Memorandum

From: Denis Lawrence, Tim Coelli and John Kain **Date:** 13 November 2015

To: Mark McLeish, Andrew Ley

CC: AER Opex Team

Subject: DNSP MTFP and Opex Cost Function Results

Economic Insights has been asked to update the electricity distribution network service provider (DNSP) multilateral total factor productivity (MTFP) and multilateral partial factor productivity (MPFP) results presented in the Australian Energy Regulator's 2014 DNSP Benchmarking Report (AER 2014). The update involves including data for the 2013–14 financial year reported by the DNSPs in their latest Economic Benchmarking Regulatory Information Notice (EBRIN) returns. It also includes a small number of revisions to DNSP data, mainly relating to MVA factors for lines and cables.

We have also been asked to update the three sets of opex cost function econometric results presented in Economic Insights (2014a, 2015a, 2015b) to include 2013–14 data for the Australian and New Zealand DNSPs and 2013 data for the Ontario DNSPs.

MTFP specification used

The DNSP MTFP measure has five outputs included:

- Energy throughput (with 12.8 per cent share of gross revenue)
- Ratcheted maximum demand (with 17.6 per cent share of gross revenue)
- Customer numbers (with 45.8 per cent share of gross revenue)
- Circuit length (with 23.8 per cent share of gross revenue), and
- (minus) Minutes off–supply (with the weight based on current AEMO VCRs).

The DNSP MTFP measure includes six inputs:

- Opex (network services opex deflated by a composite labour, materials and services price index)
- Overhead subtransmission lines (quantity proxied by overhead subtransmission MVAkms)
- Overhead distribution lines (quantity proxied by overhead distribution MVAkms)
- Underground subtransmission cables (quantity proxied by underground subtransmission MVAkms)
- Underground distribution cables (quantity proxied by underground distribution MVAkms), and

- Transformers and other capital (quantity proxied by distribution transformer MVA plus the sum of single stage and the second stage of two stage zone substation level transformer MVA).

In all cases, the annual user cost (AUC) 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.

Data revisions

In most cases where DNSPs have provided revised MVA factors for 2014, these have also been applied to earlier years (eg TasNetworks Distribution). Essential Energy has revised both its reported overhead LV line length and its reported underground cable LV length for 2014 downwards based on improved engineering models. The new figures are backcast by assuming no change between 2013 and 2014 and splicing of the previous LV length series onto the revised 2013 value.

For Ergon Energy network services opex has been revised to exclude items related to metering services previously included in DNSP reporting which were not part of network services opex.

CitiPower and Powercor have included revised Cost Allocation Methodologies (CAMs) in their EBRIN reporting for 2014. However, these revised CAMs are not due to take effect in CitiPower and Powercor regulatory reporting for some years yet and have been excluded for the purposes of economic benchmarking. To reduce the scope for potential gaming of both reporting and price resets, Economic Insights recommends the AER require all DNSPs to report EBRIN data on the basis of the CAMs in place for the initial EBRINs.

Issues raised in DNSP submissions

In their submission on the AER's Draft 2015 Benchmarking Report, Ausgrid, Endeavour Energy and Essential Energy requested explanation of any assumptions used in the selection of the output and input specification. The output and input specifications were developed following extensive consultation with stakeholders during 2013 and 2014. Background and details on the development of the specifications and their rationale can be found in Economic Insights (2013a,b,c,d,e and 2014a).

ActewAGL and the NSW DNSPs claimed they had had insufficient time to interrogate the economic benchmarking data and check for errors. We note that the process of data collection and verification has now been underway for nearly two years and the 2014 data has been in the public domain for several months. The AER has undertaken extensive checking of the data and the DNSPs have had three weeks to review the draft benchmarking results with extensions being granted where requested.

The NSW DNSPs encouraged the AER to examine whether DNSPs' respective CAMs and capitalisation policies resulted in material differences. We note that the impact of differences in capitalisation policies has been allowed for as an additional operating environment factor in the application of benchmarking for recent regulatory determinations.

The NSW DNSPs also argued that benchmarking should be limited at this point in time to comparing the performance of individual DNSPs over time and not be used to compare relative DNSP efficiency. While we consider examining each DNSP's performance over time to be a useful starting point for performance measurement, it is not what is normally considered to be 'benchmarking' which involves cross sectional comparisons across DNSPs. This was made clear by the AEMC (2012, p.vii) which stated that:

> 'The AER will be required to publish annual benchmarking reports, setting out the *relative efficiencies* of NSPs based on the information available to it.' (emphasis added)

CitiPower and Powercor questioned why both their reported network services opex and their reported connection services opex were included in the analysis when six other DNSPs separately reported network services and connections opex and, in those cases, only the network services opex component was used in the analysis. However, the connections services opex reported by CitiPower and Powercor were considerably higher than those reported by other DNSPs and the assumptions used in forming the CitiPower and Powercor connections opex series appeared hard to rationalise. Consequently, we have used the aggregate of reported network services and connection services opex for CitiPower and Powercor.

Ergon Energy raised three issues regarding its regulatory asset base (RAB) series used in forming annual user costs for the MTFP analysis. Firstly, Ergon noted there was a spreadsheet error regarding the calculation of disposals for its easements component. This series was not used in forming the AUC series and the error did not affect the asset value series used to form the AUC series. Nonetheless, the error has been corrected in the accompanying data files. Secondly, Ergon identified a spreadsheet transcription error affecting its 2013–14 asset values for underground cables of 33kV and above. This has been corrected in the accompanying data files but does not have a material effect on the results. And, thirdly, Ergon noted that its meters RAB was not included in the AUC for transformers and other assets. However, meters assets are not included for any of the DNSPs for consistency.

Ergon Energy also provided a completely revised set of asset values with its submission 'aligned … with values set by the AER in its 2015–20 Preliminary Determination (using the RFM)'. In most cases the changes to previous EBRIN reported values were quite small. As these revisions are outside the scope of the EBRIN process, they have not been included.

Jemena Electricity Networks claimed there was a potential inconsistency where DNSPs had changed their CAMs as 'nothing has been done to normalise the differences in the historical data period even though DNSPs who materially changed their CAM have been required to submit back–cast data sets'. To be clear, the network services opex used in the analysis is consistent over the time period for each DNSP. Furthermore, as noted above, we recommend the AER require DNSPs to supply future EBRIN data on the basis of their CAMs in place in 2013 to minimise scope for potential gaming.

Jemena also claimed that service classification changes could impact relative benchmarking performance. However, the scope for this to happen is minimised by the use of network services opex in the analysis.

Jemena also presented an example of its upgrading of lines to the Preston area from 6.6kV to 22kV due to maximum demand in that area exceeding current network capacity. Jemena claimed this would be reflected in a reduction in its measured productivity as its inputs would increase (due to the increased line capacity) while its output would decrease due to a reduction in circuit length. However, considering this factor alone ignores increases in the other outputs – energy delivered, ratcheted maximum demand, customer numbers and improved reliability – that could be expected to result from removing the network capacity constraint.

TasNetworks Distribution claimed that the special characteristics of its network disadvantage it in the MTFP analysis. In particular, it noted that its ranking in terms of MTFP levels had fallen following the change to the MTFP input specification introduced in response to stakeholder comments between the draft and final AER Benchmarking Reports in 2014. Whereas overhead lines' and underground cables' total capacities had originally been (separately) included, these were subsequently further disaggregated to subtransmission components for (each of) lines and cables of 33kV and higher and to distribution components for (each of) lines and cables of less than 33kV. This change was made in response to stakeholder feedback noting that, for most DNSPs, subtransmission contributed the majority of MVAkms capacity but the minority of annual user cost. The change allowed a more accurate measure of total input quantity to be obtained for DNSPs that have significant amounts of subtransmission (which includes all DNSPs other than TND).

TND is something of an outlier in terms of system structure in that it has by far the most 'downstream' boundary with transmission. It consequently has far less subtransmission capacity than other Australian DNSPs. While this gives it an advantage in terms of a lower quantity of subtransmission inputs (and hence it should have a high MPFP of these lines), these inputs also receive a very low weight in forming the total input quantity (and hence it receives little benefit for its higher productivity in this area when forming the MTFP measure). For example, TND has an overhead subtransmission lines MPFP several times higher than that of any other DNSP but, whereas subtransmission lines account for around 25 per cent of the total AUC of overhead lines for the industry as a whole, they account for only 1.5 per cent of TND's overhead lines AUC.

Conversely, TND is a relatively intensive user of overhead distribution lines and has the lowest MPFP of overhead distribution lines. TND argues it is able to use its distribution lines to meet its relatively low loads whereas other DNSPs require greater use of subtransmission lines to meet larger load requirements. We note that TND has the second highest share (by length) of 22kV lines in its overhead distribution lines and, along with the two rural Victorian DNSPs, this share is considerably higher than for other DNSPs. We agree some caution is required in interpreting TND's relatively low capital MPFP level (and consequent low MTFP level) given its unusual system structure. However, we remain of the view that substranmission assets should be separated from other lines in the input specification.

TND also argued that it has a higher requirement for transformer inputs given its predominantly rural service area. However, we note that TND's distribution transformer capacity almost tripled between 2006 and 2014 whereas that for most other DNSPs increased by less than 50 per cent over the same period. TND's other metrics such as line length, customer numbers, energy delivered, demand reported and distribution substation and transformer asset value have not increased in a similar fashion. Furthermore, we note that TND's unusual system structure means it has a relatively small quantity of zone substation transformer capacity compared to other DNSPs and in 2014 it ranked third on the more disaggregated measure of the multilateral partial productivity of installed transformer capacity. Consequently, we are not persuaded by TND's argument for special allowance for transformer capacity.

Energex noted that it incurred substantial restructuring costs in 2013 and these would make its performance look worse in that year. We note that Energex's opex MPFP did indeed dip somewhat in that year before recovering in 2014. This illustrates the need to look at performance over a number of years rather than simply one year in isolation.

AusNet Distribution advocated the inclusion of an output measuring network safety as safety requirements can drive some parts of network expenditure. While the inclusion of such an output has merit, its development is beyond the currently available time available. We note that the related issue of the impact on DNSP performance of differential regulation and enforcement of bushfire mitigation measures across states is discussed in Economic Insights (2014a, 2015a,b).

AusNet Distribution also argued that the current measure of the reliability output is based on raw customer minutes off–supply and is thus highly subject to weather effects. However, the reliability output measure excludes the effect of major event days and thus reflects the reliability of the network under normal operating circumstances.

Most DNSPs advocated inclusion of updated opex cost function econometric results in the AER's 2015 Benchmarking Report. These are included later in this memo. Most DNSPs also noted that while some operating environment factors (OEFs) are included in both the index number and econometric analyses, allowance for additional OEFs and margins for residual data and modelling limitations have to be made before regulatory decisions can be made based on the analyses. This is consistent with Economic Insights (2014a, 2015a,b).

Updated MTFP and MPFP results

DNSP MTFP, opex MPFP and capital MPFP results are presented in figures 1 to 3.

Figure 1 **DNSP multilateral total factor productivity indexes, 2006–2014**

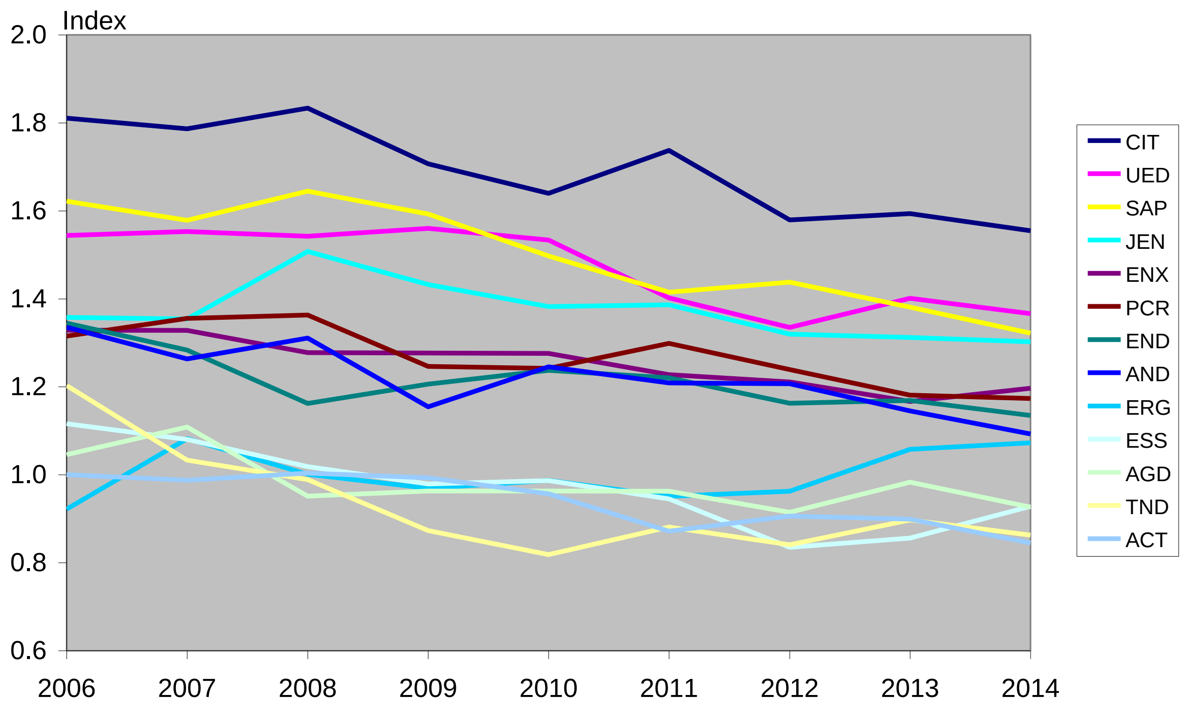


Figure 2 **DNSP multilateral opex partial factor productivity indexes, 2006–2014**

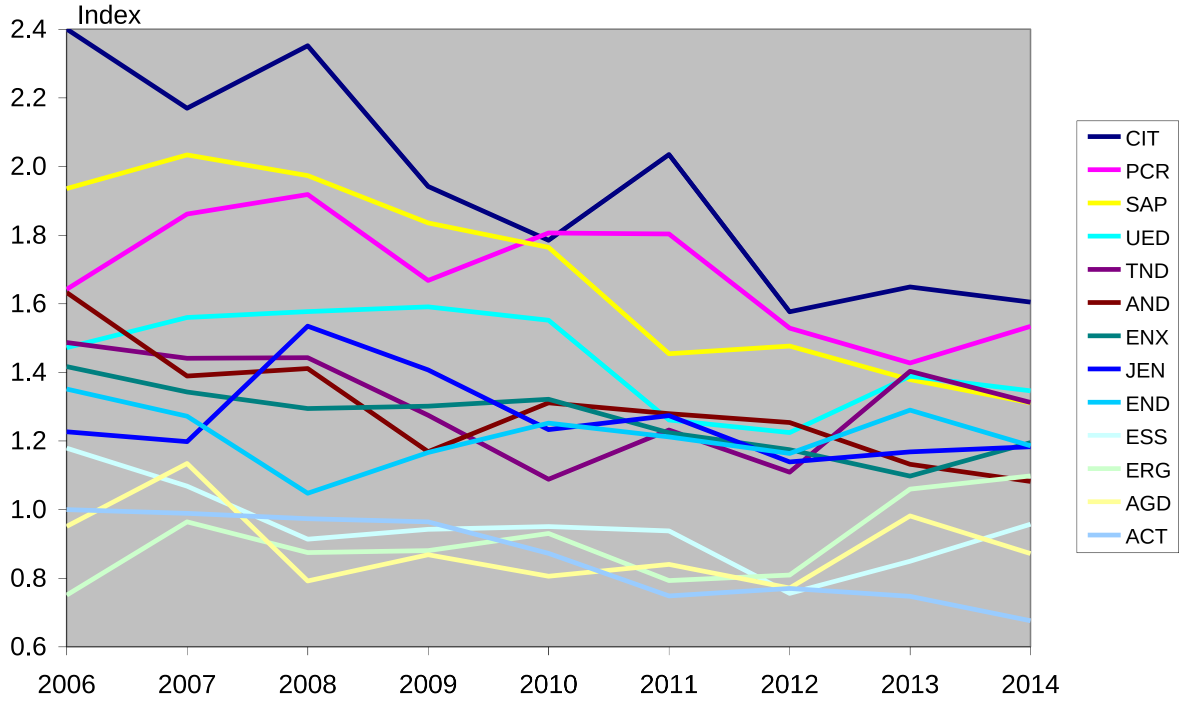
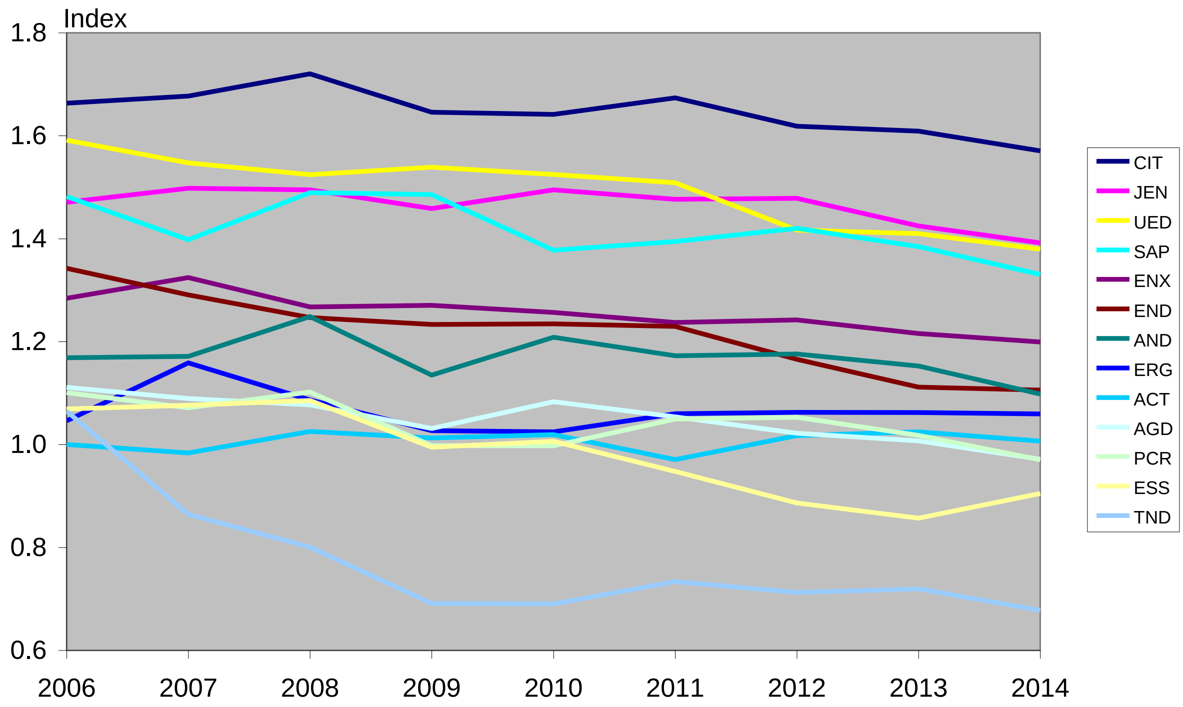


Figure 3 **DNSP multilateral capital partial factor productivity indexes, 2006–2014**



Distribution industry level output, input and TFP indexes and state level multilateral TFP indexes are presented in figures 4 and 5, respectively.

Figure 4 **Industry–level distribution output, input and total factor productivity indexes, 2006–2014**

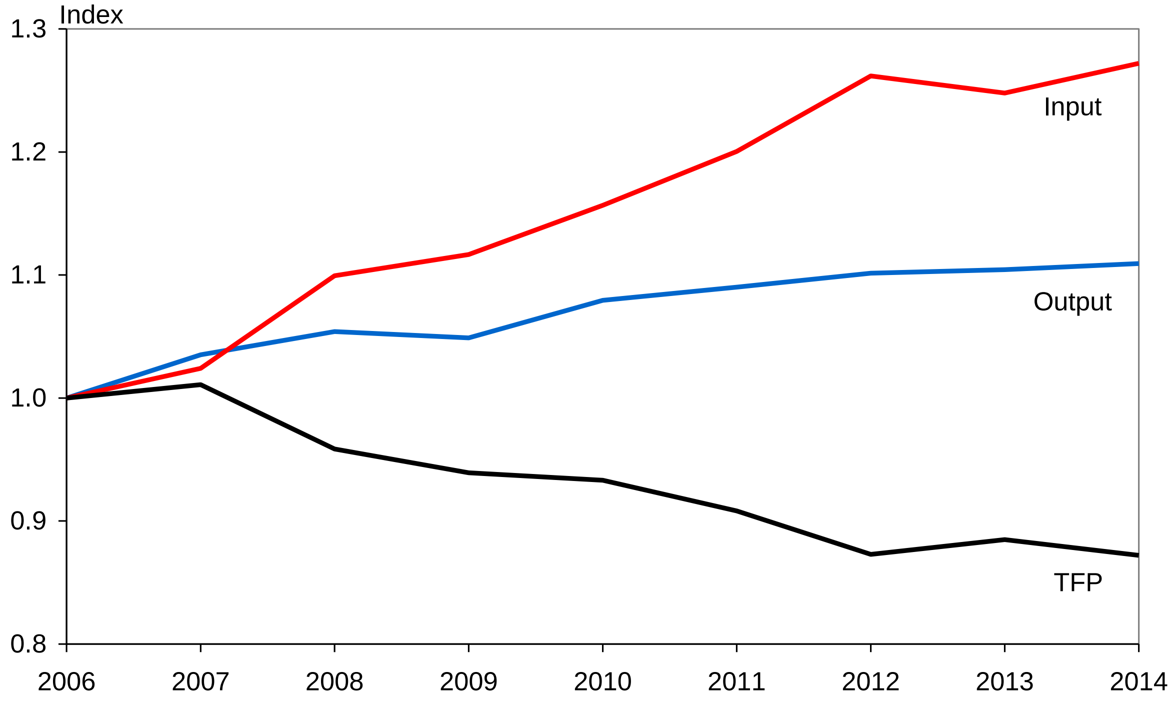
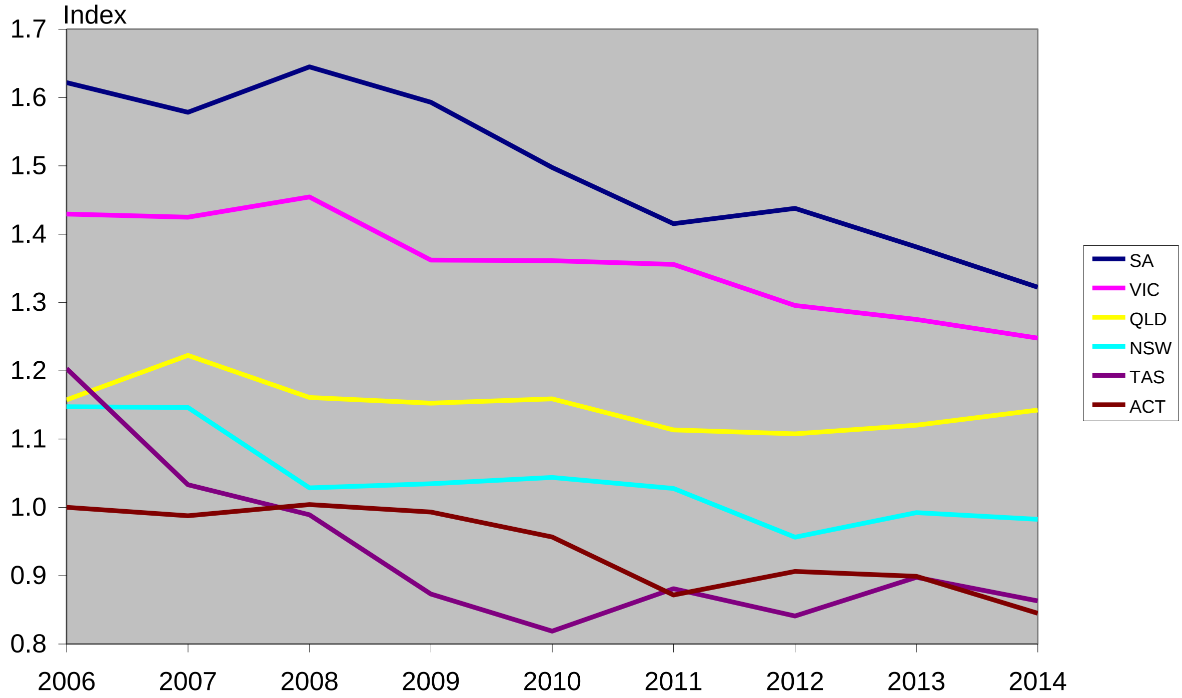


Figure 5 **State–level DNSP multilateral total factor productivity indexes, 2006–2014**



Updated opex cost function results

As well as calculating MTFP and opex MPFP index–based efficiency results, Economic Insights (2014a, 2015a,b) also estimated three econometric opex cost function models to examine DNSP opex efficiency. The three models estimated were:

- a least squares econometrics model using the Cobb–Douglas functional form (LSECD)
- a least squares econometrics model using the more flexible translog functional form (LSETLG), and
- a stochastic frontier analysis model using the Cobb–Douglas functional form (SFACD).

Unlike the non–parametric index–based MTFP and opex MPFP methods, econometric opex cost function models are able to allow for statistical noise in the data and produce confidence intervals.

A technical description of the models can be found in Economic Insights (2014a). DNSP–specific dummy variables are included in the LSE models and opex efficiency scores are derived from these. In the SFA models opex efficiency scores are calculated in the model relative to the directly estimated efficient frontier.

Because there is insufficient time–series variation in the Australian data and an inadequate number of cross–sections to produce robust econometric results, we include data on New Zealand and Ontario DNSPs. We include country dummy variables for New Zealand and Ontario to pick up systematic differences across the jurisdictions, including particularly differences in opex coverage and systematic differences in OEFs, such as the impact of harsher winter conditions in Ontario. Because we include country dummy variables, it is not possible to benchmark the Australian DNSPs against DNSPs in New Zealand or Ontario. Rather, the inclusion of the overseas data was used to increase the number of observations in the sample to improve the robustness and accuracy of the parameter estimates.

The models include three outputs – ratcheted maximum demand, customer numbers and circuit length – along with the proportion of undergrounding and a time trend.

In this exercise we update the models in Economic Insights (2015b) to include data for 2013–14 for Australian and New Zealand DNSPs and data for 2013 for the Ontario DNSPs. These models differ from the models in Economic Insights (2014a, 2015a) in using non–coincident maximum demand as the basis for forming the ratcheted maximum demand output for all included DNSPs whereas the earlier models used coincident maximum demand in the calculation for Australian and New Zealand DNSPs. The effect of this change on efficiency scores was generally not material as there were offsetting changes in the country dummy variables.

The EBRIN data are used to update the database for the Australian DNSPs. The database in Economic Insights (2014b) prepared for the New Zealand Commerce Commission is used to update the New Zealand DNSP observations while updated data drawn from the Ontario Energy Board's now annual updates of its economic benchmarking database are used to update the Ontario DNSP observations. The updated database contains 603 observations comprising 9 annual observations for each of the 67 included DNSPs. Very small New Zealand and Ontario DNSPs are again excluded from the database.

The parameter estimates and statistics for the updated SFACD, LSECD and LSETLG models are presented in tables 1, 2 and 3, respectively.

Table 1 **SFA Cobb–Douglas cost frontier estimates using 2006–2014 data**

Variable	*Coefficient*	*Standard error*	*t–ratio*
ln(Custnum)	0.730	0.080	9.140
ln(CircLen)	0.086	0.039	2.220
ln(RMDemand)	0.172	0.070	2.460
ln(ShareUGC)	–0.146	0.033	–4.430
Year	0.020	0.002	11.570
Country dummy variables:			
New Zealand	0.079	0.102	0.780
Ontario	0.197	0.075	2.610
Constant	–30.385	3.447	–8.810
Variance parameters:			
Mu	0.368	0.069	5.360
SigmaU squared	0.039	0.010	3.908
SigmaV squared	0.010	0.001	16.358
LLF			408.142

Table 2 **LSE Cobb–Douglas cost function estimates using 2006–2014 data**

Variable	*Coefficient*	*Standard error*	*t–ratio*
ln(Custnum)	0.721	0.066	10.910
ln(CircLen)	0.104	0.030	3.470
ln(RMDemand)	0.178	0.065	2.740
ln(ShareUGC)	–0.183	0.023	–8.040
Year	0.022	0.003	7.720
Country dummy variables:			
New Zealand	–0.572	0.056	–10.290
Ontario	–0.385	0.054	–7.180
DNSP dummy variables:			
AGD	–0.233	0.115	–2.030
CIT	–0.935	0.088	–10.670
END	–0.503	0.078	–6.460
ENX	–0.570	0.065	–8.770
ERG	–0.477	0.102	–4.670
ESS	–0.587	0.106	–5.540
JEN	–0.677	0.084	–8.080
PCR	–1.061	0.083	–12.760
SAP	–0.858	0.081	–10.600
AND	–0.830	0.081	–10.260
TND	–0.771	0.083	–9.280
UED	–0.877	0.078	–11.230
Constant	–33.365	5.661	–5.890
R–Square			0.994

Table 3 **LSE translog cost function estimates using 2006–2014 data**

Variable	*Coefficient*	*Standard error*	*t–ratio*
ln(Custnum)=x1	0.613	0.073	8.440
ln(CircLen)=x2	0.097	0.031	3.150
ln(RMDemand)=x3	0.266	0.065	4.120
x1*x1/2	–0.258	0.329	–0.780
x1*x2	0.207	0.105	1.960
x1*x3	0.085	0.248	0.340
x2*x2/2	–0.022	0.040	–0.540
x2*x3	–0.175	0.083	–2.100
x3*x3/2	0.129	0.195	0.660
ln(ShareUGC)	–0.170	0.027	–6.270
Year	0.022	0.003	8.090
Country dummy variables:			
New Zealand	–0.653	0.057	–11.420
Ontario	–0.494	0.054	–9.080
DNSP dummy variables:			
AGD	–0.471	0.127	–3.720
CIT	–0.978	0.085	–11.440
END	–0.672	0.082	–8.210
ENX	–0.773	0.077	–10.030
ERG	–0.548	0.126	–4.360
ESS	–0.740	0.126	–5.870
JEN	–0.625	0.092	–6.770
PCR	–1.174	0.087	–13.570
SAP	–1.004	0.088	–11.400
AND	–0.912	0.085	–10.700
TND	–0.779	0.082	–9.470
UED	–0.887	0.092	–9.610
Constant	–34.341	5.525	–6.220
R–Square			0.994

Average opex efficiency scores for the three opex cost function models are presented in figure 6 and table 4. Average opex MPFP efficiency scores are also included in the figure and table for reference.

There are several important differences across the various models. The opex cost function models include allowance for the key network density differences and the degree of undergrounding. The opex MPFP model includes allowance for the key network density differences but not the degree of undergrounding. The opex cost function models include three outputs whereas the opex MPFP model includes five outputs (the same three as the opex cost function models plus energy delivered and reliability). The opex cost function models use parametric methods whereas the opex MPFP model uses a non–parametric method. The LSE opex cost function models use least squares (line of best fit) estimation whereas the SFACD model uses frontier estimation methods. The LSE opex cost function models include allowance for heteroskedasticity and autocorrelation whereas the SFACD model does not.

Despite all these differences in model features, the opex efficiency scores produced by the four models are broadly consistent with each other. They are also very close to the results presented in Economic Insights (2015b) for the period up to 2013.

Figure 6 **DNSP average opex cost efficiency scores, 2006–2014**

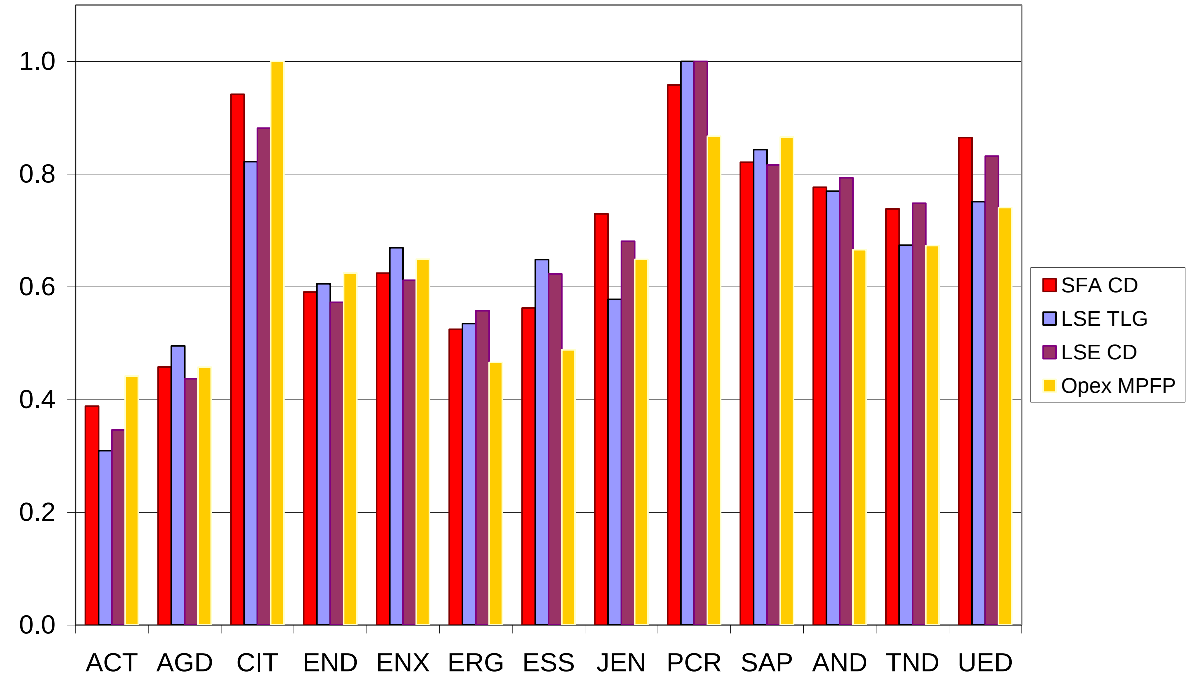


Table 4 **DNSP average opex cost efficiency scores, 2006–2014**

DNSP	*SFACD*	*LSETLG*	*LSECD*	*Opex MPFP*
ACT	0.388	0.309	0.346	0.442
AGD	0.458	0.495	0.437	0.458
CIT	0.942	0.822	0.882	1.000
END	0.591	0.605	0.572	0.625
ENX	0.624	0.670	0.612	0.649
ERG	0.525	0.535	0.558	0.466
ESS	0.562	0.648	0.623	0.488
JEN	0.729	0.578	0.681	0.649
PCR	0.958	1.000	1.000	0.867
SAP	0.821	0.844	0.816	0.866
AND	0.777	0.770	0.793	0.666
TND	0.738	0.674	0.748	0.673
UED	0.865	0.751	0.832	0.741

As noted above – and consistent with the approach adopted in Economic Insights (2014a, 2015a,b) – allowance would have to be made for additional OEFs not included directly in the models and a margin for residual data and modelling limitations included before regulatory decisions can be made based on the analyses.

References

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