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Electricity Distribution Industry Productivity Analysis: 1996–2008

Report prepared for
Commerce Commission

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EXECUTIVE SUMMARY

Section 53P(6) of the Commerce Amendment Act 2008 specifies that the rate of change in the electricity distribution default price path ‘must be based on the long–run average productivity improvement rate achieved by either or both of suppliers in New Zealand, and suppliers in other comparable countries, of the relevant goods or services, using whatever measure of productivity the Commission considers appropriate’. The Act further specifies that there should only be one rate of change and that comparative benchmarking cannot be used to set the rate of change.

The B factor from the former thresholds regime is similar in nature to the X factor specified in the Act. The C factors included in the former thresholds regime, on the other hand, were based on comparative benchmarking and so are precluded by the Act.

The Commerce Commission has engaged Economic Insights to update the productivity analysis behind the thresholds B factor to include Information Disclosure Data for 2007 and 2008 and to consider a number of refinements to the methodology. In particular, the Commission has asked us to examine the productivity growth performance of both the electricity distribution industry as a whole and of that part of the industry which is likely to be ‘non–exempt’ from the default price path, to consider the use of an indexed historic cost based asset value series, to consider the definition and weighting of system capacity output measures and to consider how the input price growth differential can be accounted for.

Economic Insights (2009a,b) presented a more fully developed approach to productivity–based regulation which takes account of the sunk cost nature of electricity distribution assets and the important regulatory principle of financial capital maintenance (FCM). Assuming that the Commerce Commission will use starting price adjustments to more closely align electricity distribution business (EDB) costs and revenues, the formula for the X factor taking account of sunk costs and financial capital maintenance is given by:

$$(ES1) \quad X \equiv \{\Delta TFP - \Delta TFP_E\} - \{(s_O \Delta w_O + s_K \Delta P_{kD}) - \Delta W_E\}$$

= TFP differential growth rate term – input price differential growth rate term.

where TFP is total factor productivity, W represents input prices, O represents operating costs, K is capital, s is the input cost share, P_{kD} is the industry capital unit amortisation charge and the subscript ‘E’ refers to an economy–wide variable.

Productivity growth differential

The first term involves the difference in TFP growth rates between the electricity distribution industry and the economy. Distribution industry TFP as specified in Lawrence (2003) – using 12.5 per cent of ODV as a capital user cost proxy and lines capacity as a proxy for system capacity – grew strongly from 1996 to 2003 but has declined since then. For the period as a whole it had a trend growth rate of 0.3 per cent per annum.

However, the capital cost proxy used made no allowance for the sunk cost nature of distribution network assets or for the important regulatory principle of ex ante financial capital maintenance. Including capital amortisation costs which allow for these

characteristics leads to industry TFP growth rates of around 0.4 to 0.5 per cent depending on whether upper bound pre-tax or lower bound (post-tax) amortisation is used.

Since the Lawrence (2003) report Statistics New Zealand has produced an official multifactor productivity series for the market sector of the New Zealand economy. This series shows a trend growth rate for the market sector as a whole of 1.1 per cent annum for the 13 years 1996 to 2008. It also shows solid TFP growth up to 2003 but then a levelling off after this.

Over the full 13 year period the lines system capacity-based series would produce a productivity growth differential in the order of -0.6 to -0.8 per cent per annum (ie industry TFP growth has been less than that for the market sector as a whole).

However, this earlier specification made no allowance for the contribution of distribution transformer capacity to overall system capacity. Distribution transformer capacity has grown rapidly over the last several years and failure to recognise the important contribution of increased distribution transformer capacity would lead to the system capacity measure (which reflects the ability to meet capacity demands) being biased downwards.

Using this broader and more appropriate definition of system capacity in the TFP analysis leads to industry TFP growing strongly to 2003 and then levelling off after that. Over the 13 year period industry TFP grows at a trend rate of between 1.0 and 1.1 per cent per annum depending on whether the former 12.5 per cent of ODV user cost proxy, pre-tax amortisation or post-tax amortisation is used. This leads to a very small productivity growth differential range of -0.05 per cent to 0.06 per cent, or effectively zero.

That part of the industry which is likely to be ‘non-exempt’ from the default price path exhibits stronger TFP growth than the industry as a whole. Using the fully specified model including the overall system capacity output leads to TFP trend growth rates for this industry segment of between 1.4 and 1.5 per cent per annum. This segment accounts for 80 per cent of industry throughput and customer numbers. Calculating the productivity growth differential term on the basis of the ‘non-exempt’ portion of the industry would lead to a productivity growth differential of 0.3 per cent to 0.4 per cent.

Based on the available information, a conservative course of action would be to set the productivity growth differential term in the X factor to zero based on the overall industry and market sector performance. If that part of the industry that is likely to be subject to the default price path is taken to be the relevant industry definition then the productivity growth differential term would have a positive value of around 0.4 per cent.

Input price growth differential

Turning to the input price growth difference between the electricity distribution industry and the economy, Lawrence (2003) recommended that this be set to zero due to conflicting information at the time from official capital goods price indexes (CGPIs), particularly those for power lines and transmission lines. The power lines CGPI has continued to exhibit erratic movement with a 26 per cent increase in 2007 alone with no corroborating evidence from related CGPIs in New Zealand or Australia. We are of the view that it would be imprudent to rely on the power lines CGPI in setting the input price difference until further information can be obtained on the reasons for its erratic and unusual movement. Relying on the higher level electrical works CGPI instead and the labour cost index for the electricity, gas and

water sector produces an industry input price trend growth rate of 2.4 per cent per annum over the 13 year period 1996 to 2008. This compares with economy-wide input price trend input price growth of 2.2 per cent per annum over the same period. This would lead to an input price growth differential of 0.2 per cent per annum.

However, to allow for the sunk cost nature of electricity distribution network assets and the important regulatory principle of ex ante FCM we need to include the change in unit amortisation charges in equation (ES1) rather than the CGPI (which is included above as a proxy for changes in capital annual user costs). If we use the amortisation method involving the upper bound pre-tax discount rate then industry input prices increase by 1.7 per cent per annum over the 13 year period. Using the post-tax discount rate amortisation method leads to a trend growth in industry input prices of 1.9 per cent per annum. This would lead to an input price growth differential of -0.2 to -0.3 per cent per annum (ie overall market sector input prices have grown marginally quicker than industry input prices over the period).

We also examine input price movements for the period 2004 to 2008 as well as the longer period from 1996 onwards. This indicates that using the change in the relevant CGPI as a proxy for the change in the user price of capital leads to a higher input price growth rate for the industry. While the corresponding market sector input price growth rate has also increased, the differential widened out to nearly 1 per cent per annum over 2004 to 2008.

However, using the more appropriate amortisation approach to forming the industry input price growth rate leads to a much smaller growth differential of around 0.3 per cent per annum. The difference in trend growth rates between the industry amortisation-based input prices and the CGPI-based input price proxy reflects the fact that the amortisation price is based on actual expenditure whereas the user CGPI-based price is based on the replacement price of all assets and, hence, largely on expenditure which is not actually incurred. All else equal, using the replacement cost CGPI proxy would lead to windfall gains for the EDBs as they would be compensated for expenditure they had not incurred.

More generally, the recent global economic slowdown means that both the industry and market sector input price growth rates are likely to be lower going forward. The 'bubble' in commodity prices may have contributed to the higher growth rate in capital input prices in recent years but the recent slowdown is likely to have substantially lessened and/or reversed commodity price growth rates with a likely dampening impact on industry capital prices.

The available evidence indicates that, using the rigorous amortisation charge approach which takes account of ex ante FCM, the distribution industry as a whole has exhibited slightly slower input price growth than the economy as a whole over the last 13 years. This would point to a small input price growth differential of in the order of -0.2 to -0.3 per cent per annum. A conservative course of action in favour of the EDBs would be to set the input price growth differential term in the X factor to zero given its relatively small magnitude over both the whole period and the more recent period.

X factor recommendation

Since the X factor is the difference between the productivity growth differential and the input price growth differential and we have conservatively recommended that each of these be set to zero, it follows that the X factor would also be zero.

Response to submissions

Appendix B provides our initial response to submissions on the theoretical framework developed in Economic Insights (2009a,b). Additional reviews are being undertaken of PEG (2009b) and the TFP estimates in PEG (2009a).

Much of the PEG (2009a,b) analysis is inappropriate because it attempts to treat energy distribution as if it were a competitive industry. The PEG analysis does not recognise the increasing returns to scale nature of the industry and the presence of sunk costs which means the ‘indexing logic’ PEG attempts to use is inappropriate. It is precisely because of these features that the industry is being regulated. Simply assuming that the industry should satisfy all the standard competitive properties, as PEG does, is neither appropriate nor useful.

The PEG assumption that Trend Revenue = Trend Cost is not a meaningful one in the context being considered if trend cost is defined or measured to include prices that deviate from competitive prices (as PEG does with its approach to defining the ex post cost of capital).

The Economic Insights technical report shows that when the assumptions of constant returns to scale and competitive pricing are relaxed in a regulatory context, it is no longer the case that TFP growth measured using traditional approaches (eg a Divisia output quantity index using market prices less a Divisia input quantity index) coincides with technical progress.

The PEG methodology does not ensure cost minimising behaviour over time as it does not ensure ex ante financial capital maintenance is achieved and in fact it has the potential to lock in excess profits for some firms and below normal profits for others. Contrary to the claims made, the PEG methodology cannot adequately address allocative efficiency issues because of its use of an ex post cost of capital.

PEG (2009a) and PwC (2009) suggest that the measure of output used in the calculation of TFP must be the same as that used for pricing purposes, with the implication that if an output measure is not priced then it cannot be included in the calculation of TFP. However, from a conceptual perspective, this interpretation does not take account of the Economic Insights (2009b) decomposition of TFP into a pure technical change term and terms showing the output weighted divergence between price and marginal cost. For the purposes of productivity-based regulation of natural monopoly industries, it is desirable to include all economic or functional outputs (of which billable outputs will be a subset). As demonstrated in appendix B, limiting coverage to only billed outputs and using revenue weights can potentially introduce significant distortions, particularly if one X factor is to be applied across a diverse range of firms.

While it has not currently been possible to fully implement the Economic Insights (2009a,b) framework, the approach adopted in this report captures key elements of it and more accurately reflects the economic and operational characteristics of EDBs than that proposed by PEG. The approach implemented in this report also ensures that ex ante FCM is exactly achieved, which the PEG proposal does not.

Vector (2009, pp.7–8) make a number of criticisms of the proposal to broaden the measure of system capacity included in TFP measurement to include transformer capacity as well as line length. Vector argues instead for measures based on peak demand and line length. But an important part of meeting customer demand is for the distribution network to provide the

capacity to supply energy to consumers where and when it is demanded. Recognising transformer capacity and network length is thus a more appropriate measure than peak demand and network length as suggested by Vector.

Vector goes on to criticise the use of output measures that include variables that also appear as inputs. However, the overall system capacity measure incorporates transformer capacity at the final stage of transformation only (ie the distribution transformer level and not the zone substation level of transformation) whereas the physical measure of transformer capital used on the input side of the TFP calculation would ideally include both distribution and zone substation levels of transformation. This means the issue raised by Vector is not relevant in principle. It also needs to be recognised that the measures of throughput and customers included as outputs in this study reduce any capacity to increase TFP by simply installing more transformers as claimed by Vector.

PEG (2009a) maintains that monetary measures of capital stocks must be used as measures of capital input quantities and that a physical measure of capital inputs will be inconsistent with ensuring capital cost recovery to set prices. This is not correct. Economic Insights (2009a,b) demonstrate at length how amortisation charges can be set taking account of the desirable regulatory principle of ex ante financial capital maintenance. These charges are then divided by the quantity of capital input to derive the price of annual capital input which is in turn used in the X factor formula. This approach is fully internally consistent.

PEG also criticises the use of the one hoss shay assumption involved in using physical measures to proxy annual EDB capital input quantities. However, the appropriateness of the one hoss shay assumption for structures (and most EDB assets are more akin to structures than equipment) has been recognised in leading academic journals, by international agencies such as the World Bank and OECD and by national statistical agencies. In particular, the national statistical agencies of the US, New Zealand and Australia have all adopted depreciation assumptions for productive capital stocks that are close to the one hoss shay profile and the opposite of the geometric profile advocated by PEG.

Orion (2009a,b) criticise the complexity and relevance of the Economic Insights (2009b) technical report. This report was necessary to ensure a thorough and rigorous approach to recognising the relevance of sunk costs and the principle of financial capital maintenance in productivity-based utility price controls. However, the recommended requirements for implementation are neither complex nor impractical. One key equation is required for practical implementation and, as applied in this report, the information demands are no more than those required for determining the B factor in the former thresholds regime.

Orion (2009b) contained a NERA appendix which questioned the relevance of the technical report's concern with household welfare and its focus on the price adjustment mechanism. However, it is clear that the Commerce Act purpose statement emphasises the importance of considering long term benefits for consumers. It is also clear that the choice and application of an appropriate price adjustment mechanism, with the adoption of principles such as financial capital maintenance and with attention to transparency and practicability, are essential to regulators and a core component of the regulatory task. It is for this reason that the relevant theory and its practical implementation have been given prominence by the Commerce Commission, in the Economic Insights (2009a,b) reports and in this report.

1 INTRODUCTION

Section 53P(6) of the Commerce Amendment Act 2008 (‘the Act’) stipulates that rates of change in default price paths ‘must be based on the long–run average productivity improvement rate achieved by either or both of suppliers in New Zealand, and suppliers in other comparable countries, of the relevant goods or services, using whatever measure of productivity the Commission considers appropriate’. Section 53P(5) of the Act states that ‘the Commission must set only one rate of change per type of regulated goods or services’ while section 53P(10) states that the ‘Commission may not ... use comparative benchmarking on efficiency in order to set ... rates of change’.

The Commerce Commission (2009, p.20) indicated that it should ‘seek to utilise the approaches used under the thresholds regime where applicable, as this approach is likely to reduce the resources required—by both suppliers and the Commission—to implement the regime’. The former thresholds regime included X factors comprising two broad components:

- a B factor, reflecting industry–wide improvements in productivity, determined through total factor productivity (TFP) analysis; and
- a C factor, reflecting the relative performance of groups of electricity distribution businesses (EDBs), determined by a combination of comparative productivity analysis and comparative profitability analysis.

The B factor from the thresholds regime is similar in nature to the X factor specified in the Act. The C factors included in the thresholds regime, on the other hand, were based on comparative benchmarking and so are precluded by the Act.

The Commerce Commission (‘Commission’) has engaged Economic Insights Pty Ltd (‘Economic Insights’) to prepare a report which updates the productivity analysis behind the thresholds B factor to include Information Disclosure Data for 2007 and 2008 and includes consideration of a number of refinements to the methodology. Specifically, the Commission has asked Economic Insights to:

- present an ‘all EDBs’ series comparison with a ‘non–exempt’ EDBs series;
- consider the use of an indexed historic cost (IHC) based asset value series;
- consider the definition and weighting of system capacity measures;
- consider how the input price growth differential can be accounted for; and
- discuss the incorporation of energy efficiency aims and the potential use of reliability information in TFP analysis.

The following section of the report reviews the use of productivity–based regulation and recent theoretical developments. In section 3 we discuss the data used in the analysis, some of the measurement issues involved and the refinements considered. In section 4 we present estimates of overall distribution industry TFP and input price movements. Finally, X factor recommendations are made in section 5. The data used in the analysis are presented in appendix A while appendix B presents our initial response to issues raised in submissions on the Commission’s discussion paper on resetting the default price path covering TFP.

2 PRODUCTIVITY–BASED REGULATION

2.1 What is total factor productivity?

Productivity indexes are formed by aggregating output quantities into a measure of total output quantity and aggregating input quantities into a measure of total input quantity. The productivity index is then the ratio of the total output quantity to the total input quantity or, if forming a measure of productivity growth, the change in the ratio of total output quantity to total input quantity.

To form the total output and total input measures we need a price and quantity for each output and each input, respectively. The quantities enter the calculation directly as it is changes in output and input quantities that we are aggregating. The relevant output and input prices are used to weight together changes in output quantities and input quantities into measures of total output quantity and total input quantity using revenue and cost measures, respectively.

In forming the output measure for competitive industries, observed revenues shares are typically used to weight together the output quantities sold as price will approximate marginal cost in these industries. For natural monopoly infrastructure industries, however, prices charged will typically not equal marginal costs and pricing patterns may have evolved instead on the basis of convenience or attitudes to risk. Therefore, for industries such as electricity distribution, it is important to ensure that all dimensions of the output supplied are recognised and that prices reflecting marginal costs are used wherever possible to weight these output dimensions into a total output quantity measure. Using marginal cost weights is necessary to determine changes in costs that are due to changes in demands; these weights can only be replaced by market selling prices in a competitive framework with price taking behaviour and constant returns to scale.

On the input side, the most difficult to measure component is the input of capital goods. Like other inputs and outputs, we need a quantity and cost for capital inputs. The appropriate measure to use for the capital input quantity in productivity analysis depends on the change in the physical service potential of the asset over time. For long–lived network assets such as poles, wires, transformers and pipelines, there is likely to be relatively little deterioration in physical service potential over the asset’s life. In this case using a measure of physical asset quantity is likely to be a better proxy for capital input quantity than using the constant price depreciated asset value series as a proxy. If this approach is adopted then the input quantity (which is the primary driver of productivity results) will be relatively unaffected by which asset valuation method is used. Rather, the asset value will affect the secondary driver of what weight is allocated to the capital quantity changes in forming the productivity measure.

The traditional approach to measuring the annual user cost of capital in productivity studies uses the Jorgenson (1963) user cost method. This approach multiplies the value of the capital stock by the sum of the depreciation rate plus the opportunity cost rate minus the rate of capital gains (ie the annual change in the asset price index).

For traditional productivity studies with a limited history of investment data available, the asset value series is typically rolled forwards and backwards from a point estimate using investment and depreciation series. The point estimate would typically reflect the market value of assets at that point in time. It would be standard practice to take the earliest point estimate of the capital stock available, provided there was reasonable confidence in the quality of the valuation process. In the case of energy distribution, sunk assets and new investment have traditionally been treated symmetrically.

TFP, technical progress and relative efficiency of firms can all be measured by a number of different techniques, the most common being index number methods, data envelopment analysis (DEA) and econometric cost functions. Index number methods have the advantage of being relatively simple and transparent – they are simply a weighted average of changes in output quantities divided by a weighted average of changes in input quantities – and of being readily replicable. They are also not restricted by requiring a large number of observations to implement. DEA, which is a linear programming based method, and econometric cost functions each require a relatively large number of observations to implement and are ‘black boxes’ by comparison to the simple index number methods. Of particular concern with econometric methods is their relative lack of reproducibility. Numerous choices can be made in implementing an econometric cost function regarding error structures and estimation methods. Each analyst will have their own preferences and, without knowing exactly which choices the analyst made, the results will not be able to be easily replicated.

The use of index number methods to calculate TFP growth, therefore, appears to be most consistent with the stated purpose of section 53K of the Act to ensure a ‘relatively low cost way’ of setting the default price path (DPP).

2.2 Traditional productivity-based regulation

Because infrastructure industries such as the provision of energy distribution networks are often subject to decreasing costs in present value terms, competition is normally limited and incentives to minimise costs and provide the cheapest and best possible quality service to users are typically not strong. The use of CPI-X regulation in such industries attempts to strengthen the incentive to operate efficiently by imposing similar pressures on the network operator similar to the process of competition. It does this by constraining the operator’s output price to track the level of estimated efficient unit costs for that industry. The change in output prices is ‘capped’ as follows:

$$(1) \quad \Delta P = \Delta W - X \pm Z$$

where Δ represents the proportional change in a variable, P is the maximum allowed output price, W is a price index taken to approximate changes in the industry’s input prices, X is the estimated TFP change for the industry and Z represents relevant changes in external circumstances beyond managers’ control which the regulator may wish to allow for. Ideally the index W would be a specially constructed index which weights together the prices of inputs by their shares in industry costs. However, this price information is often not readily or objectively available, particularly in regulatory regimes that have yet to fully mature. A

commonly used alternative is to choose a generally available price index such as the consumer price index or GDP deflator.

Productivity-based regulation, as it has been applied to date, argues that in choosing a productivity growth rate to base X on, it is desirable that the productivity growth rate be external to the individual firm being regulated and instead reflect industry trends at a national or even international level. This way the regulated firm is given an incentive to match (or better) this productivity growth rate while having minimal opportunity to ‘game’ the regulator by acting strategically. The latter can be a problem with the building blocks method for setting X which relies more heavily on specific and projected information on the firm’s own costs and likely best practice for that firm.

As outlined in Lawrence (2003), traditional productivity-based regulation has typically been implemented using CPI-X price caps where, as the result of choosing the CPI to index costs, the formula for the X factor takes on the following ‘differential of a differential’ form:

$$(2) \quad X \equiv [\Delta TFP - \Delta TFP_E] - [\Delta W - \Delta W_E] - \Delta M.$$

where the E subscript refers to corresponding variables for the economy as a whole and M refers to monopolistic mark-ups or excess profits. What this formula tells us is that the X factor can effectively be decomposed into three terms. The first differential term takes the difference between the industry’s TFP growth and that for the economy as a whole while the second differential term takes the difference between the firm’s input prices and those for the economy as whole. Thus, taking just the first two terms, if the regulated industry has the same TFP growth as the economy as a whole and the same rate of input price increase as the economy as a whole then the X factor in this case is zero. If the regulated industry has a higher TFP growth than the economy then X is positive, all else equal, and the rate of allowed price increase for the industry will be less than the CPI. Conversely, if the regulated industry has a higher rate of input price increase than the economy as a whole then X will be negative, all else equal, and the rate of allowed price increase will be higher than the CPI.

The change in mark-up term in (2) would be set equal to zero under normal circumstances but if the target firm was making excessive returns, then this term could be set negative (leading to a higher X factor).

The former thresholds regime used equation (2) but with one addition. The B factor component of the X factor was simply the first growth differential component on the right hand side of (2). Attempts were made to calculate a robust input price growth differential term but conflicting evidence from statistical agency capital goods price indexes led to a recommendation that the input price growth differential term be set to zero given the uncertainties involved (Lawrence 2003, p.51). The C₁ factor in the thresholds regime was based on TFP levels and supplemented the productivity growth differential term to take account of potential differences in future TFP growth rates given the wide spread of TFP levels in an immature regulatory regime. The C₂ factor based on profitability differences was a glide path method for implementing the ΔM term in equation (2).

2.3 Productivity-based regulation in the presence of sunk costs and FCM

Two major limitations of the theory underlying traditional productivity-based regulation have been that it has not recognised the sunk cost nature of network assets nor adequately allowed for the principle of real financial capital maintenance (FCM). Real FCM means that a controlled business is compensated for efficient expenditure and efficient investments such that, on an ex-ante basis, its financial capital is at least maintained in present value terms. A general measure of inflation (such as the CPI) is used to index the regulated firm's cost of capital, as it maintains the purchasing power of investors' funds. The sunk cost characteristic of network assets and the desirability of ensuring real FCM both have important implications for how productivity analysis is used in network regulation. Economic Insights (2009a,b) has recently extended the traditional theory of productivity-based regulation to allow for both sunk costs and real FCM.

Introducing sunk costs means that we can no longer use the standard Jorgenson user cost approach to measuring the annual cost of using capital or the total cost function in deriving parameters for optimal regulation. This is because sunk assets, by definition, cannot be freely traded in a second-hand market which is a key assumption of the standard user cost approach. Rather, it is necessary to change to using operating (or variable) expenditure (opex) cost functions for the regulated firm as explained in Economic Insights (2009b).

An opex cost function that minimises the variable input costs associated with producing an output target, conditional on the availability of a fixed quantity of capital stock components is an appropriate depiction of the situation. Using this framework we are able to recognise that the firm's relevant decision making options each period are to alter its level of opex given the quantity of sunk investments it has that period. It can opt to change the level of sunk investments gradually over time by undertaking additional investment or allowing the existing stock to run down but it cannot treat capital stocks as freely variable from period to period as has been the implication of past theory developed in this area.

The term opex or variable cost is used here to refer to all non-capital costs (assuming all capital is sunk in nature). This includes operating expenditure whose benefits are confined to the current period and routine maintenance associated with original anticipated asset lifetimes. Items such as refurbishment and remedial action which extend asset lives should be treated as capital expenditure and not as opex, ie they should be capitalised and expensed over the subsequent periods where they deliver benefits to the producer.

Instead of the Jorgenson user cost playing a key role, the opex cost function approach means that we now have a user benefit defined as the negative of the change (since it represents a saving) in the opex cost function in response to a change in the sunk cost capital stock playing an analogous role. Put another way, the user benefit is the marginal saving in opex that could be obtained by increasing sunk capital by one unit while holding output constant. In equilibrium, the (discounted) sum of these anticipated user benefit terms is equal to the purchase price of the capital input.

As explained in detail in Economic Insights (2009b), the sunk costs counterpart to the traditional 'differential of a differential' X factor formula in (2) becomes:

$$\begin{aligned}
 (3) \quad X &\equiv \{[C/R] \Delta TFP - \Delta TFP_E\} - \{[C/R](s_X \Delta W_X + s_K \Delta P_{kD}) - \Delta W_E\} \\
 &\quad + [\Pi/R] \Delta Y - \Delta \Pi/R \\
 &= \text{TFP differential growth rate term} - \text{input price differential growth rate term} \\
 &\quad + \text{nonzero profits adjustment term} - \text{rate of change of regulated profits term.}
 \end{aligned}$$

The first term in (3) is the differential rate of TFP growth between the regulated firm, ΔTFP , and the rest of the economy, ΔTFP_E . However, the TFP growth rate of the regulated firm must now be weighted by the ratio of the regulated firm's costs (including its cost of capital), C , to its revenues, R . The second term is the differential rate of growth of industry input prices (taken as a share weighted sum of the rate of the growth of opex input prices for the regulated firm, ΔW_X , and the rate of growth of allowable amortisation charges for sunk cost capital inputs, ΔP_{kD}) times C/R less the rate of growth of input prices in the rest of the economy, ΔW_E . Total cost for the regulated firm, C , is defined as the sum of variable or opex input costs plus allowable amortisation costs for sunk cost capital inputs. The regulated firm's input cost shares which appear in the input price growth differential term, s_X and s_K , are defined as the ratio of variable or opex cost to total cost and the ratio of allowable amortisation costs to total cost, respectively.

The last two terms on the right hand side of (3) involve the level of excess profits of the regulated firm, Π , the rate of change of excess profits, $\Delta \Pi$, and output, Y . If the excess profits of the regulated firm are not close to zero, then if excess profits were markedly positive, the regulator will likely want to set $\Delta \Pi$ equal to a negative number in order to reduce these excess profits over time. On the other hand, if excess profits were substantially negative, then the regulator will likely want to set $\Delta \Pi$ equal to a positive number in order to maintain the financial viability of the regulated firm. Thus, when excess profits are substantially different from zero, the regulator will typically want to set a glide path for profitability so that either profits in excess of what is required to raise capital in the industry are eliminated or, in the case of negative profits, a glide path must be set to restore the long term solvency of the regulated firm. In the case where excess profits are positive, typically the regulator will set $\Delta \Pi$ in the price cap formula (3) equal to a negative number, which will cause the proportional change in regulated prices to become smaller, ie under these conditions the price cap will become more stringent.

When regulation involves several firms and past average rates of technical progress or of TFP growth are used in setting a common rate of change going forward, then the measurement of these rates becomes critical. In particular, the use of average TFP growth rates across a number of regulated firms can create an uneven playing field since the ingredients which go into TFP growth, as shown in Economic Insights (2009b), can contain terms which are beyond the control of the individual regulated firm. The use of a common rate of TFP growth which encompasses technical progress and other factors that affect TFP can mean that factors specific to individual firms are not adequately allowed for unless appropriate adjustments can be made to starting point prices.

If a common rate of productivity growth is to be used in setting the price cap when regulating a group of firms using productivity-based regulation, then output specification becomes important since different output concepts can lead to different estimates of both technical

progress and TFP growth. In particular, it is desirable for the output measure to capture as fully as possible what regulated services are being provided by the firms in the group, independently of the institutional and historical factors that determine how the firms happen to charge consumers. As shown in Economic Insights (2009a,b) and appendix B, if a broad functional output coverage is used then it is necessary to allow for deviations of prices actually charged from marginal costs.

As noted above, when there are significant sunk costs the appropriate annual cost of capital inputs becomes the series of amortisation charges for the capital good approved by the regulator. These approved amortisation charges should ideally be the marginal user benefits from the sunk capital (ie the opex savings from an increase in sunk capital while holding output constant). They can be readily structured to achieve FCM.

A range of asset valuation methodologies can be consistent with FCM, provided that the allowed cost of capital interest rates are equal to the firm's opportunity cost of financial capital. Each methodology will generate a time-series of asset values and the series of amortisation charges are used to ensure financial capital maintenance is achieved. The main difference between asset valuation methods (assuming standard regulatory depreciation approaches such as straight-line) is on the timing of revenue receipts rather than their net present value. The important requirements are that the amount actually invested is the opening asset value in the first period and the scrap value is the closing asset value in the last period. Efficiency considerations would further suggest the amount actually invested should have been an efficient amount.

This makes the approach to measuring capital costs in productivity-based regulation in the presence of sunk costs and the achievement of FCM similar to that typically used in building blocks regulation. Note that although it is critical – given the characteristics of energy network assets – to use a service potential profile that reflects one-hoss shay deterioration in measuring the capital input quantity, the capital cost charges can be based on a range of forms of depreciation provided they satisfy the condition of ex ante FCM. To ensure consistency with regulatory reporting we use return of capital based on straight-line depreciation.

Section 53P(3) of the Act allows the Commission to set starting prices for each EDB taking account of the EDB's current and projected profitability. Commerce Commission (2009) has indicated the Commission is considering using partial building blocks analysis to inform its decisions on starting price adjustments with the aim of bringing EDB profitability levels into a narrower band. If we assume that this mechanism will be used to bring costs and revenue into (approximate) equality then we are able to considerably simplify equation (3) above as follows:

$$(4) \quad X \equiv \{\Delta TFP - \Delta TFP_E\} - \{(s_X \Delta w_X + s_K \Delta P_{kD}) - \Delta W_E\}$$

= TFP differential growth rate term – input price differential growth rate term.

As noted in Economic Insights (2009a,b) and appendix B, (4) can be implemented using measures of TFP that use either the traditional method based on revenue-weighted sold outputs or built up using estimates of technical progress, the deviation of prices from marginal costs and the deviation of amortisation charges from marginal user benefits. While

the latter decomposition is preferable, the information required is not readily available and would require more extensive econometric estimation. Instead, for the purposes of the current implementation of (4) we adopt the traditional revenue-weighted outputs approach. Since disaggregated revenue data are not part of the Information Disclosure Data and are not readily available, we use output cost shares as output weights. This approach has commonly been adopted where disaggregated revenue data are not readily available (eg PEG 2008a).

The focus of the remainder of this report is on providing estimates of the components of (4) that could be used by the Commission in setting the default price path rate of change.

2.4 Earlier electricity distribution productivity studies

The former thresholds regime was based on quantitative work reported in Lawrence (2003). To capture the multiple dimensions of lines business output Lawrence (2003) measured distribution output using three outputs: throughput, system line capacity and connection numbers. Inputs were broken into five categories: operating expenses, overhead lines, underground cables, transformers and other capital.

Lawrence (2003) used the Fisher TFP index method to calculate the productivity performance of the electricity distribution industry as a whole. For the period 1996 to 2002 aggregate distribution TFP was found to have increased at a trend annual rate of 2.1 per cent, 1.0 per cent above that for the economy as a whole. The trend incorporating the 2003 data was similar but as less confidence could be placed in the estimated operating expenditure data constructed for the full year equivalents of the three businesses which acquired UnitedNetworks half way through that year, Lawrence (2003) took the trend TFP growth rate up to 2002 as the most robust estimate.

Lawrence (2003) found there are several conflicting pieces of information on the movement of lines business input prices relative to those for the economy as a whole. Wage rates in the electricity, gas and water sector had increased by less than those for all industries in the nine years to March 2003 although the gap had narrowed somewhat in the last two years and anecdotal evidence at the time pointed to a shortage of linesmen.

Capital price indexes gave conflicting information with one power line price index increasing faster than the capital price index for all sectors and the other major power line price index increasing less rapidly than the all sectors index. Producer price indexes, on the other hand, show that lines business input prices had increased less rapidly than input prices for all industries. The implicit total input price index derived from the Lawrence (2003) distribution database increased at the same trend rate as economy-wide capital prices but substantially less than economy-wide wage rate and producer input price indexes. In light of the conflicting information coming from the official statistics Lawrence (2003) recommended setting the input price growth differential to zero.

Combining the 1.0 per cent productivity growth differential and the zero per cent input price growth differential, Lawrence (2003) recommended a B factor of 1.0 per cent for the electricity distribution industry and this was adopted by Commerce Commission (2003).

Lawrence (2007) updated the EDB productivity analysis presented in Lawrence (2003) to cover the years 2004 to 2006. Lawrence (2007) made some minor revisions to the data used

in the earlier study for the years 1996 to 2003 as errors contained in the official Disclosure Data had progressively been identified and corrected. To maintain maximum comparability with Lawrence (2003), Lawrence (2007) used an adjusted asset value series that excluded the 2004 optimised deprival value (ODV) asset revaluations.

Extending the period covered forward to 2006 led to the electricity distribution industry output trend growth rate increasing to 1.6 per cent per annum but inputs then increased by a trend growth rate of 0.7 per cent, instead of decreasing as they had up to 2002. This led to the industry TFP annual trend growth rate for the 11 year period as a whole falling to 0.9 per cent. TFP fell by just under 2 per cent in each of the years 2004 and 2005 before increasing marginally in 2006.

The fall in electricity distribution industry TFP in 2004 and 2005 was found to be mainly in response to a sharp increase in opex and strong growth in the capital stock, particularly increases in underground cables and transformers. The quantity of opex was found to have increased by 14 per cent over this two year period, accounting for nearly 40 per cent of the increase in the total input quantity. Part of the reason for this increase was thought to be large increases in opex for the three businesses that took over the former UnitedNetworks. A series of unusual storms around this time may also have contributed to the observed opex increases.

3 DATA

The principal data source for this study is the official EDB Disclosure Data required under the *Electricity (Information Disclosure) Regulations*. These data were first required for the 1995 March year and included physical, service quality and financial information. Legal (as opposed to reporting) separation of distribution and retail activities occurred during the 1999 financial year¹, and the disclosure data requirements were revised at that time. Some corrections were made to the data in Lawrence (2003) to reflect the businesses' responses to the opportunity to comment on the data set and to ensure maximum consistency of the data through time. Further minor corrections were made in Lawrence (2007) as it became apparent that different EDBs had reported variables on different bases or changed their basis of reporting through time and further corrections have been made in the current study to maintain consistency between the earlier information disclosure formats and the revised format adopted for the 2008 reporting year.

We use the 13 data years 1996–2008 to calculate trend rates of aggregate industry and 'non-exempt' productivity growth. The 1995 data year was discarded due to the apparent teething problems with providing Information Disclosure Data (IDD) in the first year and the absence of ODV estimates. A number of assumptions outlined in Lawrence (2003) are also made in this study to address opex data discontinuities in the 1999 financial year and the effects of the extended Auckland CBD outage.

The key variables for the 13 year aggregate industry database and the 'non-exempt' EDB database are listed in appendix A.

3.1 Refinements included in the current study

The Commission has asked Economic Insights to consider three possible refinements to the TFP methodology used in setting the thresholds B factor (Lawrence 2003, 2007). These relate to: using indexed historic cost (IHC) to value EDB assets instead of the Optimised Deprival Value (ODV) series formerly used and associated allowance for sunk costs and FCM; extending the output measure of system capacity to include transformer capacity as well as line capacity; and, appropriate treatment of the input price growth differential term in the full X factor formula taking account of the sunk cost nature of EDB assets.

Using indexed historic cost and FCM

As noted in section 2, to form total output and total input measures a price and quantity for each output and each input, respectively, is required. The quantities enter the calculation directly as it is changes in output and input quantities that we are aggregating. The prices are used to weight together changes in all output quantities and all input quantities into measures of total output quantity and total input quantity, respectively. Like other inputs and outputs, a quantity and cost for capital inputs are thus needed.

¹ We adopt the convention that financial years are referred to by the year in which they end.

Asset values will affect the cost of using capital inputs and can affect the capital input quantity if a constant price depreciated asset value series is used as a proxy for capital input quantities.

In the TFP analysis used in the thresholds regime, Lawrence (2003) used the annual ODVs reported in the Information Disclosure Data as the asset values used in forming the annual user cost of capital. An approximate measure of the annual user cost of capital inputs was used based on 12.5 per cent of the ODV. This method drew on earlier work done by the NZIER (2001) and earlier Australian TFP studies (eg Tasman Asia Pacific 2000). Because the TFP model used physical quantity measures to proxy the annual service potential (or capital input quantity) of overhead lines, underground cables and transformers, the ODV asset values only affected the relative weights applied to the capital and opex input quantities in forming total inputs.

The Commission retained Economic Insights to advise it on the preferred method of asset valuation for use in productivity-based regulation. Economic Insights' (2009a,b) assessment of the methods clearly supported the use of historic cost rather than replacement cost-based valuations as the preferred valuation method for use in productivity-based regulation. IHC was the only one of the three methods examined which satisfied all 7 evaluation criteria covering efficiency, financial capital maintenance, consistency, accuracy, transparency and cost effectiveness.

The review considered IHC to be superior to Depreciated Historic Cost (DHC) in terms of intertemporal economic efficiency considerations that relate to the time profile of prices. It effectively 'back-end loads' the profile of receipts which to the extent that prices influence demand encourages utilisation of the asset in the early stages of its life while serving to ration use once the asset becomes fully utilised towards the end of its life. This reflects the likelihood of network assets being constructed in discrete lumps and thus having scope to accommodate substantial demand growth over their lifetime.

Given that true historical or original costs for energy network assets are likely to be unobtainable given the long-lived nature of the assets and changes in organisational structure and record keeping over the decades, the application of IHC will need to use the earliest available reliable ODV as its starting point. In practice then, the difference between the two methods would relate to the method used for roll-forward of the asset value.

In preliminary work for the thresholds reset in 2008, the Commission retained Denis Lawrence to update the Lawrence (2003, 2007) productivity analyses but using IHC asset values rather than the ODV series used in the earlier studies.

The first obstacle encountered in this exercise was obtaining actual additions and disposals data with which to update and backdate from the starting value. Although additions data are included in the IDD filings up to 2007, these were valued at the relevant ODV unit rates rather than at actual cost. To obtain actual additions and disposals data, the Commission requested data from the EDBs under Section 98 of the Act. Given relevant data availability was limited prior to 2004, it was only possible to form an approximate IHC series from 2004 onwards (using the 2004 ODV as a proxy for opening original cost). For the years prior to 2004 it was necessary to splice the year-to-year proportional changes in the ODV series (adjusted to exclude revaluations) onto the series from 2004 onwards.

While not ideal given the need to include the years prior to 2004 using additions calculated using ODV unit rates rather than actual cost, the approach adopted appeared adequate given the TFP specification used. A similar approach is used in this study. This has been facilitated by the requirement in the IDD returns from 2008 onwards to disclose IHC consistent roll forwards going back to the 2004 ODVs. This has made it relatively straightforward to construct an IHC series from 2004 onwards and to splice the earlier ODV series as a proxy for IHC for the years prior to 2004.

Economic Insights also notes that the major issue with the 2004 electricity ODV estimates was the change in the way underground cables were valued. Some of the cables previously allocated overhead lines as the modern equivalent assets have been ‘unoptimised’ in the 2004 valuations and underground unit rates are now used in their valuation. The 2004 ODV was also the first one where disaggregated ODV information was available for all EDBs. This improved information led to significant changes in asset shares used in the productivity analysis for all EDBs and, hence, for the industry level analysis compared to the shares estimated in Lawrence (2003). Disaggregated ODV data for the 2004 year are reported in the 2008 IDD and are used in this study as the basis for splitting asset values and amortisation charges across capital components.

The other important change considered in this study is the calculation of FCM consistent amortisation charges based on the IHC series. The method for doing this is described in section 3.3.

Including transformer capacity in the system capacity output

Two criticisms of the TFP output and input specification used in setting the thresholds B factor are that: (a) the system capacity output only measures line capacity and does not include transformer capacity; and, (b) that line capacity as measured by MVA–kilometres appears in both input and output variables.

Electricity distribution output capability to serve consumers depends on the throughput capacity of the distribution transformers at the final level of transformation to utilisation voltage, as well as on the length and capacity of mains over which supply is delivered.

The MVA–kilometres measure used in Lawrence (2003, 2007) is the summation of mains length kilometres at various voltages weighted by a capacity factor appropriate to each voltage and does not recognise the role of transformation in the delivery capacity.

Between 2000 and 2008 distribution transformer capacity has grown relatively rapidly while line capacity growth has been quite modest. Over this period distribution transformer capacity measured in kVAs increased by 20 per cent while lines MVA–kilometres increased by only 9 per cent. The MVA–kilometres line length measure is, therefore, underestimating the growth in effective system capacity available. The failure to include transformer capacity in the system capacity output (which reflects the ability to meet capacity demands) means that output would be underestimated using the Lawrence (2003, 2007) TFP specification.

What is required is a system capacity measure which recognises the role of transformer capacity as well as mains length. One such measure is a simple product of the installed distribution transformer kVA capacity of the last level of transformation to the utilisation

voltage and the totalled mains length² (inclusive of all voltages but excluding streetlighting and communications lengths).

The advantage of including such a measure is that it recognises the key dimensions of overall effective system capacity. It also avoids the inclusion of elements of the MVA–kilometres variable on both the input and output sides of the TFP specification. It should be noted that the product of final level distribution transformer capacity and line length was included as the system capacity output measure in the econometric work undertaken in Lawrence (2003).

The impact of using a system capacity output measure that recognises transformer capacity as well as lines capacity is likely to be an increase in the output growth rate and, hence, measured TFP growth given that transformer capacity growth has exceeded line capacity growth in recent years. It is, however, likely to provide a better proxy for capacity demands.

Incorporating the input price growth differential in the presence of sunk costs

As noted in section 2, recognising the existence of substantial sunk cost investments in energy networks means the standard user cost approach to measuring the annual cost of using capital inputs can no longer be used. This is because sunk assets, by definition, cannot be freely traded in a second–hand market and hence a key assumption the standard user cost approach is based on is violated. The standard user cost approach multiplies the value of the capital stock by the sum of the depreciation rate plus the opportunity cost rate minus the rate of capital gains (ie the annual change in the asset price index).

As shown in Economic Insights (2009a,b), the appropriate term to include in calculating the input price growth differential in equation (4) is the rate of growth of allowable amortisation charges for sunk cost capital inputs rather than either the standard user cost or simply the capital goods price index as has been used in the past.

Implementing the input price growth differential component of the traditional X factor formula (2) has often proven problematic for regulators because of the erratic and unreliable movements in many input price indexes, particularly capital goods input price indexes. This is because statistical agencies typically devote fewer resources to compiling industry input price indexes and the samples tend to be relatively small. In setting the former EDB thresholds, the Commission decided not to include an input price growth differential term because of contradictory information coming from relevant available capital goods price indexes.

Setting the amortisation charges for capital inputs which are relevant when there are sunk costs involves a similar process to that currently used in building blocks regulation. That is, the initial regulatory asset base is taken as the starting point and this is then amortised over the weighted average asset life to satisfy ex ante FCM. New investment which enters during the regulatory period is similarly allowed for (over its full expected lifetime) to ensure ex ante FCM is satisfied. This is done for the industry and for ‘non–exempt’ EDBs as a whole.

If there was rapid inflation in the price of capital inputs used by EDBs then using the X factor formula in (4) would likely lead to lower price increases than using the traditional X factor formula – were the input price growth differential term to be included in the latter based on

² Note this is kilometres and not MVA–kilometres.

capital input prices (and without FCM). This is because the amortisation charges for capital that is already sunk are determined based on the amount actually spent in the past (with indexing of sunk capital based on the CPI) and are not affected by subsequent differential inflation between capital asset prices and the CPI. However, inflation in capital asset prices would be incorporated in additional capital expenditure as it is incurred. Conversely, in times of deflation in the price of capital inputs used by EDBs, the use of (4) would lead to higher price increases than the traditional formula because it is based on amortisation charges using the original investment cost rather than prices of the day applied to the whole capital stock.

3.2 Output and input definitions

Output quantities

Throughput: The quantity of electricity distribution throughput is measured by the number of kilowatt hours of electricity supplied.

System line capacity: The quantity of the electricity distribution system line capacity is measured by its total MVA kilometres. The MVA kilometres measure seeks to provide a more representative measure of system line capacity than either line length alone or the simpler measure obtained by summing the product of line kilovolt rating by corresponding line kilometres. Low voltage distribution lines were converted to system capacity in MVA kilometres using a factor of 0.4, 6.6kV high voltage distribution lines using a factor of 2.4, 11kV high voltage distribution lines using a factor of 4, 22kV high voltage distribution lines using a factor of 8, 33kV high voltage distribution lines using a factor of 15, 66 kV lines using a factor of 35, and 110 kV lines using a factor of 80. These factors are based on Parsons Brinckerhoff Associates (2003). They have been tailored specifically to reflect New Zealand operating conditions and the fact that the effective capacity of an individual line depends not only on the voltage of the line but also on a range of other factors, including the number, material and size of conductors used, the allowable temperature rise as well as limits through stability or voltage drop.

Overall system capacity: Overall system capacity is measured by the product of the electricity distribution industry's installed distribution transformer kVA capacity of the last level of transformation to the utilisation voltage and its totalled kilometres of mains length (inclusive of all voltages but excluding streetlighting and communications lengths).

Connections: Connection dependent and customer service activities are proxied by the distributor's number of connections.

Output weights

To aggregate a diverse range of outputs into an aggregate output index using indexing procedures, we have to allocate a weight to each output. In traditional TFP estimates for industries producing multiple outputs these output weights are taken to be the revenue shares. However, in the case of natural monopoly network industries information on disaggregated revenue is often not readily available. A common practice in these situations has been to use information on output cost shares derived from econometric cost functions as a proxy for revenue shares (eg PEG 2008a). We use the output cost shares derived from the econometric Leontief cost function presented in Lawrence (2003) using data for the years 1996–2002. A

weighted average of the output cost shares was formed using the share of each observation's estimated costs in the total estimated costs for all EDBs and all time periods. This produced an output cost share for throughput of 22 per cent, for system capacity of 32 per cent and for connections of 46 per cent. This is the closest approximation currently available to the output shares derived in Economic Insights (2009b).

Total electricity distribution industry revenue is taken to be 'deemed' revenue comprising line charges plus revenue from 'other' business plus AC loss rental rebates less payment for transmission charges less avoided transmission charges less AC loss rental expense paid to customers. Line charge revenue is taken to be net of discounts to customers.

Input quantities

Operating expenditure: The quantity of electricity distribution operating and maintenance expenses is derived by deflating the sum of the grossed up values of direct costs per kilometre and indirect costs per customer by the index of labour costs for the electricity, gas and water sector. The grossed up values of direct costs per kilometre and indirect costs per customer are used as the value of operating costs because these measures best reflect the purchases of actual labour, materials and services used in operating the electricity distribution system and exclude rebates. The index of labour costs for the electricity, gas and water sector is used as the price of operating expenditure as it directly measures the price of a major component of operating expenditure.

Overhead network: The quantity of poles and wires input in the overhead network is proxied by the electricity distribution industry's overhead MVA kilometres calculated using the same factors as listed above.

Underground network: The quantity of underground cables input is proxied by the electricity distribution industry's underground MVA kilometres calculated using the same factors as listed above.

Transformers and other assets: The quantity of transformer and other asset inputs is proxied by the KVA of the electricity distribution industry's installed transformers.

Input weights

For the update of the Lawrence (2003, 2007) specification, the value of total costs is formed by summing the estimated value of operating expenditure and 12.5 per cent of total (estimated) IHC. The latter is based on the NZIER (2001) assumption of a common depreciation rate of 4.5 per cent and an opportunity cost rate of 8 per cent for capital assets. In the specification recognising sunk costs and FCM we take total costs to be the sum of operating expenditure and amortisation charges. The method used to calculate amortisation charges is described in section 3.3.

The weight given to opex is its share in total cost while the residual weight is given to capital. The weights given to the three capital input components are the shares of each component in the 2004 ODV multiplied by the overall capital share in total cost.

'Non-exempt' EDBs

The Commission has requested Economic Insights to prepare TFP estimates for the group of 'non-exempt' EDBs as well as for the electricity distribution industry as a whole. The Act specifies that 'consumer-owned' EDBs will be exempt from price-quality regulation. However, the exact composition of this group is not yet known. Rather, the assessment of consumer-owned status is intended to be retrospective and will not occur until May 2010.

It is, therefore, only possible to do a preliminary appraisal of the EDBs against the four criteria listed in section 54D of the Act to assess their likely status. A preliminary appraisal has indicated that 12 EDBs may qualify for 'consumer-owned' status in that they:

- are 100 per cent consumer owned (trust owned) as required by criterion (a)
- have trust deeds meeting the election requirements stipulated by criterion (b)
- have at least 90 per cent of consumers benefiting from income distribution as required by criterion (c), and
- have less than 150,000 ICPs as required by criterion (d).

The 12 EDBs are:

- Buller Electricity
- Counties Power
- Electra
- MainPower New Zealand
- Marlborough Lines
- Network Waitaki
- Northpower
- Scanpower
- The Power Company
- Waipa Networks
- WEL Networks, and
- Westpower

Our 'non-exempt' results thus exclude these 12 EDBs.

3.3 Amortisation charges

FCM consistent amortisation charges

FCM-consistent amortisation charges can be calculated using a large number of different capital charge profiles. In this study, the profile assumes straight line depreciation of existing assets and capital expenditure based on respective asset lives and estimates the charges in nominal terms for each year using a building blocks approach. This entails adjusting the starting point asset value each year for inflation, the carry forward of depreciation charges

adjusted for inflation and the use of a real pre-tax return each year. As a real pre-tax rate of return is used and assets are revalued to take account of inflation there is no need to make an additional adjustment to remove revaluation gains from the estimated nominal capital charges.

A range of amortisation charges is calculated corresponding to an assumption that the relevant real post-tax discount rate is in the order of 6 per cent. The pre-tax discount is actually the one that is most relevant for determining prices since taxes have to be paid out of gross revenue received. However, the effective pre-tax discount rate applying to EDBs is not currently known. If the effective tax rate was zero the pre-tax discount rate would coincide with the post-tax rate. If the current corporate tax rate of 30 per cent was the effective tax rate then the pre-tax rate would be 8.6 per cent (since $0.06/(1-0.3)=0.086$). However, the effective tax rate paid by EDBs will be less than the statutory corporate tax rate. We, thus, look at an upper bound pre-tax discount rate of 8.6 per cent and a lower bound pre-tax discount rate (ie the post-tax discount rate) of 6 per cent.

Starting point asset values, new investment and asset lives

The amortisation charges for system fixed assets were calculated for the electricity distribution industry as a whole for the period 1996 to 2008. As in Lawrence (2003, 2007) non-system fixed assets are excluded due to their relatively small size. As noted in sections 3.1 and 3.4, an 'IHC' asset value series is available from 2004 to 2008 using the 2004 ODV revaluations as the starting point. The components required to roll back before 2004 on an IHC basis are not available and so the earlier ODV series from Lawrence (2003, 2007) was spliced onto the 2004 ODV to proxy the IHC series from 1996 to 2003.

The ODV for year ended 2004 was used as a base to determine the amortisation charge over the remaining life of the assets from 2005 onwards. A charge also had to be calculated for new investment from 2005 to 2008 to recover the cost of new investments over their assumed lives. Asset additions data from the IDD were used as estimates of new investment from 2005 to 2008.

To calculate charges from 1996 to 2004 a similar process was applied to the estimate of capital as at the end of 1995. Since no ODV value was reported in the 1995 IDD, it is estimated by applying the average annual growth rate of the ODV series from 1996 to 2003 to the 1996 reported ODV.

Estimated nominal asset additions for 1996 to 2003 were calculated by use of the perpetual inventory formula $I_t=K_t-(1-d)K_{t-1}(1+p)$, where the depreciation rate 'd' was assumed to be 0.039 based on the average of IDD reported depreciation for the period 1996 to 2003 and the inflation rate 'p' was based on the all groups CPI from Statistics New Zealand.

In order to calculate the amortisation charges, asset lives for new investment and remaining asset lives for the asset value bases at the start of 1996 and start of 2005 had to be estimated. Estimates of total asset lives and remaining asset lives as of March 2007 were obtained from Farrier Swier Consulting (2007). Based on this report, the mean standard asset life for the total asset base was 52 years and the ratio of the average age of the network to mean standard lives was 0.49 as of March 2007. Based on these estimates, the remaining mean asset life of

the existing asset based was assumed to be 26 years as of March 2007 (37 years in 1996) and the mean standard asset life of new investment was assumed to be 52 years.

The charges prior to 2005 were also adjusted to remove discontinuity in the two series (given that the data prior to 2004 provide only an approximation to relevant IHC series). This was done by obtaining estimates of amortisation charges for 2005 by both approaches and applying the ratio of the 2005 estimate based on the 2004 ODV asset value to the 2005 estimate based on the 1996 spliced ODV and IHC asset value, to the estimated charges based on the latter asset values.

Nominal amortisation charges based on a building blocks approach

The amortisation charges comprise a return on capital and a return of capital in nominal terms for each year.

To determine the nominal return on capital in current year prices it is necessary to calculate an opening value of the asset base each year adjusted for inflation and then multiply it by the real pre-tax rate of return.

The opening asset base for each year is equal to the closing book value of the preceding year calculated as follows:

Closing book value = Opening book value plus current year capex less depreciation (excluding depreciation on current capex) less depreciation on current year capex plus revaluation of depreciated opening assets.

The depreciation for the first year is calculated on a straight line basis and residual asset life.

The depreciation of current year capex is calculated at half the normal depreciation rate for new assets (based on assuming installation at mid-year).

The depreciation in each year for existing assets (except the first year) is the depreciation for the preceding year (excluding depreciation of current year capex) adjusted for inflation using the current year inflation rate, plus a full year's depreciation on the previous year's capex (after deducting the previous half year of depreciation).

The revaluation of depreciated opening assets is calculated by applying the inflation rate for the current year to the opening asset value less depreciation (excluding depreciation of current year capex).

The return of capital in each year is the sum of the depreciation of existing assets and the depreciation of current year capex.

The return on capital each year is the sum of the product of the real pre-tax return on capital and the opening asset value and half the product of the real pre-tax return on capital and current year capex. This latter component recognises that current year capex is put in place mid-year.

Issues for future consideration

There are a number of issues that warrant further consideration. These include:

- Taxation: There is scope to refine the appropriate real pre-tax rate of return once more information on EDB effective tax rates comes to hand (as prices need to be specified in

pre-tax terms).

- Asset classes: Allowing for several asset classes (with different asset lives) is straightforward, as one only has to vary the asset life and undertake the calculations by asset class before aggregating into a total amortisation charge.
- Disposals: Adjustment of the amortisation charge for disposals would involve determining what year the asset being disposed of was first included in the capital base and then deducting for subsequent years the amortisation amount corresponding to that asset.

3.4 Data changes compared to Lawrence (2003, 2007)

Apart from the specification changes discussed in the preceding sections, the three significant data changes in this study compared to Lawrence (2003, 2007) all relate to capital.

The Lawrence (2003) study was undertaken before the 2004 ODV revaluations were available. To maintain comparability with Lawrence (2003), the Lawrence (2007) study removed the effect of the 2004 revaluation step change increase from the ODV series used. Since the 2004 ODV valuations are now used as the starting point for IHC calculations (as their treatment of underground cables, in particular, is considered superior to earlier valuations) in the current study we splice the series for the years prior to 2004 onto the 2004 ODV value. In Lawrence (2007) the alternative approach of splicing the 2004 and later years' series onto the old series up to 2003 was adopted. All else equal, the effect of the approach used in this study compared to Lawrence (2003, 2007) will be to allocate a somewhat higher weight to capital inputs compared to opex.

The second change relates to the shares allocated to the capital components. In Lawrence (2003) only limited disaggregated ODV data were available. A number of allocation assumptions had to be made and the quality of the available data was very variable. To allocate ODV to the four asset classes used, Lawrence (2003) took the weighted average shares for the EDBs that had these data in each of four groups (rural high density, rural low density, urban high density and urban low density) and applied these shares to all EDBs in the respective group. This strategy was adopted to minimise risks as little confidence could be placed in the disaggregated asset data for several of the EDBs. Input weights were then formed from the share of the cost of each of the five inputs in total cost.

Lawrence (2007) used the same approach but also reported results using EDB-specific shares derived from the much more detailed 2004 ODV data. This exercise revealed that some of the EDBs in the four groups used in Lawrence (2003) were outliers compared to their group averages and so the use of the averaged group shares was less appropriate for them. More generally, the earlier ODV exercises had significantly undervalued underground cable assets. In the current study we use the disaggregated ODV data reported for 2004 in the 2008 IDD. In line with the practice of using publicly available IDD information wherever possible, this source is used in preference to the corresponding Commission calculations used in Lawrence (2007) and corresponding information obtained in 2008 under the Section 98 requests.

The 2008 IDD disaggregated ODV information is reported for seven categories: Subtransmission; Zone substations; Distribution and LV lines; Distribution and LV cables;

Distribution substations and transformers; Distribution switchgear; and, Other system fixed assets. The last three of these and the second are allocated to Transformers and other assets in the current study. Distribution and LV lines and cables are allocated to Overhead and Underground, respectively, in the current study. To allocate the IDD Subtransmission category between Overhead and Underground in the current study we assume that underground subtransmission cable costs three times the amount per kilometre of corresponding overhead line. We then divide Subtransmission on the basis of overhead and underground subtransmission reported lengths and this difference in costs per kilometre. The difference in costs per kilometre is based on unit rates reported in the 2004 ODV Handbook.

The third change we make in the current study compared to Lawrence (2003, 2007) is to combine the transformers and other assets components in the earlier studies into one component in this study. The quantity of the combined component is taken to be the transformer capacity. The share of other assets in the Lawrence (2003, 2007) databases was quite small and there was not a satisfactory way of deriving a separate quantity for this residual input.

3.5 Other measurement issues

Including reliability as an output

The Lawrence (2003) output and input specification included three outputs (throughput, system capacity and customer numbers) and five inputs (opex, overhead lines, underground cables, transformer capacity and other capital). This general specification was used in Lawrence (2007) and is retained in the current study although some significant refinements are made. While a significant advance over earlier TFP specifications, this general specification of outputs and inputs still has a number of limitations. Prime among these is the desirability of including reliability as an additional output variable. This is because providing a more reliable service will require more inputs to be used and, as the output specification stands, the electricity distribution industry will not receive any recognition or ‘credit’ on the output side for the better quality service while being ‘penalised’ for its higher input usage. However, Lawrence (2003) highlighted the difficulties of including reliability measures in the productivity measurement framework. This is because all common reliability measures involve improvements being decreases in the variable rather than increases as in the productivity framework. Previous attempts to convert reliability measures into a format consistent with the productivity framework have proven unsuccessful and so more work is required on this task. An additional important but problematic issue is the one of what output weight to assign to a measure of reliability in calculating total output within a TFP study.

Allowing for energy efficiency aims

Productivity-based regulation in the form of a default price path will be consistent with promoting some aspects of energy efficiency. For example, the use of embedded generation may be encouraged to the extent that it requires less additional line length to be constructed compared to additional connections to remote transmission off-take points – assuming that embedded generation energy is cost competitive with bulk supply energy.

EDBs may also have an incentive to better manage the profile of their demand under productivity-based regulation as there will be an incentive to maximise asset utilisation which will be achieved by flattening the load profile. More generally, EDBs will have an incentive to adopt more innovative solutions than under cost of service or building block regimes.

However, demand management that simply involves reducing the quantity of demand without a flattening in the load profile is unlikely to be consistent with productivity-based regulation unless the regulatory regime includes additional incentive parameters to reward the EDB or, at a minimum, compensate it for the loss of revenue it faces from a general reduction in throughput. Implementation of such schemes would face a number of practical issues such as the need to distinguish between reduced output from demand management initiatives and, say, general economic downturns.

Since the DPP is intended to be a generic and low cost form of regulation, it will not be possible to cover all energy efficiency contingencies or the individual circumstances of all EDBs.

Calculating growth rates

TFP studies have differed in the method used to calculate the TFP growth rate. Some have used the average annual growth rate between the first and last observations calculated using the logarithm of the ratio of the index values divided by the difference between the first and last years. Lawrence (2003), on the other hand, used a regression-based trend method which regressed the logarithm of the relevant variable against a constant and a linear time trend. The time trend regression coefficient is then the relevant growth rate.

Whether the difference between the two methods is material depends on whether the relevant series is stable or volatile and whether the first and last observations are relative outliers from the trend of the intervening years. If the series is relatively stable the two methods will give similar results. Economic Insights (2009c) demonstrates that when the first and last observations lie away from the underlying trend – and particularly if they lie in opposite directions from the underlying trend – then the endpoint to endpoint method can give results that are not representative of the underlying trend. This effect can be pronounced if a subset of years is taken as ‘more representative’ of the trend growth.

In this report we adopt the regression trend method used in Lawrence (2003) when reporting growth rates as this is less susceptible to endpoint outliers distorting the reported growth rate and thus gives a better representation of the underlying trend growth over the whole period.

4 ELECTRICITY DISTRIBUTION INDUSTRY PRODUCTIVITY

In this section we use the Fisher TFP index method to calculate the productivity performance of the electricity distribution industry as a whole and for the ‘non–exempt’ EDBs as a whole for the 13 years 1996 to 2008. We also examine the effect of using the overall system capacity output measure as compared to the system line capacity output measure previously used and the effect of using capital amortisation charges instead of the previous capital user cost proxy in forming the total inputs index. We first up date the TFP estimates from Lawrence (2003, 2007) before moving to our preferred specification based on Economic Insights (2009a,b). The update of the earlier specification is presented as a sensitivity analysis only. We then examine alternative approaches to forming the input price growth differential term.

4.1 The Fisher TFP index

TFP growth, under the traditional approach, is defined as the proportional change in total output divided by the proportional change in total inputs used between two periods. Mathematically, this is given by:

$$(5) \quad TFP = \Delta Q / \Delta I$$

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

We showed in our technical report that equation (5) can be decomposed into a pure technical change term, a term that weights output changes by the difference between price and marginal cost, a term that weights capital input changes by the difference between the cost of capital and user benefits and a term that weights output growth by the ratio of profits to cost (which will be zero if there are normal profits). However, we do not have the information to measure TFP in this way and, for the current implementation, we have defined TFP in the traditional way.

To operationalise equation (5) we need a way to combine changes in diverse output and input quantities into measures of change in total output quantity and total input quantity. To aggregate these changes in diverse components into a total change, index number methodology essentially takes a weighted average of the changes in the components. Different index number methods form this weighted average change in different ways. Alternative index number methods can be evaluated by examining their economic properties or by assessing their performance relative to a number of axiomatic tests. The index number which performs best against these tests and which is being increasingly favoured by statistical agencies is the Fisher ideal index.

Mathematically, the Fisher ideal output quantity index is given by:

$$(6) \quad Q_F^t = [(\sum_{i=1}^m P_i^B Y_i^t / \sum_{j=1}^m P_j^B Y_j^B)(\sum_{i=1}^m P_i^t Y_i^t / \sum_{j=1}^m P_j^t Y_j^B)]^{0.5}$$

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

P_i^B	is the price of the i th output for the base observation;
Y_i^t	is the quantity of the i th output for observation t ;
P_i^t	is the price of the i th output for observation t ; and
Y_j^B	is the quantity of the j th output for the base observation.

In this case we have three outputs (so $m = 3$) and 13 years (so $t = 1, \dots, 13$).

As noted in section 3.2, disaggregated revenue information is not reported in the Information Disclosure Data and is not readily available. We use the output cost shares derived from the econometric cost function presented in Lawrence (2003) as a proxy.

Similarly, the Fisher ideal input quantity index is given by:

$$(7) \quad I_F^t = [(\sum_{i=1}^n W_i^B X_i^t / \sum_{j=1}^n W_j^B X_j^B) (\sum_{i=1}^n W_i^t X_i^t / \sum_{j=1}^n W_j^t X_j^B)]^{0.5}$$

where:	I_F^t	is the Fisher ideal input quantity index for observation t ;
	W_i^B	is the price of the i th input for the base observation;
	X_i^t	is the quantity of the i th input for observation t ;
	W_i^t	is the price of the i th input for observation t ; and
	X_j^B	is the quantity of the j th input for the base observation.

In this case we have four inputs (so $n = 4$) and 13 years (so $t = 1, \dots, 13$).

The Fisher ideal TFP index is then given by:

$$(8) \quad TFP_F^t = Q_F^t / I_F^t .$$

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

$$(9) \quad Q_F^{1,t} = 1 \times Q_F^{1,2} \times Q_F^{2,3} \times \dots \times Q_F^{t-1,t} .$$

4.2 Distribution industry productivity growth

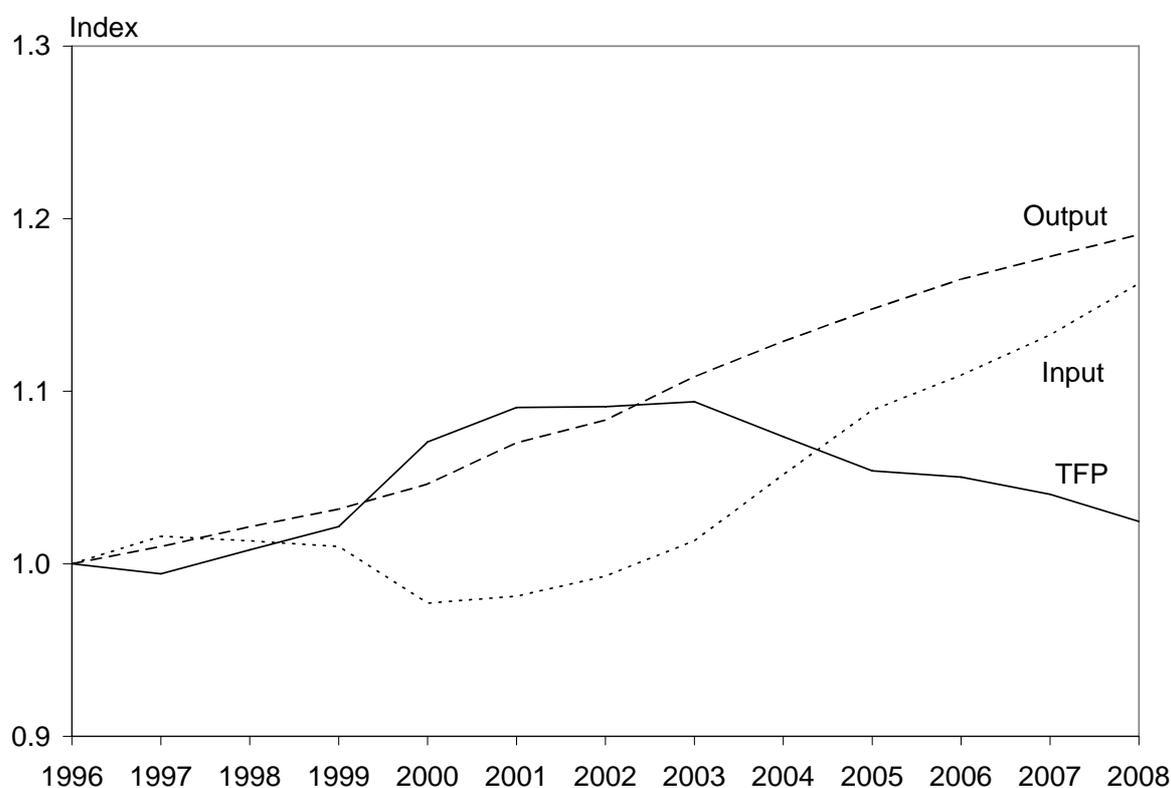
Updating TFP with lines system capacity output and 12.5% of ODV capital cost proxy

We look first at the results of updating the Lawrence (2003, 2007) analyses (but with the capital data changes outlined in section 3.4). The outputs are energy delivered in kilowatt hours, system line capacity in MVA kilometres and connection numbers. The four inputs are operating costs, overhead lines capital, underground lines capital, and transformer and other

capital items. The simple proxy of 12.5 per cent of adjusted ODV is used to approximate annual capital user costs in forming the total inputs index.

TFP results for the aggregate distribution industry are presented in figure 1 and table 1 using the chained Fisher indexing method for the 13 years of available data from 1996 to 2008. The output trend growth rate over this period was 1.6 per cent per annum while that for inputs was 1.3 per cent per annum. This leads to the TFP annual trend growth rate for the 13 year period as a whole falling to only 0.3 per cent per annum. TFP falls in each of the years after 2003 with falls of nearly 2 per cent in 2004 and 2005 and 1.5 per cent in 2008. Input use increases proportionately twice as much as output between 2003 and 2005 at 7.5 per cent compared to output's 3.5 per cent. However, the output measure used takes no account of improved reliability and higher levels of system backup, nor of the contribution of transformer capacity to overall system capacity.

Figure 1: **Distribution industry output, input and TFP indexes, 1996–2008**



Source: Economic Insights estimates using Lawrence (2003) specification

To understand what has caused the rapid increase in input use in later years we need to examine the partial productivity indexes. In figure 2 and table 1 we present the four aggregate distribution partial productivities – the output quantity index divided by the relevant input quantity index. The four input quantity indexes are also graphed in figure 3 for clarity.

The only partial productivity index that increases between 2003 and 2005 is that of overhead lines – all of the other three partial productivity indexes decrease indicating that the quantity of the respective input increased faster than the quantity of output over this period. The partial productivity of opex decreased the most with a fall of over 9 per cent. This was

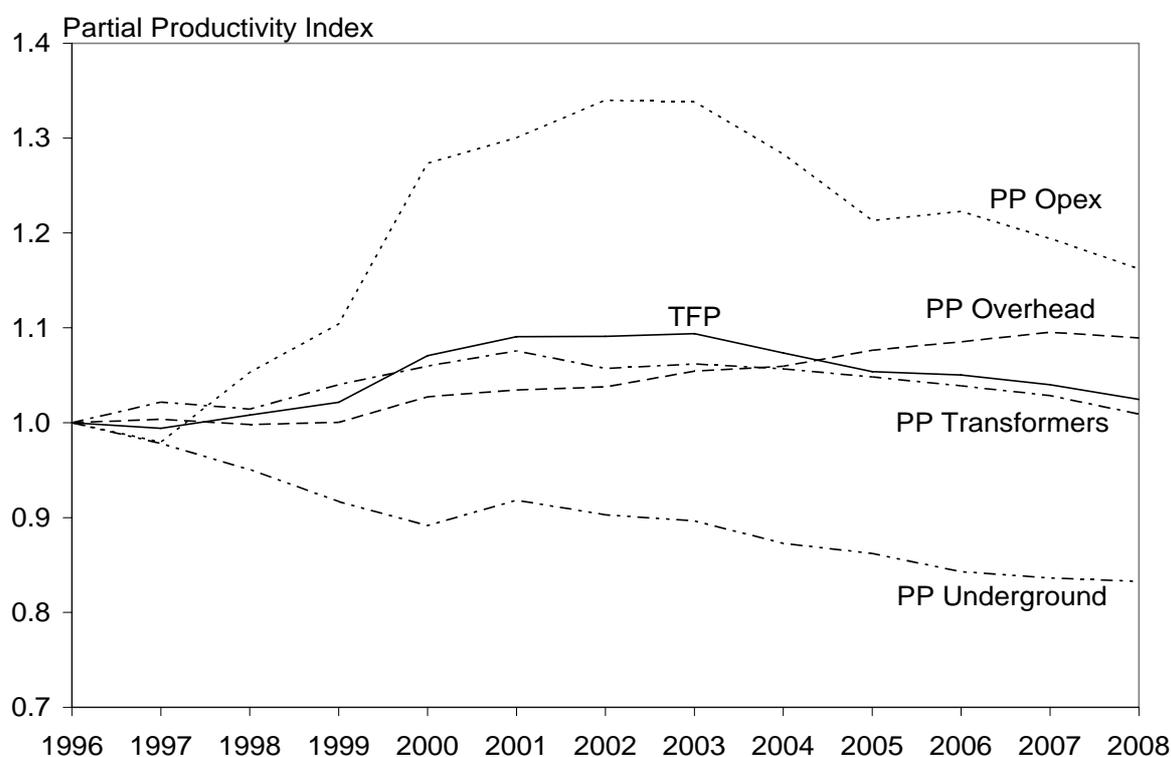
followed by underground lines with a fall of nearly 4 per cent. The partial productivity of overhead lines, on the other hand, increased by just over 2 per cent for the same period.

Table 1: **Distribution industry TFP and partial productivity indexes, 1996–2008**

	Quantity indexes		TFP	Partial productivities			
	Outputs	Inputs		OpEx	O/H lines	U/G cables	T'formers
1996	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1997	1.010	1.016	0.994	0.980	1.004	0.978	1.022
1998	1.021	1.013	1.008	1.053	0.998	0.951	1.014
1999	1.032	1.010	1.022	1.104	1.000	0.917	1.040
2000	1.046	0.977	1.071	1.273	1.027	0.892	1.060
2001	1.070	0.981	1.091	1.300	1.035	0.918	1.076
2002	1.083	0.993	1.091	1.340	1.038	0.903	1.057
2003	1.108	1.013	1.094	1.338	1.054	0.897	1.062
2004	1.129	1.052	1.074	1.283	1.060	0.873	1.057
2005	1.148	1.089	1.054	1.213	1.076	0.862	1.048
2006	1.165	1.109	1.050	1.223	1.085	0.843	1.039
2007	1.178	1.133	1.040	1.194	1.095	0.836	1.029
2008	1.191	1.162	1.024	1.162	1.089	0.833	1.009
Growth	1.57%	1.25%	0.31%				

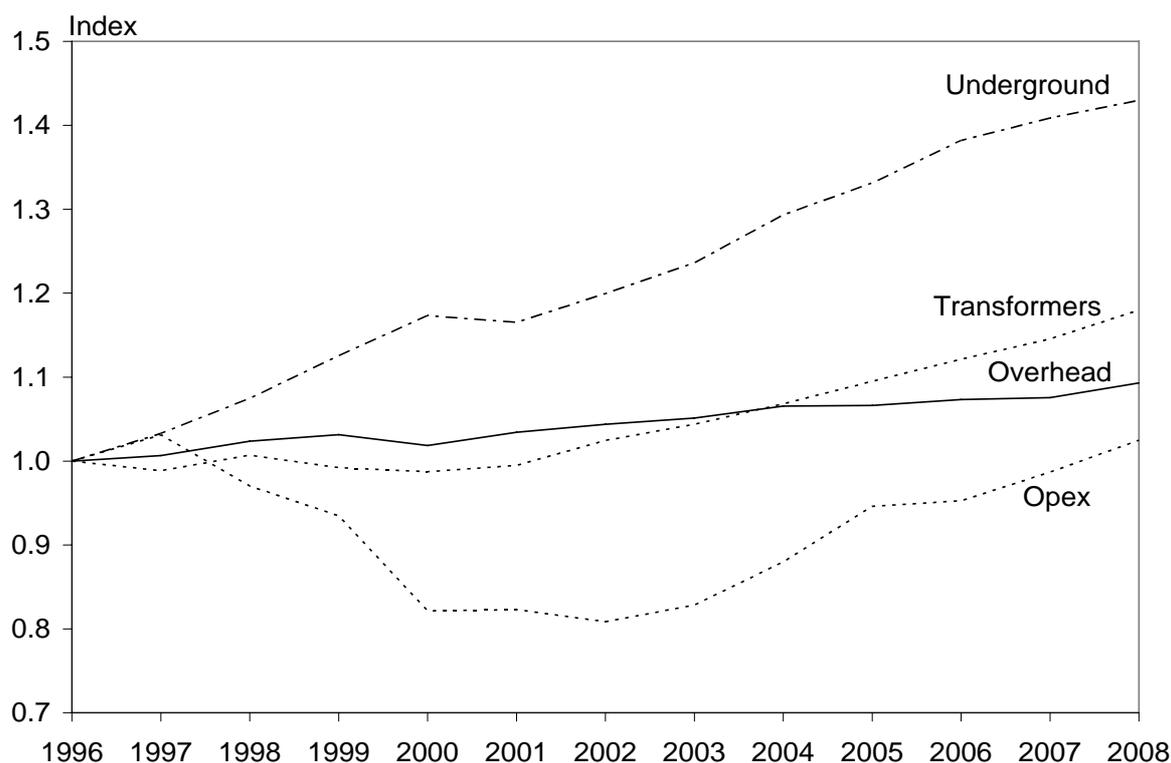
Source: Economic Insights estimates using Lawrence (2003) specification

Figure 2: **Distribution industry partial productivity indexes, 1996–2008**



Source: Economic Insights estimates using Lawrence (2003) specification

Figure 3: Distribution industry input quantity indexes, 1996–2008



Source: Economic Insights estimates

The drivers of the fall in this measure of TFP between 2003 and 2008 can be seen more clearly in figure 3 where the quantity of opex can be seen to increase by 24 per cent over this period. Underground cable quantity increased by the next highest amount with an increase of 16 per cent, closely followed by transformer and other capital with an increase of 13 per cent. Overhead lines quantity, on the other hand, only increased by 4 per cent.

Rapid increases in opex between 2003 and 2005 and again in 2007 and 2008 are the major driver of the observed fall in TFP since 2003, followed by strong expansion in transformer and underground cable stocks and ongoing but more modest growth in the overhead line stock.

Lawrence (2007) noted that there was some evidence that the former United Networks had underspent on system maintenance and that considerable expenditure was required from the time of its acquisition by Vector, Powerco and Unison to ensure reasonable reliability levels. For instance, Vector (2007, p.18) noted:

‘In demonstration that Vector takes its quality of supply responsibilities very seriously, subsequent to the acquisition of the Wellington and Northern networks from United Networks, Vector has increased the level of capital and maintenance expenditures significantly. In the year prior to Vector’s acquisition, combined capital and maintenance expenditure on the Wellington and Northern networks was approximately \$34 million. In the June 2006 year, Vector has spent \$107 million on these networks and this is projected to increase to \$125 million in the year-ended 31 March 2007, with increased capital expenditures on these networks beyond.’

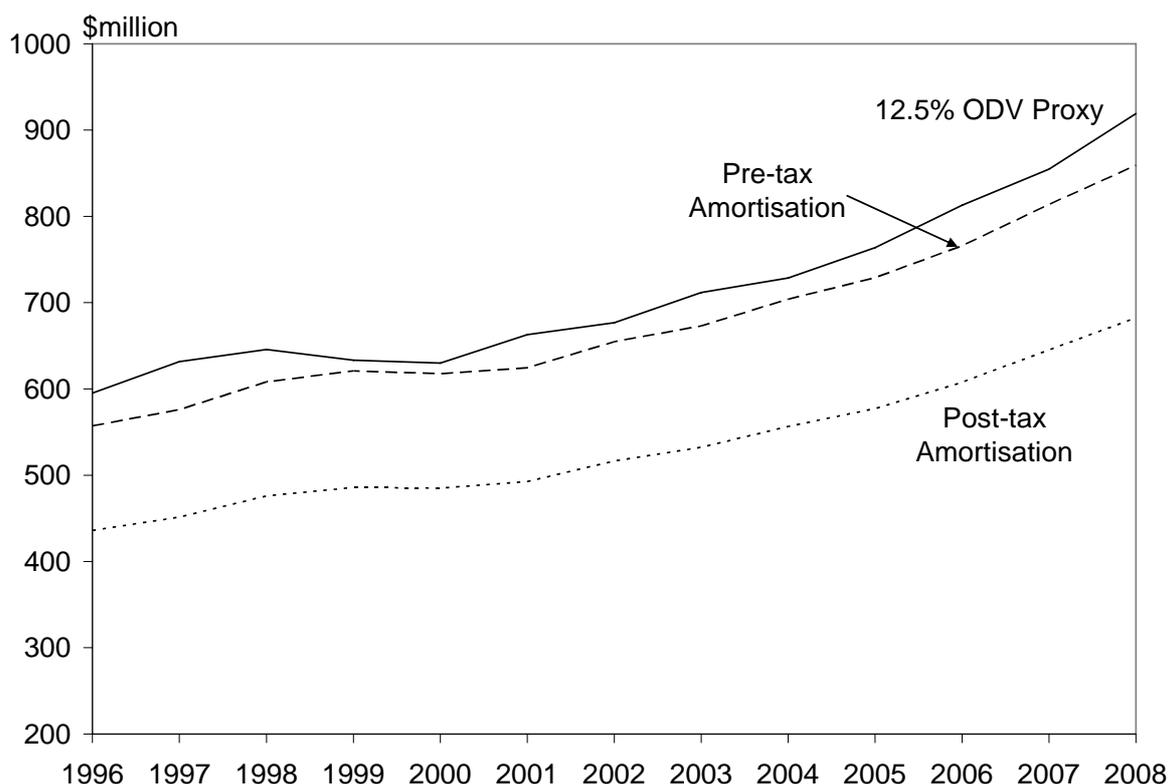
Lawrence (2007) also noted that some of the smaller EDBs had identified an increase in maintenance following the deployment of geographic information systems and improved planning processes as reasons for the large increases in opex after 2003.

TFP using FCM-consistent amortisation charges

We turn now to the refinements outlined in section 3. We first examine the impact of using amortisation charges to weight the capital inputs in forming the total input measure. The amortisation charges outlined in section 3.3 take account of the sunk cost nature of electricity distribution system fixed assets and allow us to incorporate FCM – something that is important for providing appropriate investment incentives and which makes the productivity-based regulation framework more consistent with the alternative building blocks regulatory framework. As outlined in section 3.3, we examine two series of amortisation charges – one based on a post-tax discount rate and one based on an upper bound pre-tax discount rate.

We first present the three annual capital input costs in figure 4. The proxy of 12.5 per cent of adjusted ODV is the highest of the three series and increases by 54 per cent over the period.

Figure 4: Distribution industry annual capital input costs, 1996–2008



Source: Economic Insights estimates

The upper-bound pre-tax amortisation series is the next highest and also increases by 54 per cent over the period while the post-tax amortisation charges are lower and increase by 57 per cent over the period.

These results indicate that the simple proxy measure of 12.5 per cent of ODV (adjusted to exclude the impact of the 2004 revaluation) was a reasonable estimate of the annual cost of

capital inputs and is close to the upper-bound pre-tax amortisation charge taking both the sunk cost nature of network assets and FCM into account.

The TFP indexes using the upper-bound pre-tax and the post-tax amortisation charges – but the same lines capacity-based output measure considered to date – are presented in the left hand side of table 2. The TFP index with upper-bound pre-tax amortisation charges increases at a trend rate of 0.4 per cent per annum over the 13 year period 1996 to 2008 while the TFP index with post-tax amortisation charges increases at a trend rate of 0.5 per cent per annum over the same period. This compares to the 0.3 per cent per annum growth rate using the former 12.5 per cent of ODV proxy for the annual cost of capital inputs. Whether either the pre-tax or post-tax amortisation charges or the former proxy measure for annual capital input costs is used thus has relatively little impact on the observed productivity trend growth rate.

TFP using the overall system capacity output measure

Turning to the specification of output, it was noted in section 3.1 that the measure of system capacity output included in Lawrence (2003, 2007) only covered line capacity and ignored transformer capacity. But transformer capacity is also an important component of overall system capacity and has increased by 19 per cent since 2001 while line capacity (as measured by MVA-kilometres) has increased by only 8 per cent. Ignoring the increase in transformer capacity is effectively ignoring a significant component of system productivity growth. Furthermore, as demonstrated in Economic Insights (2009a,b) it is important to use as comprehensive a measure of output as possible when applying the same X factor across a range of EDBs.

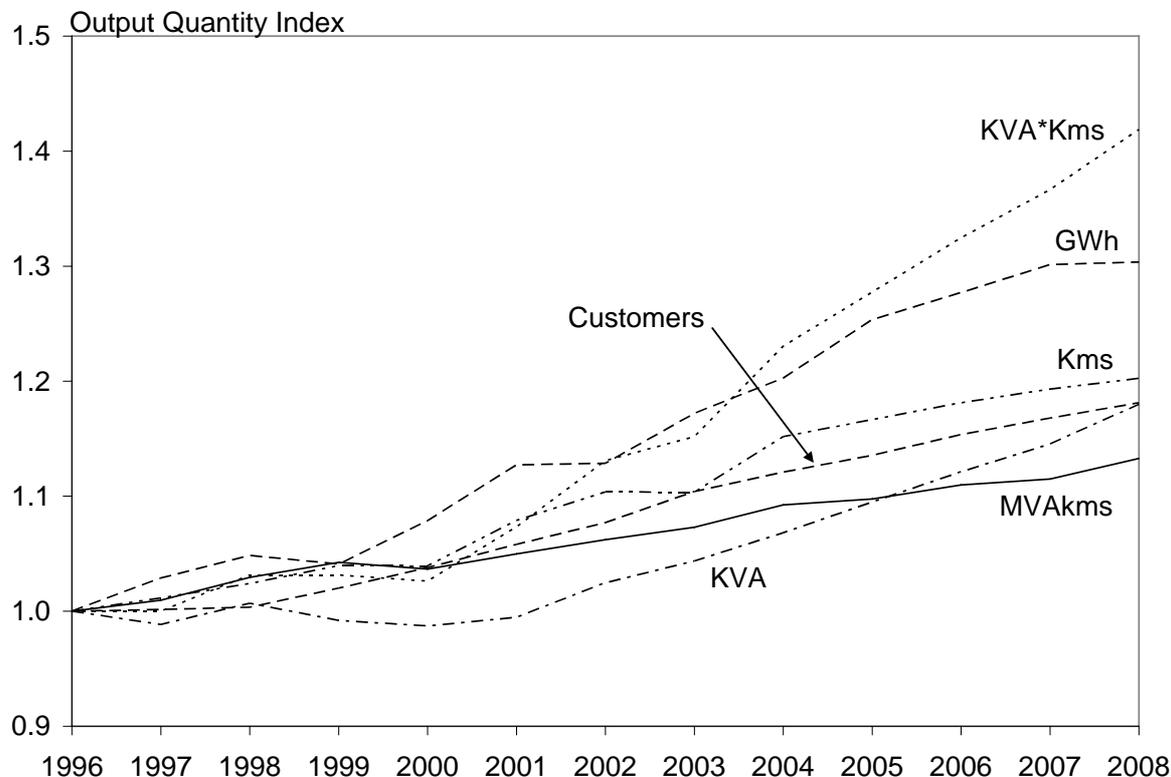
To allow for transformer capacity as well as line capacity in our system capacity output, we use the simple engineering measure of the product of the installed distribution transformer KVA capacity of the last level of transformation to the utilisation voltage and the totalled mains length in kilometres (inclusive of all voltages but excluding streetlighting and communications lengths). We call this measure ‘KVA*Kms’ for convenience.

In figure 5 we plot the various components that can be used to form output measures. As noted previously, transformer capacity has increased rapidly since 2001. But it was almost unchanged for the 5 years prior to this. Throughput has increased steadily and relatively rapidly over the whole period while customer numbers have increased steadily but at a lesser pace than throughput. System line capacity, on the other hand, has only increased modestly over the period. The increase in transformer capacity has been an important factor in supporting the more rapid growth of throughput. The KVA*Kms measure increases somewhat faster than throughput from 2001 onwards reflecting the increased deployment of transformers on the distribution system.

Replacing the system line capacity measure with the overall system capacity measure (and giving it the same weight as the system line capacity measure had) leads to a somewhat higher TFP growth rate. With the 12.5 per cent of ODV proxy of capital costs, the TFP measure using overall system capacity now grows at a trend rate of 1 per cent per annum over the 13 year period. Using the upper-bound pre-tax amortisation capital costs, the TFP growth rate using the overall system capacity measure now also becomes 1 per cent per

annum while that using the post-tax amortisation capital costs becomes 1.1 per cent per annum.

Figure 5: **Distribution industry output components, 1996–2008**



Source: Economic Insights estimates

To summarise, the TFP sensitivity analysis presented in table 2 shows TFP trend growth rates ranging between 0.3 per cent per annum and 1.1 per cent per annum over the period 1996 to 2008. The specification used in Lawrence (2003) (but with changes to the construction of the asset value series as outlined in section 3.4) is at the lower end of this TFP growth rate range. This specification appears to underestimate TFP growth for two reasons: the simple annual user cost of capital proxy used overstates somewhat annual capital input costs relative to amortisation measures that recognise the sunk cost nature of network assets and which allow for the desirable regulatory principle of ex ante FCM and, secondly, it ignored the increasingly important contribution of transformer capacity to overall system capacity. Recognising these factors leads to trend TFP growth rates of between 1 and 1.1 per cent per annum for the electricity distribution industry.

The other item we require information on to be able to implement the productivity component of the X factor formula (4) is the rate of productivity growth for the economy as whole. Lawrence (2003) used a one-off measure of economy wide multifactor productivity constructed by The Treasury and which updated the earlier Diewert and Lawrence (1999) study of the productivity of the New Zealand market sector. Lawrence (2007) looked only at electricity distribution productivity and did not examine economy-wide productivity.

Table 2: **Distribution industry TFP indexes sensitivity analysis, 1996–2008**

	System line capacity output			Overall system capacity output			Economy SNZ MFP
	12.5% ODV proxy	Real pre-tax amortisation	Real post-tax amortisation	12.5% ODV proxy	Real pre-tax amortisation	Real post-tax amortisation	
1996	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1997	0.994	0.994	0.992	0.991	0.991	0.989	1.014
1998	1.008	1.009	1.013	1.009	1.009	1.013	1.029
1999	1.022	1.023	1.029	1.018	1.019	1.026	1.022
2000	1.071	1.072	1.087	1.067	1.069	1.084	1.079
2001	1.091	1.092	1.108	1.098	1.100	1.116	1.083
2002	1.091	1.093	1.111	1.113	1.115	1.134	1.092
2003	1.094	1.096	1.114	1.119	1.121	1.139	1.114
2004	1.074	1.075	1.091	1.115	1.117	1.133	1.120
2005	1.054	1.055	1.067	1.106	1.107	1.120	1.128
2006	1.050	1.052	1.065	1.111	1.113	1.126	1.128
2007	1.040	1.041	1.053	1.110	1.111	1.124	1.118
2008	1.024	1.025	1.036	1.101	1.102	1.113	1.128
Growth	0.31%	0.36%	0.46%	1.04%	1.04%	1.14%	1.08%

Source: Economic Insights estimates

Since the Lawrence (2003) study Statistics New Zealand (2009) has produced an official time-series of New Zealand market sector multifactor productivity which is reproduced in table 2. This index grows at a trend rate of 1.1 per cent between 1996 and 2008.

4.3 ‘Non-exempt’ distribution productivity growth

‘Non-exempt’ distribution accounted for around 80 per cent of electricity distribution industry throughput and customer numbers in 2008. It accounted for nearly 90 per cent of the industry’s underground cable length but only 70 per cent of its overhead line length.

The productivity performance of the ‘non-exempt’ distribution segment has generally exceeded that of the distribution industry as a whole over the last 13 years. The same range of TFP indexes as presented for the industry in table 2 are presented for ‘non-exempt’ distribution in table 3. Using the Lawrence (2003) specification (but with the data changes outlined in section 3.4), the ‘non-exempt’ distribution TFP growth rate is 0.7 per cent per annum compared to the corresponding industry TFP growth rate of 0.3 per cent per annum. Using the overall system capacity output specification with real post-tax amortisation charges, the ‘non-exempt’ distribution TFP growth rate is 1.5 per cent per annum compared to the corresponding industry TFP growth rate of 1.1 per cent per annum.

Most of the difference in productivity growth between ‘non-exempt’ distribution and the distribution industry as a whole arises from differences in input growth rather than differences in output growth. Over the 13 year period input use in non-exempt distribution increased by only around two-thirds as much as it did for the distribution industry as a

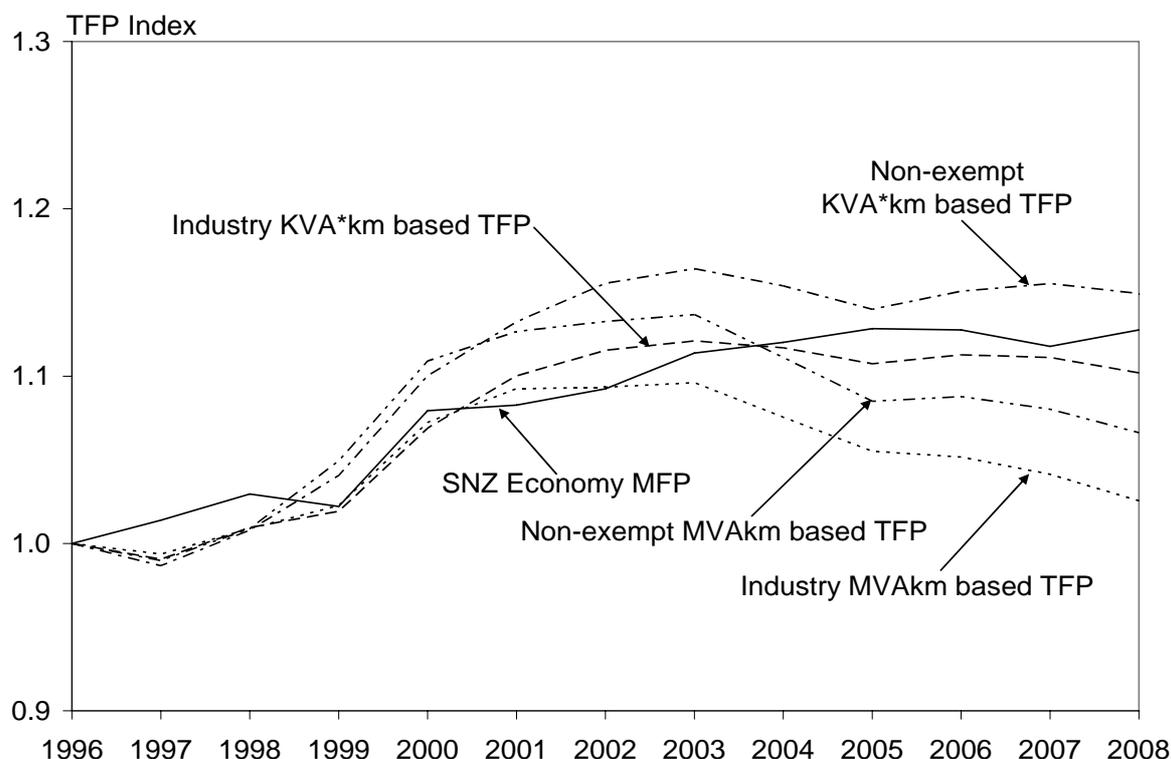
whole. This is despite the former accounting for around 80 per cent of industry throughput and customer numbers in 2008.

Table 3: 'Non-exempt' distribution TFP indexes, 1996–2008

	System line capacity output			Overall system capacity output		
	12.5% ODV proxy	Real pre-tax amortisation	Real post-tax amortisation	12.5% ODV proxy	Real pre-tax amortisation	Real post-tax amortisation
1996	1.000	1.000	1.000	1.000	1.000	1.000
1997	0.990	0.990	0.988	0.987	0.987	0.985
1998	1.008	1.009	1.013	1.007	1.008	1.012
1999	1.048	1.049	1.060	1.039	1.041	1.052
2000	1.107	1.109	1.130	1.098	1.100	1.121
2001	1.125	1.127	1.147	1.131	1.132	1.153
2002	1.130	1.133	1.156	1.153	1.155	1.179
2003	1.134	1.137	1.160	1.162	1.164	1.188
2004	1.109	1.111	1.131	1.152	1.154	1.174
2005	1.084	1.085	1.100	1.139	1.140	1.156
2006	1.086	1.088	1.104	1.149	1.151	1.169
2007	1.079	1.080	1.096	1.154	1.155	1.173
2008	1.065	1.066	1.081	1.148	1.149	1.165
Growth	0.67%	0.68%	0.80%	1.39%	1.40%	1.53%

Source: Economic Insights estimates

Figure 6: 'Non-exempt', industry and economy TFP indexes, 1996–2008



Source: Economic Insights estimates

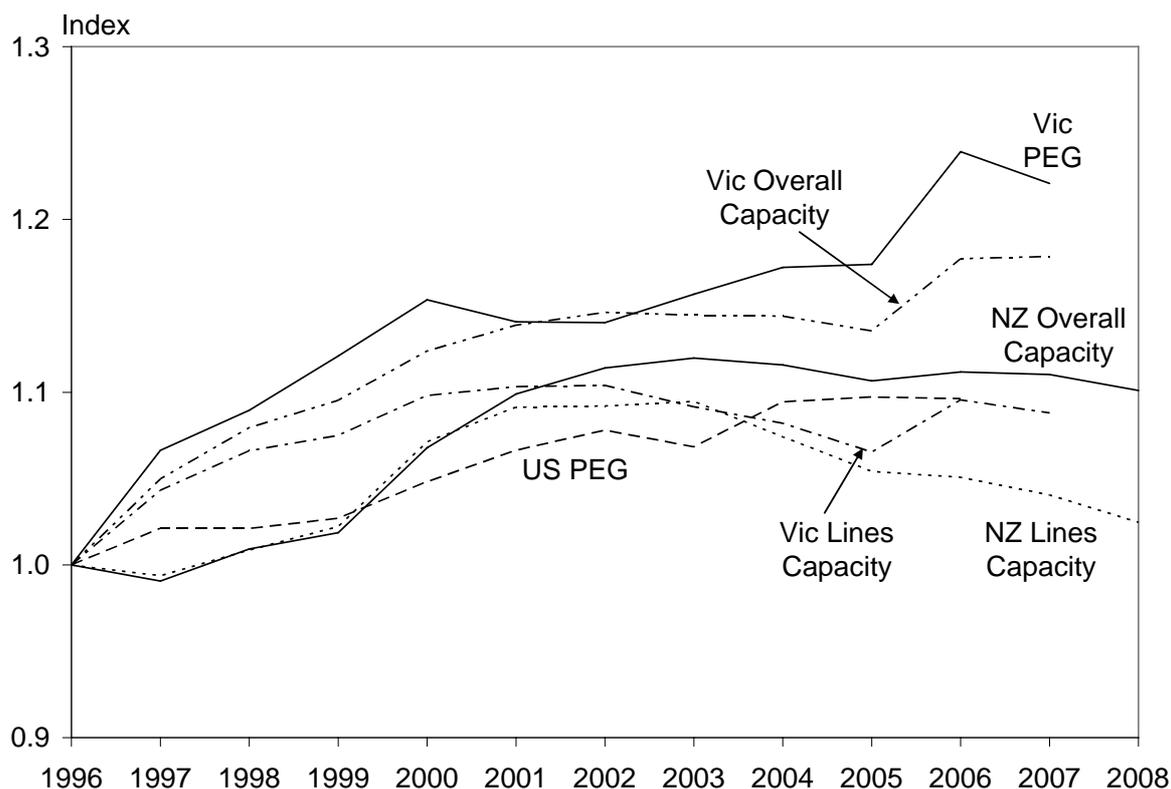
‘Non-exempt’ TFP, distribution industry TFP and economy market sector multifactor productivity are plotted in figure 6. The ‘non-exempt’ and distribution industry TFP series all use real upper-bound pre-tax amortisation charges. It can be seen that both economy and distribution productivity increased more rapidly in the first half of the period before levelling off from around 2003 onwards. As previously, the ‘non-exempt’ and distribution industry specifications using the overall system capacity output increase more than those using the system line capacity output.

4.4 Overseas EDB productivity growth

It is useful to compare the trend TFP growth rates presented in this report with comparable results that have been presented for overseas jurisdictions. This provides a worthwhile means of ‘sanity checking’ the results to identify any anomalies.

Electricity distribution TFP studies have been presented recently for the Australian state of Victoria and the United States investor-owned utilities.

Figure 7: **Victorian, US and New Zealand EDB TFP indexes, 1996–2008**



Source: Economic Insights estimates

Economic Insights (2009c) presented TFP estimates for Victoria including a series using an analogous specification to Lawrence (2003). We have extended the analysis here to include a series using the overall system capacity output specification. The database used in Economic Insights (2009c) draws on data assembled by the Essential Services Commission (ESC) and used by PEG (2008b) and on confidential data collected by Economic Insights staff in previous benchmarking studies for the Victorian EDBs. Results are presented in figure 7 for

Victoria as a whole for the period 1996 to 2007 (the latest year for which data are currently available) to maximise comparability with the current study. Growth rates are also reported using the regression-based trend method to maximise comparability.

Firstly, the Victorian and New Zealand TFP indexes using lines capacity as the system capacity proxy show similar growth up to 2005. The Victorian TFP indexes all have a step up in 2006 due to a seemingly anomalous reduction of over 9 per cent in opex quantity in that year. It is suspected this may be due to reclassifications made by the ESC rather than actual reductions in input use by the EDBs but this has yet to be confirmed by the ESC. Taking the Victorian data at face value, the trend growth rate for the lines system capacity proxy series is 0.5 per cent per annum compared to the corresponding New Zealand growth rate of 0.4 per cent.

There is also a reasonable similarity in movement of the Victorian and New Zealand TFP indexes using the overall system capacity specification. The trend growth rate for the overall system capacity series for Victoria is 1.2 per cent per annum compared to the corresponding New Zealand growth rate of 1.0 per cent.

The Victorian TFP index using the PEG (2008b) specification shows higher trend growth of 1.5 per cent per annum. This is because this index places most output weight on relatively fast growing throughput and peak demand outputs and uses the constant price depreciated asset value as the capital input quantity proxy which is likely to overstate the decay in capital service potential and thus overstate TFP growth.

Finally, the US investor-owned EDB TFP index presented in PEG (2008a) shows trend growth of 1.0 per cent per annum for the period 1996 to 2006 (the latest year for which results were presented).

The evidence available from Victoria and the US thus lends empirical support to the TFP estimates presented here for New Zealand. TFP trend growth has been in the range of 0.4 per cent per annum to 1.5 per cent per annum with most series producing trend TFP growth rates of close to 1 per cent per annum.

4.5 Input price growth

The remaining components of equation (4) we require information on are the input price growth terms for the electricity distribution industry and the economy as a whole. As demonstrated in Economic Insights (2009a,b), where industry assets have sunk cost characteristics the appropriate industry input price term is the cost share weighted sum of the opex price and unit changes in amortisation charges. The amortisation charges used in this study have been calculated on the basis of ex ante financial capital maintenance as would be found in building blocks regulation.

Before turning to the sunk cost specification, we note that the approach examined in Lawrence (2003) was a simpler one which did not take account of sunk costs and instead attempted to proxy the difference between industry and economy-wide capital input price changes by differences in official capital goods price index (CGPI) growth rates. This was based on the assumption that depreciation rates and real opportunity cost rates remained constant over time for each of the industry and the economy so that changes in user costs can

be proxied by the change in the relevant CGPI. However, no conclusive evidence was available at the time because of conflicting information from relevant official capital goods price indexes. In particular, the CGPIs for Construction of Power Lines and Construction of Transmission Lines showed quite different behaviour despite information supplied by Statistics New Zealand at the time indicating the indexes had similar regimen (or composition). As a result, Lawrence (2003) recommended that the input price growth differential be set to zero.

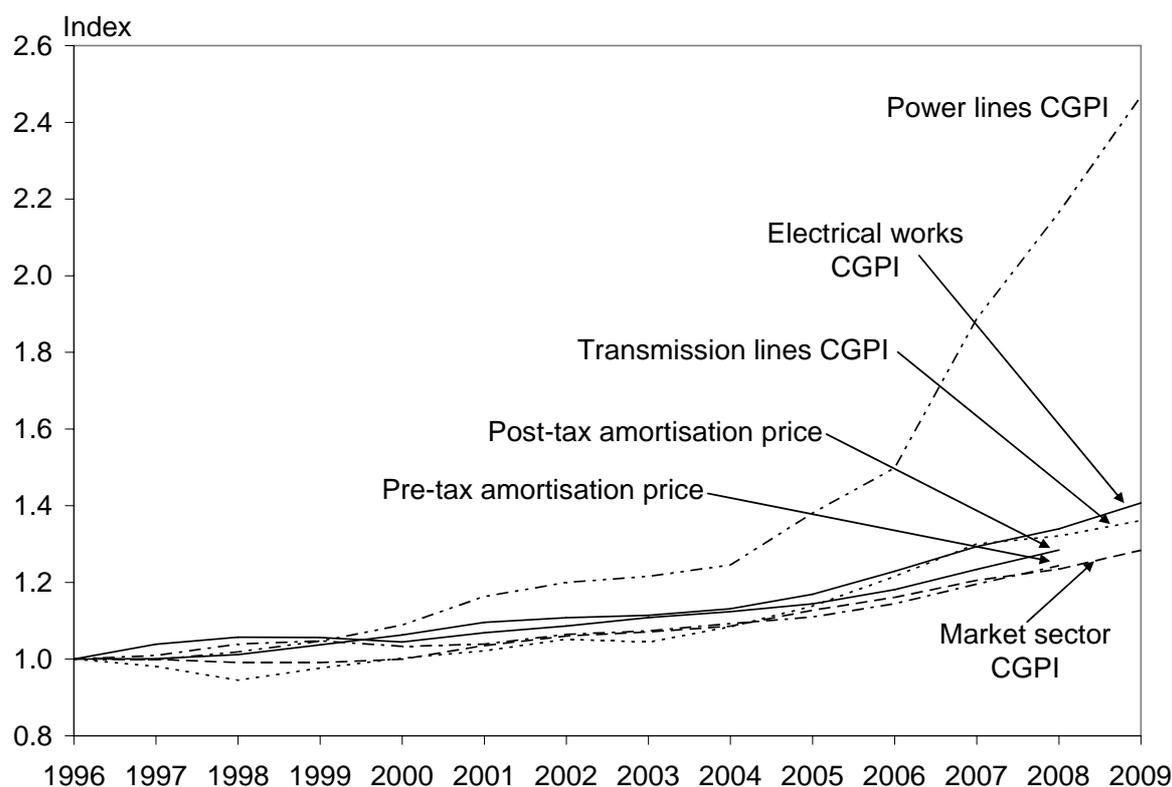
Table 4: **Input component price indexes, 1996–2009**

	Labour cost index		Capital goods price index			
	EGW sector	All sectors	Power lines	Transmission lines	Electrical works	All groups
1996	1.000	1.000	1.000	1.000	1.000	1.000
1997	1.017	1.021	0.998	0.981	1.001	1.000
1998	1.028	1.044	1.019	0.945	1.012	0.991
1999	1.040	1.063	1.047	0.977	1.037	0.991
2000	1.058	1.078	1.089	1.002	1.063	1.000
2001	1.071	1.097	1.163	1.022	1.096	1.035
2002	1.094	1.118	1.200	1.052	1.108	1.060
2003	1.124	1.143	1.216	1.044	1.115	1.071
2004	1.150	1.169	1.246	1.084	1.131	1.086
2005	1.177	1.197	1.381	1.138	1.169	1.127
2006	1.215	1.233	1.499	1.215	1.229	1.161
2007	1.262	1.272	1.887	1.301	1.294	1.205
2008	1.306	1.313	2.165	1.321	1.340	1.235
2009	1.356	1.361	2.467	1.361	1.407	1.284
Growth 96–08	2.16%	2.18%	5.77%	2.60%	2.37%	1.88%

Source: Statistics New Zealand

We now examine the latest information available on industry and economy-wide input price indexes and industry amortisation charges. In table 4 we present the Statistics New Zealand labour cost indexes for the Electricity, gas and water (EGW) sector and the economy as a whole and a selection of relevant CGPIs. There has been minimal difference in the movement of the labour cost indexes for the EGW sector and the economy as a whole. There has, however, been wide variation in the movement of the official CGPIs. The power line and transmission line CGPIs again show divergent behaviour with the power line CGPI reporting a very large increase of 25 per cent in 2007 while the transmission line CGPI only showed an increase of 7 per cent in the same year despite having a similar regimen. The power lines CGPI grows at over twice the trend rate of the transmission lines CGPI. Both these CGPIs feed into the higher level electrical works CGPI which also draws on a range of other electrical works construction activities such as installation of traffic lights and radio and television transmitters. The electrical works CGPI shows broadly similar movement to the transmission lines CGPI. By comparison with movements in related indexes, the movement of the power lines CGPI thus appears anomalous, as is illustrated in figure 8.

Figure 8: Capital price indexes, 1996–2009



Source: Statistics New Zealand and Economic Insights estimates

To assess whether a similar pattern of movement in capital input prices has occurred in Australia we have also examined the Australian Bureau of Statistics (2009, table 57) implicit price deflators for net capital stocks for the Australian EGW sector and the Australian market sector as a whole. Between 1996 and 2008 the Australian EGW sector CGPI grew by 6.5 per cent more than that for the Australian market sector. For New Zealand the electrical works CGPI increased by 8.5 per cent more than that for the market sector as a whole – broadly similar to the Australian experience. By contrast the New Zealand power lines CGPI increased by 75 per cent more than that for the market sector as a whole. On the basis of this information it would be imprudent to use the New Zealand power lines CGPI in calculations until more is understood of the reasons for its erratic movement. Instead we use the electrical works CGPI which appears less erratic in movement and more in line with similar indexes in Australia which one would expect to be generally comparable.

We next form overall input price indexes for both the electricity distribution sector and the economy as a whole using the simple user cost-based approach used in Lawrence (2003). We form a Fisher input price index for the distribution industry using the EGW sector labour cost index and the electrical works CGPI. The weights used are the shares of opex and the simple proxy user cost of 12.5 per cent of ODV in total cost from the electricity distribution industry database. We then form an economy-wide input price index consistent with the multifactor productivity series by aggregating the all groups labour cost index and the all groups CGPI using the shares given in the productivity growth accounting table of SNZ (2009). For consistency with the productivity growth calculations, we form the trend growth rates of the

resulting overall input price indexes for the period 1996 to 2008. The electricity distribution input price index growth rate is 2.3 per cent per annum while that for the economy as whole is 2.1 per cent per annum.

The simple calculation above is not, however, consistent with the sunk cost nature of electricity distribution assets and does not allow for ex ante FCM. To incorporate these important features we need to form amortisation-based capital prices. We do this by dividing the distribution industry amortisation values for both post-tax and upper bound pre-tax amortisation by the capital quantity index. The capital quantity index was formed by aggregating overhead lines MVA-kilometres, underground cable MVA-kilometres and transformer KVAs using the shares of the three capital inputs in the 2004 ODV given in the 2008 IDD. For the industry as a whole these shares are around 30 per cent for overhead lines, 34 per cent for underground cables and 36 per cent for transformers and other capital.

Table 5: **Amortisation and total input price indexes, 1996–2008**

	Distribution capital price indexes		Distribution and market total input price indexes		
	Real post-tax amortisation	Real pre-tax amortisation	Real post-tax amortisation	Real pre-tax amortisation	Market sector
1996	1.000	1.000	1.000	1.000	1.000
1997	1.039	1.009	1.029	1.012	1.012
1998	1.057	1.039	1.045	1.035	1.023
1999	1.056	1.048	1.049	1.045	1.035
2000	1.045	1.033	1.048	1.040	1.047
2001	1.069	1.039	1.068	1.048	1.073
2002	1.087	1.065	1.088	1.073	1.096
2003	1.109	1.074	1.113	1.088	1.114
2004	1.123	1.092	1.131	1.109	1.136
2005	1.144	1.110	1.154	1.129	1.170
2006	1.181	1.145	1.191	1.165	1.205
2007	1.234	1.196	1.242	1.214	1.246
2008	1.284	1.244	1.290	1.261	1.282
Growth 96–08	1.77%	1.57%	1.91%	1.74%	2.06%
Growth 04–08	3.43%	3.34%	3.36%	3.31%	3.06%

Source: Economic Insights estimates

The post-tax amortisation-based capital input price is presented in table 5 and figure 8 and increases at 1.8 per cent per annum over the 13 year period. The upper bound pre-tax amortisation-based capital input price listed in table 5 increases less rapidly at 1.6 per cent per annum. The distribution industry total input price indexes listed in table 5 which incorporate the amortisation-based capital input prices grow at a slightly lower trend rate than the market sector input price. The post-tax amortisation-based total input price index grows at a trend rate of 1.9 per cent per annum compared to 1.7 per cent annum for the upper bound pre-tax amortisation-based total input price index and 2.1 per cent per annum for the market sector total input price index. These trend growth rates are all somewhat lower than

the industry total input price growth rate of 2.3 per cent per annum when the user cost-based approach from Lawrence (2003) is used.

Since we have had to form the amortisation series using a two stage process as outlined in section 3.3 where we form an actual series from 2004 onwards and then form an estimated series from 1996 to 2005, we also present trend growth rates of the capital amortisation and total input prices for the period 2004 to 2008. The growth in both the amortisation prices and the industry input prices were higher over this more recent period with amortisation price trend growth of 3.3 to 3.4 per cent per annum and industry input price growth of a similar order of magnitude. However, the overall market sector input price index also grew more rapidly over this period with a trend growth rate of 3.1 per cent per annum. The trend growth rate of the industry total input price for this more recent period using the capital goods price index-based approach from Lawrence (2003) was higher at 4.1 per cent per annum. The difference in trend growth rates between the industry amortisation prices and the user cost-based price reflects the fact that the amortisation price is based on actual expenditure whereas the user cost-based price is based on the replacement price of all assets and, hence, largely on expenditure which is not actually incurred.

5 RECOMMENDATIONS

The objective of this report has been to provide information relevant to the determination of the electricity distribution industry default price path rate of change or X factor. The formula for the X factor taking account of sunk costs and financial capital maintenance – and assuming P_0 adjustments are used to address profitability issues – was given in equation (4) and is repeated here for convenience:

$$(10) \quad X \equiv \{\Delta TFP - \Delta TFP_E\} - \{(s_X \Delta W_X + s_K \Delta P_{kD}) - \Delta W_E\}$$

= TFP differential growth rate term – input price differential growth rate term.

where the industry capital price included is the unit amortisation charge.

5.1 Productivity growth differential

The first term in (10) involves the difference in TFP growth rates between the electricity distribution industry and the economy. In this report we have examined a number of different specifications for industry TFP growth and the resulting productivity growth differentials are presented in table 6.

Table 6: **Industry productivity growth differentials, 1996–2008, per cent pa**

	Industry TFP trend growth	Market sector TFP trend growth	Productivity growth differential
<i>Using lines system capacity output</i>			
12.5% ODV user cost proxy	0.31%	1.08%	-0.77%
Pre-tax amortisation	0.35%	1.08%	-0.73%
Post-tax amortisation	0.45%	1.08%	-0.63%
<i>Using overall system capacity output</i>			
12.5% ODV user cost proxy	1.04%	1.08%	-0.05%
Pre-tax amortisation	1.04%	1.08%	-0.05%
Post-tax amortisation	1.14%	1.08%	0.06%

Source: Economic Insights estimates

Distribution industry TFP as specified in Lawrence (2003) – using 12.5 per cent of ODV as a user cost proxy – grew strongly from 1996 to 2003 but has declined since then. For the period as a whole it had a trend growth rate of 0.3 per cent per annum³. However, the capital cost proxy used made no allowance for the sunk cost nature of distribution network assets or for the important regulatory principle of ex ante financial capital maintenance. Including capital amortisation costs which allow for these characteristics leads to industry TFP growth rates of around 0.4 to 0.5 per cent depending on whether upper bound pre-tax or post-tax amortisation is used.

Since the Lawrence (2003) report Statistics New Zealand has produced an official multifactor productivity series for the market sector of the New Zealand economy. This series shows a

³ The whole period is used because the Act requires the estimate to be of long run achieved productivity growth and so the longest period for which data are available should be used.

trend growth rate of 1.1 per cent annum for the 13 years 1996 to 2008. It also shows solid TFP growth up to 2003 but then levels off after this.

Over the full 13 year period the lines system capacity-based series would produce a productivity growth differential in the order of -0.6 to -0.8 per cent per annum (ie industry TFP growth has been less than that for the market sector as a whole).

However, this specification made no allowance for the contribution of distribution transformer capacity to overall system capacity. As noted in section 3.1, distribution transformer capacity has grown rapidly over the last several years and failure to recognise the important contribution of increased distribution transformer capacity will lead to system capacity measure being biased downwards. We also note that the overall system capacity measure taking account of transformer capacity was used in the econometric work undertaken in 2003. Using this broader and more appropriate definition of system capacity in the TFP analysis leads to industry TFP growing strongly to 2003 and then levelling off after that. Over the 13 year period industry TFP grows at a trend rate of between 1.0 and 1.1 per cent per annum depending on whether the former 12.5 per cent of ODV user cost proxy, pre-tax amortisation or post-tax amortisation is used. This leads to a very small productivity growth differential range of -0.05 per cent to 0.06 per cent, or effectively zero.

Table 7: **'Non-exempt' productivity growth differentials, 1996–2008, per cent pa**

	'Non-exempt' TFP trend growth	Market sector TFP trend growth	Productivity growth differential
<i>Using lines system capacity output</i>			
12.5% ODV user cost proxy	0.67%	1.08%	-0.41%
Pre-tax amortisation	0.68%	1.08%	-0.41%
Post-tax amortisation	0.80%	1.08%	-0.28%
<i>Using overall system capacity output</i>			
12.5% ODV user cost proxy	1.39%	1.08%	0.31%
Pre-tax amortisation	1.40%	1.08%	0.32%
Post-tax amortisation	1.52%	1.08%	0.44%

Source: Economic Insights estimates

That part of the industry which is likely to be 'non-exempt' from the default price path exhibits stronger TFP growth than the industry as a whole. Using the Lawrence (2003) TFP specification produces a trend TFP growth rate of 0.7 per cent per annum and using the more fully specified model leads to TFP trend growth rates of between 1.4 and 1.5 per cent per annum. This segment accounts for 80 per cent of industry throughput and customer numbers. As shown in table 7, calculating the productivity growth differential on the basis of the 'non-exempt' portion of the industry would lead to productivity growth differentials of -0.3 per cent to -0.4 per cent using the lines system capacity output specification and of 0.3 per cent to 0.4 per cent using the overall system capacity output specification.

The available evidence indicates that, using the improved TFP specification which takes account of important industry and regulatory characteristics (ie overall system capacity and ex ante FCM consistent amortisation charges), the distribution industry as a whole has exhibited equal or higher productivity growth than the economy as a whole over the last 13

years. If that portion of the industry which is likely to be subject to the default price path is considered then corresponding TFP growth has been higher than that for the economy as a whole. Based on the available information, a conservative course of action would be to set the productivity growth differential term in the X factor to zero based on the overall industry and market sector performance. If that part of the industry that is likely to be subject to the default price path is taken to be the relevant industry definition then the productivity growth differential would have a positive value of around 0.4 per cent.

5.2 Input price growth differential

Turning to the input price growth difference between the electricity distribution industry and the economy, Lawrence (2003) recommended that this be set to zero due to conflicting information at the time from official capital goods price indexes (CGPIs), particularly those for power lines and transmission lines. The power lines CGPI has continued to exhibit erratic movement with a 25 per cent increase in 2007 alone with no corroborating evidence from related CGPIs in New Zealand or Australia. We are of the view that it would be imprudent to rely on the power lines CGPI in setting the input price difference until further information can be obtained on the reasons for its erratic and unusual movement. Relying on the higher level electrical works CGPI instead and the labour cost index for the electricity, gas and water sector produces an industry input price trend growth rate of 2.3 per cent per annum over the 13 year period 1996 to 2008. This compares with economy-wide input price trend input price growth of 2.1 per cent per annum over the same period⁴. As shown in table 8 this would lead to an input price growth differential of 0.2 per cent per annum.

Table 8: **Input price growth differentials, 1996–2008 and 2004–2008, per cent pa**

	Industry input price trend growth	Market sector input price trend growth	Input price growth differential
<i>1996–2008</i>			
CGPI user price proxy	2.30%	2.06%	0.24%
Pre-tax amortisation	1.74%	2.06%	-0.32%
Post-tax amortisation	1.91%	2.06%	-0.16%
<i>2004–2008</i>			
CGPI user price proxy	4.06%	3.06%	0.99%
Pre-tax amortisation	3.31%	3.06%	0.25%
Post-tax amortisation	3.36%	3.06%	0.30%

Source: Economic Insights estimates

However, to allow for the sunk cost nature of electricity distribution network assets and the important regulatory principle of ex ante FCM we need to include the change in unit amortisation charges in equation (10) rather than the CGPI (which is included above as a proxy for changes in capital annual user costs). If we use the amortisation method involving the upper bound pre-tax discount rate then industry input prices increase by 1.7 per cent per annum over the 13 year period. Using the post-tax discount rate amortisation method leads to

⁴ This calculation assumes the depreciation rates and the real opportunity cost rates for both the industry and the market sector remain constant over the period.

a trend growth in industry input prices of 1.9 per cent per annum. This would lead to an input price growth differential of -0.2 to -0.3 per cent per annum (ie market sector input prices have grown marginally quicker than industry input prices over the period).

In constructing our amortisation charges we have had to use actual data on additions from 2005 to 2008 and estimated additions data for 1996 to 2004. We then splice the earlier amortisation series onto the later series using the overlap year of 2005. The effect of this process on the productivity estimates is likely to be minimal (as demonstrated by the relative invariance of the TFP growth rates to the capital cost method used) and so we only examine the whole period 1996 to 2008 for the TFP analysis. However, the effects could be more significant for input price growth rate calculations and so we examine the shorter period 2004 to 2008 as well the longer period 1996 to 2008. Another reason for undertaking a sensitivity analysis of time period coverage for input prices is that some sources indicate that EDB capital prices have increased more rapidly in recent years due to the effects of the resources boom on commodity prices.

In table 8 we thus present results for the period 2004 to 2008 as well as the longer period. This indicates that using the change in the relevant CGPI as a proxy for the change in the user price of capital (as in Lawrence 2003) does indeed lead to a higher input price growth rate for the industry. While the corresponding market sector input price growth rate has also increased, the growth differential widened out to nearly 1 per cent per annum over the last 5 years. However, using the more appropriate amortisation approach to forming the industry input price growth rate leads to a much smaller growth differential of around 0.3 per cent per annum for this latter period. The difference in trend growth rates between the industry amortisation-based input prices and the CGPI-based input price proxy reflects the fact that the amortisation price is based on actual expenditure whereas the user CGPI-based price is based on the replacement price of all assets and, hence, largely on expenditure which is not actually incurred. All else equal, using the replacement cost CGPI proxy would lead to windfall gains for the EDBs in this case.

More generally, the recent global economic slowdown means that both the industry and market sector input price growth rates are likely to be lower going forward. The ‘bubble’ in commodity prices may have contributed to the higher growth rate in capital input prices in recent years but the recent slowdown is likely to have substantially lessened and/or reversed commodity price growth rates. We are, therefore, of the view that the full 13 year period is the appropriate period over which to calculate the input price growth differential and that growth differential should be based on amortisation charges that are ex ante FCM consistent.

The available evidence indicates that, using the rigorous amortisation charge approach which takes account of ex ante FCM, the distribution industry as a whole has exhibited slightly slower input price growth than the economy as a whole over the last 13 years. This would point to a small input price growth differential of in the order of -0.2 to -0.3 per cent per annum. All else equal, this would tend to make the X factor marginally larger than it would be based solely on productivity considerations. A conservative course of action in favour of the EDBs would be to set the input price growth differential term in the X factor to zero given its relatively small magnitude over both the whole period and the more recent period.

5.3 X factor recommendation

As outlined in the preceding sections we believe that a conservative approach based on the available evidence would set both the productivity growth differential and the input price growth differential to zero. Since the X factor as set out in (10) is the difference between the productivity growth differential and the input price growth differential, it follows that our recommended X factor would also be zero.

Table 9: **Derived X factors, 1996–2008, per cent per annum**

	Productivity growth differential	Input price growth differential	X factor
<i>Using lines system capacity output</i>			
Lawrence (2003) method	-0.77%	0.24%	-1.01%
Pre-tax amortisation	-0.73%	-0.32%	-0.41%
Post-tax amortisation	-0.63%	-0.16%	-0.48%
<i>Using overall system capacity output</i>			
Lawrence (2003) method	-0.05%	0.24%	-0.29%
Pre-tax amortisation	-0.05%	-0.32%	0.27%
Post-tax amortisation	0.06%	-0.16%	0.21%

Source: Economic Insights estimates

The full range of X factors considered is presented in table 9. Using the output and capital cost methods adopted in Lawrence (2003) would lead to an X factor of around –1 per cent. However, this method does not adequately measure overall system capacity nor allow for the sunk cost nature of EDBs assets nor allow for ex ante FCM. Allowing for these important characteristics and regulatory principles leads to an X factor of 0.2 to 0.3 per cent. If the industry coverage was limited to those EDBs that are likely to be subject to the default price path then the resulting X factor would be higher at around 0.6 per cent. Taking account of the uncertainties involved – including future economic conditions – a conservative decision in favour of the EDBs would be to set the X factor at zero.

APPENDIX A: THE DATABASE USED

Table A1: Electricity distribution industry database, 1996–2008

<i>Variable</i>	<i>Unit</i>	<i>1996</i>	<i>1997</i>	<i>1998</i>	<i>1999</i>
Deemed revenue	\$m	770.72	867.44	914.19	791.44
Energy throughput	GWh	24,595	25,308	25,788	25,604
Customers	'000	1,651	1,654	1,671	1,684
Adjusted operating expenditure	\$m	293.99	308.06	292.97	289.24
Operating expenditure price	Index	1.000	1.016	1.027	1.039
Overhead MVA–kilometres	No	440,578	443,394	450,913	454,355
Underground MVA–kilometres	No	58,918	60,845	63,308	66,311
Line length	Kms	130,740	132,101	133,929	135,732
Transformer capacity	MVA	14,637	14,469	14,740	14,520
Annual user cost of overhead lines	\$m	178.31	189.19	193.46	189.72
Annual user cost of underground cables	\$m	200.03	212.23	217.02	212.82
Annual user cost of transformers, etc	\$m	216.90	230.13	235.33	230.77
Amortisation of overhead (pre–tax)	\$m	173.05	176.21	186.05	189.91
Amortisation of u'ground (pre–tax)	\$m	196.12	199.71	210.85	215.23
Amortisation of t'formers (pre–tax)	\$m	207.66	211.45	223.26	227.89
Amortisation of overhead (post–tax)	\$m	132.65	138.96	145.09	146.77
Amortisation of u'ground (post–tax)	\$m	150.34	157.49	164.43	166.34
Amortisation of t'formers (post–tax)	\$m	159.18	166.75	174.11	176.13

<i>Variable</i>	<i>Unit</i>	<i>2000</i>	<i>2001</i>	<i>2002</i>	<i>2003</i>
Deemed revenue	\$m	932.47	980.22	1,019.84	886.78
Energy throughput	GWh	26,531	27,725	27,759	28,784
Customers	'000	1,714	1,747	1,778	1,823
Adjusted operating expenditure	\$m	258.32	262.03	263.54	278.19
Operating expenditure price	Index	1.055	1.069	1.094	1.127
Overhead MVA–kilometres	No	448,658	455,707	459,875	463,112
Underground MVA–kilometres	No	69,134	68,659	70,678	72,833
Line length	Kms	135,960	140,964	143,710	143,778
Transformer capacity	MVA	14,451	14,560	14,997	15,277
Annual user cost of overhead lines	\$m	188.67	198.51	202.74	213.26
Annual user cost of underground cables	\$m	211.64	222.69	227.43	239.23
Annual user cost of transformers	\$m	229.49	241.47	246.61	259.40
Amortisation of overhead (pre–tax)	\$m	188.91	191.05	200.28	205.89
Amortisation of u'ground (pre–tax)	\$m	214.10	216.52	226.98	233.34
Amortisation of t'formers (pre–tax)	\$m	226.70	229.26	240.33	247.07
Amortisation of overhead (post–tax)	\$m	146.44	150.61	156.69	162.91
Amortisation of u'ground (post–tax)	\$m	165.97	170.69	177.58	184.63
Amortisation of t'formers (post–tax)	\$m	175.73	180.73	188.02	195.49

Source: Economic Insights database formed from Disclosure Data

Table A1: Electricity distribution industry database, 1996–2008 (cont'd)

<i>Variable</i>	<i>Unit</i>	<i>2004</i>	<i>2005</i>	<i>2006</i>
Deemed revenue	\$m	1,022.07	1,086.40	1,133.24
Energy throughput	GWh	29,515	30,777	31,412
Customers	'000	1,851	1,875	1,905
Adjusted operating expenditure	\$m	303.54	334.45	347.36
Operating expenditure price	Index	1.158	1.186	1.224
Overhead MVA–kilometres	No	469,420	469,790	472,923
Underground MVA–kilometres	No	76,194	78,435	81,420
Line length	Kms	150,079	152,273	154,211
Transformer capacity	MVA	15,636	16,027	16,412
Annual user cost of overhead lines	\$m	218.30	227.88	242.25
Annual user cost of underground cables	\$m	244.89	257.33	274.13
Annual user cost of transformers	\$m	265.54	278.41	296.63
Amortisation of overhead (pre–tax)	\$m	215.32	222.93	235.39
Amortisation of u'ground (pre–tax)	\$m	244.03	252.66	266.78
Amortisation of t'formers (pre–tax)	\$m	258.39	267.52	282.47
Amortisation of overhead (post–tax)	\$m	169.75	176.16	186.20
Amortisation of u'ground (post–tax)	\$m	192.39	199.65	211.03
Amortisation of t'formers (post–tax)	\$m	203.70	211.39	223.44

<i>Variable</i>	<i>Unit</i>	<i>2007</i>	<i>2008</i>
Deemed revenue	\$m	1,210.57	1,260.96
Energy throughput	GWh	32,009	32,095
Customers	'000	1,929	1,950
Adjusted operating expenditure	\$m	373.83	407.68
Operating expenditure price	Index	1.271	1.335
Overhead MVA–kilometres	No	473,884	481,552
Underground MVA–kilometres	No	82,999	84,240
Line length	Kms	155,709	156,651
Transformer capacity	MVA	16,764	17,269
Annual user cost of overhead lines	\$m	255.01	273.50
Annual user cost of underground cables	\$m	287.75	310.10
Annual user cost of transformers	\$m	311.96	335.44
Amortisation of overhead (pre–tax)	\$m	249.52	264.90
Amortisation of u'ground (pre–tax)	\$m	282.79	300.22
Amortisation of t'formers (pre–tax)	\$m	299.43	317.88
Amortisation of overhead (post–tax)	\$m	197.35	209.69
Amortisation of u'ground (post–tax)	\$m	223.66	237.65
Amortisation of t'formers (post–tax)	\$m	236.82	251.63

Source: Economic Insights database formed from Disclosure Data

Table A2: 'Non-exempt' electricity distribution database, 1996–2008

<i>Variable</i>	<i>Unit</i>	<i>1996</i>	<i>1997</i>	<i>1998</i>	<i>1999</i>
Deemed revenue	\$m	636.36	720.20	765.86	645.02
Energy throughput	GWh	20,552	21,033	21,377	21,182
Customers	'000	1,349	1,351	1,351	1,378
Adjusted operating expenditure	\$m	257.51	272.45	255.51	231.68
Operating expenditure price	Index	1.000	1.016	1.027	1.039
Overhead MVA–kilometres	No	302,343	304,230	305,899	308,791
Underground MVA–kilometres	No	54,025	55,523	57,590	60,238
Line length	Kms	95,542	96,646	96,913	98,280
Transformer capacity	MVA	12,246	12,085	12,289	12,030
Annual user cost of overhead lines	\$m	127.64	136.77	137.13	131.90
Annual user cost of underground cables	\$m	186.26	199.59	200.11	192.47
Annual user cost of transformers, etc	\$m	176.04	188.63	189.13	181.91
Amortisation of overhead (pre–tax)	\$m	121.32	127.38	132.35	131.62
Amortisation of u'ground (pre–tax)	\$m	177.32	186.17	193.43	192.37
Amortisation of t'formers (pre–tax)	\$m	167.98	176.38	183.25	182.25
Amortisation of overhead (post–tax)	\$m	94.60	99.34	103.25	102.83
Amortisation of u'ground (post–tax)	\$m	138.27	145.19	150.91	150.29
Amortisation of t'formers (post–tax)	\$m	130.99	137.55	142.96	142.38

<i>Variable</i>	<i>Unit</i>	<i>2000</i>	<i>2001</i>	<i>2002</i>	<i>2003</i>
Deemed revenue	\$m	775.54	812.91	854.16	719.58
Energy throughput	GWh	21,966	23,009	23,025	23,821
Customers	'000	1,403	1,431	1,457	1,497
Adjusted operating expenditure	\$m	201.81	209.79	207.67	218.81
Operating expenditure price	Index	1.055	1.069	1.094	1.127
Overhead MVA–kilometres	No	302,688	307,223	308,828	308,380
Underground MVA–kilometres	No	62,679	61,458	63,070	64,765
Line length	Kms	98,658	102,761	105,254	105,236
Transformer capacity	MVA	11,907	11,961	12,343	12,528
Annual user cost of overhead lines	\$m	130.51	137.64	140.48	148.83
Annual user cost of underground cables	\$m	190.45	200.85	205.00	217.18
Annual user cost of transformers	\$m	180.00	189.83	193.75	205.26
Amortisation of overhead (pre–tax)	\$m	129.46	132.51	137.67	143.23
Amortisation of u'ground (pre–tax)	\$m	189.21	193.67	201.21	209.34
Amortisation of t'formers (pre–tax)	\$m	179.25	183.48	190.62	198.32
Amortisation of overhead (post–tax)	\$m	101.57	104.28	108.45	112.95
Amortisation of u'ground (post–tax)	\$m	148.45	152.41	158.50	165.08
Amortisation of t'formers (post–tax)	\$m	140.64	144.38	150.16	156.39

Source: Economic Insights database formed from Disclosure Data

Table A2: 'Non-exempt' electricity distribution database, 1996–2008 (cont'd)

<i>Variable</i>	<i>Unit</i>	<i>2004</i>	<i>2005</i>	<i>2006</i>
Deemed revenue	\$m	864.24	919.81	956.55
Energy throughput	GWh	24,517	25,595	26,049
Customers	'000	1,516	1,533	1,557
Adjusted operating expenditure	\$m	243.16	271.49	279.17
Operating expenditure price	Index	1.158	1.186	1.224
Overhead MVA–kilometres	No	316,535	316,541	319,280
Underground MVA–kilometres	No	67,580	69,576	71,212
Line length	Kms	111,429	113,310	114,620
Transformer capacity	MVA	12,768	13,072	13,367
Annual user cost of overhead lines	\$m	151.85	158.04	167.13
Annual user cost of underground cables	\$m	221.59	232.63	247.17
Annual user cost of transformers	\$m	209.43	219.14	232.30
Amortisation of overhead (pre–tax)	\$m	149.39	154.41	162.62
Amortisation of u'ground (pre–tax)	\$m	218.34	225.68	237.68
Amortisation of t'formers (pre–tax)	\$m	206.85	213.80	225.17
Amortisation of overhead (post–tax)	\$m	117.81	122.02	128.66
Amortisation of u'ground (post–tax)	\$m	172.18	178.34	188.04
Amortisation of t'formers (post–tax)	\$m	163.12	168.95	178.14

<i>Variable</i>	<i>Unit</i>	<i>2007</i>	<i>2008</i>
Deemed revenue	\$m	1,025.80	1,062.33
Energy throughput	GWh	26,482	26,396
Customers	'000	1,575	1,592
Adjusted operating expenditure	\$m	296.40	321.97
Operating expenditure price	Index	1.271	1.335
Overhead MVA–kilometres	No	319,807	322,113
Underground MVA–kilometres	No	72,472	72,651
Line length	Kms	116,100	116,453
Transformer capacity	MVA	13,666	14,045
Annual user cost of overhead lines	\$m	175.19	187.02
Annual user cost of underground cables	\$m	258.63	278.28
Annual user cost of transformers	\$m	243.21	260.76
Amortisation of overhead (pre–tax)	\$m	171.73	181.72
Amortisation of u'ground (pre–tax)	\$m	251.00	265.58
Amortisation of t'formers (pre–tax)	\$m	237.79	251.61
Amortisation of overhead (post–tax)	\$m	135.87	143.92
Amortisation of u'ground (post–tax)	\$m	198.58	210.34
Amortisation of t'formers (post–tax)	\$m	188.13	199.27

Source: Economic Insights database formed from Disclosure Data

APPENDIX B: RESPONSE TO SUBMISSIONS

B1 Introduction

This appendix provides a response to the main issues raised in the various submissions in relation to the two Economic Insights reports released with Commerce Commission (2009):

- Economic Insights (2009a), *Asset valuation and productivity-based regulation taking account of sunk costs and financial capital maintenance*, 11 June ('the summary report'); and
- Economic Insights (2009b), *The theory of network regulation in the presence of sunk costs*, 8 June ('the technical report').

Given time and space constraints, not all issues are responded to in this appendix and, where a response is not provided, Economic Insights confirms that there should be no presumption that it agrees with criticisms or points made in any of the submissions and reserves the right to provide a further more comprehensive response to all issues and matters covered in the submissions (including those covered in this appendix).

The submissions and reports that are responded to in this appendix in relation to total factor productivity issues are:

- Pacific Economics Group (2009a), *X Factor Recommendations for New Zealand Electricity Distribution Price Controls*, Report prepared for Electricity Networks Association, July, particularly appendices one and two;
- PricewaterhouseCoopers (2009), *Comments on the Reports by Economic Insights about the use of TFP in Price Caps*, Note by Jeff Balchin and Craig Rice to Powerco, 3 August;
- Orion (2009a), *Submission on Reset of Default Path – Quality Path for Electricity Distribution Businesses*, 17 July;
- Orion (2009b), *Submission on Economic Insights Papers*, 31 July; and.
- Vector (2009), *Submission to Commerce Commission on Productivity Measurement*, 31 July.

This appendix addresses framework issues raised in the submissions listed above. It does not address issues relating to particular empirical implementations.

Additional reviews are being undertaken by Economic Insights in respect of:

- Pacific Economics Group (2009b), *Reset of Default Price Path for Electricity Distribution Businesses: Submission to the Commerce Commission*, Report prepared for Electricity Networks Association, August;
- asset valuation issues raised in the Orion (2009a,b) submissions; and
- specific quantitative issues and calculations presented in the Pacific Economics Group (2009a) report.

The response in this appendix considers the following issues:

- the relevance of using a TFP framework that makes assumptions based on a competitive market when non-competitive conditions exist (this is only discussed briefly and will be covered in more detail in the subsequent report);
- outputs and output weights;
- capital input quantities;
- capital input prices;
- other technical issues; and
- complexity and implementation.

B2 The lack of relevance of a TFP framework based on assuming competitive conditions in markets with non-competitive conditions

Underlying assumptions

It is important to recognise that much of the PEG (2009a,b) analysis is not appropriate because it attempts to treat energy distribution as if it were a competitive industry. The PEG analysis does not recognise the increasing returns to scale nature of the industry and the presence of sunk costs which means the ‘indexing logic’ PEG uses is inappropriate. It is precisely because of these features that the industry is being regulated.

Large parts of the PEG reports on Economic Insights (2009a,b) are thus based on assessing the Economic Insights framework and key conclusions using the PEG framework which does not take proper account of important economic characteristics of energy distribution businesses. If one were to accept the PEG competitive industry framework as a starting point this may give the impression that many of the criticisms that are raised have some credibility but this is based on assuming a framework that does not take explicit or adequate account of the underlying economic characteristics of the industry under consideration.

Furthermore, even if the PEG framework were accepted there are numerous problems in its interpretation and implementation (although many of these problems are not considered specifically here). In particular, the PEG TFP framework assumes that all capital invested in electricity distribution businesses is not sunk, ie it is variable and can be readily bought and sold in a competitive market and switched to alternative uses. The PEG TFP framework also does not make any explicit allowance for the scope for prices to reflect monopoly or market power related mark ups, ie output prices are assumed to be competitive.

It is well recognised by Economic Insights that a focus of the approach to regulation in New Zealand and in many other jurisdictions is to try to regulate natural monopoly industries to mimic the outcomes that would arise in a ‘workably’ competitive market. However, there is a big difference in assuming a framework that relies on assumptions that a competitive market exists, as PEG does, and developing a framework that takes account of relevant characteristics not consistent with a competitive market in order to provide guidance on appropriate regulatory decisions to help achieve conditions consistent with a competitive market outcome, which is what Economic Insights (2009a,b) does.

In short, the PEG (2009a) report misinterprets the approach in the Economic Insights (2009b) technical report by interpreting many of the conclusions in the context of the framework that PEG uses which is not designed to take proper practical or theoretical account of the relevant market characteristics.

It is important to recognise that the Economic Insights (2009b) approach leads to some fundamental differences in the relationship between TFP growth and technical change compared with the approach proposed by PEG. In particular, the decomposition of TFP established in the Economic Insights technical report shows the specific role of a divergence between price and marginal cost and the role of additional sunk capital in contributing to a saving in operating (or variable) expenses as well as the role of pure technical progress in impacting on TFP.

The 'indexing logic' claimed by PEG is not applicable

The 'indexing logic' PEG proposes relies on the assumption of an underlying 'competitive model' which does not apply in the circumstances and which leads to interpretations and definitions in the PEG TFP framework that are inappropriate. As noted above, simply assuming that the industry should satisfy all the standard competitive properties is neither appropriate nor useful, particularly when there is an alternative approach that does not require such an assumption.

Equation (4) on page 38 of PEG (2009a) is essentially based on the seminal work of Jorgenson and Griliches (1967) which shows that the primal and dual methods for calculating TFP growth coincide under certain conditions. In other words $Trend P - Trend W = - (Trend Y - Trend X) = - Trend TFP$ is by definition only true when there is competitive price taking behaviour (where prices are equal to marginal cost) and constant returns to scale. For example, if there is not competitive price taking behaviour then equation (1) in PEG (2009a) which equates revenues and costs does not apply so one cannot arrive at (4). Similarly, if there are economies of scale equation (3) need not apply. In addition, the derivation of (3) requires competitive conditions to hold in the factor markets for all the firm's inputs: for example, the marginal cost of each input (including all capital inputs) is assumed to equal its market price in a competitive market in order to arrive at the share terms assumed in the equation. But clearly there is not a competitive market (nor a 'workably' competitive market) for sunk capital in the electricity distribution industry in New Zealand.

In other words, stating (as per equation (1)) that $Trend Revenue = Trend Cost$ is not meaningful in the context being considered if trend cost is defined or measured to include prices that deviate from competitive prices (as PEG does with its approach to defining the ex post cost of capital).

It is more reasonable to propose that non-competitive price taking behaviour and increasing returns to scale are more appropriate assumptions for the electricity distribution industry as a starting point for TFP measurement and recommendations for regulatory considerations, than assuming these conditions do not hold.

PEG claim on page 39 that:

'The indexing logic applies only to calibrating the terms of tariff adjustment formulas, not setting rate levels at the outset of an indexing regime. The

competitive market paradigm therefore focuses on only a narrow issue – how revenues and costs evolve over time in competitive markets – and works from this premise towards deriving implications for the appropriate calibration of changes in tariffs for regulated markets. Equation (1) has no implications for the regulated industries’ price levels; for example, it never says that regulated prices should approximate marginal costs, as occurs in perfectly competitive markets. This distinction between what the paradigm implies for appropriate price changes and price levels is sometimes not appreciated.’

The propositions in the foregoing paragraph are not correct. The competitive paradigm does not just focus on revenues equalling costs over time; it also sets prices equal to marginal costs which are equal to average costs with constant returns to scale. So the competitive paradigm implies revenues equal costs over time but it also has strong implications about the pricing of products, which cannot be ignored.

To take an extreme example: suppose in a base period, an EDB was earning large monopoly profits. The PEG methodology will ensure that these large monopoly profits will persist for a long period of time. Such an outcome would be contrary to the purpose statement of the Commerce Act.

At pages 39–40 PEG (2009a) claim:

‘Second, equation (1) has implications about the dimensions of efficiency which need to be captured in a TFP measure used to adjust tariffs. Economists often distinguish between productive efficiency and allocative efficiency. Productive efficiency focuses on cost efficiency eg whether firms use the minimal number of inputs to produce a given level of output. Productive efficiency is focused exclusively on costs, which appear only on the right–hand side of equation (1). If an industry is productively efficient, then the trend rate of change in costs on the right–hand side of (1) will be the lowest possible change in costs that is necessary to satisfy the industry’s changing output (given existing technology).’

Productive efficiency as defined in the third sentence above by PEG is what is known as ‘technical efficiency’, ie the maximum amount of output that could be produced with a given input vector is being produced. Technical efficiency is a necessary, but not sufficient, condition for productive efficiency. Productive efficiency simply means that any given quantity (or, for multi–product firms, bundle of quantities) of output is produced at minimum cost. This requires that a firm uses the lowest cost technology and also that it uses inputs in proportions that will minimise costs. The second definition, in the last sentence above, amounts to (competitive) cost minimising behaviour over time. However, the extent to which productive efficiency will be ensured over time will depend on how the inputs are measured and, in this respect, the PEG methodology does not ensure cost minimising behaviour over time as it does not ensure ex ante financial capital maintenance is achieved and in fact has the potential to lock in excess profits for some firms and below normal profits for others.

At page 40, PEG (2009a) makes further claims with respect to economic efficiency:

‘The indexing logic which links TFP trends to changes in tariffs begins with equation (1). Our exposition above indicates that equation (1) necessarily reflects

both allocative efficiency (in the relationship between changes in revenues and changes in costs for the industry) and productive efficiency (with respect to the efficient change in costs that appears on the right-hand side of (1)). It follows that the TFP measure that emerges from the further elaboration of this logic – and which appears in equation (4) – must also embody both productive and allocative efficiency. Importantly, the appropriate measure of industry TFP growth that is used in TFP-based regulation must be one that would tend to promote changes in industry revenues that approximate changes in industry costs. It should be emphasized that this relationship applies to the industry and not an individual utility; any individual utility would still have incentives to keep its cost growth below what is reflected in the industry-wide norms, as is the case in competitive markets.’

PEG’s equation (1) is an accounting identity which PEG arrives at in practice by using an endogenous rate of return to make costs equal to revenues. It does not ensure allocative efficiency. The Economic Insights (2009b) technical report shows that achieving allocative efficiency in an economy where one industry is subject to increasing returns to scale or decreasing costs is a difficult task. It cannot be achieved by reference to PEG’s equation (1) which is an oversimplification based on inappropriate competitive industry assumptions.

PEG’s equation (1) can be consistent with large monopoly profits (or large economic losses) due to the endogenous nature of the balancing rate of return that PEG calculates. Consider a situation where prices are proportional to marginal costs and revenues are equal to costs. Now substantially change the tariff schedule so prices are not proportional to marginal costs but preserve revenues equal to costs. Both of these situations are allocatively efficient according to PEG but not according to the Economic Insights model, which focuses on welfare. The PEG methodology does not provide a way of determining optimal tariffs (or second best optimal tariffs if lump sum taxes are not available) and, hence, optimal regulation.

Put another way, PEG’s approach does ensure that industry revenues track industry costs but the industry costs may include excessive or deficient profits and would therefore not represent real opportunity costs. This feature of PEG’s methodology is not consistent with achieving allocative efficiency (nor with achieving dynamic efficiency). Although there may be circumstances where it is appropriate to calculate the cost of capital in an endogenous manner (eg where competitive conditions apply or where a firm has been subject to building blocks regulation for an extended period), it is not generally consistent with ensuring the principle of ex ante financial capital maintenance nor with achieving allocative efficiency in increasing returns industries.

The need to take account of monopolistic conditions was flagged in 2003

It is important to note that the methodology presented in Lawrence (2003) that was used by the Commission in specifying the parameters for the threshold regime identified a monopolistic mark-up term (ΔM in equation (2) of section 2.2 above) that is not identified in the approach proposed by PEG (2009). The derivation was presented again in Economic Insights (2009a) on page 11. However, the economic theory that informs the interpretation of the monopolistic mark-up term was not developed in 2003. The Economic Insights (2009b)

technical report develops the relevant theory and provides an interpretation of TFP that identifies the specific role of a price–marginal cost mark–up.

It is relevant to recognise the link between the Lawrence (2003) specification and the Economic Insights (2009a,b) specification to highlight the evolution of the underlying methodology and the recognition in 2003 of the need to make some adjustment to the competitive paradigm that was traditionally used in productivity–based regulation.

B3 Outputs and output weights

PEG (2009a) and PwC (2009) suggest that the measure of output used in the definition of TFP must be the same as that used for pricing purposes, with the implication that if an output measure is not priced then it should not be included in the calculation of TFP. However, this interpretation is again based on the inappropriate assumption of competitive conditions in the energy distribution industry. It does not take account of the increasing returns and sunk cost characteristics actually observed in the industry. Economic Insights (2009b) shows that TFP can be decomposed into a pure technical change term and terms showing the divergence between price and marginal cost and the divergence between capital prices and the marginal saving in operating costs from capital investment where the industry is characterised by non–competitive conditions.

In particular, for the purposes of productivity–based regulation of natural monopoly industries, it is desirable to include all economic or functional outputs (of which billable outputs will be a subset). As will be demonstrated below, limiting coverage to only billed outputs and using revenue weights can introduce significant distortions, particularly if one X factor is to be applied across a diverse range of firms.

In the following subsections we will firstly present a simple numerical example comparing the ‘traditional’ approach advocated by PEG and PwC and the Economic Insights (2009a,b) approach which takes account of the non–competitive characteristics of the industry. We then present a simplified theoretical model to further illustrate the issues.

Before doing this, however, it is important to note that the materiality of output specification and weighting issues depends on whether outputs are all growing at similar or differing rates. If all outputs are growing at similar rates, total output growth will be less sensitive to specification and weighting choices.

PwC’s comments on output selection

PwC (2009, p.8) states:

‘It is submitted that the question of what definition of output is ‘right’ for regulatory purposes is not the definition that reflects ‘exactly what service does an energy distribution business provide’ or the service that reflects best the utility gained by customers. Rather the right definition of output is the one that is most likely to generate a price path that aligns an EDB’s revenue stream with its costs (that is, achieves ex ante financial capital maintenance). Assessed against this objective, it seems self evident that using a measure of output that does not reflect how prices are set can lead to obvious errors (that is even if there is only one

regulated firm). This argument is explained most simply by providing a simple example, which is set out in Box 1 below.’

In the Box 1 referred to, PwC presents a simple example where they define output exclusively in terms of an ‘abstract’ measure such as capacity that is not charged for and that measure of output is used exclusively relative to an input measure to define TFP. PwC claim that if this measure of TFP is to be the X factor and used in conjunction with unit cost increases to define allowable price increases, then revenue would not be sufficient to recover cost.

This example does not, however, reflect the proposal in the Economic Insights (2009a,b) reports. The PwC example is an interpretation of the way that TFP has been traditionally implemented to date but with the substitution of an output measure that does not have a market price. But the Economic Insights approach does not entail the exclusive use of an ‘abstract’ output measure with no market price. Thus, the simple PwC example is neither relevant nor reflective of the Economic Insights approach.

To demonstrate that the PwC example does not interpret our approach correctly, an example is presented below to show that the Economic Insights methodology does derive a price increase which ensures revenue aligns with cost. We do this in a simplified framework that uses the same basic data as presented in the PwC example⁵. The point is that although some outputs included in the calculation of TFP may not be priced, the price of those outputs that do have a market price must increase sufficiently to ensure revenues align with costs.

Consider a two period situation for a single firm producing two outputs, where one output has a market price and the other output does not have a market price for two periods, $t=0,1$. Denote the prices of the two outputs in period t by P_1^t and P_2^t and the quantities of the two outputs in period t by Q_1^t and Q_2^t . Assume the first output is electricity sales or throughput and the second output is a capacity measure. Due to institutional constraints, only the first output is priced so that P_2^0 and P_2^1 are both zero. Set P_1^0 equal to 1.

Assume that in period 0, the volumes of the two outputs were both equal to 100 units. Based on these assumptions and the growth rates in the PwC example, the following output assumptions apply:

$$(B1) Q_1^0 = 100 ; Q_2^0 = 100 ; Q_1^1 = 105 ; Q_2^1 = 120.$$

Note that $Q_1^1/Q_1^0 = 1.05$ and $Q_2^1/Q_2^0 = 1.20$.

Let the amount of input used in periods 0 and 1 be Z^0 and Z^1 , respectively, and let the corresponding input prices be W^0 and W^1 .

Assume that there are zero profits in period 0 so that the value of input, $W^0 Z^0$, is equal to the value of market output, $P_1^0 Q_1^0 = 1 \times 100 = 100$. Set $W^0 = 1$ and since P_1^0 is also equal to 1, this means that Z^0 must be equal to 100 as well. Based on these assumptions and the growth rates in the PwC example, the following input assumptions apply:

$$(B2) W^0 = 1; W^1 = 1.04 ; Z^0 = 100 ; Z^1 = 115.$$

⁵ The PwC example uses logarithmic derivatives of prices and quantities but for convenience we use a discrete time framework here. As is the case for the PwC example, the example presented here abstracts from problems associated with sunk costs, in order to focus on the non-priced output issue raised by PwC.

Now assume, following PwC's example, that the regulator sets market prices in period 1 so that the firm makes zero profits in period 1. P_1^1 is then the solution to the following equation:

$$(B3) P_1^1 \times 105 = W^1 Z^1 = 1.04 \times 115 = 119.6$$

or $P_1^1 = 119.6/105 = 1.1390$. Thus, to ensure revenues align with costs the price cap must allow for a 13.9 per cent increase in the market price of Q_1 , which is very close to PwC's 14 per cent increase⁶.

The basic price and quantity data for the two outputs can be summarised as follows:

$$(B4) P_1^0 = 1 ; P_2^0 = 0 ; P_1^1 = 1.139 ; P_2^1 = 0.$$

With all of the price and quantity data determined, define (one plus) the TFP growth factor (TFPGF) as the market output index, Q_1^1/Q_1^0 , divided by the input quantity index, Z^1/Z^0 :

$$(B5) \text{TFPGF} \equiv [Q_1^1/Q_1^0]/[Z^1/Z^0] = 1.05/1.15 = 0.913.$$

Conventionally measured TFP growth is TFPG minus 1, which is -8.70 per cent. PwC find that conventional TFP growth is -10 per cent – this difference is due to applying the conventions used in index number theory with TFPGF defined as an output index divided by an input index, whereas PwC used a difference approach to measuring TFP growth.

Now, equate cost to revenue in each period so that:

$$(B6) P_1^0 Q_1^0 = W^0 Z^0 ;$$

$$(B7) P_1^1 Q_1^1 = W^1 Z^1.$$

Taking the ratio of (B7) to (B6) and using definition (B5), the following very simple price cap formula is derived:

$$(B8) P_1^1/P_1^0 = [W^1/W^0]/\text{TFPGF}.$$

One plus the rate of increase in capped prices is set equal to (one plus) the rate of increase in input prices divided by (one plus) the rate of growth in TFP.

To show the consistency of the Economic Insights methodology in arriving at the estimated price increase of 13.9 per cent it is necessary to develop the counterpart to equation (278) in the Economic Insights (2009b) technical report. This equation requires estimates of the rate of technical progress and estimates of marginal costs and this information was not presented in the PwC example.

Assume that some econometric estimation has been undertaken and the parameters of the period t cost function, $C(W, Q_1, Q_2, t)$, have been determined where:

$$(B9) C(W, Q_1, Q_2, t) = W[\alpha + \mu_1 Q_1 + \mu_2 Q_2][1 - \tau t] ; \quad t = 0, 1$$

where α , μ_1 , μ_2 and τ are the estimated parameters. These parameters have the following interpretations: α can be interpreted as a fixed cost parameter, μ_1 and μ_2 are the marginal costs of outputs 1 and 2 in period 0 and τ is the rate of technical progress (or of exogenous cost reduction). Period t total cost is equal to $W^t Z^t$ so if observed period 0 and 1 total costs were given by the right hand side of (B9) for $t = 0, 1$, the following equations will hold:

⁶ The difference is due to PwC's use of continuous time compared to the discrete time presentation above.

$$(B10) W^0 Z^0 = W^0 [\alpha + \mu_1 Q_1^0 + \mu_2 Q_2^0];$$

$$(B11) W^1 Z^1 = W^1 [\alpha + \mu_1 Q_1^1 + \mu_2 Q_2^1] [1 - \tau].$$

Also, assume that the fixed cost α is equal to 10, the two marginal costs μ_1 and μ_2 are equal to 0.1 and 0.8 respectively and $1 - \tau$ is equal to 115/116.5 so that τ is equal to 0.0129 and hence the rate of technical progress is approximately 1.3% per year:

$$(B12) \alpha = 10; \mu_1 = 0.1; \mu_2 = 0.8; \tau = 0.0129.$$

It can be verified that if the data for periods 0 and 1 satisfy (B1), (B2) and (B4) and the parameters of the cost function satisfy (B12), then equations (B10) and (B11) hold exactly. Thus, the assumed parameters are perfectly consistent with PwC's basic assumptions.

Now equate cost to revenue in each period so that equations (B6) and (B7) hold. Using equations (B10) and (B11) and equating them to (B6) and (B7) respectively and taking ratios, the following equation for the allowed rate of increase in the price of market outputs that will ensure zero profits in each period is obtained :

$$(B13) P_1^1/P_1^0 = [W^1/W^0][1 - \tau][(\alpha + \mu_1 Q_1^1 + \mu_2 Q_2^1)/(\alpha + \mu_1 Q_1^0 + \mu_2 Q_2^0)]/[Q_1^1/Q_1^0].$$

Substituting the data and parameter assumptions (B1), (B2), (B4) and (B9) into the right hand side of (B13) produces $P_1^1/P_1^0 = 119.6/105 = 1.1390$ and thus the price cap must allow for a 13.9% increase in the market price of Q_1 to keep pure profits at a zero level. This is the same answer as that in using the conventional TFP growth methodology; see (B3) and (B8) above.

To provide further clarification, in the interpretation of the Economic Insights proposal, consider the measure of TFP defined by the last three terms of equation (278) from the Economic Insights (2009b) technical report which PwC also considers in Box 2 (p.10) of their report:

$$(278) \alpha'(t) = \beta + \{w'(t) \cdot z(t) + P_k'(t) \cdot k(t) - \tau(t)C_z(t) - [p(t) - \mu(t)] \cdot y'(t) + [P_k(t) - \pi(t)] \cdot k'(t)\} / R(t).$$

where:

$\alpha'(t)$ = the regulated allowable rate of change of prices;

β = a profit adjustment term;

$w'(t) \cdot z(t)$ = the rate of change in opex input prices weighted by opex input quantities;

$P_k'(t) \cdot k(t)$ = the rate of change in capital input prices weighted by sunk capital input quantities;

$\tau(t)C_z(t)$ = the rate of technical progress with respect to operating expenses weighted by operating costs;

$[p(t) - \mu(t)] \cdot y'(t)$ = the gap between price and marginal cost for all outputs weighted by the rates of change for all outputs;

$[P_k(t) - \pi(t)] \cdot k'(t)$ = the gap between the price of sunk capital and the marginal saving in operating costs from using additional capital weighted by the rate of change of sunk capital inputs;

$R(t)$ = total revenue; and

t = time period.

Note that equation (B13) above is the exact discrete time counterpart to three components of the continuous time equation (278) in the Economic Insights (2009b) technical report. The discrete time term W^1/W^0 is the counterpart to the continuous time term $w'(t) \cdot z(t)$, the term $1 - \tau$ is the counterpart to the term $-\tau(t)C(t)$ and the term $[(\alpha + \mu_1 Q_1^1 + \mu_2 Q_2^1)/(\alpha + \mu_1 Q_1^0 + \mu_2 Q_2^0)]/[Q_1^1/Q_1^0]$ is the counterpart to the term $[\mu(t) - p(t)] \cdot y'(t)$. The other terms in (278) – a profit adjustment term and a term taking account of sunk costs do not appear in (B13) because no profit adjustment is required and the example presented here does not incorporate sunk costs, in order to focus on the output issue raised by PwC.

Returning to PwC's simple example in their Box 1, note that their proposed 'correct' measure of TFP growth is deducted from the weighted change in input prices to determine the allowable change in output prices. The same 'correct' measure of TFP growth that PwC defines can be decomposed as explained in the example presented above. However, ideally our measure requires an estimate of pure technical change available to all firms, marginal cost and market prices, amortisation charges and user benefits. As an approximation, some of the terms may be ignored but it is noted that the inclusion of the divergence between marginal cost and prices is important in terms of addressing underlying economic welfare considerations and is likely to be important in practice where the divergences across firms may be very significant.

It may be helpful to consider the intuition for the last two terms in (278) as follows. Consider the term $[p(t) - \mu(t)] \cdot y'(t)$. Suppose demand for regulated output m is increasing so that $y_m'(t)$ is positive. If $p_m(t)$ is greater than $\mu_m(t)$, then the extra revenue that is generated by the increase in demand will be greater than the incremental cost of producing the increased amount of output m and profits will increase. To keep profits at zero, capped prices have to decrease. Now consider the term $[P_k(t) - \pi(t)] \cdot k'(t)$. Suppose $k'(t)$ is positive and assume that k is a scalar. To maintain financial capital, the firm needs extra revenues to recover the incremental capital charges, $P_k(t)k'(t)$. However, opex will fall incrementally by $\pi(t)k'(t)$ due to the extra capital that has been added. Thus, the net amount of extra revenues that are needed are $[P_k(t) - \pi(t)]k'(t)$ and capped prices will have to adjust to generate this net charge.

As noted earlier, for 'abstract' outputs – or, to be more accurate, economic or functional outputs – where market prices do not exist those market prices would be treated as zero in (278) but the input costs associated with those outputs would be captured. This is because the weight is the difference between marginal cost and market prices, which in this case is simply marginal cost. For billed outputs changes would be weighted by the differences between marginal costs and market prices. Thus, the appropriate measure of output in our approach is one that includes all relevant economic outputs irrespective of whether they are explicitly billed for or not. However, all outputs that are priced would also need to be included (ie these would, by definition, be a subset of economic outputs), along with terms to reflect operating cost and capital cost increases in order to ensure financial capital maintenance.

Our approach recognises that TFP growth is not the same for all firms and, importantly and consistent with underlying economic logic, specifies that prices should increase more than on average if marginal costs exceed prices and more than on average if the price of capital

(based on amortisation charges) exceeds the marginal benefit. Although there may be legislative restrictions on taking account of differences in price–marginal cost differences for individual firms in setting an X factor, it may be possible to make adjustments in other ways and it may also be relevant to make an industry–wide adjustment.

A simplified model highlighting the different definitions of TFP

PEG’s and PwC’s definition of TFP growth can be shown to be equivalent to Economic Insights’ (2009a,b) measure in terms of the impact on prices but, in contrast, the Economic Insights’ (2009a,b) measure decomposes TFP into a pure technical change term, an output change term weighted by the difference between marginal cost and market prices and a capital input change term weighted by the difference between amortisation charges and the marginal user benefit from using additional capital.

The following simple model shows the equivalence of PEG’s and PwC’s definition and the Economic Insights’ approach in terms of defining the impact on prices *ceteris paribus* and shows how the Economic Insights’ measure of TFP growth provides a more informative decomposition in terms of underlying impacts on TFP growth.

In this simple exposition, assume, for the time being, that all inputs are variable to avoid the complications associated with sunk capital.

Revenue and cost at time t, R(t) and C(t) are defined as in the Economic Insights technical report except that k is dropped from the cost function c:

$$(B14) R(t) \equiv p(t) \cdot y(t) ;$$

$$(B15) C(t) \equiv c(y(t), w(t), t) = w(t) \cdot z(t).$$

Differentiating (B14) and the first equation in (B15) gives the following two equations:

$$(B16) R'(t) = p'(t) \cdot y(t) + p(t) \cdot y'(t) ;$$

$$(B17) C'(t) = w'(t) \cdot z(t) + w(t) \cdot z'(t).$$

Now force the prices of billed outputs to vary proportionally so that p'(t) in (B16) is replaced by the following expression:

$$(B18) p'(t) = \alpha'(t)p(t)$$

where $\alpha(t)$ is set equal to one. Suppose also for simplicity that at time t, pure profits, $\Pi(t)$ defined to be R(t) less C(t), are zero. Now regard all variables as exogenous except for the prices of billed outputs and find the rate of change of these prices which will leave the rate of change of profits, $\Pi'(t)$ defined to be R'(t) less C'(t), unchanged. This will ensure that pure profits remain at their initial zero level.⁷ This requires solving the following equation:

$$\begin{aligned}
 (B19) \quad 0 &= \Pi'(t) \\
 &= R'(t) - C'(t) \\
 &= p'(t) \cdot y(t) + p(t) \cdot y'(t) - [w'(t) \cdot z(t) + w(t) \cdot z'(t)] && \text{using (B16) and (B17)} \\
 &= \alpha'(t)R(t) + p(t) \cdot y'(t) - [w'(t) \cdot z(t) + w(t) \cdot z'(t)] && \text{using } p'(t) = \alpha'(t)p(t).
 \end{aligned}$$

⁷ More complex situations where pure profits are not initially zero are dealt with in the Economic Insights technical report; see equation (278).

Now equation (B19) can readily be solved for $\alpha'(t)$ which gives the allowable rate of increase for the billed outputs:

$$(B20) \alpha'(t)R(t) = w'(t) \cdot z(t) + w(t) \cdot z'(t) - p(t) \cdot y'(t).$$

Equation (B20) can be put into ‘productivity’ form if TFP growth $T^{*'}(t)$ is defined as the rate of growth of outputs less the rate of growth of inputs at market prices as follows:

$$(B21) T^{*'}(t) \equiv p(t) \cdot y'(t) - w(t) \cdot z'(t).$$

Note that if some outputs do not have a market price then they would have a weight of zero but (B21) would still hold.

Substituting definition (B21) into (B20) gives the following familiar equation for the rate of increase in capped prices:

$$(B22) \alpha'(t)R(t) = w'(t) \cdot z(t) - T^{*'}(t).$$

Thus, the rate of growth of capped prices is equal to the rate of growth of input prices less TFP growth at market prices. This is the standard, traditional productivity based CPI–X approach that PEG maintains is appropriate, even in the circumstances where there is market power or sunk costs or increasing returns to scale.

In order to highlight the approach of Economic Insights, first differentiate the second equation in (B15) with respect to time. Using Shephard’s Lemma and the definitions of technical progress and marginal cost derivatives, $\tau(t)$ and $\mu(t)$, leads to the following equation:

$$(B23) C'(t) = \mu(t) \cdot y'(t) + z(t) \cdot w'(t) - \tau(t)C(t).$$

Now substitute the right hand side of (B10) into (B6), replacing the term $C'(t)$ in those equations. The resulting equation is:

$$(B24) 0 = \alpha'(t)R(t) + p(t) \cdot y'(t) - [\mu(t) \cdot y'(t) + z(t) \cdot w'(t) - \tau(t)C(t)].$$

Solving equation (B24) for the rate of increase in capped prices gives the following expression:

$$(B25) \alpha'(t)R(t) = w'(t) \cdot z(t) - \tau(t)C(t) + [\mu(t) - p(t)] \cdot y'(t).$$

Thus, according to (B25) the rate of increase in capped prices should be set equal to the rate of increase in input prices $w'(t) \cdot z(t)$ less a measure of technical progress $\tau(t)C(t)$ plus a term that is the inner product of marginal costs less market prices for outputs, $[\mu(t) - p(t)]$, times the expected rate of increase in outputs, $y'(t)$. The point of all this is that *both* equations (B22) and (B25) will hold. They can be reconciled by noting that TFP growth at market prices, $T^{*'}(t)$, and technical progress, $\tau(t)$, satisfy the following identity:

$$(B26) T^{*'}(t) = \tau(t)C(t) - [\mu(t) - p(t)] \cdot y'(t).$$

If there is marginal cost pricing, then $T^{*'}(t) = \tau(t)C(t)$; ie TFP growth is equal to technical change. This is just the dual expression of the usual Solow residual which is identified with technical change (an upward shift in the production function due to improving technology or equivalently, a downward shift in the cost function) and *under the assumptions of competitive pricing and constant returns to scale, TFP growth is equal to technical change*. However, if marginal cost pricing does not hold and there are not constant returns to

scale, then conventionally defined TFP growth as defined by PEG (2009a) and PwC (2009) is not equal to technical change.

Note that with respect to (B25) for those outputs where there is no market price, the respective output changes would be weighted by respective marginal costs whereas in (B21) they would receive a zero weight.

The problem with (B22) is that accidents of history can leave some firms with big TFP disadvantages due to the term $-\ [\mu(t) - p(t)] \cdot y'(t)$ being negative while for other firms, this term will be positive. Thus, while technical progress may be available to all firms, some firms will be disadvantaged and some favoured if (B22) is used in place of (B25).

It may be helpful to provide a concrete example of the distortions that can arise from using simple revenue weights and billable outputs to form an estimate of TFP growth that could be used in setting an X factor. The Australian states of Victoria and Queensland have diametrically opposed charging practices. In Victoria the EDBs place the majority of their charges on the variable components of throughput and, to a lesser extent, peak demand. In Queensland, on the other hand, EDBs place nearly all their charges on fixed components, ie there are negligible throughput and peak demand charges. Throughput has been growing faster than customer numbers in recent years. If billable outputs and revenue weights were used to form the average TFP growth rate across these two states and a common price cap applied based on this then the resulting estimate would be appropriate for none of the EDBs. This is because the output weights used to form the average industry TFP estimate would reflect to any meaningful extent neither the pricing nor the underlying costs of any of the EDBs given the diametrically opposed charging practices of the two states. If the alternative approach of using functional (or economic) outputs (of which billable outputs are a subset) and allowing for both costs and prices in forming output weights is used, then all EDBs are put on an even footing and the resulting TFP estimate will be more appropriate for use in setting a common X factor across all the EDBs.

PEG's comments on output selection

PEG (2009a) at pages 41–42 state:

‘More specifically, equation (2) has two direct implications for the output quantity specification. One is that the specific output quantities that are used to compute the output quantity index must be the billing determinants that are used in the tariffs for the regulated sector. No other output quantity measures can be compatible with equation (2) in the logic above.’

PEG's equation (2) is just based on the identity that collected revenues equal the sum of the product of a billing price times the quantity billed. This identity has to be taken into account when revenues and changes in revenues are calculated over time. Consider equation (B25) which is repeated below for convenience:

$$(B25) \alpha'(t)R(t) = w'(t) \cdot z(t) - \tau(t)C(t) + [\mu(t) - p(t)] \cdot y'(t).$$

The Economic Insights methodology does take into account the fact that allowable revenues must equal the product of allowed billing prices times billed quantities sold. Equation (B25) says that the allowed rate of change of regulated prices should equal expected input price

inflation (this is the term $w'(t) \cdot z(t)$) less expected technical progress (this is the expected cost reduction term $-\tau(t)C(t)$) plus the term $[\mu(t) - p(t)] \cdot y'(t)$. This last term is zero if there is marginal cost pricing so that the vector of marginal costs, $\mu(t)$, is equal to the vector of billed prices, $p(t)$. However, if prices are not equal to marginal costs, then anticipated changes in outputs, $y'(t)$, should be multiplied by the corresponding divergence between marginal costs and billing prices, $[\mu(t) - p(t)]$, in order to ensure that the rate of change of profits stays on the desired path.

In the situation where profits are initially zero, then to keep profits at the zero level, the rate of change of billed output prices should be set equal to the rate of opex input price inflation less the rate of technical progress less the term $p(t) \cdot y'(t)$ plus the term $\mu(t) \cdot y'(t)$. The $p(t) \cdot y'(t)$ term gives the effects on revenues of changes in demands at the initial prices so if the components of $y'(t)$ are positive, this means profits will increase at constant prices and hence this term should be offset by imposing lower billed prices. The $\mu(t) \cdot y'(t)$ term needs to be regarded as an offset to the term $p(t) \cdot y'(t)$ since in the case where the components of $y'(t)$ are positive, the increased demands will increase operating costs by the amount $\mu(t) \cdot y'(t)$ (to the accuracy of a first order approximation to the changes in demands).

The key point of this explanation is that the Economic Insights methodology does not ignore the identity that collected revenues equal the sum of the product of billing prices times the corresponding quantities billed. Rather, as highlighted above the traditional definition of TFP in equation (B21) and the Economic Insights definition in equation (B26) define TFP in an equivalent manner but show a different decomposition of the factors that define TFP. The key point of the algebraic example is that the claim that outputs that do not have market prices cannot be included in the measure of TFP is not correct.

However, a question that may arise in the context of interpreting the algebraic example is that if the numerical estimate of TFP is the same under both approaches then why bother with the proposed new approach. There are two answers to this. The first is that the new approach highlights important factors that contribute to TFP other than technical progress whereas the traditional approach effectively defines TFP as technical progress which is incorrect for natural monopoly industries. The Economic Insights approach identifies those components of TFP growth other than technical progress. The second is that the Economic Insights (2009a,b) reports recognise other important features that impact on both the measures of output and inputs and their respective weights, including how to exactly incorporate the principle of financial capital maintenance.

Finally, it is worth noting that some assumptions have to be made to implement either the Economic Insights or the PEG output frameworks. Despite arguing that it uses 'billable' outputs, PEG (2009a) has used proxies of varying accuracy in forming its output measure. In particular, PEG (2008a) argues for using 'non-coincident demand' as one of three EDB 'billing determinants'. It is presumed this variable is formed as the summation of observed peak demand for each EDB (and those individual EDB peaks will not all occur at the same time). However, this measure represents the peak energy entering the network at the bulk supply points and is likely to be a poor proxy for the contracted demands that large customers pay for. This is because diversification of demand within the network means that the total peak energy entering the network at any one time will be less than the sum of maximum

demands at the final customer level (which will all occur at different times). Rather, the final distribution level of transformer capacity for each EDB would be likely to provide a better proxy. It should also be noted that larger customers pay both throughput and capacity charges rather than just a capacity charge.

Vector's comments on the measure of network output

Vector (2009, pp.7–8) make a number of criticisms of the proposal in Commerce Commission (2009) to broaden the measure of system capacity included in TFP measurement to include transformer capacity as well as line length. Vector argue that including a measure based on the product of transformer capacity and line capacity (in MVA–kms) is including inputs as outputs and would lead to EDBs being able to increase their TFP simply by increasing transformer capacity, regardless of whether or not this was warranted to meet consumer demand. Vector argues instead for measures based on peak demand and line length.

It is important to note firstly that Vector has misinterpreted the proposal in Commerce Commission (2009) which was not to include a measure of transformer capacity multiplied by line capacity (in MVA–kms) as interpreted by Vector but rather to include a measure which was the product of transformer capacity at the last level of transformation and line length (ie in simple kilometres, not MVA–kms). Economic Insights agrees that the measure Vector has mistakenly assumed to be the one proposed would give an incorrect measure of system capacity as it would include measures of transformer capacity and overall line capacity and hence overestimate overall system capacity. Rather, multiplying transformer capacity by line length gives an accurate measure of overall system capacity as it incorporates the maximum transformation capacity and the length over which energy is carried. The only difference between the measure that Vector (2009, p.7) proposes of peak demand and network length and the Commerce Commission (2009) proposal of transformer capacity and network length is thus whether to use the demand–side measure of peak demand or the supply–side measure of transformer capacity in the calculation.

It is also worth noting that (non–coincident) peak demand for the New Zealand electricity distribution industry (as presented in PEG 2008a) has increased at twice the rate of transformer capacity from 1999–2008. Using Vector's preferred measure would, thus, lead to a higher rate of TFP growth than using the overall system capacity measure proposed in Commerce Commission (2009) and adopted in this study. Our measure is thus conservative in favour of the EDBs.

Vector goes on to criticise the use of output measures that include variables that also appear as inputs. Vector's misinterpretation of the Commission proposal is likely to have increased its concerns on this issue. However, it is worth noting that the overall system capacity measure incorporates transformer capacity at the final stage of transformation only (ie the distribution transformer level and not the zone substation level of transformation) whereas the physical measure of transformer capital used on the input side of the TFP calculation would ideally include both distribution and zone substation levels of transformation. This means the issue raised by Vector is not relevant in principle.

Prior to 2008 there was no specification of what level of transformation capacity EDBs had to provide in the Information Disclosure Data. It appears that most EDBs disclosed the

distribution transformation level capacity only. From 2008 onwards both distribution and zones substation transformation levels have to be disclosed and so over time it will be possible to include better information. The effect of using distribution transformer capacity as a proxy for the total transformer input quantity is likely to have been an understatement of TFP growth. This is because zone substation capacity is likely to have increased at a much slower rate than distribution transformer capacity in recent years (as the latter has been driven in large part by the growth in new subdivisions). This means that total EDB transformer capacity is likely to have increased at a slower rate than distribution transformer capacity and recognising this in the TFP calculation would lead to a higher rate of TFP growth. The approach adopted in this report is thus again conservative in favour of the EDBs.

Vector appears to argue that including transformer capacity as an output might lead to EDBs increasing their transformer capacity to increase their TFP growth. However, it needs to be borne in mind that the throughput and customer measures included in the TFP specification would significantly reduce the ability to increase TFP simply by increasing transformer capacity.

Finally, it should be noted that the overall system capacity measure is not new. It was used in the econometric work done in Lawrence (2003) to make estimation tractable. The efficiency results obtained in the econometric modelling coincided with those obtained from the index number methods using the line-only capacity measure at the time. The divergence in growth between line-based measures and distribution transformer capacity since that time has made it important to move to using the broader capacity measure for all aspects of the productivity analysis, not just econometric studies.

B4 Capital input quantities

PEG (2009a, appendix 2) and PwC (2009) have raised the issue of the most appropriate way to measure capital input quantities in TFP studies.

TFP is the ratio of total output quantity to total input quantity. Individual input quantities are aggregated into a measure of total input quantity using indexing methods with shares in total cost as weights. We thus require a quantity and price for each individual input, including capital inputs. Given the long-lived nature of capital inputs we require a measure of the annual 'service potential' quantity for capital inputs. This represents the quantity of service it could potentially provide each year. This will in turn be influenced by the pattern of physical deterioration in the asset.

Two commonly used physical deterioration profiles are 'one hoss shay' depreciation where the service potential quantity remains relatively constant over the asset's life and declining balance or 'geometric' depreciation where the service potential quantity declines by a given percentage each year. In the latter case the decline in service potential quantity is rapid in the early years of the asset's life. A simple proxy for a pattern of one hoss shay service potential quantity is the physical quantity of the capital input available while a simple proxy for a pattern of geometric deterioration of service potential is the constant price depreciated asset value formed using the declining balance method.

PEG (2009a, p.43) makes the statement that ‘with extremely rare exceptions, PEG believes that only monetary measures of capital stocks should be used to measure capital in energy utility TFP studies’. PEG claims that this is ‘overwhelmingly’ supported by economic theory and empirical evidence. However, the evidence PEG presents in support of this claim is extremely selective and ignores both the characteristics of the industry and current statistical agency practice.

Before addressing PEG’s points in turn, it is worth noting that the primary data required for TFP studies are output and input *quantities*. The PEG statement that only monetary measures of capital should be used in energy utility TFP studies is hard to reconcile with this basic requirement of TFP studies. We assume PEG means that it prefers that values deflated by a price index are used as a proxy for the required quantity measure. It is worth noting at the outset, however, that this indirect method of deriving the required quantity measure will always be a second best method compared to direct quantity information, if the latter is available. This is because the price indexes used to deflate values to arrive at proxy quantities will never accurately reflect the prices paid by an individual firm or industry. If direct quantity information is available, along with the corresponding prices, then this source of error can be eliminated.

PEG (2009a, p.44) commence by arguing that capital input quantities will only be consistent with total cost and opex quantities if a monetary capital value approach is used. PEG goes on to argue that setting an X factor using a physical method for measuring capital input quantities will be ‘inconsistent’ with using the capital cost to set starting prices. This argument is incorrect. Economic Insights (2009a, b) demonstrates at length how amortisation charges can be set taking account of the desirable regulatory principle of ex ante financial capital maintenance and these charges – which are analogous to those used in building blocks regulation – are then divided by the quantity of capital input to derive the price of annual capital input which is in turn used in the X factor formula. This is the approach adopted in this report and is fully internally consistent – a fact that is recognised by PwC (2009). Furthermore, as demonstrated by the empirical application in this report, the Economic Insights method does not exacerbate price volatility and is fully transparent.

Rather, the user cost formula adopted by PEG (2009a) is not consistent with the sunk cost characteristics of the energy distribution industry and, as will be shown in the following section, is likely to be biased upwards as it does not accurately reproduce the Jorgenson (1967) user cost formula.

Returning to the issue of the most appropriate proxy for the pattern of deterioration in the quantity of the service potential of network assets over time, it may be useful to consider a simple example. Suppose an EDB installs 100 MVA–kilometres of line with a 50 year life. In the first year of the asset’s life it will have a service potential of 100 MVA–kilometres. The question is how does this change over time? The one hoss shay approach would say that it remains at 100 MVA–kilometres for the next 49 years. The geometric approach advocated by PEG (2009) would say that this progressively declines – in fact relatively rapidly – so that by the 49th year the service potential of the line might only be, say, 2 MVA–kilometres.

While any simple proxy will be an approximation to the true underlying pattern of change in the service potential, those familiar with the operational characteristics of the electricity

distribution industry agree that the service potential of the 100 MVA–kilometre line will change little over its lifetime. It may deteriorate to, say, 95 MVA–kilometres towards the end of its life but it will certainly not deteriorate rapidly and end up near zero at the end of its life. The geometric profile advocated by PEG (2009) thus has little to recommend it for measuring the productivity of energy distribution industries and the one hoss shay proxy will be far more appropriate.

It should be noted, for the avoidance of doubt, that Economic Insights is not saying that the geometric profile has no role to play in any TFP study. There will be some industries that have too many types of capital items to make the application of a physical quantity proxy approach implementable. The issue may also be less critical in industries with relatively short–lived capital. But in energy distribution there are relatively few types of capital, they are all relatively long–lived and all exhibit relatively little physical deterioration over their lifetime. In this case it is possible to provide a far more accurate proxy to the pattern of change in the quantity of annual service potential by use of a physical quantity proxy. PEG (2009a) goes on to quote a number of academics and agencies in an attempt to discredit the one hoss shay approach. However, it is important to recognise that this depreciation profile has a long history, has been found to be a good proxy by many studies and is closer to the approach used by leading statistical agencies than the geometric approach advocated by PEG.

In a seminal article on depreciation published in the *American Economic Review*, Coen (1975, p.73) found the following:

‘Geometric decay of productive capacity – a commonly employed assumption in recent studies of investment behavior – does not appear to underlie actual capital spending decisions. Equipment generally evidences losses in productive capacity as it ages, though not necessarily at a geometric rate, but structures in the majority of industries suffer no loss in productive capacity over their lives (they resemble one–hoss shays).’

Major energy distribution assets are more akin to structures than equipment and so one hoss shay proxies will be appropriate.

With regard to capital inputs for utilities and transport, a major World Bank primer for regulators has observed the following:

‘The quantity of capital should reflect the potential service flow that can be derived from the capital equipment in each year. Expecting the potential service flow to be quite similar in each of the 20 years is reasonable, though more down time could be required in the latter years of the asset's life as more maintenance is required. Hence the potential service flow in year 20 could be 5 or 10 percent below that in year 1 (an engineer could provide advice on this matter). In any case, it is often reasonable to assume that the potential service flow will be quite similar from one year to the next ... Note that when we use physical proxies as our capital measures, such as network length and transformer capacity, we are also implicitly assuming that the service flow of the asset is not affected by its age.’ (Coelli, Estache, Perelman and Trujillo 2003, pp.109–110)

This illustrates that the practice of using physical quantities to proxy capital input quantities has considerable international support.

The US Bureau of Labor Statistics (BLS) (which is the statistical agency in the US responsible for multifactor productivity analysis) has recognised the role of physical deterioration as opposed to financial depreciation in productivity studies as follows:

‘It is not possible to describe some plausible age/efficiency profiles in terms of a constant pattern of deterioration. A good illustrative example is that of a light bulb. It deteriorates very little (if any) through most of its lifetime, That is, its services (converting electricity into light) remain nearly constant. Then, one day, it burns out, after which it has no value whatsoever. While the light bulb is an extreme example (and often too short-lived to be considered capital), many assets appear to provide nearly constant service flows during their initial years. Automobiles are one example. Even though automobile resale values decline rapidly (depreciate) during the first three years of their service lives, two and three year old autos are often as nice looking and reliable as new ones. In other words, their services do not deteriorate very rapidly. Why, then, do their values depreciate? The depreciation reflects the buyers expectations of the future services the auto will provide. Buyers and sellers are evidently quite aware that a three year old auto will become unreliable much sooner than a new one, even if it is presently in ‘good condition’.

‘The distinction between depreciation and deterioration corresponds to the distinction between the value of a capital good and its service flow. The fundamental neoclassical assumption, that the value of an asset equals the discounted value of future services (rents), addresses precisely this issue. At BLS, what we have concluded from this is that, for productivity measurement, we want the specification ... to reflect an asset’s efficiency profile and not its price profile. To emphasize that our measures are constructed with productivity measurement in mind, we have dubbed them ‘productive capital stocks’. We sometimes refer to capital stocks constructed from age/price profiles as ‘wealth stocks.’ (Harper 1997, pp.9–10)

The key component used in forming the productive capital stocks used for productivity analysis is the age–efficiency profile described by the OECD (2001, p.53) as follows:

‘The loss in productive capacity of a capital good over time is shown in its age–efficiency profile or the rate at which the physical contributions of a capital good to production decline over time, as a result of wear and tear. ... A one–year old truck may have lost 20% of its market value but it has not necessarily lost 20% of its capacity to ship goods from one place to another. Indeed, the trucking services of a one–year old vehicle are probably nearly identical to those of a new one.’

Age–efficiency profiles are commonly assumed to be either hyperbolic in shape (ie little deterioration in the early stages of the asset’s life but more in the later years) or geometric (ie rapid deterioration in the early years and little deterioration in the later years). PEG (2009a) argues in favour of a geometric age–efficiency profile. One of the smaller US research agencies quoted by PEG – the Bureau of Economic Analysis (BEA) – has used a geometric

age–efficiency profile in productivity studies but the major US statistical agency responsible for multifactor productivity studies, the BLS, has rejected the geometric profile in favour of the hyperbolic profile.

Importantly, both Statistics New Zealand and the Australian Bureau of Statistics have adopted the hyperbolic age–efficiency profile in their productivity studies. A key parameter in the hyperbolic age–efficiency profile can be set to influence the degree of curvature. A value of one for this parameter leads to a flat or one hoss shay profile while a value of zero would give equal deterioration each year (ie approximate straight line deterioration). Both SNZ and the ABS set this parameter at 0.5 for equipment and 0.75 for structures. That is, they are assuming closer to one hoss shay deterioration for structures. This is the complete opposite of the geometric deterioration profile advocated by PEG.

PEG (2009a, p.48) also raises the issue of whether a ‘portfolio effect’ might apply whereby even if individual assets exhibit one hoss shay depreciation, the aggregate of those assets may still exhibit geometric depreciation. This proposition may have some traction if there was a large number of firms with a wide spread of asset ages. By definition it does not apply for the case of a single firm. In the case of the New Zealand EDBs there are relatively few firms and the age characteristics of the assets are likely to be similar. Indeed, the EDBs have previously highlighted the ‘bunched’ nature of previous network rollouts and the likelihood of an impending ‘wall of wire’ as assets all of similar age require replacement. These characteristics mean that this ‘portfolio effect’ argument in favour of geometric depreciation in aggregate does not apply in this case.

PEG (2009a, p.49) quote an earlier paper by Diewert (2001) where alternative depreciation methods were assessed using aggregate Canadian National Accounts data covering the period 1965 to 1999. Only two types of capital were included in the study – equipment and non–residential construction – and Diewert (2001, p.73) specifically noted that infrastructure capital was not included in the study. The study was not designed to determine which method was appropriate but rather to show the differences in the various methods and leave open which method was best but the study showed that it is perfectly feasible to implement a one hoss shay model of capital accumulation with National Accounts data.

PEG (2009a, p.50) also quotes an early report by Lawrence (1999) which criticised the use of simple total route kilometres as a measure of capital in an early Australian benchmarking study. It should be noted that these criticisms cannot be levelled against the approach adopted in this report as PEG appear to imply. Firstly, the current report uses a measure of line capacity rather than simple route kilometres which allows the aggregation of lines of differing sizes – the kilometres travelled by the Boeing 747 versus the Cessna example contained in the quote is thus not relevant in this case. Furthermore, the current study distinguishes between overhead lines and underground cables and thus the substantially different level of resources required to install each.

Finally, PEG (2009a, pp.50–51) makes a number of claims regarding regulatory proceedings in Ontario in 2008 which are incorrect. PEG claims that the issue of ‘physical versus monetary capital values’ (sic) was debated ‘extensively and transparently’. However, there were very few data items available for the Ontario EDBs. There was some detail on opex and there were data on a few physical items, including overall line length. But there were no data

on capital expenditure and recent data only existed for the period 2002 to 2006. There were thus inadequate data available for Ontario to construct a TFP measure using PEG's 'monetary' approach. Instead, PEG (as advisor to the regulator) advocated using its US database instead which showed ongoing TFP growth.

London Economics International which was representing some of the Ontario EDBs produced alternative estimates for the short period 2002 to 2006 using the very limited data on line length as a measure of capital quantity. This allowed at least some information on TFP for Ontario for recent years to be entered. However, the major problem with the Ontario estimates was that there were no data for the period 1998 to 2002 and data prior to 1998 was not available on the same basis as the recent data. The regulator was concerned that a 'patchwork' approach would have to be adopted that involved different approaches to capital measurement (given that the original Ontario study covering the period up to 1997 had used a 'monetary' approach). There was thus no 'extensive' or independent evaluation of the merits of the two approaches in this proceeding.

It should be noted that the Ontario regulator also rejected some aspects of its own advisor's analysis (Ontario Energy Board 2008, p.12).

In conclusion, it can be seen that the physical proxy approach to measuring capital input quantity adopted in this study is consistent with underlying engineering and economic logic and day-to-day experience. It fully recognises the cost of capital inputs and, unlike the PEG approach, is consistent with ex ante financial capital maintenance. It is also consistent with the bulk of empirical evidence on depreciation patterns and current New Zealand, US and Australian statistical agency practice. It represents a more accurate and improved way forward for regulatory proceedings.

B5 Capital Input Prices

The PEG measure of the user cost of capital

PEG (2009a, pp.14–16) refers to the standard Jorgenson user cost of capital model which they note 'has a solid basis in economic theory'. However, that theory assumes that capital is freely variable from year to year, which is not the case for EDB capital as discussed in Economic Insights (2009a,b).

However, it is notable that even if the standard user cost of capital model is assumed to apply PEG's user cost formula (8) neglects the anticipated or actual capital gains term (which Jorgenson always includes) and so with positive asset price inflation, this measure of user cost as defined by PEG is biased upwards (substantially if inflation is substantial). If this user cost were to be used in an exogenous (or ex ante) format and become part of the regulatory allowable cost it would look as if there were no excess profits or losses for the EDBs (when in fact, there were).

This can be demonstrated as follows. Using the notation in section 10 of the Economic Insights (2009b) technical report but now using the geometric model of depreciation, the first period user cost C_1 (computed according to Diewert's (1974) discrete time formula) is:

$$(B27) C_1 \equiv P_1 - (1+r_1)^{-1}(1-\delta)P_2$$

$$= (1+r_1)^{-1}[r_1P_1 + \delta P_2 - (P_2 - P_1)]$$

where P_1 is the beginning of the period price of a new unit of the asset and P_2 is the end of the period price of a new unit of the asset (so at the end of the period, the depreciated asset is only worth $(1-\delta)P_2$ and not the full P_2). Note that we have discounted the end of the period value of the asset, $(1-\delta)P_2$, by the applicable beginning of period 1 nominal cost of capital, r_1 . Note that (B27) assumes that the user charge is made at the beginning of the period, whereas in equation (308) of section 10 of our technical report, we assumed that the charge was made at the end of the period.

The period 2 user cost of a new unit of capital would be $P_2 - (1+r_2)^{-1}(1-\delta)P_3$ where r_2 is the nominal cost of capital that is applicable at the beginning of period 2 and P_3 is the price of a new unit of capital at the end of period 2. But, at the beginning of period 2, our newly purchased unit of capital at the beginning of period 1 is equivalent to only $(1-\delta)$ units of a new unit of capital so we have to multiply the user cost for a new unit at the beginning of period 2, $P_2 - (1+r_2)^{-1}(1-\delta)P_3$, by $(1-\delta)$ in order to obtain the appropriate period 2 user charge, C_2 , for the unit of capital that was purchased at the beginning of period 1:

$$(B28) C_2 \equiv (1-\delta)[P_2 - (1+r_2)^{-1}(1-\delta)P_3] \\ = (1+r_2)^{-1}[r_2P_2 + \delta P_3 - (P_3 - P_2)](1-\delta).$$

In a similar fashion, we can calculate the appropriate user charge for period t using the geometric model of depreciation and the Jorgensonian user cost methodology:

$$(B29) C_t \equiv (1-\delta)^{t-1}[P_t - (1+r_t)^{-1}(1-\delta)P_{t+1}] \\ = (1+r_t)^{-1}[r_tP_t + \delta P_{t+1} - (P_{t+1} - P_t)](1-\delta)^{t-1}; \quad t = 1, 2, \dots$$

Now we are in a position to calculate the discounted sum of all of the user charges if the EDB buys one unit of infrastructure capital at the beginning of period 1:

$$(B30) C_1 + (1+r_1)^{-1}C_2 + (1+r_1)^{-1}(1+r_2)^{-1}C_3 + \dots \\ = [P_1 - (1+r_1)^{-1}(1-\delta)P_2] + (1+r_1)^{-1}(1-\delta)[P_2 - (1+r_2)^{-1}(1-\delta)P_3] \\ + (1+r_1)^{-1}(1+r_2)^{-1}(1-\delta)^2[P_3 - (1+r_3)^{-1}(1-\delta)P_4] + \dots \quad \text{using (B29)} \\ = P_1.$$

Thus, the appropriately discounted sum of the Jorgensonian ex post user charges is exactly equal to the initial purchase cost of the asset, P_1 . Hence the use of these ex post user charges will ensure that the regulated firm earns a fair rate of return on its asset purchases.

However, PEG does not use the user charge formula defined by (B29) above. Instead, they use the following user cost formula, C_t^* , which ignores the discount factor $(1+r_t)^{-1}$ and the capital gains term, $P_{t+1} - P_t$:

$$(B31) C_t^* \equiv [r_tP_t + \delta P_{t+1}](1-\delta)^{t-1}; \quad t = 1, 2, \dots$$

Note that we have the following relationship between the PEG user costs, C_t^* , and the Jorgensonian user costs, C_t :

$$(B32) C_t^* = [r_tP_t + \delta P_{t+1}](1-\delta)^{t-1}; \quad t = 1, 2, \dots \\ = (1+r_t)C_t + \Delta P_t(1-\delta)^{t-1}$$

$$= C_t + r_t C_t + (1-\delta)^{t-1} \Delta P_t$$

where ΔP_t is the period t price change for a new unit of the asset defined as follows:

$$(B33) \Delta P_t \equiv P_{t+1} - P_t ; \quad t = 1, 2, \dots$$

Now we can calculate the discounted sum of all of the PEG user charges if the EDB buys one unit of infrastructure capital at the beginning of period 1:

$$(B34) C_1^* + (1+r_1)^{-1} C_2^* + (1+r_1)^{-1} (1+r_2)^{-1} C_3^* + \dots$$

$$= \sum_{t=1}^{\infty} (1+r_1)^{-1} \dots (1+r_{t-1})^{-1} [C_t + r_t C_t + (1-\delta)^{t-1} \Delta P_t] \quad \text{using (B32)}$$

$$= P_1 + \sum_{t=1}^{\infty} (1+r_1)^{-1} \dots (1+r_{t-1})^{-1} r_t C_t + \sum_{t=1}^{\infty} (1+r_1)^{-1} \dots (1+r_{t-1})^{-1} (1-\delta)^{t-1} \Delta P_t \quad \text{using (B30)}$$

Thus, if the Jorgensonian user charges C_t are all nonnegative and the capital gains terms ΔP_t are also nonnegative, the discounted sum of the PEG user charges will exceed the purchase price of the asset, P_1 . The regulated firm will earn excess profits on its capital investment if the PEG user costs are used in a regulatory context. The excess profits could be substantial.

However, PEG (2009a) appears to only use its equation (8) in practice to derive a residual or 'ex post' rate of return since it is noted in the discussion (p.16, first paragraph) leading to the equation that an ex post approach to measuring capital cost is adopted which is described as follows:

'An ex post approach to capital cost measurement looks at the actual gross returns to capital at the end of each period. In each year, this was measured as each EDB's regulated revenues minus its O&M and regulatory depreciation expenses, divided by the value of the RAB at the end of the preceding year. This approach constrains regulated cost to equal regulated revenue.'

The foregoing explanation entails the determination of the rate of return as an endogenous variable that ensures revenue equals total costs including the endogenous rate of return that is solved for. If regulated revenues are determined independently this means that the ex post rate of return is defined as a residual after allowing for all other costs. This is only consistent with financial capital maintenance if the regulated revenues explicitly incorporated financial capital maintenance in the first place. But it is not clear how the PEG methodology proposes to do that.

In addition, the explanation provided by PEG in relation to how it determines the cost of capital is inconsistent with applying the Jorgenson equation on an ex ante basis or, as shown above, to achieving financial capital maintenance. The PEG explanation of how it determines the cost of capital is only consistent with its definition of user cost in equation (8) if the r_t term in that equation is endogenous. But as noted above, equation (8) misrepresents Jorgenson's approach since it excludes an explicit term for capital gains.

The PwC interpretation of the relationship between measuring capital input prices and capital input quantities

PwC (2009, p.8) states (with respect to the Economic Insights approach to measuring capital input quantities and capital input prices) that:

‘Regarding the first of the proposals, the effect of this change is effectively to align the results from using a physical approach to measuring output with a financial approach for the measured growth in capital, which was a matter of disagreement between experts when the current thresholds were set. More specifically, to the extent that the physical method would deliver a different estimate of TFP growth than the financial approach (for example, if capital assets deteriorate over their lives), there would be an offsetting impact on the measured capital input price trend (deteriorating capital assets would imply a higher measured input price trend under the EI approach).

‘The fact that this proposal aligns the results of the different methods for measuring capital inputs means that the EI’s proposal would be appropriate if the Commerce Commission (the Commission) continued to use a physical measure of capital input quantities. However, the equivalence suggests that there is little merit in continuing its somewhat unorthodox practice of using a physical measure of capital input quantities when estimating TFP.’

It is not clear exactly what PwC is saying here but it may be mixing the concepts of financial capital maintenance, physical input measurement and whether or not geometric or one hoss shay depreciation is appropriate. The concept of financial capital maintenance can be adhered to irrespective of whether or not capital quantity is measured in physical or ‘monetary’ units and introducing the concept of financial capital maintenance is also independent of a decision about the appropriate time profile of amortisation charges which can be front–end or back–end loaded in real terms or held constant in real terms or set in an infinite number of ways while still maintaining FCM. We have demonstrated in section B4 above that the overwhelming bulk of evidence and logic points to energy distribution network assets exhibiting a one hoss shay profile of service potential and so physical measures of capital input quantities are unambiguously preferred in this instance.

B6 Other technical issues

Revaluation gains

PwC (2009, p.2 and pp.11–12) interprets the Commission’s approach to creating an estimated indexed historical cost series that predates 2004 as being in a manner that excludes revaluation gains and hence underestimates the rate of capital price increase up to 2004. This is not correct. Revaluation gains are included in the IHC series by the use of indexing with the CPI and the estimation of a consistent series for the period 1996 to 2008. The only revaluations that were excluded were the step changes resulting from the changed approach to valuing underground cables in the 2004 ODVs.

It is important to recognise that the new ODV estimates for 2004 differed substantially from the earlier ODVs because of the methodology adopted. In the earlier ODVs much of the underground cable network had been ‘optimised out’ and overhead line unit rates were instead applied to much of the underground network. In the 2004 ODV revaluations the inappropriateness of this earlier practice was recognised and underground unit rates were instead applied to most of the underground network that had previously been ‘optimised out’.

Thus, the significant increase in the 2004 ODVs largely did not reflect a revaluation gain but rather the recognition of a cost that was not previously recognised. Removing the step change resulting from the new 2004 ODVs thus provides a more like-with-like basis for comparing asset values over time.

The method used to form the estimated IHC series used in this report is explained in detail in section 3.3 above.

FCM and investment

PEG (2009b) appears to be under the impression that investment is not allowed for in the FCM discussion in Economic Insights (2009a,b). For clarity, new capital investment of a sunk nature is included in allowable costs and reflected in price increases by the inclusion of an appropriate amortisation schedule as such capital expenditure is incurred. This is explained in detail in section 3.3 above.

The past may not necessarily be an appropriate guide for predicting TFP growth and setting an X factor

PwC (2009 p.2) note the above proposition when assessing TFP trends. We agree with this point and stress it in our technical report (Economic Insights 2009b, p.2). This proposition has been taken into account in this report in making recommendations for an appropriate X factor.

Asset valuation methodologies

Orion (2009a,b) has challenged a number of assessments in the Economic Insights (2009a,b) reports in relation to asset valuation issues. The issues raised by Orion with respect to asset valuation issues will be addressed in a subsequent response by Economic Insights.

B7 Complexity, implementation and relevance

Complexity and implementation

The Orion (2009b) submission considers the Economic Insights model is complex and suggests that it is impractical to implement.

The complexity of the Economic Insights (2009b) report reflects a thorough and rigorous approach to understanding the theoretical implications of formally recognising the relevance of sunk costs and the principle of financial capital maintenance in productivity-based utility regulation. Recognising both these important characteristics is essential for the implementation of a control regime using a productivity-based default price path. However, in terms of implementation the requirements are not complex nor impractical as highlighted by the following:

- for implementation, only one equation from the technical report (equation 305) is required and it has a straightforward interpretation;
- the framework presented allows efficient implementation of a method that allows a superior regulatory treatment of key characteristics of the energy distribution industry.

- this report implements key parts of the framework and it should be clear from the quantitative material presented above that implementation is perfectly tractable and not difficult.

Relevance

Orion (2009b) also contained an appendix prepared by Jeff Makhholm, a Senior Vice President of NERA. Makhholm's note is brief and in the form largely of opinions that the proposed framework or aspects of it are not necessary or mistaken about the need to make adjustments to take account of the impact of sunk costs or are difficult to implement. He presents nothing that undermines the validity of the framework presented in Economic Insights (2009a,b) or which identifies any flaws in it.

Makhholm first claims that the goal of CPI-X regulation is not to improve the welfare of households but rather to make cost-based regulation more streamlined and efficient by allowing prices to move according to a defined path during a set number of years (Orion 2009b, p.14). This is a misrepresentation of one of the key objectives of economic regulation and the use of the CPI-X framework. It also does not reflect the objectives of the Commerce Act which contains many provisions that highlight objectives that entail improving household welfare and overall economic efficiency. This is confirmed by reference to Sections 52A and 52B of the Commerce Act which read as follows:

52A Purpose of Part

“(1) The purpose of this Part is to promote the long-term benefit of consumers in markets referred to in section 52 by promoting outcomes that are consistent with outcomes produced in competitive markets such that suppliers of regulated goods or services—

“(a) have incentives to innovate and to invest, including in replacement, upgraded, and new assets; and

“(b) have incentives to improve efficiency and provide services at a quality that reflects consumer demands; and

“(c) share with consumers the benefits of efficiency gains in the supply of the regulated goods or services, including through lower prices; and

“(d) are limited in their ability to extract excessive profits.”

52B Outline of Part

“(1) This Part provides—

“(a) generic provisions for imposing any 1 or more of 3 types of regulation on goods or services (*see* subpart 2); and

“(b) for the Commission to determine input methodologies applying to the supply of goods or services regulated under this Part (*see* subpart 3).

“(2) The different types of regulation under this Part are as follows:

“(a) information disclosure regulation, under which regulated suppliers are required to disclose information in accordance with requirements determined by the Commission (*see* subpart 4):

“(b) negotiate/arbitrate regulation, under which regulated suppliers are required to negotiate with other parties on prices and quality, and, if negotiation is unsuccessful, to enter into binding arbitration (*see* subpart 5):

“(c) price–quality regulation, of which there are 2 types:

“(i) default/customised price–quality regulation, under which default price–quality paths are set for regulated suppliers, but individual suppliers may seek a customised price–quality path instead (*see* subpart 6); and

“(ii) individual price–quality regulation, under which the Commission sets a price–quality path for an individual regulated supplier (*see* subpart 7).

“(3) Regulation of the following services is dealt with by subparts 9 to 11:

“(a) electricity lines services (subpart 9):

“(b) gas pipeline services (subpart 10):

“(c) services at certain airports (subpart 11).”

Makholm next claims that Economic Insights is ‘totally mistaken’ in assuming that sunk costs are a relevant feature that imply the need for adjustment with respect to regulatory approaches, citing the scope for adding and retiring capital as providing sufficient flexibility (Orion 2009b, p.14). However, for network assets with long physical lives with no meaningful alternative use, the flexibility that Makholm alludes to is not in fact sufficient to validate the underlying competitive framework that is used in traditional TFP measurement. Makholm does not acknowledge this underlying competitive framework and its key role in defining the components of traditional TFP measurement.

Makholm also claims that the framework is not capable of being implemented objectively (Orion 2009b, p.15). There are two responses to this. The first is that considerable judgement is required in applying the traditional framework and one large judgement that has been made in its application is that sunk costs do not matter for the determination of relevant price and quantity measures and appropriate weights. However, Economic Insights (2009a,b) highlight that the existence of sunk costs does matter. Furthermore, the experience with the implementation presented in this report shows that the approach is very practicable.

Makholm also characterises the Economic Insights reports as treating:

“the price adjustment mechanism as the central focus of a “unified theory” of regulation, contrary to the real work of regulators, whose task centers (at least in common law countries like New Zealand) on the sanctity of private property put into public services, the adequacy and efficient provision of those services and

the administration of reasonably objective and orderly administration of methods of price control.” (Orion 2009b, p.16)

This is not an accurate representation of the material presented in Economic Insights (2009a,b). The price adjustment mechanism is clearly a critical and resource consuming task for regulators. The choice and application of an appropriate price adjustment mechanism, with the adoption of principles such as financial capital maintenance and with attention to transparency and practicability, are essential to regulators and a core component of the ‘real work’ of regulators referred to above. It is for reason that the relevant theory and its practical implementation have been given prominence by the Commerce Commission and in the Economic Insights reports. They are, of course, integral to the efficient provision of network services and ‘objective and orderly administration of methods of price control’.

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