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Economic Benchmarking Assessment of Operating Expenditure for NSW and Tasmanian Electricity TNSPs

Report prepared for
Australian Energy Regulator

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TNSP NAME ABBREVIATIONS

The following table lists the TNSP name abbreviations used in this report and the State in which the TNSP operates.

<i>Abbreviation</i>	<i>TNSP name</i>	<i>State</i>
ANT	AusNet Transmission	Victoria
ENT	ElectraNet	South Australia
PLK	Powerlink	Queensland
TNT	TasNetworks Transmission	Tasmania
TRG	TransGrid	New South Wales

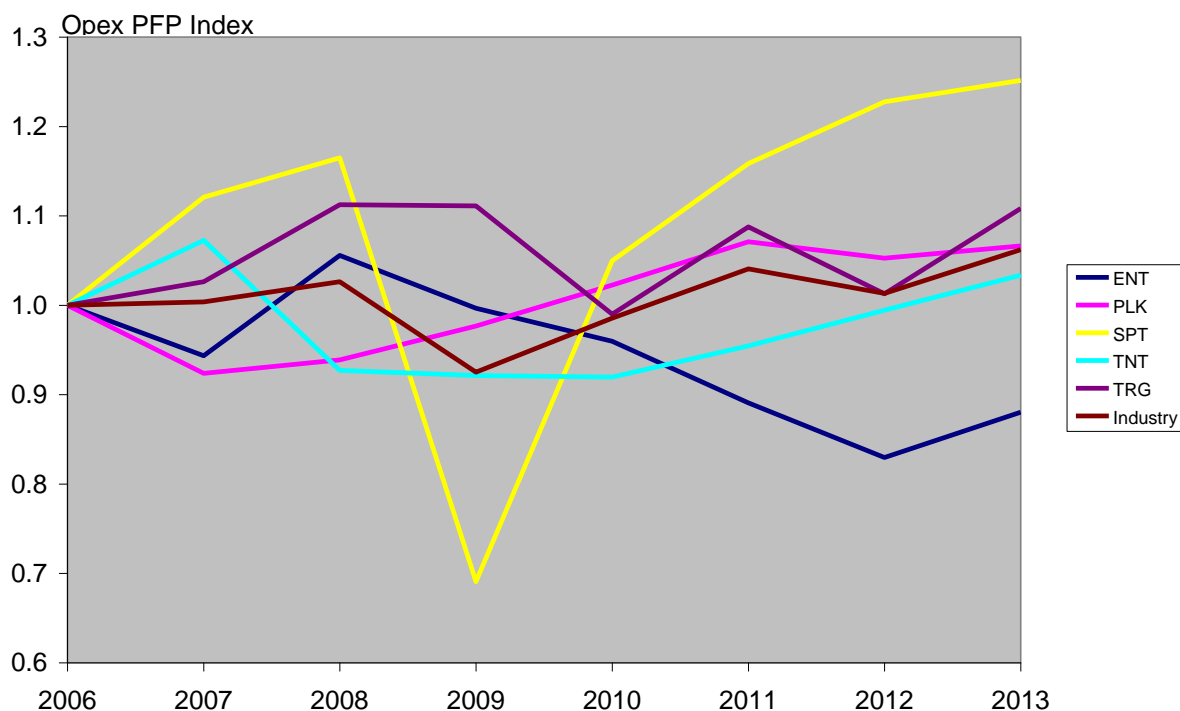
EXECUTIVE SUMMARY

The Australian Energy Regulator has engaged Economic Insights to assist with the application of economic benchmarking and to advise on the productivity change to be applied to forecast opex for the NSW and Tasmanian electricity transmission network service providers (TNSPs) for the five-year regulatory period commencing on 1 July 2014.

Economic benchmarking of TNSPs is constrained by a much smaller number of observations generally being available compared to distribution network service provider (DNSP) studies. As a result we use extrapolation of partial factor productivity (PFP) indexes in this report to forecast TNSP opex productivity growth as there are insufficient observations available to be able to reliably use econometric methods.

Forecast opex partial productivity growth for the next regulatory period is a key component of the rate of change formula used in assessing TNSPs’ opex forecasts.

Figure A TNSP opex partial factor productivity indexes, 2006–2013



Individual TNSP and TNSP industry opex PFP indexes are plotted in figure A. The temporary downturn in AusNet’s opex PFP in 2009 is due to an explosive failure at South Morang Terminal Station and a conductor drop on the Bendigo to Ballarat Line.

Since we have to use extrapolation methods, we follow the productivity-based regulatory practice of using the industry opex productivity growth for all TNSPs rather than TNSP-specific growth (see Lawrence 2003, p.3). This is done to improve incentive properties since an individual TNSP has less scope to influence the industry productivity growth rate than it does its own productivity growth rate. And, given that TNSP productivity measures are still

under development, a more conservative approach of taking an industry weighted average growth rate is prudent.

Including step changes in TNSP opex we estimate TNSP industry average annual opex PFP growth to have been 0.86 per cent over the period 2006 to 2013. This estimate is derived from a model that includes five TNSP outputs: energy, ratcheted maximum demand, voltage-weighted entry and exit connections, circuit length and energy not supplied (the latter entering as a negative output). Sensitivity analysis using alternative output specifications indicated that this estimate was at the bottom end of the range of opex PFP growth rates.

Excluding identified and estimated step changes during the 2006 to 2013 period from TNSP opex leads to a considerably higher average annual opex PFP growth rate of 1.43 per cent. This is the rate of opex PFP growth applying to like-with-like activities and scope over time.

Adoption of the relatively conservative average annual opex PFP growth rate of 0.86 per cent and no additional allowance for step changes would accommodate a modest step change allowance by virtue of the measured opex PFP growth rate underestimating the underlying like-with-like opex PFP growth for similar activities and scope. If an explicit allowance is made for step changes at the reset then it would be appropriate to use the higher average annual opex PFP growth rate of 1.43 per cent which excludes the measurement impact of previous step changes.

1 INTRODUCTION

The Australian Energy Regulator (AER) is currently reviewing the expenditure proposals of electricity transmission network service providers (TNSPs) in New South Wales (NSW) and the Tasmania for the five year regulatory period commencing on 1 July 2014.

AER (2013a) presented expenditure forecast assessment (EFA) guidelines to be used for future electricity distribution and transmission regulatory resets. The development of the EFA guidelines followed a long consultation process as part of the AER's *Better Regulation* program responding to the Australian Energy Market Commission's rule changes for electricity network regulation (AEMC 2012). The rule changes clarified the AER's powers to undertake benchmarking and the EFA guideline indicates that economic benchmarking will be one of a number of assessment techniques the AER will use in assessing TNSP expenditure proposals.

The AER has engaged Economic Insights to assist with the application of economic benchmarking and to advise on the productivity change to be applied to forecast opex for the NSW and Tasmanian TNSPs.

1.1 The opex assessment process

AER (2013a) states that the 'base-step-trend' method will be the preferred method for assessing TNSP opex proposals. Under this method a nominated year (or years) from the previous regulatory period is determined to be the base from which forecast opex for future years is rolled forward for each TNSP. If the TNSP is assessed to have an efficient level of opex in the base year then the TNSP's actual opex in that year will be rolled forward using a rate of change formula. If the TNSP's base year opex is assessed to be inefficient then it may be adjusted downwards by the assessed amount of inefficiency and the adjusted amount would then be rolled forward to form the forecast of efficient opex. Step changes may be added (or subtracted) for any other costs not otherwise captured in base opex or the rate of change that are required for forecast opex to meet the National Electricity Rules opex criteria. The base-step-trend method can thus be summarised as follows:

$$Opex_t = \prod_{i=1}^t (1 + rate\ of\ change_i) \times (A_f^* - efficiency\ adjustment) \pm step\ changes_t \quad (1.1)$$

where:

- *rate of change_i* is the annual percentage rate of change in year *i*
- A_f^* is the actual opex in the base year
- *efficiency adjustment* is an adjustment for the difference between efficient and actual opex in the base year, and
- *step changes_t* is the determined step change in year *t*.

Under this assessment approach the product of the annual rates of change accounts for changes in real opex input prices (changes in opex input prices relative to changes in the

consumer price index), output growth¹ and opex partial productivity in the forecast regulatory control period. The rate of change can be summarised as:

$$\text{Rate of change}_t = \text{output growth}_t + \text{real opex price growth}_t - \text{opex productivity growth}_t \quad (1.2)$$

Economic benchmarking could be used to assist in reviewing the relative efficiency of historical TNSP opex and whether base year opex can be directly trended forward or whether it may be necessary to make adjustments to base year opex to remove observed inefficiencies. Economic benchmarking can also be used in quantifying the feasible rate of opex partial productivity growth that a business could be expected to achieve over the next regulatory period.

The main economic benchmarking techniques include:

- total factor productivity (TFP) indexes which calculate growth rates of the total output quantity relative to total input quantity for an NSP over time
- multilateral TFP (MTFP) indexes which allow productivity levels as well as growth rates to be compared across NSPs
- econometric cost function models
- stochastic frontier analysis (SFA) which constructs an efficient production frontier from the included observations using statistical methods, and
- data envelopment analysis (DEA) which uses linear programming to construct an efficient production frontier from the included observations.

While economic benchmarking of distribution network service providers (DNSPs) is relatively mature and has a long history, there have been very few economic benchmarking studies undertaken of TNSPs. Economic benchmarking of transmission activities is in its relative infancy compared to distribution. As a result, in this report we do not apply the above techniques to assess the base year efficiency of TNSPs. We present an illustrative set of MTFP results using an output specification analogous to our preferred specification for DNSPs but caution against drawing strong inferences about TNSP efficiency levels from these results. However, output growth rates and opex input quantity growth rates can be calculated with a higher degree of confidence and used to forecast opex partial productivity growth for the next regulatory period which is a key component of the rate of change formula in equation (1.2) above.

Economic benchmarking of TNSPs is also constrained by a much smaller number of observations generally being available compared to DNSP studies. As a result we use extrapolation of partial factor productivity (PFP) indexes in this report to forecast TNSP opex productivity growth as there are insufficient observations available to be able to reliably use econometric or DEA methods.

Economic Insights (2013) provides a detailed discussion of economic benchmarking methods, variable specification considerations and data requirements.

¹ Output is used as a driver of opex in the rate of change formula rather than capital. Using the latter would create adverse incentive effects.

1.2 Economic benchmarking RINs

Following lengthy consultation with TNSPs and other stakeholders over the course of 2013, the AER issued economic benchmarking Regulatory Information Notices (RINs) to the 5 TNSPs in the Australian National Electricity Market in November 2013. The RINs required the TNSPs to supply and document detailed data on the values and quantities of outputs, inputs and operating environment factors for the 8-year period 2005–06 to 2012–13. The AER provided detailed definitions of all variables and instructions on the coverage of activities to be included in reporting. TNSPs were given three months to supply an initial draft of their data to be signed off at Chief Executive Officer level and a further two months to provide a final data return with the most recent five years of value information to be signed off by auditors and quantity information to be certified by engineering experts.

Upon receipt of the draft data the AER commenced a detailed data checking process with any apparent errors or anomalies being notified to TNSPs for explanation or correction. Data were checked against other pre-existing reporting sources and subjected to extensive ratio and other filtering ‘sanity checks’. The documented basis of preparation statements were checked in detail to identify any differences in the way TNSPs had interpreted the instructions provided. All RIN data were published on the AER website following receipt of final audited/certified data. TNSPs were then given an additional period in which to lodge cross submissions on other TNSPs’ data where any differences in bases of preparation had been identified by the TNSP.

While no dataset will likely ever be perfect, the AER’s economic benchmarking RIN data provides the most consistent and thoroughly examined TNSP dataset yet assembled in Australia. Previous datasets have reflected differences in reporting requirements across jurisdictions and, in most cases, over time as jurisdictional reporting requirements progressively evolved in response to changes in the application of building blocks regulation, in many cases to counter any possible gaming by TNSPs. The AER’s economic benchmarking RIN data have been supplied using a consistent set of definitions and coverage both over time and across jurisdictions. In our assessment, the AER’s economic benchmarking RIN data are also considerably more detailed, comprehensive and consistent than regulatory data in comparable countries, including the United States.

Given the extensive process that has been gone through in forming the AER’s economic benchmarking RIN database to ensure maximum consistency and comparability both across TNSPs and over time, the database is fit for the purpose of undertaking economic benchmarking to forecast future opex partial productivity growth rates.

The following section of the report presents more detail on the economic benchmarking method used in the study. Section 3 then discusses output and input specification issues and the preferred specifications adopted. We also present illustrative MTFP results in section 3. Section 4 presents opex PFP results using the Fisher Ideal index method and analyses TNSP opex partial productivity growth rates. We also consider the impact of step changes on measured opex partial productivity. Finally, we present our recommendations on NSW and Tasmanian TNSP forecast opex PFP growth rates in section 5.

2 ECONOMIC BENCHMARKING METHODS USED TO ASSESS OPEX PRODUCTIVITY GROWTH

In this section we describe, in general terms, the methods that are used in this report to measure opex partial productivity growth rates of TNSPs. We make use of productivity index numbers (PIN) measurement methods that have been widely used in both academic and regulatory analyses of electricity distribution and many other industries.

The PIN methodology is described in some detail in Coelli et al (2005) and also in ACCC (2012), the latter publication containing particular reference to electricity industry applications.

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

Productivity is measured by constructing a ratio of output produced over inputs used. There are two types of productivity measures considered in this study: TFP and PFP. TFP measures total output relative to an index of all inputs used. Output can be increased by using more inputs, making better use of the current level of inputs and by exploiting economies of scale. PFP measures one or more outputs relative to one particular input (eg opex partial productivity is the ratio of total output to opex input).

Total factor 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 over time.

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.

Opex Partial Factor Productivity (Opex PFP) measures are obtained by forming the ratio of a total output quantity index divided by an opex input quantity index for each TNSP.

Opex PFP indexes have a number of advantages including:

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

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

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

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

In this study we generally use the translog cost function method to form output cost shares for the included output components and hence prices that are used in the index number application. Where it did not prove possible to estimate a translog cost function we have used the simpler Leontief cost function method developed in Lawrence (2003).

Traditional measures of TFP have enabled comparisons to be made of *rates of change* of productivity between firms but have not enabled comparisons to be made of differences in the *absolute levels* of productivity in combined time series, cross section firm data. This is due to the failure of conventional TFP measures to satisfy the important technical property of transitivity. This property states that direct comparisons between observations m and n should be the same as indirect comparisons of m and n via any intermediate observation k . Multilateral Total Factor Productivity (MTFP) and Multilateral Partial Factor Productivity (MPFP) index numbers use a more sophisticated indexing method which does satisfy the transitivity property and can be used to obtain an estimate of productivity growth over time

and also to measure productivity differentials across DNSPs (Caves, Christensen and Diewert 1982).

Lawrence, Swan and Zeitsch (1991) and the Bureau of Industry Economics (BIE 1996) used the MTFP index to compare the productivity levels and growth rates of the five major Australian state electricity systems and the United States investor-owned system. Lawrence (2003) and PEG (2004) also use this index to compare electricity distribution business TFP levels and Lawrence (2007) and Economic Insights (2012) used it to compare TFP levels across the three Victorian gas distribution businesses.

However, as noted in section 2, economic benchmarking of transmission activities is in its relative infancy compared to distribution. As a result, while we present an illustrative set of MTFP results using an output specification analogous to our preferred specification for DNSPs in the following section, we caution against drawing strong inferences about TNSP efficiency levels from these results. More confidence can be placed in productivity growth rate results because they simply measure year-to-year changes without passing judgement on relative efficiency levels.

3 TNSP OUTPUTS AND INPUTS

In this section we review a number of output and input specification issues and describe the specification adopted in the remainder of the study.

3.1 TNSP output specification

TNSP output specification issues were discussed at length in Economic Insights (2013) and during the AER's preceding consultation process. It was noted that under building blocks regulation there is typically not a direct link between the revenue requirement that the TNSP is allowed by the regulator and how the TNSP structures its prices. Rather, the regulator typically sets the revenue requirement based on the TNSP being expected to meet a range of performance standards (including reliability performance) and other deliverables (or functional outputs). TNSPs then set prices on the outputs they charge for that have to be consistent with broad regulatory pricing principles but this is a separate process from setting the revenue requirement.

Given that the outputs to be included in economic benchmarking for building blocks expenditure assessments will need to be chosen on a functional basis, Economic Insights (2013) specified criteria to guide the selection of outputs to be included in economic benchmarking based on those proposed by the AER (2012, p.74):

- 1) the output aligns with the National Electricity Law and National Electricity Rules objectives
- 2) the output reflects services provided to customers, and
- 3) the output is significant.

The first selection criterion states that economic benchmarking outputs should reflect the deliverables the AER expects in setting the revenue requirement which are, in turn, those the AER believes are necessary to achieve the expenditure objectives specified in the NER. The NER expenditure objectives for both opex and capex are to:

- meet or manage the expected demand for prescribed transmission services over that period;
- comply with all applicable regulatory obligations or requirements associated with the provision of prescribed transmission services;
- to the extent that there is no applicable regulatory obligation or requirement in relation to:
 - 1) the quality, reliability or security of supply of prescribed transmission services; or
 - 2) the reliability or security of the distribution system through the supply of prescribed transmission services,to the relevant extent:
 - 3) maintain the quality, reliability and security of supply of prescribed transmission services; and

-
- 4) maintain the reliability and security of the transmission system through the supply of prescribed transmission services; and
- maintain the safety of the distribution system through the supply of prescribed transmission services.

If the outputs included in economic benchmarking are similar to those the TNSPs are financially supported to deliver then economic benchmarking can help ensure the expenditure objectives are met at an efficient cost.

The second selection criterion is intended to ensure the outputs included reflect services provided directly to customers rather than activities undertaken by the TNSP which do not directly affect what the customer receives. If activities undertaken by the TNSP but which do not directly affect what customers receive are included as outputs in economic benchmarking then there is a risk the TNSP would have an incentive to oversupply those activities and not concentrate sufficiently on meeting customers' needs at an efficient cost. However, as noted above, given the characteristics of transmission and its critical role in the electricity supply chain there may be a case for including as outputs in economic benchmarking secondary deliverables which are not directly provided to customers. If this route is taken then the second criterion becomes less relevant.

The third selection criterion requires that only significant outputs be included. TNSP costs are dominated by a few key outputs and only those key services should be included to keep the analysis manageable and to be consistent with the high level nature of economic benchmarking.

Economic Insights (2013) presented a preferred output specification which included outputs of energy throughput, system capacity (measured as the product of line plus cable circuit length and the total installed capacity of downstream-side transformers), the number of entry and exit points (capturing fixed elements of TNSP output) and reliability (measured by energy not supplied and entering as a negative output).

This specification concentrated on the supply side, giving TNSPs credit for the network capacity they have provided. It has the advantage of capturing both line and transformer dimensions of system capacity. A similar specification (but excluding reliability) has previously been used at the electricity distribution industry level (eg Economic Insights 2009) where it captures the key functional elements of DNSP output well. However, it has not previously been used to benchmark a diverse range of NSPs of differing sizes. A potential disadvantage of the specification in the economic benchmarking context is the multiplicative nature of the system capacity variable which introduces a degree of non-linearity thereby potentially advantaging large TNSPs.

An output specification used recently by Pacific Economics Group Research (PEGR 2013) in work on electricity distribution for the Ontario Energy Board included outputs of energy throughput, ratcheted maximum demand, customer numbers, circuit length and reliability. It covers similar components to our system capacity measure but not in a multiplicative form and so has attractions given the widely varying sizes of the Australian TNSPs.

This output specification also has the advantage of capturing both the demand side transformer dimension of system capacity and the line length dimension. It thus addresses

another criticism of the preferred specification listed in Economic Insights (2013) which was that it placed insufficient weight on demand side outcomes. In consultation undertaken by the AER in 2013, some user groups argued for the inclusion of demand side functional outputs so that the TNSP is only given credit for network capacity actually used and not for capacity that may be installed but excess to users' current or reducing requirements. Including observed maximum demand instead of network capacity was argued to be a way of achieving this. However, this measure would fail to give the TNSP credit for capacity it had been required to provide to meet previous maximum demands which may have been higher than those currently observed.

Economic Insights (2013) suggested that inclusion of a 'ratcheted peak demand' variable may be a way of overcoming this problem and PEGR (2013) also used the same variable (that it described as 'system peak demand'). This variable is simply the highest value of peak demand observed in the time period up to the year in question for each EDB. It thus recognises capacity that has actually been used to satisfy demand and gives the TNSP credit for this capacity in subsequent years, even though annual peak demand may be lower in subsequent years.

The four output TNSP specification covering energy throughput, ratcheted maximum demand, voltage-weighted entry and exit connections, and circuit length represents a useful way forward as it captures the key elements of TNSP functional output in a linear fashion and introduces an important demand side element to the measurement of system capacity outputs. We also add a fifth output of reliability (measured by energy not supplied and entering as a negative output).

This specification performs well using the selection criteria listed in Economic Insights (2013). It recognises key aspects of the expenditure objectives by including both energy throughput and peak demand. By including the key dimensions of system capacity it recognises the importance of maintaining the quality, reliability and security of prescribed transmission services. And it also includes measures of reliability directly. It also performs well against the second criterion as it directly reflects the range of services provided to customers, including energy throughput, peak demand and reliability along with the key element of system capacity required to support delivery of those services to customers. And it covers the most significant outputs and thus performs well against the third criterion.

To operationalise our preferred five output specification in index number methods we have to next derive output cost-based weights. We do this using the shares of the first order output coefficients from a translog cost function in the sum of those first order coefficients. Estimated output cost shares were energy 21.4 per cent, ratcheted maximum demand 22.1 per cent, weighted entry and exit connections 27.8 per cent and circuit length approximately 28.7 per cent. Energy not supplied was treated as a negative output with a weight based on the value of consumer reliability (VCR).

The Australian Energy Market Operator (AEMO 2014) has recently released updated VCR estimates. Analogous to our approach for DNSPs, we have adopted the updated VCRs in allocating a weight to energy not supplied.

3.2 TNSP input specification

Input specification issues were discussed at some length in Economic Insights (2013). The preferred opex specification in Economic Insights (2013) and AER (2013c) uses total opex deflated by a price index comprising labour and materials and services price indexes to proxy the quantity of opex inputs. Net changes in provisions are included.

The price of opex is taken as a weighted average of the Electricity, gas, water and waste sector (EGWW) Wages price index (WPI) and five ABS Producer price indexes (PPIs) as used in Economic Insights (2012) and using opex shares reported in PEG (2004) based on analysis of Victorian electricity DNSP regulatory accounts data². The component price indexes and weights are as follows:

- EGWW sector WPI – 62.0 per cent
- Intermediate inputs – domestic PPI – 19.5 per cent
- Data processing, web hosting and electronic information storage PPI – 8.2 per cent
- Other administrative services PPI – 6.3 per cent
- Legal and accounting PPI – 3.0 per cent, and
- Market research and statistical services PPI – 1.0 per cent.

The preferred capital input specification in Economic Insights (2013) and AER (2013c) used overhead MVAkms to proxy the annual input quantity of overhead lines capital input, cables MVAkms to proxy the annual input quantity of underground cables, and total transformer MVA to proxy the annual input quantity of transformers and other capital inputs. Use of the MVAkms measure allows the aggregation of lines and cables of differing voltages and capacities into a single robust measure. MVAkms measures are formed using the MVA ratings for each voltage class specified by each TNSP and its reported circuit length. The annual user cost of capital is made up of the return of capital, return on capital and tax components calculated in a way which approximates the corresponding building blocks calculations and is pro-rated across the three capital inputs based on their relative shares in the regulated asset base.

This input specification has the advantage of best reflecting the physical depreciation profile of TNSP assets. Movements in the quantities of each of the three capital inputs over time are relatively smooth as one would expect TNSP capital input quantities to be given the long-lived nature of TNSP assets. It best fulfilled the selection criteria identified in Economic Insights (2013) of:

- 1) input coverage is comprehensive and non-overlapping
- 2) measures of capital input quantities are to accurately reflect the quantity of annual capital service flow of assets employed by the NSP
- 3) capital user costs are to be based on the service provider's regulatory asset base (RAB)

² We note that in recent determinations the AER has used the consumer price index (CPI) to escalate non-labour opex costs instead of disaggregated PPIs. A sensitivity analysis of the effect of using the CPI compared to the five disaggregated PPIs indicated no material difference in results. To implement rate of change calculations it will be necessary to use CPI forecasts for the non-labour component of opex as forecasts of disaggregated PPIs are not currently available and would be unlikely to be sufficiently robust.

and should approximate the sum of the return of and return on capital components used in building blocks, and

- 4) specification to be consistent with the NEL and NER.

3.3 TNSP operating environment factors

Economic Insights (2013) identified a range of operating environment factors which may impact TNSP efficiency levels. These included a range of weather factors, terrain factors and network characteristics variables. The AER economic benchmarking RIN commenced the collection of operating environment data covering these factors. Because many of the variables are relatively new, TNSPs appear to have interpreted some of the variables in different ways. Because of this, and because these variables were only requested for a shorter period, more refinement and extension of these variables is required before they could be used in economic benchmarking.

And while these factors may have a material impact on relative TNSP efficiency levels, they are less likely to have a material impact on relative opex PFP growth rates across TNSPs. Given the focus of this study on opex PFP growth rates and the still relatively undeveloped nature of TNSP operating environment factor variables, we do not include operating environment factors in this study.

3.4 Illustrative TNSP MTFP results

As discussed earlier in this section, the illustrative TNSP MTFP measure has five outputs included as follows:

- Energy throughput (with 21.4 per cent share of gross revenue)
- Ratcheted maximum demand (with 22.1 per cent share of gross revenue)
- Voltage-weighted entry and exit connections (with 27.8 per cent share of gross revenue)
- Circuit length (with 28.7 per cent share of gross revenue), and
- (minus) Energy not supplied (with the weight based on current AEMO VCRs).

The illustrative TNSP MTFP measure includes four inputs:

- Opex (network services opex deflated by a composite labour, materials and services price index)
- Overhead lines (quantity proxied by overhead MVAkms)
- Underground cables (quantity proxied by underground MVAkms), and
- Transformers and other capital (quantity proxied by transformer MVA).

In all cases, the annual user cost of capital is taken to be the return on capital, the return of capital and the tax component, all calculated in a broadly similar way to that used in forming the building blocks revenue requirement.

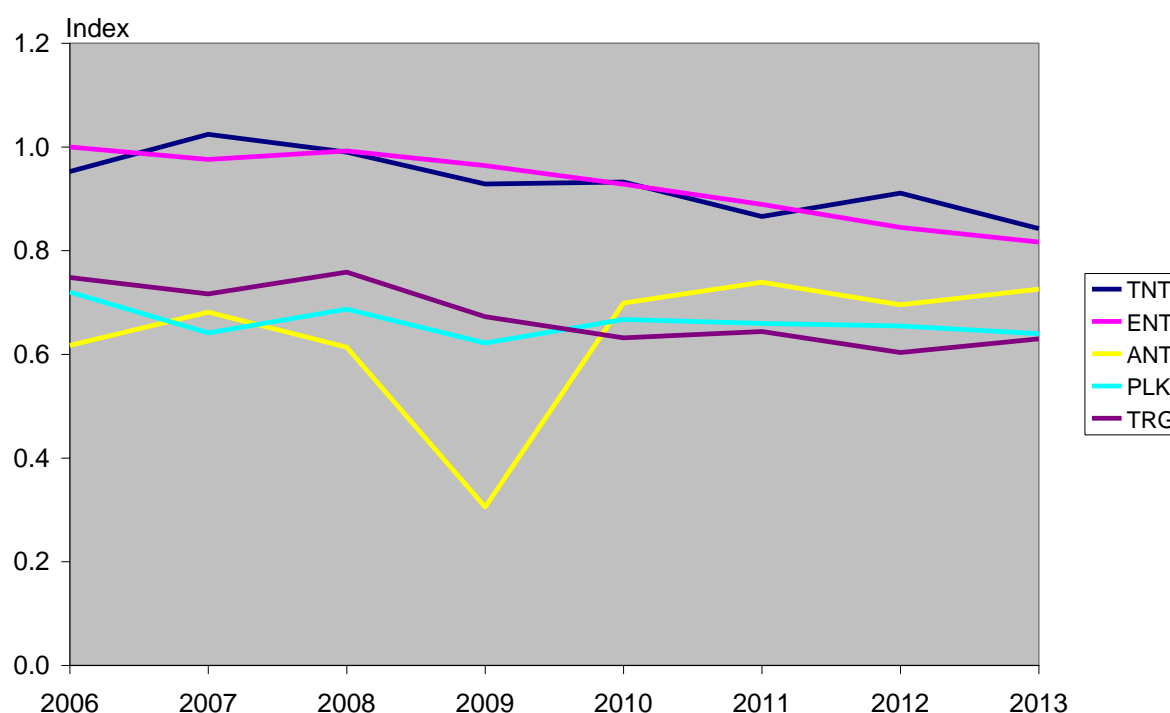
The multilateral index number methodology is presented in appendix B.

Illustrative TNSP MTFP results are presented in table 3.1 and figure 3.1. For presentational purposes the observation for ElectraNet in 2006 is given the value one. The Tasmanian TNSP has had the highest average MTFP level over the 8-year period, followed closely by ElectraNet. Although AusNet Transmission has the lowest average MTFP level over the 8 years, this is mainly due to the one-off dip in 2009. For the second half of the period AusNet Transmission was in the middle of the MTFP range. Powerlink and TransGrid had similar MTFP levels over the 8 years. MTFP growth rates over the period have been negative for four of the five TNSPs with only AusNet Transmission displaying positive MTFP growth. As noted in section 1, however, we caution against drawing strong inferences about TNSP efficiency levels from these results given the early stage of development of productivity level measures.

Table 3.1 **Illustrative TNSP multilateral total factor productivity indexes and annual growth rates, 2006–2013**

<i>TNSP</i>	<i>Average MTFP index level</i>	<i>Average annual MTFP growth rate</i>
TNT	0.931	-1.75%
ENT	0.926	-2.90%
TRG	0.676	-2.46%
PLK	0.661	-1.69%
ANT	0.635	2.31%

Figure 3.1 **Illustrative TNSP multilateral total factor productivity indexes, 2006–2013**

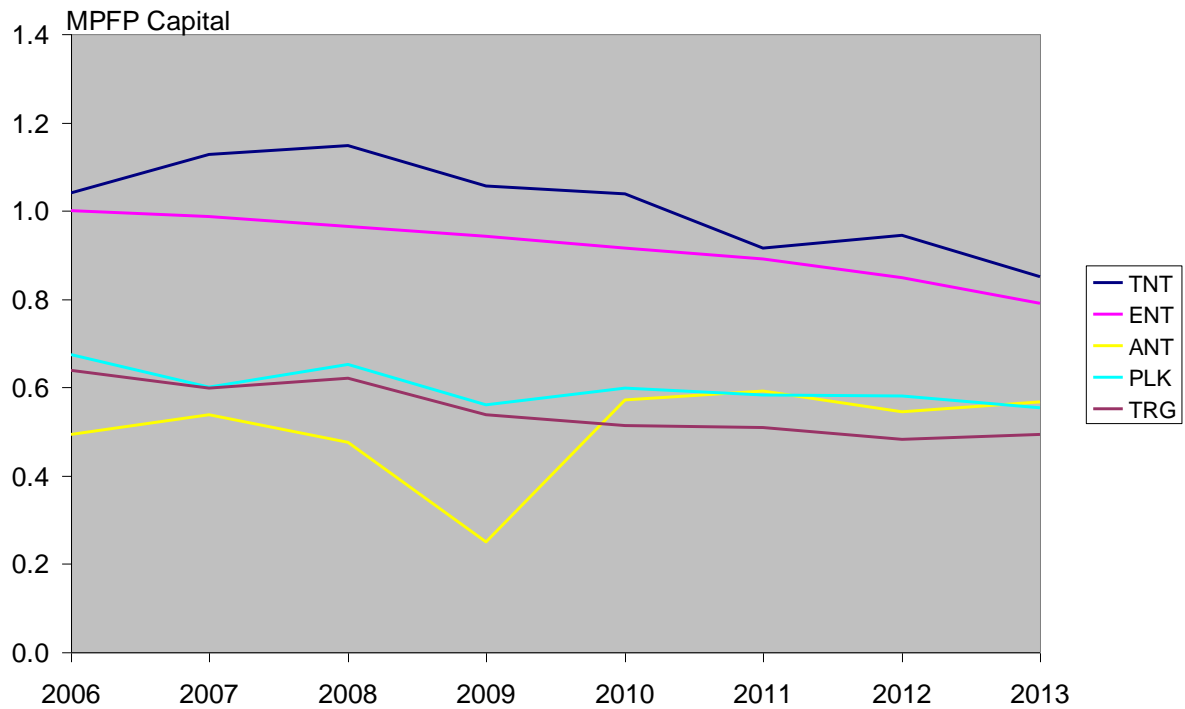


In figures 3.2 and 3.3 we present the corresponding opex multilateral partial factor productivity (MPFP) and capital MPFP indexes. Again, given the early stage of development of TNSP productivity level measures, we caution against drawing strong inferences about TNSP opex and capital efficiency levels from these results.

Figure 3.2 Illustrative TNSP multilateral opex partial factor productivity indexes, 2006–2013



Figure 3.3 Illustrative TNSP multilateral capital partial factor productivity indexes, 2006–2013



In the following section we analyse TNSP productivity growth rates. More confidence can be placed in growth rate results because they reflect the TNSP's performance relative to its own historical performance and are not affected by relative rankings.

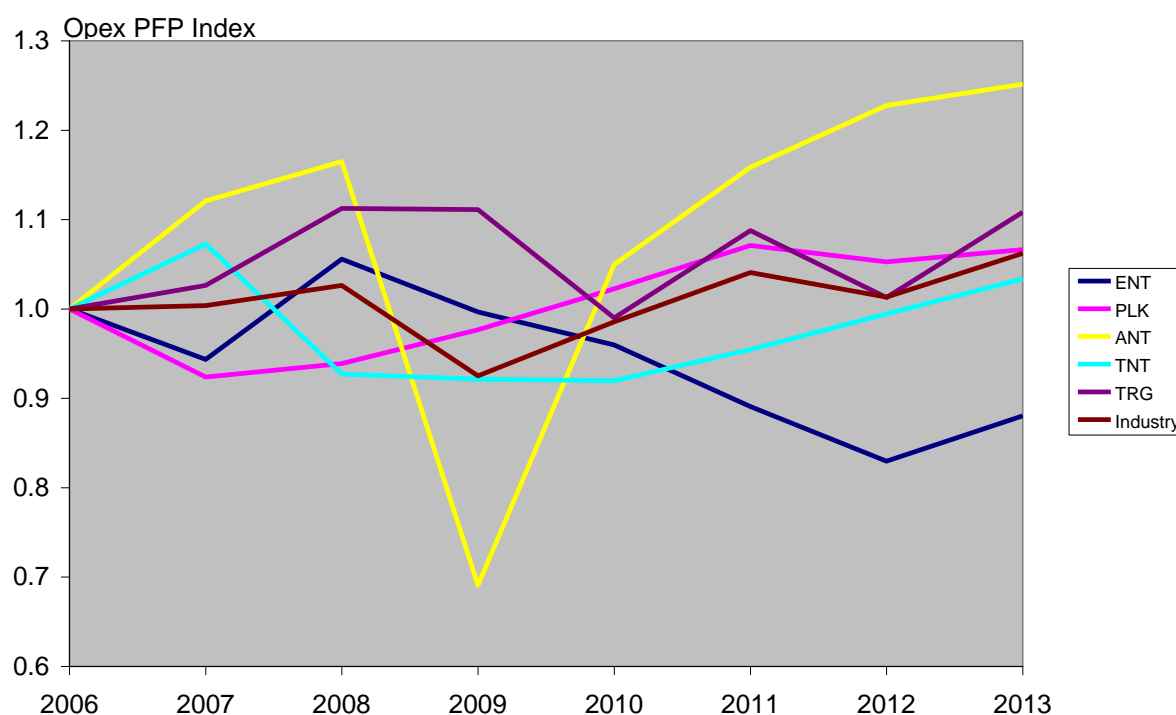
4 OPEX PFP INDEX RESULTS

We now turn to the TNSP opex PFP results which are presented in table 4.1 and figure 4.1.

Table 4.1 **TNSP opex partial factor productivity indexes and average annual growth rates, 2006–2013**

TNSP	2006	2007	2008	2009	2010	2011	2012	2013	Annual Growth
ENT	1.000	0.943	1.056	0.997	0.960	0.891	0.830	0.880	-1.82%
PLK	1.000	0.924	0.939	0.977	1.023	1.071	1.053	1.066	0.92%
ANT	1.000	1.121	1.165	0.691	1.050	1.158	1.228	1.251	3.20%
TNT	1.000	1.073	0.927	0.921	0.920	0.955	0.994	1.034	0.47%
TRG	1.000	1.026	1.113	1.111	0.990	1.088	1.013	1.108	1.47%
Industry	1.000	1.004	1.026	0.925	0.986	1.041	1.013	1.062	0.86%

Figure 4.1 **TNSP opex partial factor productivity indexes, 2006–2013**



As discussed in section 3, the TNSP opex PFP measure we use has five outputs included:

- Energy throughput (with 21.4 per cent share of gross revenue)
- Ratcheted maximum demand (with 22.1 per cent share of gross revenue)
- Weighted entry and exit connection numbers (with 27.8 per cent share of gross revenue)
- Circuit length (with 28.7 per cent share of gross revenue), and
- (minus) Energy not supplied (with the weight based on current AEMO VCRs).

The output quantity index is then divided by an opex input quantity index to form the opex PFP measure. The opex quantity index is total opex deflated by a composite labour, materials and services price index.

From table 4.1 and figure 4.1, AusNet Transmission can be seen to have had the highest opex PFP growth over the 8 year period, despite a significant drop in 2009 caused by an explosive failure at South Morang Terminal Station and a conductor drop on the Bendigo to Ballarat Line. AusNet Transmission achieved an opex PFP average annual growth rate of 3.2 per cent over the 8–year period. TransGrid had the next highest average annual opex PFP growth rate of 1.5 per cent, followed by Powerlink on 0.9 per cent and Tasmania Networks Transmission on 0.5 per cent. As will be discussed further in the following section, the opex series used to calculate these growth rates for Powerlink and Tasmania Networks Transmission both include significant step changes which will lead to lower measured opex PFP growth rates. Only ElectraNet had negative opex PFP growth over the period with an average annual growth rate of –1.8 per cent.

The industry average annual opex PFP growth rate was 0.9 per cent.

Table 4.2 TNSP industry opex partial factor productivity indexes and growth rates using alternative output specifications, 2006–2013^a

<i>Outputs included</i>	2006	2007	2008	2009	2010	2011	2012	2013	<i>Annual Growth</i>
5 outputs	1.000	1.004	1.026	0.925	0.986	1.041	1.013	1.062	0.86%
4 outputs	1.000	1.010	1.032	0.938	1.002	1.058	1.034	1.082	1.12%
3 outputs	1.000	1.007	1.033	0.947	1.019	1.085	1.072	1.132	1.77%

^a 5 outputs include energy, ratcheted maximum demand, weighted entry and exit connections, line length and energy not supplied. 4 outputs include energy, ratcheted maximum demand, weighted entry and exit connections and energy not supplied. 3 outputs include ratcheted maximum demand, weighted entry and exit connections and energy not supplied.

Given the relative immaturity of economic benchmarking of TNSPs, we have examined the sensitivity of the opex PFP growth rate to changes in output specification. The results are presented in table 4.2.

We look at two alternative output specifications. The first includes four outputs: energy, ratcheted maximum demand, weighted entry and exit connections and energy not supplied. This specification is similar to our preferred specification but omits the line length output. Output cost shares of energy 24 per cent, ratcheted maximum demand 33 per cent and connections 43 per cent were derived from a translog cost function. Energy not supplied was again treated as a negative output and weights formed based on the current VCRs. The average annual opex PFP growth rate obtained from this model was higher than that from the preferred model at 1.1 per cent.

The second alternative output specification examined included three outputs: ratcheted maximum demand, weighted entry and exit connections and energy not supplied. In this case attempts to estimate a translog cost function were not successful as one first order output coefficient had a negative sign. We therefore used the simpler Leontief cost function method of Lawrence (2003) and obtained output cost shares of ratcheted maximum demand 35 per cent and connections 65 per cent. Energy not supplied was again treated as a negative output and weights formed based on the current VCRs. The average annual opex PFP growth rate obtained from this model was 1.8 per cent – considerably higher than that obtained from our preferred model.

4.1 Step changes and measured opex productivity

As noted in section 1, the rate of change method for calculating the future opex allowance takes efficient opex for a base year (usually taken to be the second last year of the preceding regulatory period) and rolls it forward each year by the forecast rate of change in opex input prices plus the forecast rate of change in output minus the forecast rate of change in opex partial factor productivity (PFP). The idea is that over time more real opex allowance will be required if opex input real prices increase and if output increases (as more inputs are required to supply more output). But increases in opex partial productivity over time will normally reduce the quantity of opex required per unit of output, all else equal, and so this also has to be allowed for.

The base/step/trend method extends the rate of change method to allow for step changes which may be added to the efficient base year opex to reflect changes in NSPs' recognised responsibilities over time. For example, in the last Victorian electricity distribution reset conducted by the AER, the five Victorian DNSPs were allowed average step change increases in opex of just under 10 per cent, mainly in recognition of increased installation of line dampeners and spacers following the February 2009 Victorian bushfires. TNSPs have also received significant step change allowances with Powerlink, for example, receiving a step change of over 6 per cent at its last reset for land tax and tower and building refurbishment. Tasmania Networks Transmission also received a step change in excess of 6 per cent at its last reset for scope changes and skills development programs.

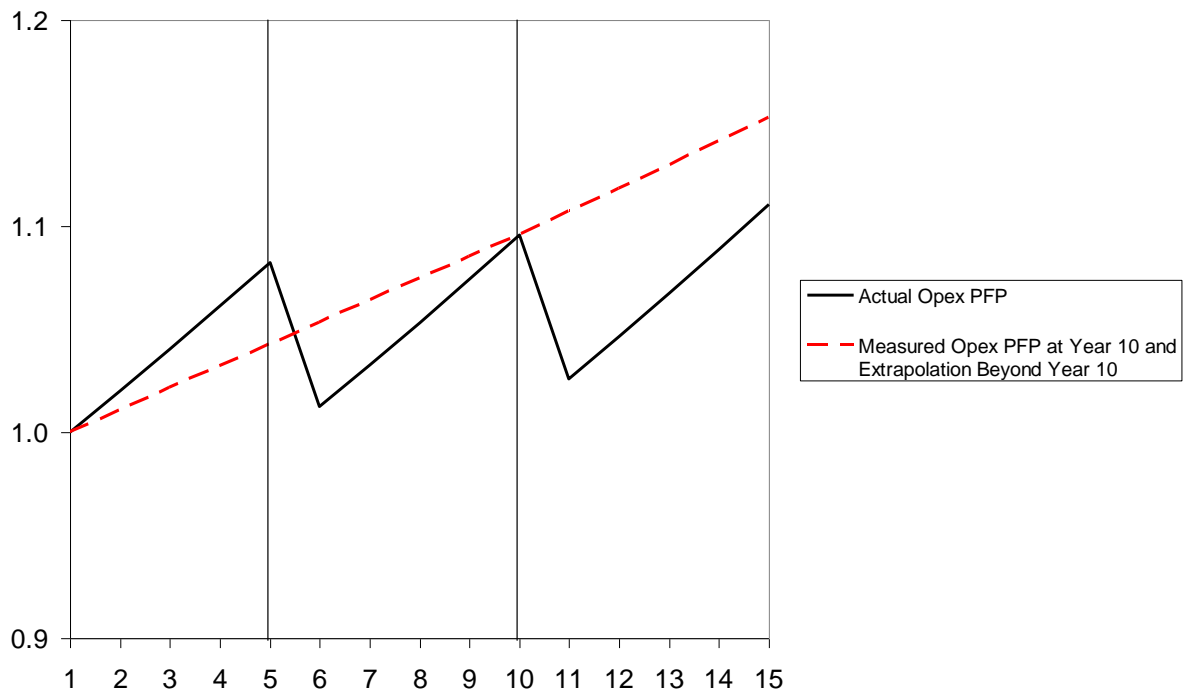
Step changes are likely to have significant implications for measured productivity growth as, without specific allowance for the impact of step changes, they will make measured opex PFP look worse than what it would be for more like-with-like comparisons over time which removed the step change from reported historic opex. Without allowance for past step changes, there is a risk that TNSPs could potentially get a double benefit – once from a lower opex PFP growth rate in the roll forward plus full allowance for subsequent step changes as well.

To illustrate this consider the case where there has been ongoing regulatory and/or obligation 'creep' over a number of regulatory periods and certainly over the length of historic data. Assume that each of the previous changes occurred at the beginning of each regulatory period and then the productivity growth rate within each period was the same as it would have been in the absence of the series of increased obligations. If we do not explicitly allow for the impact of past step changes when we calculate productivity growth over the historic period spanning more than one regulatory period, we will have a lower productivity growth rate than the within period productivity growth rate going forward as illustrated in figure 4.2 using a stylised example.

In figure 4.2 the within-period annual opex PFP growth rate is 2 per cent in all three 5-year regulatory periods. There is a step change of 10 per cent of base opex at the start of the second regulatory period and a further proposed step change of 10 per cent for the start of the third regulatory period. If the step change at the start of the second regulatory period is not allowed for when calculating the opex partial productivity growth rate at the reset at the end of the second period – and assuming that data are available for both the first and second regulatory periods and as long a time period as available is used to calculate the trend, as

would be normal practice – then the measured opex PFP growth rate will underestimate the actual opex PFP growth rate. In this example the measured annual opex PFP growth rate is only 1 per cent instead of the actual within–period growth rate of 2 per cent. Similarly, failure to allow for step changes at a time of declining measured opex productivity will make the measured opex PFP growth appear more negative than it should be.

Figure 4.2 Illustrative impact of step changes on measured productivity growth



If the first step change is not allowed for in calculating the opex PFP growth rate (assuming simple extrapolation is used for the opex PFP growth rate to be used in the rate of change formula for the third period opex allowance³), the TNSP will be overcompensated if it is also allowed the proposed 10 per cent step change at the start of the third period.

There would appear to be two possible solutions to this – either base the opex PFP growth rate for the third period on the within–period opex PFP growth rate for the second period (and possibly the first period if the size of the step change is known) or else use the measured opex PFP growth rate from the longer period and reduce the size of the step change allowed at the start of the third period. The advantage of the first method is that it attempts to obtain a measure of underlying opex PFP growth. But the disadvantages are that it may be more reliant on short time periods which tend to produce more volatile and less accurate measures of trend growth rates and the size of step changes may not be known for all TNSPs (given the way past resets have been done). This makes the second option the likely more tractable approach.

A number of complications need to be recognised in practical applications. The principal of these is that in practice the opex PFP growth rate is usually measured based on industry

³ A broadly similar result would apply if the opex cost function method was used instead of simple extrapolation.

performance and not all TNSPs in the industry will have had the same experience with step changes. The size of step changes allowed may have varied considerably across jurisdictions with some TNSPs not having been allowed any step changes while others may have been granted relatively generous step changes. The measured opex PFP growth rate will reflect a weighted average of these various step change experiences. A further practical difficulty is that past resets for some NSPs may have been reported in such a way that step changes are not separately identified. And resets for different jurisdictions have, of course, occurred at different times which further complicates the situation.

To illustrate the importance of allowing for step changes when calculating the industry productivity growth rate, we have recalculated TNSP opex PFP for the 8 years 2006–2013 excluding the identified step changes for Powerlink (taking effect from 2013) and Tasmania Networks Transmission (taking effect from 2010). The results are presented in table 4.3.

Table 4.3 TNSP opex partial factor productivity indexes and average annual growth rates excluding identified step changes, 2006–2013

<i>TNSP</i>	<i>2006</i>	<i>2007</i>	<i>2008</i>	<i>2009</i>	<i>2010</i>	<i>2011</i>	<i>2012</i>	<i>2013</i>	<i>Annual Growth</i>
ENT	1.000	0.943	1.056	0.997	0.960	0.891	0.830	0.880	–1.82%
PLK	1.000	0.924	0.939	0.977	1.023	1.071	1.053	1.150	1.99%
ANT	1.000	1.121	1.165	0.691	1.050	1.158	1.228	1.251	3.20%
TNT	1.000	1.073	0.927	0.921	0.987	1.022	1.060	1.104	1.41%
TRG	1.000	1.026	1.113	1.111	0.990	1.088	1.013	1.108	1.47%
Industry	1.000	1.004	1.026	0.925	0.992	1.048	1.019	1.095	1.29%

The effects of excluding the step changes are to increase Powerlink’s average annual opex PFP growth rate from 0.9 per cent to 2.0 per cent and to increase Tasmania Networks Transmission’s average annual opex PFP growth rate from 0.5 per cent to 1.4 per cent. The TNSP industry average annual growth rate increases from 0.9 per cent to 1.3 per cent. That is, the industry opex PFP growth rate is 1.5 times higher when identified actual step changes are allowed for.

Table 4.4 TNSP opex partial factor productivity indexes and average annual growth rates excluding identified and estimated step changes, 2006–2013

<i>TNSP</i>	<i>2006</i>	<i>2007</i>	<i>2008</i>	<i>2009</i>	<i>2010</i>	<i>2011</i>	<i>2012</i>	<i>2013</i>	<i>Annual Growth</i>
ENT	1.000	0.943	1.056	0.997	0.960	0.891	0.830	0.914	–1.28%
PLK	1.000	0.924	0.939	0.977	1.023	1.071	1.053	1.150	1.99%
ANT	1.000	1.121	1.165	0.691	1.050	1.158	1.228	1.283	3.56%
TNT	1.000	1.073	0.927	0.921	0.987	1.022	1.060	1.104	1.41%
TRG	1.000	1.026	1.113	1.111	0.990	1.088	1.013	1.108	1.47%
Industry	1.000	1.004	1.026	0.925	0.992	1.048	1.019	1.105	1.43%

Insufficient information was available to identify actual step changes for the other three TNSPs in the 8 year period 2006–2013. However, AusNet has had a step change of nearly 2.5

per cent approved from 2015 and ElectraNet has had a step change of over 3 per cent approved from 2014. No material step changes could be identified for TransGrid. To estimate the potential overall impact of step changes, we have recalculated opex PFP growth rates assuming the step changes to take effect for AusNet and ElectraNet in 2015 and 2014, respectively, took place in 2013 instead. The results are presented in table 4.4.

The effect of including the two additional estimated step changes is to increase ElectraNet's average annual opex PFP growth rate from -1.8 per cent to -1.3 per cent and to increase AusNet's growth rate from 3.2 per cent to 3.6 per cent. The effect on the TNSP industry average annual opex PFP growth rate is a further increase to over 1.4 per cent.

5 FINDINGS

Economic Insights has been asked to provide advice on the productivity change to be applied to forecast opex for the NSW and Tasmanian TNSPs for the five year regulatory period commencing on 1 July 2014.

Economic benchmarking of TNSPs is constrained by a much smaller number of observations generally being available compared to DNSP studies. As a result we use extrapolation of partial factor productivity (PFP) indexes in this report to forecast TNSP opex productivity growth as there are insufficient observations available to be able to reliably use econometric methods.

Since we have to use extrapolation methods, we follow the productivity-based regulatory practice of using the industry opex productivity growth for all TNSPs rather than TNSP-specific extrapolation (see Lawrence 2003, p.3; Christensen Associates 1997, p.25). This is done to improve incentive properties since an individual TNSP has less scope to influence the industry productivity growth rate than it does its own productivity growth rate. And, given that TNSP productivity measures are still under development, a more conservative approach of taking an industry weighted average growth rate is prudent.

Including step changes in TNSP opex we estimate TNSP industry average annual opex PFP growth to have been 0.9 per cent over the period 2006 to 2013. This estimate is derived from a model that includes five TNSP outputs: energy, ratcheted maximum demand, voltage-weighted entry and exit connections, circuit length and energy not supplied (the latter entering as a negative output). Sensitivity analysis using alternative output specifications indicated that this estimate was at the bottom end of the range of opex PFP growth rates.

Excluding identified and estimated step changes during the 2006 to 2013 period from TNSP opex leads to a considerably higher average annual opex PFP growth rate of over 1.4 per cent. This is the rate of opex PFP growth applying to like-with-like activities and scope over time.

Adoption of the relatively conservative average annual opex PFP growth rate of 0.86 per cent and no additional allowance for step changes would accommodate a modest step change allowance by virtue of the measured opex PFP growth rate underestimating the underlying like-with-like opex PFP growth for similar activities and scope. If an explicit allowance is made for step changes at the reset then it would be appropriate to use the higher average annual opex PFP growth rate of 1.43 per cent which excludes the measurement impact of previous step changes.

APPENDIX A: FISHER IDEAL INDEX

Mathematically, the Fisher ideal output index is given by:

$$(A1) \quad Q_F^t = \left[\left(\sum_{i=1}^m P_i^B Y_i^t / \sum_{j=1}^m P_j^B Y_j^B \right) \left(\sum_{i=1}^m P_i^t Y_i^t / \sum_{j=1}^m P_j^t Y_j^B \right) \right]^{0.5}$$

where:

- Q_F^t is the Fisher ideal output 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.

Similarly, the Fisher ideal input index is given by:

$$(A2) \quad I_F^t = \left[\left(\sum_{i=1}^n W_i^B X_i^t / \sum_{j=1}^n W_j^B X_j^B \right) \left(\sum_{i=1}^n W_i^t X_i^t / \sum_{j=1}^n W_j^t X_j^B \right) \right]^{0.5}$$

where:

- I_F^t is the Fisher ideal input 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.

The Fisher ideal TFP index is then given by:

$$(A3) \quad TFP_F^t = Q_F^t / I_F^t.$$

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:

$$(A4) \quad Q_F^{1,t} = 1 \times Q_F^{1,2} \times Q_F^{2,3} \times \dots \times Q_F^{t-1,t}.$$

APPENDIX B: THE MULTILATERAL TFP INDEX

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

$$\begin{aligned}
 \log (TFP_m / TFP_n) &= \sum_i (R_{im} + R_i^*) (\log Y_{im} - \log Y_i^*) / 2 - \\
 &\quad \sum_i (R_{in} + R_i^*) (\log Y_{in} - \log Y_i^*) / 2 - \\
 &\quad \sum_j (S_{jm} + S_j^*) (\log X_{jm} - \log X_j^*) / 2 + \\
 &\quad \sum_j (S_{jn} + S_j^*) (\log X_{jn} - \log X_j^*) / 2 \quad (3.1)
 \end{aligned}$$

where R_i^* (S_j^*) is the revenue (cost) share of the i -th output (j -th input) averaged over all utilities and time periods and $\log Y_i^*$ ($\log X_j^*$) is the average of the log of output i (input j). In this analysis we have five outputs and, hence, i runs from 1 to 5. Revenue shares are derived from cost-reflective shadow prices. We have four inputs and, hence, j runs from 1 to 4. The Y_i and X_j terms are the output and input quantities, respectively. The R_i and S_j terms are the output and input weights, respectively.

Equation (3.1) gives the proportional change in MTFP between two observations (denoted m and n). An index is formed by setting some observation (usually the first in the database) equal to one and then multiplying through by the proportional changes between all subsequent observations in the database to form a full set of indexes. The index for any observation then expresses its productivity level relative to the observation that was set equal to one. However, this is merely an expositional convenience as, given the invariant nature of the comparisons, the result of a comparison between any two observations will be independent of which observation in the database was set equal to one.

This means that using equation (3.1) comparisons between any two observations m and n will be both base-TNSP and base-year independent. Transitivity is satisfied since comparisons between, say, two TNSPs for 2009 will be the same regardless of whether they are compared directly or via, say, one of the TNSPs in 2012. An alternative interpretation of this index is that it compares each observation to a hypothetical average TNSP with output vector Y_i^* , input vector X_j^* , revenue shares R_i^* and cost shares S_j^* .

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