Memorandum

From: Denis Lawrence, Tim Coelli and John Kain **Date:** 31 July 2014

To: Mark McLeish, Andrew Ley

CC: AER Opex Team

Subject: TNSP MTFP Results

The purpose of this memo is to document the process followed in arriving at the preferred output and input specifications used in reporting transmission network service provider (TNSP) multilateral total factor productivity (MTFP) results.

The process involved examining four Multilateral Output Quantity indexes covering the alternative output specifications listed in Economic Insights (2013b) and AER (2013) and a small number of variants of these. We also examined Multilateral Input Quantity indexes for the three alternative input specifications covered in the same reports.

We now briefly review the results of examining each of these output and input specifications, noting that there have been very few previous studies of TNSP MTFP. Consequently, and unlike the case of distribution network service provider (DNSPs) where productivity measurement is relatively mature, TNSP productivity measurement – and output specification, in particular – is still being developed.

Output Specification #1: Energy, MVA*Kms, Weighted Entry and Exit Connections, Reliability

Output Specification #1 included outputs of energy throughput, system capacity (measured as the product of line plus cable circuit length and the total installed capacity of distribution level transformers), weighted entry and exit connections (capturing fixed elements of TNSP output) and reliability (measured by energy not supplied and entering as a negative output). A similar specification was listed as the preferred specification in Economic Insights (2013b).

Entry and exit connection numbers are weighted by their respective voltage levels in recognition of their relative importance.

This specification concentrates 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.

Weights for outputs (other than reliability) were generally derived from a translog cost function where this was able to be estimated on the relatively small dataset of 40 observations. Where estimation of a translog cost function was not successful – mainly due to one output having a negative first order coefficient, as was the case with Output Specification #1 – we proceeded to estimate a simpler Leontief cost function system similar to that used in Lawrence (2003) and form output cost shares from that. The weights derived were energy

19.1 per cent, MVA*Kms 44.5 per cent and weighted entry and exit connections 36.4 per cent. Energy not supplied was weighted based on the Australian Energy Market Operator's current Valuations of Customer Reliability (VCRs). To accommodate inclusion of a negative output, total revenue was grossed up by the value of interruptions so that the sum of the four revenue components equalled reported total revenue.

AEMO is currently reviewing its estimates of the VCR although the review is not due to be completed until late 2014. The current VCRs imply placing a relatively high weight on reliability in the context of productivity studies. Consequently, analogous to our approach for DNSPs, we have adopted a conservative approach of halving the current VCRs in allocating a weight to energy not supplied.

It should be noted that transmission systems tend to exhibit very high levels of reliability and so the weight given to energy not supplied is, in most cases, only a few percentage points of revenue. The exception to this is the impact of the 2009 Victorian bushfires which led to a weight of around 30 per cent of gross revenue being allocated to energy not supplied in that year for the Victorian TNSP.

A similar specification (but excluding reliability) has previously been used at the electricity distribution industry level (eg Economic Insights 2009a) where it captures the key functional elements of DNSP output well. It has not previously been used to benchmark a diverse range of NSPs of differing sizes. A potential disadvantage of the specification in this context is the multiplicative nature of the system capacity variable which introduces a degree of non–linearity thereby potentially advantaging large NSPs.

Output specification #3 includes the key elements of this output specification but in a non–multiplicative way and so does not artificially advantage large NSPs at the expense of small NSPs. As a result, output specification #3 is preferred to output specification #1.

Output Specification #2: Energy, Ratcheted Maximum Demand, Weighted Entry and Exit Connections, Reliability

Output Specification #2 included outputs of energy throughput, ratcheted maximum demand (the highest maximum demand observed in the sample period up to that point for each TNSP), weighted entry and exit connections and reliability. A similar specification was listed as a backup specification in Economic Insights (2013b).

In the workshops conducted 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 (2013a) suggested that inclusion of a 'ratcheted peak demand' variable may be a way of overcoming this problem and Pacific Economics Group Research (PEGR 2013) has also used a similar variable in work on Ontario electricity distribution. The ratcheted maximum demand variable is likely to be a better functional output than a smoothed maximum demand variable as the smoothing method chosen will introduce a degree of arbitrariness.

Weights for outputs (other than reliability) were derived from a translog cost function. Estimated output cost shares were energy 36 per cent, ratcheted maximum demand 43 per cent and weighted entry and exit connections 21 per cent. Energy not supplied was again treated as a negative output and weights formed based on half the current VCRs.

This specification has the advantage of capturing the demand side transformer dimension of system capacity but does not recognise the line length dimension although it does recognise the system had to be built to meet the highest previous maximum demand.

While output specification #2 appears to perform relatively well, output specification #3 is similar to this specification but also includes a line length variable and is thus preferred to specification #2.

Output Specification #3: Energy, Ratcheted Maximum Demand, Weighted Entry and Exit Connections, Circuit Length, Reliability

Output Specification #3 included outputs of energy throughput, ratcheted maximum demand, weighted entry and exit connections, circuit length and reliability. This specification was not listed in Economic Insights (2013b) but has been used recently by Pacific Economics Group Research (2013) in work on electricity distribution for the Ontario Energy Board. The analogous output specification is currently our preferred one for DNSPs. 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 NSPs. It also has the advantage of capturing both the demand side transformer dimension of system capacity and the line length dimension.

The four output specification covering energy throughput, ratcheted maximum demand, 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.

Weights for outputs (other than reliability) were again derived from a translog cost function. Estimated output cost shares were energy 30 per cent, ratcheted maximum demand 28 per cent, weighted entry and exit connections 31 per cent and circuit length 11 per cent. Energy not supplied was again treated as a negative output and weights formed based on half the current VCRs.

The results obtained using output specification #3 did not appear to favour any particular type of TNSP and, along with its superior in principle characteristics, this lent further support to using output specification #3 as the preferred specification.

Output Specification #4: Ratcheted Maximum Demand, Weighted Entry and Exit Connections, Reliability

Output Specification #4 included outputs of ratcheted maximum demand, weighted entry and exit connections and reliability. A similar specification was listed as the preferred specification in AER (2013).

This specification is similar to output specification #2 except that energy is omitted. A number of participants in the 2013 workshops questioned the inclusion of energy as an output given that it is not viewed as a major cost driver for TNSPs.

As with output specification #2, this specification has the advantage of capturing the demand side transformer dimension of system capacity but does not recognise the line length dimension although it does recognise the system had to be built to meet the highest previous maximum demand.

It has the significant disadvantage of omitting a potentially important billable output for TNSPs – energy throughput.

Weights for outputs (other than reliability) are derived from a Leontief cost function system as estimation of a translog system produced a negative first order output coefficient. Estimated output cost shares were ratcheted maximum demand 33 per cent and weighted entry and exit connections 67 per cent. Energy not supplied was again treated as a negative output and weights formed based on half the current VCRs.

The results from this were considerably more dispersed than for specifications #2 and #3 with smaller TNSPs being relatively advantaged. We consequently believe this specification is less preferred than output specification #3.

Conclusions on outputs

Output specification #3 is our preferred output specification on both conceptual and empirical grounds. It captures the key dimensions of TNSP functional output; it includes the important dimension of reliability; it includes demand side as well as supply side dimensions of system capacity; and, it does not appear to favour one type of TNSP at the expense of another. It is also analogous to our preferred specification for DNSPs thus providing a similar output measurement framework that can be used across all NSPs.

Inputs

Turning to the specification of inputs, the main issue is how to proxy the quantity of the annual input of capital in NSP economic benchmarking studies. Some studies have used physical quantity based measures (eg MVAkms of lines and MVA of transformer capacity) which assume ‘one hoss shay’ depreciation (of physical capacity) while others have used a deflated depreciated asset value series to proxy annual capital input quantity. The latter approach typically involves a straight–line depreciation assumption.

There have also been different approaches adopted to measuring the annual user cost of capital. Economic Insights (2014) adopted an exogenous amortisation approach which recognised the principle of financial capital maintenance which is central to building blocks regulation. Some studies have adopted a simpler endogenous method whereby the difference between revenue and opex is allocated as the annual user cost of capital (eg Economic Insights 2012).

We have examined the three input specifications listed in Economic Insights (2013b). In all cases the quantity of opex input is derived by deflating total opex by a composite price index comprising the Electricity, gas, water and waste sector Wages price index and five Producer price indexes (PPIs) covering materials and services used by TNSPs[1]. And, in all cases, the annual user cost of capital is taken to be the return on capital, return of capital and benchmark

[1] We note that in recent determinations the AER has used the consumer price index (CPI) to escalate non–labour opex costs instead of PPIs. A sensitivity analysis of the effect of using the CPI compared to the five PPIs indicated no material difference in results.

tax liability calculated in a broadly similar way to that used in forming the building blocks revenue requirement.

Input Specification #1: OPEX, O/H MVAkms, U/G MVAkms, Transformers & Other MVA

Input Specification #1 was listed as the preferred specification in Economic Insights (2013b) and AER (2013). It uses 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. MVAkms measures are formed using the MVA ratings for each voltage class specified by each TNSP. The annual user cost of capital is pro–rated across the three capital inputs based on their relative shares in the regulated asset base.

Input Specification #1 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.

Input Specification #2: OPEX and Constant Price Depreciation

Input specification #2 was listed as a backup specification in Economic Insights (2013b). It proxies the quantity of annual capital input by constant price regulatory depreciation.

For most TNSPs the pattern of the constant price regulatory depreciation variable was broadly similar to the constant price depreciated asset value used in input specification #3 below, although the constant price depreciation series is not as smooth as the constant price depreciated asset values series (reflecting, among other things, changes in regulatory depreciation reporting practices over time). Because this variable is likely to be influenced by changes in reporting practices more than changes in actual capital input over time, it is less preferred than input specification #3 if a financial–based proxy of measuring capital input quantity is chosen rather than a physical proxy.

Input Specification #3: OPEX and Constant Price Depreciated Asset Value

Input specification #3 was listed as a backup specification in Economic Insights (2013b) and is commonly used in other industries where a more diverse range of capital inputs are used and it may be impractical to form a small number of physical proxy measures for key asset categories (eg see Economic Insights (2009b) study of Australia Post's TFP).

The TNSP constant price depreciated asset value implicit quantities generally increase more rapidly than the corresponding direct physical quantities series. This is in large part due to this being a net capital stock measure rather than a gross capital stock measure (which the physical quantity series is akin to) and so in periods of relatively high investment it grows more rapidly as the investments adds to a smaller base than is the case with a gross capital stock measure. Given the characteristics of electricity transmission assets, this is not thought to be an accurate reflection of either the change in or levels of annual capital input quantities. As a result, input specification #3 is less preferred than input specification #1.

MTFP Results

Given the results of the examination of a range of both output specifications and input specifications reported above, we recommend using output specification #3 and input specification #1 as the preferred ones for presentation of TNSP benchmarking results.

The MTFP measure thus has five outputs included:

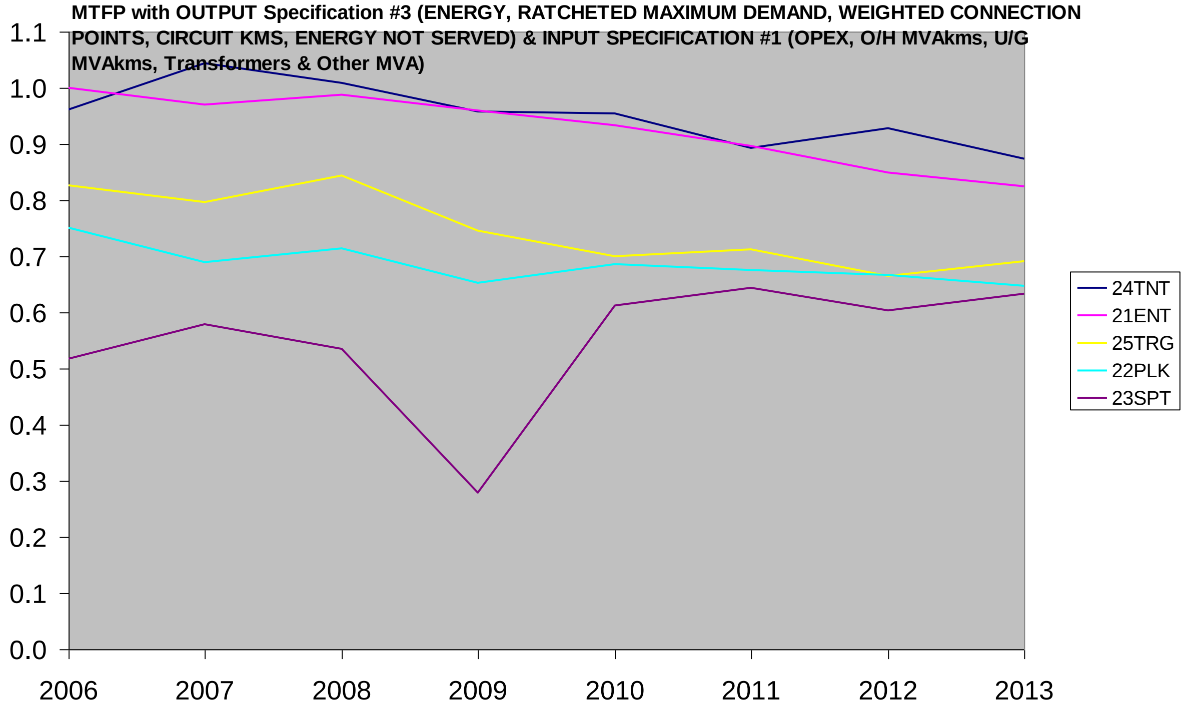
- Energy throughput (with 30 per cent share of gross revenue)
- Ratcheted maximum demand (with 28 per cent share of gross revenue)
- Weighted entry and exit connections (with 31 per cent share of gross revenue)
- Circuit length (with 11 per cent share of gross revenue), and
- (minus) Energy not supplied (with the weight based on current AEMO VCRs halved).

The MTFP measure thus has four inputs included:

- Opex (total opex deflated by 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 and return of capital calculated in a broadly similar way to that used in forming the building blocks revenue requirement.

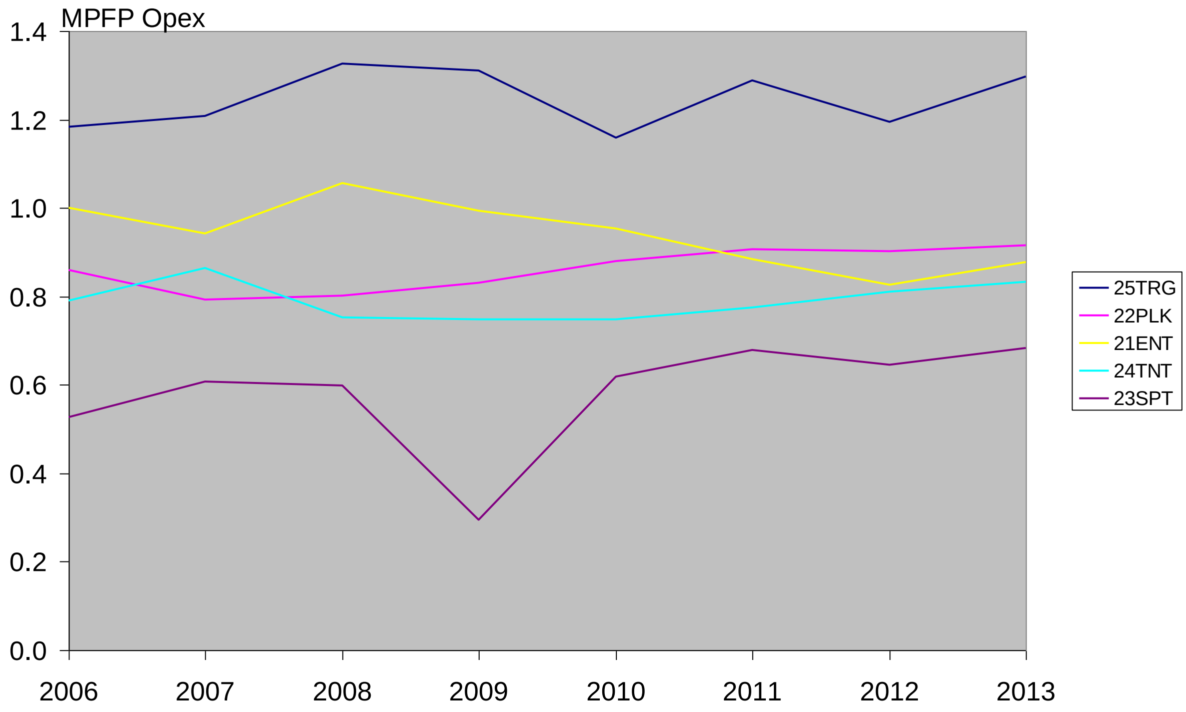
TNSP MTFP results using this specification are presented in the following graph.

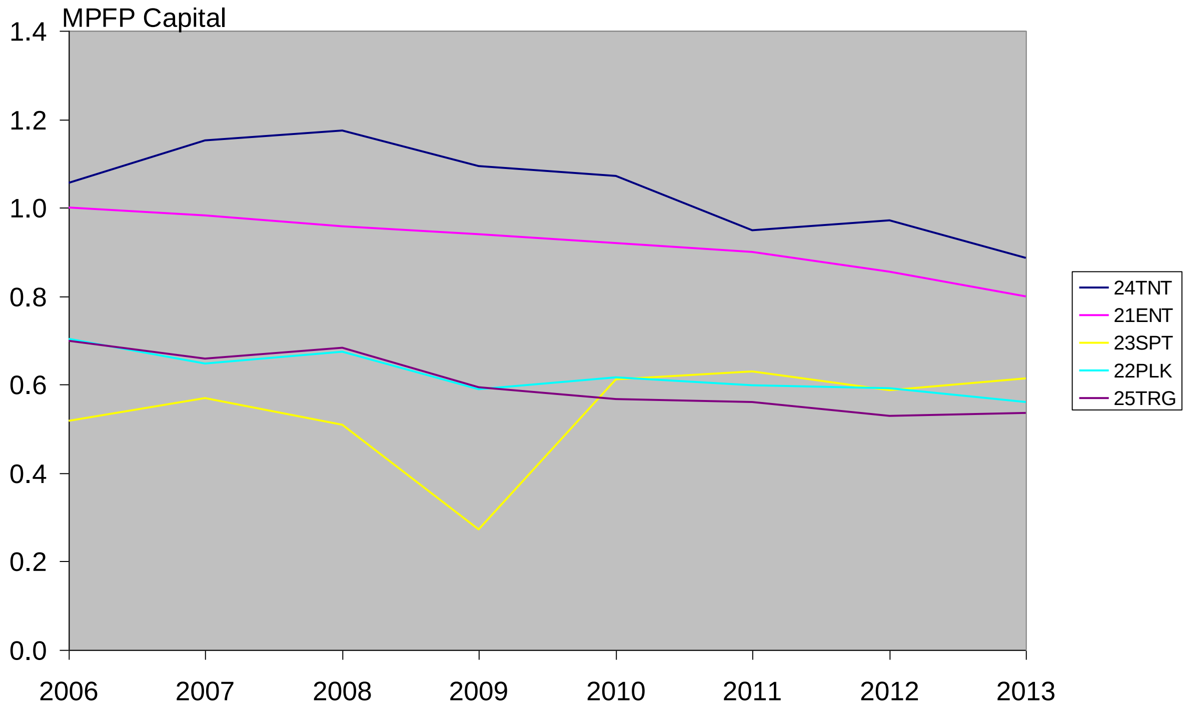


Multilateral Partial Productivity Results

Multilateral partial factor productivity (MPFP) indexes are derived by taking the ratio of the Multilateral Output Quantity Index to the Multilateral Quantity Index of a particular input. The Opex MPFP index is thus formed as the ratio of the Multilateral Output Quantity Index using output specification #3 to the constant price opex input (since there is only one input in this case, there is no need to form a Multilateral Input Quantity Index).

The TNSP Opex MPFP and Capital MPFP results are presented in the following graphs.





The Capital MPFP index is formed as the ratio of the Multilateral Output Quantity Index using output specification #3 to the Multilateral Capital Quantity Index using input specification #1. The Multilateral Capital Quantity Index is formed by aggregating the quantities of overhand lines, underground cables and transformers and other capital using their annual user costs as weights.

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