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Claire Preston
Director, Network Expenditure
Australian Energy Regulator
Melbourne VIC 3000

By email: [redacted]

10 September 2024

Dear Claire

Submission on AER's review of TFP and MTFP non-reliability output weights

Jemena Electricity Networks (Vic) Ltd (**JEN**) welcomes the opportunity to respond to the Australian Energy Regulator (**AER**) on its review of the output weights used in the Total Factor Productivity (**TFP**) and Multilateral Factor Productivity (**MTFP**) benchmarking models prepared by The University of Queensland's Centre for Efficiency and Productivity Analysis department (**CEPA**).

We appreciate a fresh perspective on the benchmarking models from time to time. In this submission, we highlight three key recommendations for the AER and CEPA, with more details provided in the *Annexure A* –

1. **Use more recent data—**CEPA's report replicated output weights from the 2020 Economic Insights benchmarking report, which only includes data up to 2018. It does not account for updated data from 2019-2023 and data revisions since 2020. We recommend updating the output weights to incorporate all data till 2023 to ensure the weights provide the latest insight.

2. **Ensure consistency between MTFP output and input weights—**This review has not considered how the changes in the AER's capitalisation approach impact MTFP output weights[1]. The current output weights are derived using the 2014 Cost Allocation Methodology (**CAM**) data while the input weights are determined using the new capitalisation approach. This inconsistency can significantly distort the productivity results. We recommend updating the output weights to align with the new capitalisation approach used for input weights.

3. **Introduce a fixed cost component—**The current Leontief cost function does not account for fixed costs which is an important part of a DNSP's cost structure. In the

[1] AER, 2023, How *the AER Will Assess the Impact of Capitalisation Differences on Our Benchmarking: Final Guidance Note*

real world, every business will incur a certain level of fixed costs which AER itself assumes when determining the capitalised overheads for businesses. Introducing a fixed cost component would improve the statistical robustness of the model.

We are committed to working collaboratively with the AER and welcome any further queries regarding this submission. We look forward to further engagement on these matters. Please contact Jerrie Li at [redacted] if you would like to discuss this submission further.

Yours sincerely

Sandeep Kumar
Group Manager Regulatory Analysis, Pricing and Strategy

Annexure A

The AER has engaged CEPA to review its approach for determining non-reliability output weights used in the TFP and MTFP benchmarking models. CEPA's report concludes that no flaws or errors exist in the AER's current methodology or its application. However, we believe there are some areas where refinements can be made, which we outline below -

1. Updating output weights

The output weights reviewed by CEPA considers data up to 2018 and uses weights determined using 2014 CAM. The review should consider weights that are determined using the latest data and the new CAM approach applied by the AER.

In 2023, the AER adopted a new approach to account for capitalisation differences across DNSPs, which classifies capitalised corporate overheads (**CCO**) as part of opex[2]. This change was applied retrospectively to all historical years, including 2018 and earlier. In light of this change, Quantonomics has updated the TFP and MTFP input weights accordingly[3]:

> *The revised definition of Opex that includes CCOs has implications for the calculation of input weights. The reallocation of CCOs to Opex means that a consistent adjustment needs to be made to the AUC… Changes to opex for a number of DNSPs related primarily to the shifting from 2014 Cost Allocation Methods (CAMs), used for all years, to 2022 CAMs used for all years.*

However, while the MTFP input weights were determined under the new capitalisation approach, the output weights remain to be based on the old approach of 2014 CAM. This creates an internal inconsistency in the MTFP approach as it does not fully reflect the new capitalisation approach. This internal inconsistency can lead to inaccuracy in productivity indices and consequently incorrect estimation of productivity changes over time.

We use an illustrative example to show how the inconsistency between input and output weights can distort productivity results. Consider a simple scenario where a firm produces two outputs (A and B) using two inputs (opex and capital). Each output requires one unit of opex and one unit of capital input. There are 2 years of data where the unit of outputs produced and inputs used are shown in Table 1. To estimate output index we estimate the output weights by regressing opex and capex on the two outputs using the 2 years of data. This mimics the Leontief cost function estimation in the AER's current approach and gives regression coefficients which are then used to estimate the output weights using the Quantanomics approach. With this information, we can estimate the TFP indices in each year and the change in productivity from year 1 to year 2 as shown in Table 1.

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[2] AER, 2023, How *the AER Will Assess the Impact of Capitalisation Differences on Our Benchmarking: Final Guidance Note*

[3] Quantonomics, 2024, *DNSP Economic Benchmarking Results,* 7 August 2024, Pg.4.

Table 11: Estimating TFP indices of the illustrative example

	Output A (units)	**Output B** (units)	**Opex** ($Real)	**Capital Input** ($Real)
Year 1	1 *(a)*	2 *(b)*	$3 ($O_1$)	$3 ($K_1$)
Year 2	2 *(c)*	1 *(d)*	$3 ($O_2$)	$3 ($K_2$)

	Opex Input Weight	**Capital Input Weight**	**Input index**
Year 1	50% (=$O_1/(O_1+K_1)$=3/6)	50% (50%=1-50%)	3 (=3*50% + 3*50%)
Year 2	50% (=$O_2/(O_2+K_2)$=3/6)	50% (50%=1-50%)	3 (=3*50% + 3*50%)

Regression coefficients[1]	**Output A**	**Output B**
Opex	1.0 *(e)*	1.0 *(g)*
Capital Input	1.0 *(f)*	1.0 *(h)*

	Output Weights
Output A	$\frac{1}{2} * \left[\frac{a*(e+f)}{(a*(e+f)+b*(g+h))}+\frac{c*(e+f)}{(c*(e+f)+d*(g+h))}\right]$ =50%
Output B	=1-50% =50%

	Output Index	**TFP index (Output index/Input index)**
Year 1	50%**a* + 50%**b* =0.5 + 1.0 = 1.5	1.5/3 = 0.5
Year 2	50%**c* + 50%**d* =1.0 + 0.5 = 1.5	1.5/3 = 0.5
TFP growth		0.5/0.5 - 1= 0%

In this example, the input index is 3 in both years and the output index is 1.5 in both years resulting in TFP of 0.5 in both years 1 and 2. The change in productivity index is therefore 0% from year 1 to year 2.

Now consider a scenario where the output weights were derived based on incorrectly reported opex of $2 (instead of $3) in year 1 while input weights continue to be derived correctly. This could be due to CAM change or data errors (shown in red in the below Table 2). The resulting output weights and output indices would have been incorrectly estimated (shown in red in Table 2).

Table 2: Re-estimating output weights with incorrect input

	Output A	Output B	Opex	Capital Input
Year 1	1 *(a)*	2 *(b)*	$2	$3
Year 2	2 *(c)*	1 *(d)*	$3	$3

as follows -

Regression coefficients	Output A	Output B
Opex	1.33 *(e)*	0.33 *(g)*
Capital Input	1.0 *(f)*	1.0 *(h)*

	Output Weights
Output A	$\frac{1}{2} * \left[\frac{a*(e+f)}{(a*(e+f)+b*(g+h))} + \frac{c*(e+f)}{(c*(e+f)+d*(g+h))}\right]$ =64%
Output B	=1-64% =36%

	Output Index	TFP
Year 1	64%**a* + 36%**b* =0.64 + 0.72 = 1.36	1.36/3 = 0.45
Year 2	64%**c* + 36%**d* =1.27 + 0.36 = 1.64 (rounding)	1.64/3 = 0.55

	TFP growth
TFP growth (incorrect output weights with correct input weights)	0.55/0.45 - 1= 20%

Due to the incorrect opex data being used in estimating output weights, the coefficients from the regression are over-estimated for output A and under-estimated for output B. This leads to incorrect estimates of the output indices (1.36 in year 1 and 1.64 in year 2) and therefore incorrect productivity growth from year 1 to year 2 of 20%. This compares to the first scenario in Table 1 where the output indices were correctly derived (as 1.5 for both year 1 and 2) resulting in a productivity growth of 0%.

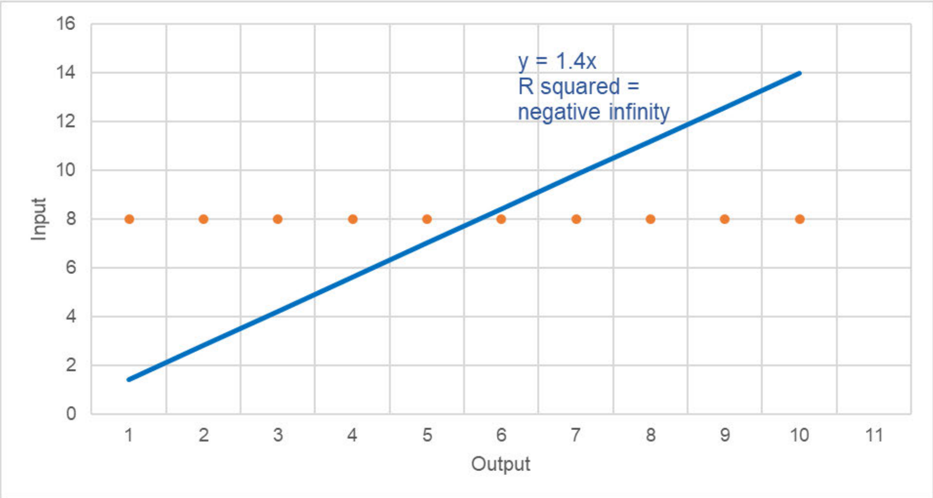
This simple example illustrates the importance of updating the output weights to reflect the new capitalisation approach in alignment with the input weight calculations. This alignment ensures accuracy and helps avoid significant distortions in productivity levels.

2. Adding a fixed cost component

The current Leontief cost function does not account for fixed costs which are an essential part of a DNSP's cost structure. This leads, in some cases, to poor statistical fits in the regressions, reflected by negative R^2 values. Typically, R^2 values range from 0 (indicating a poor fit) to 1 (indicating a perfect fit). Negative R^2 values suggest that the model's predictions are worse than simply using the average of the observed data. There is also a disconnect to the AER's standardised capex forecasting approach which assumes that 75% of capitalised overheads are fixed in nature, while 25% vary based on direct capex projects.

We can use a simple example to illustrate how excluding a fixed cost component in a model can lead to negative R^2 values. Consider an input that remains constant in the face of growing output (shown as the orange dots in Figure 1) -

Figure 1: Illustration of fitting a regression with zero constant in the presence of fixed cost



If we attempt to fit a line through these input values without accounting for fixed costs (i.e. assuming a zero constant), as shown by the blue line in Figure 1, the result is a very poor fit, with an R^2 value of negative infinity.

This follows from the definition of R^2:

$$R^2 = 1 - \frac{Sum\ of\ Squared\ residuals\ of\ regression}{Sum\ of\ Squared\ residuals\ relative\ to\ the\ mean}$$

R^2 will be negative when the numerator in the above equation is larger than the denominator (i.e., when the regression explains the variables worse than simply taking the average).

For example, the regression model for CitiPower's overhead lines currently has an adjusted R^2 value of -42, implying an extremely poor fit. However, when a fixed cost component (i.e. a constant) is added to the model, the adjusted R^2 improves to 0.4, indicating that the model explains 40% of the variation in overhead lines—a significant improvement in its explanatory power.

We tested the inclusion of a fixed cost variable across all DNSPs. The result shows that 8 out of 13 DNSPs saw improvement in R^2 after this addition. Improvements were observed not only in R^2 values but also in the Bayesian Information Criterion (**BIC**), which is a measure of a model's fit[4]. A reduction of 2 or more units in the BIC indicates a significant improvement in model fit, according to Fabozzi et al. (2014)[5], who suggest the following thresholds of reductions in BIC:

- Less than 2, not worth mentioning
- Between 2 and 6, positive evidence of improvement
- Between 6 and 10, strong evidence
- Greater than 10, very strong evidence

Table summarises the improvements in DNSP's BIC values after including a fixed cost component. Green highlights indicate the degree of improvement in BIC: light green represents positive evidence, medium green signifies strong evidence, and dark green shows very strong evidence.

Table 3: Improvement in DNSP's BIC by adding a fixed cost component

DNSP	Number of regressions improved out of 4 regressions	Average reduction in BIC*
ACT	3	6.9
AGD	1	3.0
CIT	1	8.4
END	2	2.2
ENX	1	0.2
ERG	1	1.6
ESS	2	11.7
JEN	2	21.6
PCR	4	6.6
SAP	1	0.1
AND	0	0.0
TND	2	0.8
UED	2	3.7

* *In regressions where the value improved after including the fixed cost component.*

While some regressions did not show an improvement in BIC, the ones that showed improvements represent a significant portion of the total number of regressions. The reductions in BIC are very evident. One possible approach the AER could consider is incorporating the fixed cost component only in cases where this leads to a BIC reduction of more than 2. For those regressions where no improvement was observed, the original model specification (without the fixed cost) can be retained. This ensures fixed costs are applied only where they enhance the statistical properties of the model.

After deriving the parameters from the Leontief cost function, the percentage of fixed costs relative to total costs can be estimated for each DNSP. To assess the reasonableness of the derived fixed cost proportions, we have plotted the relationship between the fixed cost

[4] BIC helps determine which model best explains a given dataset. It looks to balance two factors: fit and simplicity. Lower BIC values are preferred, as they indicate a model that achieves a good balance between model fit and simplicity.

[5] Fabozzi F.J., Focardi S.M., Rachev S.T., and Arshanpali B.G., 2014, *The Basics of Financial Econometrics: Tools, Concepts, and Asset Management Applications, John Wiley & Sons*, Pg. 204

percentage and outputs such as customer numbers and circuit length. Figure 2 helps to visualise how fixed costs correlate with key outputs.

Figure 2: Fixed cost relationship with customer number and line length

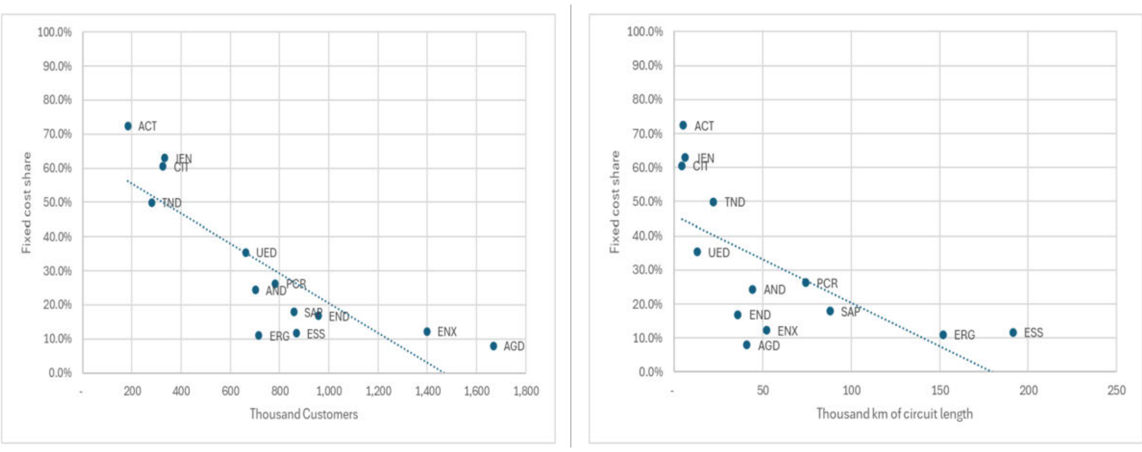


Figure 2 shows that smaller networks with fewer customers and shorter circuit lengths tend to have higher fixed costs as a proportion of total costs. This finding is logical and reflect the financial realities faced by DNSPs as they will have some fixed costs irrespective of their size. It is also consistent with AER's capex forecasting approach which assumes 75% fixed capitalised overheads.

Given the improvement in model fit after introducing a fixed cost component and the observed relationship between fixed cost proportions and network size, we recommend that the AER and CEPA consider incorporating a fixed cost component into the current model where it improves the BIC. This adjustment would improve the overall reliability of the TFP and MTFP benchmarking models.