity growth is not separate from wage growth as PEG claims. Economic theory would suggest that its impact would be likely to be of the other sign - with higher productivity growth being associated with higher earnings growth.

I find PEG's derivation of the weights to apply to the forecasts unconvincing. PEG's criteria are overlapping. It says that AE is superior in the accuracy of its data in that it covers all employees and only takes into account that the index AE uses is less reflective of total earnings when considering the criterion of economic theory. It finds BIS superior on consistency with economic theory yet finds that AE provides a more detailed and comprehensive explanation of wage changes. Even in theory, let alone in the reasons put forward by PEG, I find it hard to distinguish either between the criteria of accuracy and appropriateness of data or between the criteria of consistency with economic theory and explanation of long run behaviour. There is no discussion of the rigour and robustness of the econometric or other modelling techniques used by BIS and AE. The reasons for preference cited under the two headings are actually ones appropriate to conformity with economic theory. The considerations cited by PEG under each of these six criteria suggest that it does not distinguish sharply between them.

By using a ratio of 5:1 PEG is in effect saying that the AE forecast is five times better than the BIS one. Such a difference in quality is very large and seems a priori implausible. I have not studied the forecasts or the underlying models and cannot say whether that is the case. However, PEG's analysis has not convinced me that it is. My own view of the principle differences between the forecasts as described by PEG is that:

- It is not clear whether the omission of female employees will bias BIS's forecast;
- The nature of the index used by AE is agreed to be likely to bias its forecast downwards;
- The forecast relative depression of the Victorian market is said by PEG to bias BIS's forecast, which uses a national index, upwards;
- The analysis of short term and cyclical considerations by AE is said by PEG to warrant a lower long term forecast.

Even assuming the assessments that I have attributed to PEG to be correct, they would seem to justify a more even weighting.

For the reasons given above, any weighting should be applied to real wage movements and not nominal wages.

4.2 Other costs

Neither Meyrick nor PEG provides a reason for the forecast of the growth in the price index of non-labour costs to differ from that of the CPI. Meyrick puts forward the average of the last five years, which it says was *"around the same rate as the CPI"* and combines it with a slightly higher CPI forecast. PEG accepts the same forecast but couples it with a higher CPI forecast, thereby increasing the inconsistency.

In the absence of any evidence to the contrary, the null hypothesis is not that prices of particular inputs remain the same whatever the general rate of inflation. It is that relative prices do not change and that the price of non-labour inputs rises at the same rate as the CPI. It is therefore reasonable to assume a rise in non-labour costs equal to the assumed CPI growth if no reason is put forward to expect a relative price shift.

5 Output growth and productivity

A forecast of real cost increases must be combined with projections of output and of partial factor productivity (PFP) in order to generate a projection for operating costs as a whole. This section comments briefly on the output projections, considers the possibility of projecting future productivity gains on the basis of past gains, discusses the factors determining PFP and assesses the models estimated by PEG.

It is worth noting in passing that the concept of partial factor productivity required is a slightly unusual one, combining the productivity of labour with that of other inputs. This point is discussed further in section 6.

5.1 Output growth

The difference between the output growth projections made by PEG (1.77%) and Meyrick (1.93%) is well within the margin of error of the forecast. I am not familiar with the method used by ESC but it is usual to specify price control formulae such that they are robust to differences between the output projection used in reviewing the formula and the out-turn. I therefore make no further comment on the output projections other than to say that, as discussed below, the relevant definition of output to forecast is an appropriately weighted sum of cost drivers – probably quantity distributed, customer numbers and network length.

5.2 Extrapolating from the past

All forecasting, indeed the inductive method in general, assumes that the future will be like the past. This can suggest a simple approach whereby future productivity growth is assumed to be like that of the past. Unfortunately, this raises problems in both forecasting and regulation.

The forecasting problem is that the simple method holds true only if the future is expected to be like the past in other respects. The most obvious respect in which this is not true for the GDBs is that the past includes a period of rapid efficiency improvement after privatisation whereas the future does not. A slowing down of productivity improvement is a common phenomenon. Both Meyrick and PEG discuss "overshooting", when the level productivity actually falls back again in a period of negative growth, as has been seen in Victoria's electricity distribution businesses.

There is also a regulatory problem in using this method. It creates perverse incentives if future productivity growth assumptions are based on a company's own achieved annual percentage cost reductions. The ideal regulatory position is that the efficient cost level that is assumed should replicate competition by being derived from the industry as a whole. If a company has a competitive advantage it should retain the benefits of it until the rest of the industry catches up. This replicates competition in giving companies an incentive and does not involve reducing the allowance if the company's own costs have fallen. However, if an industry-wide comparison is difficult and so the ideal position is unattainable, the basic incentive principle may be breached so that the company retains the benefit of outperformance for a set period (say five years) after which the lower level of costs that has now been reached forms the basis of future revenue allowances.

However, if the rate of change of costs is to be extrapolated, a company will be less likely to pursue efficiency. For example, if a 10% cost reduction (2% a year for five years) appears

possible it is less likely to be made if the company believes not only that its revenue in future periods will be assessed on the basis of the lower costs but also that an additional 10% reduction will be assumed in each future period as a result.

The problem is less acute if, as is the case here, there are three companies being considered rather than one but it is still present.

5.3 Determinants of partial factor productivity

Some other rationale must therefore be found to support a PFP forecast. A disaggregated approach, referred to and adopted by PEG in a slightly different form, looks at the separate elements in the production function that affect PFP.

- Scale: If there are economies of scale (such that inputs rise x% as fast as output) a unit percentage increase in output will be associated with an increase in productivity of (1-x/100)%.

- Capital substitution: If the factor in question is becoming a smaller proportion of inputs in general, its productivity will tend to rise. Labour productivity growth is normally faster than total factor productivity growth because the amount of capital per worker increases.

- Technical progress: Total factor productivity, output per unit of any input, may rise over time as a result of technical progress.

- Operating environment: PEG separately identifies changes in the operating environment that may affect productivity. It cites the proportion of pipes made of cast iron or steel, the number of dual fuel customers, the proportion of residential and commercial customers and the length of distribution mains. This list illustrates some of the problems of moving from a theoretical discussion to a practical application. None of these factors is really separate from the other categories. The nature of the gas pipes is a feature of the capital stock and should ideally be taken into account in assessing its value. The other variables are all aspects of the output produced by the GDB, which is delivery of gas over certain distances to specific customers. The status of the length of main variable is particularly important and will be discussed further below.

- Efficiency: Finally productivity may increase if the existing technology is applied more efficiently and the company moves towards the production possibility frontier.

5.4 PEG's cost model

PEG has estimated a cost model on both US and Australia/New Zealand data to enable it to estimate these various factors.

5.4.1 Specification and data

Although the PEG report describes the model specification and results in the text and there are further details in an appendix, the information given is incomplete and a full evaluation is not possible.

There are two estimations of the model using pooled cross section and time series data – on forty US gas distribution companies and on what is described as the ANZ database. Estimation using pooled data is not unusual but it increases the importance of having a correct dynamic specification to the model. The data set includes observations for companies A and B in years t and t+1. The model must be capable of distinguishing between the short run cost impact of a possibly temporary change in output between t and t+1 and the permanent difference in levels of output between companies A and B, which will probably have been operating at different scales for decades. It is, as PEG says, a short-run cost model in that the dependent variable is variable costs but it is also long run in that it includes long run effects.

Dynamic specification can affect estimated parameter values. For example, if the short run impact of output on costs is smaller that that in the long run but there is no dynamic term in the estimated equation to reflect that fact, the negative coefficient on the time trend may be exaggerated to offset the impact of short run output increases and the long run output coefficient may be understated. The former would tend to exaggerate the impact of technical progress, the latter that of the scale effect.

The model estimated by PEG is a general static form. The variables are in natural log form. Costs are related to outputs, factor prices and exogenous variables. However, the cost elasticities are allowed to vary in that the equation form (with log costs on the left hand side) has on the right hand side as variables not only logged variables of output, factor prices and exogenous factors (plus a time trend) but also terms that are the products of the output and price logged variables (e.g. log wages times log wages and log wages times log output).

This general form is a standard translog cost function but the treatment of the "business condition" variables, which include both the capital stock and the length of the network, is slightly different. They have not been included in the general form (i.e. also cross-multiplied with other factors) but as single variables.

It is not said what method has been used to value the capital stock. This is a notoriously difficult problem.

5.4.2 Results

Two sets of result are presented – for the US and ANZ data sets. The estimated coefficients for a selection of the more influential variables are reproduced in rounded form in the table below.

Coefficient	Throu-ghput	Log^2Throughput	Custo-mers	Line length	Wages	Log^2 Wages	Capital stock	Time trend
US data	0.20	0.02	0.57	0.14	0.49	-0.73	0.06	-0.015
ANZ data	0.06	0.30	0.09	0.22	0.65	0.02	0.69	-0.060

Table 2. Coefficients estimated by PEG

There is a substantial difference in the results. In several cases the difference in the size of coefficient exceeds twice the standard error of the coefficient estimate, indicating that the two estimated relationships are significantly different. This is even the case with the wages term where at first sight the estimates seem relatively close. Either the US and ANZ gas distribution industries do not have the same cost function, which is possible but surprising and

in which case the US results would be not relevant to ESC's decision, or these substantial differences suggest that the functions are uncertain and that the estimated results need to be treated with considerable caution. Either conclusion implies that they are not a reliable basis on which to calculate productivity growth.

Even had the results been similar, there are always errors in coefficient estimates[6] and these are likely to be important when the coefficients are used to calculate items such as scale effects where the relevant consideration is the extent to which the sum of the output coefficients differs from one.

The coefficient on the log of wages squared in the US equation is surprising. It implies that the elasticity of costs with respect to wages decreases by three quarters of a percent[7] for every percentage increase in wages. The homogeneity restrictions will imply an offsetting effect of materials prices. This suggests a large elasticity of substitution between labour and materials that is not present in ANZ. This seems implausible.

Another disturbing feature is that the capital stock coefficient is positive, highly significantly so in the case of the ANZ data. Since the dependent variable is operating costs, i.e. excluding capital costs, this implies that there is no substitution between capital costs and labour and materials costs. Indeed, in ANZ they would appear to be highly complementary and that an increase in capital assets increases variable costs for the same level of output. This too is implausible[8]. It seems more likely that the variables that vary with the scale of the company – throughput, customer numbers, line length and capital stock – are collinear and that the capital stock coefficient is picking up a scale effect.

The differences in the time trend coefficients (productivity growth of 1.5% a year in the US, 6% a year in ANZ) may reflect in part the additional recent improvements after privatisation in Australia and New Zealand but the coefficients will also be likely to be affected by the uncertainty in the other coefficients.

5.4.3 Conclusions drawn by PEG

PEG then used three elements from these equations to project PFP growth:

- Technical progress, as represented by the time trend.
- The scale effect, which is the extent to which costs do not rise proportionately with output;
- The effect of business conditions, which reflects the mix of output and the change in the capital stock and corresponds with capital substitution (but in this case complementarity) and operating environment as discussed in 5.3 above.
- No change in the fifth factor, efficiency levels, is postulated.

[6] The quoted t-statistic is merely a measure of the probability that the coefficient differs from zero.
[7] Assuming that the estimated form used the variable ½.lnW.lnW as described in the appendix. If it did not the impact would be 1.5%.
[8] If it were true it would mean that a higher investment programme should be accompanied by a lower productivity growth forecast.

The ANZ *technical progress* coefficient, the 6% time trend, has been recognised in both reports to be unlikely to be sustained. The 1.5% US coefficient is taken by PEG to be representative of change in a mature industry. However, like all coefficients and particularly given that other coefficients are suspect, it is uncertain. There is the possibility that the coefficient has been affected by the lack of dynamic specification. Moreover, the use of what is hypothesised to be a steady state trend presupposes that there has been no efficiency overshooting.

When calculating the *scale effect* PEG took the coefficients on customers and units, applied them to projected growth rates and effectively averaged the results from US and ANZ coefficients. My own view is that the use of the ANZ coefficients is unsound because their estimates are likely to have been influenced by the implausibly high and incorrectly signed coefficient on another scale variable, the capital stock. This coefficient is described as suspect by PEG and disregarded. If PEG wished to have regard to aspects of the ANZ equation it should have been re-estimated without the capital stock term. PEG takes the scale variables to be customer numbers and line length. In my view km of pipe is a further scale variable. The UK energy regulator has for some time used a composite scale variable of network length[9], customer numbers and units distributed when assessing electricity distribution costs. The sum of the coefficients on these three scale variables in PEG's US equation is 0.91.

There has been debate on the degree of economies of scale to be found in electricity and gas distribution. In electricity distribution some studies have concluded that they exist[10] but others have concluded that only very small scale is a disadvantage[11]. For New Zealand Meyrick and Associates[12] concluded that they are unimportant. In gas distribution, regression work undertaken by PB Power[13] on disaggregated costs in the present UK gas distribution price control review indicates the presence of some economies of scale. It seems to me reasonable to assume a gain to productivity of something between 5% (slightly less than the result of using my interpretation of PEG's US scale coefficients) and 15% (the factor suggested by CEPG after general study of utilities) of the rate of output growth.

PEG's assessment of the impact of *business conditions* ignores the impact estimated for the ABNZ capital stock. Excluding the impact of the scale variable, network length, the only significant factor is that of the change in the proportion of iron and steel pipes. This is estimated to increase productivity growth by up to 0.3% pa. I have no confidence in the estimated coefficient, particularly if it has been entered as a log variable[14], but am not in a position to assess the true effect. An engineering assessment of the impact may be more useful than an econometric one. However, if, as seems to be the case from PEG's figures, the overall capital stock is not rising even though mains are being replaced, it may be unreasonable to attribute a gain in productivity to a rise in one part of the stock without attributing a corresponding fall to the implicit decrease in the rest of the stock. The business conditions impact would then be ignored.

[9] E.g. Ofgem 2004 p.69
[10] Cambridge Economic Policy Associates Ltd 2003; Filippini, Wild, & Kuenzle 1999.
[11] Kelly 2001, Kwoka 2000
[12] Meyrick and Associates 2003
[13] PB Power 2007
[14] In which case an increase in the proportion from 10% to 11% would be estimated to have the same marginal percentage impact on costs as an increase from 50% to 55%, whereas one would expect the latter to be larger both because the absolute amount is larger and because the cost base being reduced is smaller.

PEG does not include any impact of a change in *efficiency* in spite of its conclusion that *"there is a significant probability that cost overshooting has occurred in Victoria's gas distribution industry"*. A lower rate of growth of productivity would be expected after such overshooting. PEG's discussion is not entirely clear but it appears that it has not made any overshooting adjustment for two reasons:

- "*whenever cost overshooting has occurred for a company, such an objective measure [of the long run, sustainable PFP trend] cannot be based on that company's actual or projected data until all the excess cost cuts have been reversed*" ; and

- *"companies should not be rewarded again because of cost overshooting that occurred in the past"*.

PEG may not be relying on the former argument in order not to make an adjustment, which it would not support, but merely against basing the assessment of the steady state trend on the company's own costs. If the path of efficient costs had to be assessed without reference to the company's own costs the approach being used by ESC would be invalidated, since it involves deriving the path by projecting from a base year cost. This must involve an assessment of whether the base year position is on the steady state path. If it has "overshot" there will be a period of productivity growth that is lower than the steady state in order to return to the path.

The second argument is invalid for reasons of both regulatory theory and fact. If a company reduces costs below the long term trend and then there is a period during which costs fall less rapidly as they return to the trend, it cannot be concluded that the low cost period was in some sense an illegitimate result of overshooting and that the company is not entitled to retain the profits. It is merely a period of outperformance during which the company's costs were below the long term trend. If there were an adverse consequence of any cost reduction it would be addressed through quality and performance monitoring. Any ex post removal of the benefit of outperformance, whether in past or future price control periods, has adverse incentive effects and is bad regulatory practice. This is particularly the case in the Victorian gas distribution industry where I understand that there is a rolling adjustment mechanism that is designed to enable the company to retain the benefit of outperformance for a specific period.

5.5 Conclusions

Taking these tentative conclusions - that the technical progress effect might be rather below the estimated trend rate because of the possibility of both dynamic specification effects and overshooting, that there may be a modest scale effect and that there is no capital substitution – it is unreasonable to hypothesise that PFP growth is likely to be of the size estimated by PEG rather than at a similar rate to that of real input prices. That is the long term expectation from economic theory and would result in opex growing at much the same rate as the sum of the growth rates of output and the CPI.

6 An aggregate approach

Section 3.3 suggested that an aggregate approach may sometimes be appropriate. Section 5 described the definition of partial factor productivity being analysed in the disaggregated approach as being unusual. It is a combination of inputs that might be expected to have different productivity growths. It is neither total factor productivity growth nor labour productivity growth, for which relevant comparisons might be found, but an amalgam with no obvious parallel elsewhere.

There are (at least) four possible measures of productivity that can be confused. Indeed, PEG says that some confusion has been made in the examples put forward by Meyrick: They are:

- Total factor productivity (TFP) growth, the difference between output growth and the weighted average growth of all inputs;
- Labour productivity growth, the difference between output growth and the weighted average growth of the labour input;
- Non-capital input productivity growth, the difference between output growth and the weighted average growth of inputs other than capital. This is the concept discussed in section 5;
- Operating expenditure productivity growth, the difference between the rates of growth of output and real operating expenditure (opex deflated by the CPI). This last, while not having a clear economic interpretation, is the answer sought by ESC and has sometimes been directly analysed by regulators, including in UK electricity distribution.

The growth of operating expenditure productivity in an industry will differ from zero insofar as its TFP growth differs from that in the economy as a whole (which is embodied in the CPI), as the relative price of its inputs changes and as a result of capital substitution.

6.1 TFP growth

The 2003 Cambridge Economic Policy Associates report concluded that it expected "*total factor productivity [growth in electricity distribution] over the next five years to lie in the range 1.4-3.4%, with a central case expectation in the middle of this range of 2.4%, or just over 1% above the rate of growth for the economy.* Commenting on that report Horton 4 concluded[15] that its assessment of TFP, based on the evidence presented, differed from that reached by CEPA. It was that the forecast of the potential for trend DNO TFP growth is subject to significant error but there are no strong grounds to expect it to be much higher than that for the economy as a whole[16].

I consider the arguments relating to TFP growth in gas distribution to be similar to those in electricity distribution. PEG argues that differences such as those relating to output trends, undergrounding, and the impact of customer density mean that trends in other utilities are not

[15] Horton 4 Consulting 2004

[16] At that time Ofgem accepted the view of its consultants CEPA and assumed 1.5% pa reductions in real operating costs for electricity distribution.

"consistent" with GDB business conditions and therefore ignores evidence from other utilities. My view is that the similarities considerably outweigh the differences.

In appendix 6 of its present gas distribution review initial proposals[17] Ofgem now adopts a figure of 1.4% for normal TFP growth in gas distribution, based on the work of its consultants Reckon LLP and Europe Economics. This is less than that in the economy as a whole. However, it considers that the advent of comparative competition following the separation of the gas distribution networks from the transmission company Transco will enable a further temporary gain of 1.1% a year during the next price control period, taking the total to 2.5%.

I consider that this work confirms my previously published view that there is no reason to expect normal energy distribution TFP growth to differ from that in the economy as a whole.

6.2 Relative price movement

I am not in a position to say whether the price of inputs into Victorian gas distribution is likely to move differently from those in the economy as a whole. PEG appears to consider that the relative price is inflated at present and that the relative position will return to normality. Meyrick appears to consider that relative shortages are still to have their full impact on the relative price.

6.3 Capital substitution

PEG's tables 6 and 7 show capital input decreasing in both SP Ausnet and Multinet and increasing less rapidly than output in Envestra Victoria. There is therefore not likely to be capital substitution but, if anything, a substitution of other factors for capital.

6.4 Conclusion

There is little reason to think that TFP growth will not match the economy in general. There is no clear view of input prices but, if they do increase relatively slowly, this may be offset by slow capital growth. Therefore, as with the disaggregated assessment, consideration at an aggregate level does not suggest that operating expenditure productivity will rise but that operating costs (deflated by the CPI) are likely to increase with output.

PEG should have checked the implications of its disaggregated results, which I consider to be based on inconsistent price forecasts and unreliable cost modelling, for these aggregate concepts. Had it done so, it would have found it hard to justify its implicit conclusion of CPI-2 for unit operating costs.

[17] Ofgem 2007

Bibliography

Access Energy, Labour Cost Indices for the Energy Sector, April 2007

Access Energy, Wage Growth Forecasts in the Utilities Sector, November 2006

Cambridge Economic Policy Associates Ltd, Productivity Improvements in Distribution Network Operators, report to Ofgem, November 2003

Filippini, Massimo, Wild, Jörg, & Kuenzle, Michael; Scale and cost efficiency in the Swiss electricity distribution industry: evidence from a frontier cost approach. Centre for Energy Policy and Economics Working Paper Number 8 (1999).

Fisher M.F, The Existence of Aggregate Production Functions, Econometrica 1969

Hendry David F. and Hubrich Kirstin Combining disaggregate forecasts or combining disaggregate information to forecast an aggregate Department of Economics, Oxford University and Research Department, European Central Bank August, 2007

Horton 4 Consulting, Comments on "Productivity Improvements in Distribution Network Operators", January 2004

Hubrich, Kirstin, Forecasting euro area inflation: Does aggregating forecasts by HICP component improve forecast accuracy? International Journal of Forecasting 2005

Kelly, John, Evidence on Scale Economies in Electric Utility Distribution and What it Implies: "Is Bigger Better?", American Public Power Association, March 2001;

Kwoka, John E. Jr, Electric Power Distribution Costs: Analysis and Implications for Restructuring. report to the American Public Power Association, December 2000.

Meyrick and Associates, Regulation of Electricity Lines Businesses, Analysis of Lines Business Performance – 1996–2003 Report prepared for the New Zealand Commerce Commission, December 2003

Meyrick and Associates, Victorian Gas Distribution Business: Opex Rate of Change, March 2007

Ofgem, Electricity Distribution Price Control Review: Final Proposals, November 2004

Ofgem, Gas Distribution Price Control Review: Updated Proposals Document, September 2007

PB Power, Gas Distribution Price Control Review: Opex Update Report to Ofgem, October 2007

Pacific Economics Group, Opex Rate of Change and Productivity: Response to Meyrick and Associates Reports, July 2007