10 September 2024
Submitted by email to: [redacted]

Dear Mr Thomas

Review of non-reliability output weights

Evoenergy welcomes the opportunity to provide feedback on the Australian Energy Regulator's review of non-reliability output weights used for its annual benchmarking report undertaken by The University of Queensland's Centre for Efficiency and Productivity Analysis (CEPA). We acknowledge the AER for progressing this review, which we consider to be an important part of the AER's benchmarking development program.

Given the technical nature of the review, we engaged Frontier Economics to provide advice on CEPA's analysis and findings. Frontier Economics' response is attached.

Most importantly, Evoenergy encourages the AER to update the estimation of the output weights to include the most recent five years of data. The output weights are currently estimated using data to 2018. Updating the weights to reflect the additional five years of data to 2023 materially changes the weights, and better reflects changes in outputs and productivity performance across the industry since 2018.[1]

We note that in the November 2018 annual benchmarking report the AER updated the output weights for an additional five years of data. In that review the AER considered the balance between consistency in the approach and updating for better data as it becomes available. The AER concluded that it was timely to update the output weights since five years had passed and there were longer term benefits from reflecting the most recent data.[2]

While more frequent updates would be best practice, in Evoenergy's view there appears to be no reasonable basis not to at least update the output weights for data to 2023 given that a further five years have passed since the last update in 2018.

Consistent with our previous feedback, the attached Frontier Economics response also highlights the need for a high degree of caution when interpreting the annual benchmarking results, given a number of serious limitations.

Evoenergy welcomes opportunities for continuing engagement with the AER on its benchmarking development program. We would also be happy to arrange a time for Frontier Economics to discuss their findings with CEPA. Please contact Gillian Symmans, Group Manager Regulatory Reviews and Policy at [redacted]

Yours sincerely

[redacted]

Megan Willcox
General Manager, Economic Regulation

[1] *Frontier Economics, Response to CEPA report on non-reliability output weights, section 1.5.1*

[2] *AER, DNSP Annual Benchmarking Report, November 2018, p. 56.*

Memo

To:	Gillian Symmans
From:	[redacted]
Date:	9/09/2024
Subject	**Response to CEPA report on non-reliability output weights**

1.1 Summary

This memo provides an assessment of a report prepared for the Australian Energy Regulator (AER) by the Centre for Efficiency and Productivity Analysis (CEPA).[1] The CEPA report:

- Independently verifies, through empirical estimation, the existing non-reliability output weights that the AER uses in to construct the various productivity index numbers (PIN) models presented in the AER's Distribution Annual Benchmarking Reports. CEPA finds no evidence that these output weights have been estimated incorrectly.
- Makes a number of recommendations for simplifying the process for estimating the Leontief cost function used to derive the output weights. CEPA recommends:
  - The linearisation of the time trend term in the cost function;
  - The use of quadratic programming to estimate the cost function;
  - The adoption of a Least Absolute Deviation (LAD) approach, in order to transform the model into a linear program that is simpler to estimate.
- Recommends a 'direct cost benchmarking' approach, whereby the AER would use an estimated cost function to set DNSP opex allowances directly, thus avoiding the need to obtain estimates of output weights and construct the PINs.

In respect of CEPA's recommendations, we conclude the following:

- We agree that linearising the time trend element of Leontief cost function would potentially make the model easier to estimate. However, the resulting linearised model can no longer be interpreted as a Leontief cost function, and the theoretical underpinnings of the cost function would no longer hold. Linearisation of the time trend would also complicate the calculation of the cost shares required when calculating the output weights.
- We support CEPA's recommendation of using quadratic programming as a means of estimating the Leontief cost function, particularly if combined with a grid search on the coefficient of the time trend.

[1] CEPA, *Review of the AER's estimated non-reliability output weights used in the TFP and MTFP benchmarking models*, August 2024.

- The LAD approach recommended by CEPA is typically used when there are large outliers in the data. As this is not the case in the dataset used to estimate the Leontief cost function, the use of LAD estimation seems less relevant. Furthermore, the problem that CEPA seeks to address with LAD estimation—multiple solutions for the same value of the objective function—is not one that we have encountered in practice when estimating the Leontief model, for the purposes of estimating DNSP output weights. In other words, we have seen no clear need for the change of approach proposed by CEPA.
- CEPA's recommendation of conducting direct cost benchmarking would seem to render the PINs redundant. However, the results from those models serve a practical purposes for stakeholders. For example, DNSPs use the MPFP and MTFP models to track their own performance over time, and relative to their peers. In our experience, these comparisons (through the Annual Benchmarking Reports) motivate DNSPs to improve their efficiency over time. These benefits would likely be lost if CEPA's recommendation were adopted.

CEPA's report does not address a number of important and relevant issues that the AER should consider:

- Currently, the AER updates output weights very infrequently (approximately every five years). However, the data can change materially in the intervening years due to action by DNSPs or due to revisions/corrections to the historical data. In our view, now would be an appropriate time to update the output weights using all of the latest data available. Ideally, the AER should revise the output weights annually, and back-cast the PINs to allow like-with-like comparisons of the indices over the whole historical period.
- The Leontief models that the AER rely on in order to estimate the DNSP output weights suffer from serious multicollinearity problems. The resulting output weights are not reliable. Whilst there is no straightforward remedy, the AER should make this limitation transparent so that stakeholders can interpret the PINs with appropriate caution.
- Both the existing Leontief models, and the linearised models proposed by CEPA, fail to account for the fact that DNSP opex has changed over time in a very non-linear way. (The same problem affects the econometric benchmarking models the AER uses to assess the efficiency of DNSPs' base year opex.) This is a serious mis-specification problem that is likely to result in mis-estimated output weights. The AER should explore alternative models that are capable of accounting for non-linear changes in opex over time.

1.2 CEPA's investigations and key findings

The AER has engaged CEPA to investigate the econometric model it uses in the estimation of the non-reliability output weights the AER uses to construct various PIN models, including the Partial Factor Productivity (PFP), Total Factor Productivity (TFP), Multilateral Partial Factor Productivity (MPFP) and Multilateral Total Factor Productivity (MTFP) index numbers that the AER relies on to benchmark DNSPs.

As a verification exercise, CEPA first estimates independently the non-reliability output weights using the Leontief input demand functions currently used by the AER, and data between 2006 and 2018. CEPA concludes that its own estimates "do not differ substantially" from the estimates currently adopted by the AER (which were derived by Economic Insights in 2020).

CEPA then goes on to discuss a number of practical challenges that may be encountered when estimating the Leontief input demand functions. The non-linear specification of the Leontief model requires the model to be estimated numerically using non-linear optimisation techniques. Several issues can arise in the estimation of non-linear models:

1. There can be several local optima, and the solver used to estimate the model may inadvertently identify one of these turning points rather than the global optimum.
2. There may be multiple solutions for each optimum value of the objective function. That is, even if the global optimum is identified, there may be other sets of parameter estimates that attain the same global optimum, in which case there is no unique optimum.

As a solution to the first problem, CEPA recommends specifying a linear time trend in the cost function. CEPA argues that this simplification allows the model to be estimated using quadratic programming. This, in turn, obviates the need to estimate the model using non-linear optimisation, and avoids estimation problems such as model non-convergence, or inadvertent identification of a local rather than global optimum.

In order to address the second problem, CEPA proposes the estimation of the Leontief input demand functions using a Least Absolute Deviations (LAD) approach. CEPA argues that this transforms the estimation task into a linear programming problem. Since linear programs typically have unique solutions (except in rare edge cases that are readily detected), there would be no risk of identifying multiple sets of parameter estimates for the same model.

Finally, although beyond the scope of work requested by the AER, CEPA proposes that the AER consider undertaking what it refers to as 'direct cost benchmarking', whereby the estimated cost function is used directly to estimate an efficient level of opex for each DNSP. CEPA argues that this would avoid the need for the AER to estimate non-reliability output weights, and to construct the PIN models, altogether – since the opex allowance for each DNSP could be set directly in line with the 'efficient' level of opex predicted using the estimated cost function.

The remainder of this report assesses CEPA's key recommendations, and discusses a number of important issues that are not considered by CEPA, but that should be addressed by the AER.

1.3 Assessment of CEPA's key recommendations on the Leontief function

One of the main objectives of CEPA's investigations was to review the calculations undertaken to produce the output weights used in the AER's total factor and partial factor performance indices. While CEPA was able to more or less replicate the calculations of the output weights used in those indices, it noted that there are potential issues with the stability of the numerical routines used to estimate the Leontief input demand equations that underpin the calculation of the output weights.

These issues relate primarily to the fact that the Leontief demand equations specified in the AER's work contain non-linearities. There are two different sources of non-linearity in the specifications:

- The coefficient on the time trend variable in the equations is multiplied by the coefficients on the output variables; and
- The coefficients on the output variables appear in the equations in squared form.

The first of these non-linearities is inherent in the specification of the Leontief cost function from which the input demand functions are derived. However, specifying the coefficients of the output variables in squared form is not inherent in the cost function specification and is merely a technique used to ensure that the estimated coefficients on the output variables are non-negative. There are other way of ensuring this outcome.

The estimation of non-linear regression models is more complex than the estimation of linear regression models. It requires iterative numerical procedures to find the least squares or maximum likelihood estimates of the parameters of the models. The CEPA report comments on two problems that can arise with these numerical procedures: (i) the potential presence of local minima for least squares (or local maxima for maximum likelihood) with the procedure finding a local minimum rather than the global minimum, and (ii) the possibility that there are two or more sets of estimates for the parameters that produce exactly the same value of the objective function.

The CEPA report makes several recommendations for overcoming or mitigating these issues:

1. Modify the specification of the Leontief function to "linearise" the time trend term so that the coefficient on the time trend is no longer multiplied by the coefficients on the output variables.

2. Use quadratic programming to estimate regression models instead of squaring the coefficients on the output variables.

3. Use the LAD method instead of least squares to estimate the regression models.

We comment on each of these suggestions in turn.

1.3.1 Linearisation of time trend term

Linearising parts of a non-linear model will overcome or mitigate the potential estimation problems with the Leontief model discussed by CEPA and make the model easier to estimate. To achieve this aim, CEPA recommends re-specifying the way the trend term enters the input demand equations. Instead of the coefficient of the trend term being multiplied by the coefficients of the output variables, the time trend now enters the model as a separate stand-alone variable. We agree that this will make the model easier to estimate.

However, the resulting linearised model can no longer be interpreted as a Leontief cost function, since it cannot be derived from a cost function analogous to the Leontief cost function (2) on p. 8 of CEPA's report. For example, one of the features of the Leontief cost function is that if all outputs are increased by the same percentage, costs and inputs will increase by the same percentage. That property does not hold for CEPA's linearised cost function. Moreover, unless the input demand equations can be derived from a cost function analogous to the steps shown in equations (2) and (3) in the report, they are not based on sound economic principles. It is not clear how one could specify a cost functions analogous to (2) that would lead to CEPA's linearised input demand functions.

Another practical problem with CEPA's linearised cost function is that it complicates how one would calculate the cost shares required when calculating the weighted averages of the parameter estimates to derive the output weights since the contribution of the time trend to the predicted inputs cannot be allocated to the separate outputs in a natural way.

1.3.2 Use quadratic programming to estimate models

CEPA also recommends using quadratic programming as an alternative way of ensuring that the estimated output coefficients are non-negative. Quadratic programming is well suited to estimating the CEPA's linearised Leontief input equations while imposing the non-negative constraints on the output coefficients. However, this approach can also be used to estimate the AER's specification of the Leontief function if it is combined with a grid search on the coefficient of the time trend. Since the coefficient of the time trend is expected to fall within a very small range, bounded by, say, -0.1 to 0.1 (representing a 10% per annum decrease or increase in inputs), it would be straightforward to combine this grid search with quadratic programming to estimate the Leontief functions.

We note that for most of the 52 input equations for the DNSPs and the 20 input equations for the TNSPs, the AER's numerical algorithm for estimating the equations converges quite quickly, and does not seem to present any issues. However, using the quadratic programming approach may provide greater assurance that the numerical algorithm will converge, and that the solution found does not correspond to a local rather than optimum of the objective function.

1.3.3 Use of LAD estimation

CEPA indicates that with least squares estimation it is possible that there are two or more solutions to the optimisation routine that have the same value of the objective function (i.e. lack of identification). CEPA proposes that the models can be estimated using the LAD method rather than least squares. This transforms the estimation task into a linear programming exercise. Since linear programs typically have unique solutions, there would be no risk of inadvertently identifying multiple sets of parameter estimates for the same model.

LAD estimation is usually adopted if the data contain outliers. When outliers are not a problem, least squares estimates have better statistical properties than LAD estimates. Since the data used for this exercise have undergone close scrutiny, we do not believe that outliers are a serious issue. Hence, adopting LAD instead of least squares estimation of the Leontief input demand functions would only be advantageous if the identification issue discussed by CEPA arises in practice.

In our experience with estimating Leontief functions using the AER's data, we have never found multiple solutions with the same value of the objective function. Given the continuous nature of the objective function, and the way the linear planes representing the non-negativity constraints intersect the objective function, we believe that the probability of this situation occurring in practice is infinitesimally small. Hence, we do not see any convincing evidence for replacing least squares estimation of the Leontief input demand functions by LAD estimation.

1.4 Direct cost benchmarking

CEPA suggests that rather than constructing the PIN (e.g., the MPFP and MTFP) models, the AER should estimate a cost function (e.g., using a technique such as Data Envelopment Analysis) and then use that model directly to 'predict' an efficient level of opex for individual DNSPs. The predicted/fitted opex could then be used to set the DNSP's opex allowance directly.

CEPA appears to have misunderstood the role of the MPFP and MTFP models in the AER's framework. Those models are used by the AER to track changes in efficiency over time. The AER presents these models over time, in its Annual Benchmarking Reports, as a way of encouraging DNSPs to compare themselves to one another and to incentivise improvement over time relative to their peers. The potential benefits of these 'reputational effects' in promoting efficiency improvements over time (which are evident for some DNSPs) would be lost if CEPA's recommendation were adopted.

We therefore do not think that the AER should replace the PIN models with direct cost benchmarking.

1.5 Important matters not addressed by CEPA

There are a number of important issues relevant to the estimation of non-reliability output weights that the AER should consider as part of this review, which CEPA has not addressed:

- The need for regular and frequent updates of output weights;
- Multicollinearity; and
- Non-linearity of opex over time.

This section explores each of these issues.

1.5.1 The need for regular and frequent updates of output weights.

The non-reliability output weights that the AER currently uses to construct the PIN models are estimated using historical data between 2006 and 2018. At the present time, there are an additional five years of historical data (i.e., up to and including 2023) that could be used to estimate the output weights. However, the AER has not employed those additional years of data.

Furthermore, since 2018, there have been several data revisions and corrections to the historical data. This means that the existing output weights reflect erroneous data that the AER has subsequently revised for the purposes of conducting benchmarking analysis.

In 2018, the AER's adviser Economic Insights updated the output weights used in the PIN models for the first time since those weights were originally determined in 2014. At that time, the AER explained that its intention was to only update the estimates of output weights periodically (i.e., every five years) to "provide consistency in the benchmarking scores over time."[2] The AER explained that:

> *There needs to be an appropriate balance between maintaining consistency in the approach to measuring the productivity of firms, and updating the models with better data when it becomes available. On balance, we and Economic Insights consider it is now an appropriate time to update the output weights. Five years have passed since the original estimation was undertaken, and there are longer-term benefits of providing results that reflect the most recent data.*[3]

That is, the AER was concerned that updating the output weights too frequently would make comparisons of DNSPs over time difficult.[4]

In our view, the non-reliability output weights should be estimated using all the available, including data that has been revised to correct historical errors. This means that, each year, as new data becomes available, the output weights should be refreshed to reflect the new information. This is a very straightforward updated exercise once the models and calculations required to calculate the output weights have been set up.

The AER is correct that in order to track DNSP performance meaningfully over time, it is important that the PINs reflect a consistent set of output weights over time. Otherwise, one cannot tell if movements in the index over time are due to changes in productivity or due to a reweighting of the outputs. The way to overcome this problem is to back-cast the indices, once the output weights have been refreshed. This would ensure that the indices reflect a consistent set of output weights over the whole period. The AER back-cast the indices in 2020 when it corrected the estimated output weights, demonstrating the feasibility of the exercise. This back-casting task can also be updated readily.

In our view, it is critical that the PINs reflect the latest possible information available – including the most up-to-date view on output weights. If the purpose of the PINs is to influence DNSP behaviour (e.g., by motivating DNSPs to improve their efficiency over time and relative to their

[2] AER, *DNSP Annual Benchmarking Report*, November 2018, p. 56.

[3] AER, *DNSP Annual Benchmarking Report*, November 2018, p. 56.

[4] Of course, cross-sectional comparisons between DNSPs (e.g., in the case of the MPFP and MTFP) at a particular point in time would be valid, even if intertemporal comparisons would not be.

peers), the PINs need to provide DNSPs and decision-makers within those businesses the most accurate possible information about DNSP performance.

Table 1 below presents the existing estimates of the non-reliability output weights (i.e., estimated using data from 2006 to 2018 as presented in the 2020 ABR) and updated estimates of the weights (i.e., using data from 2006 to 2023). The table shows that there can be significant changes in output weights over time as new data become available and historical data is revised. As the PINs can be highly sensitive to these weights, the measured performance of individual DNSPs over time, and relative to peers, can also be highly sensitive to new/corrected data.

Table 1: Comparison of existing and updated weights

Output	Existing weights	Updated weights
Energy delivered	8.58%	6.82%
Ratcheted maximum demand	33.76%	52.08%
Customer numbers	18.52%	15.16%
Circuit length	39.14%	25.93%

Source: Quantonomics, Frontier Economics analysis of Consolidated benchmarking dataset (2023)

Based on the material change in the weights, the AER should at the very least update the non-reliability weights accounting for any new data, and data revisions/corrections since 2018, as the existing output weights are currently five years out of date.

Ideally, and as a matter of good practice, the AER should in our view update the output weights annually, and back-cast the PINs using the revised weights. This could be done readily as part of the AER's Annual Benchmarking Reports.

1.5.2 Multicollinearity

Many of the output variables specified in the Leontief cost function are highly correlated with one another. For example, Table 2 shows that, in Evoenergy's case:

- ratcheted maximum demand is very highly correlated with customer numbers and circuit length; and
- customer numbers is highly correlated with circuit length.

Table 2: Evoenergy output correlations

	Energy delivered	RM Demand	CustNum	CircLen
Energy delivered	1			
RM Demand	0.5096	1		
CustNum	0.4872	0.9457	1	
CircLen	0.4618	0.9205	0.9897	1

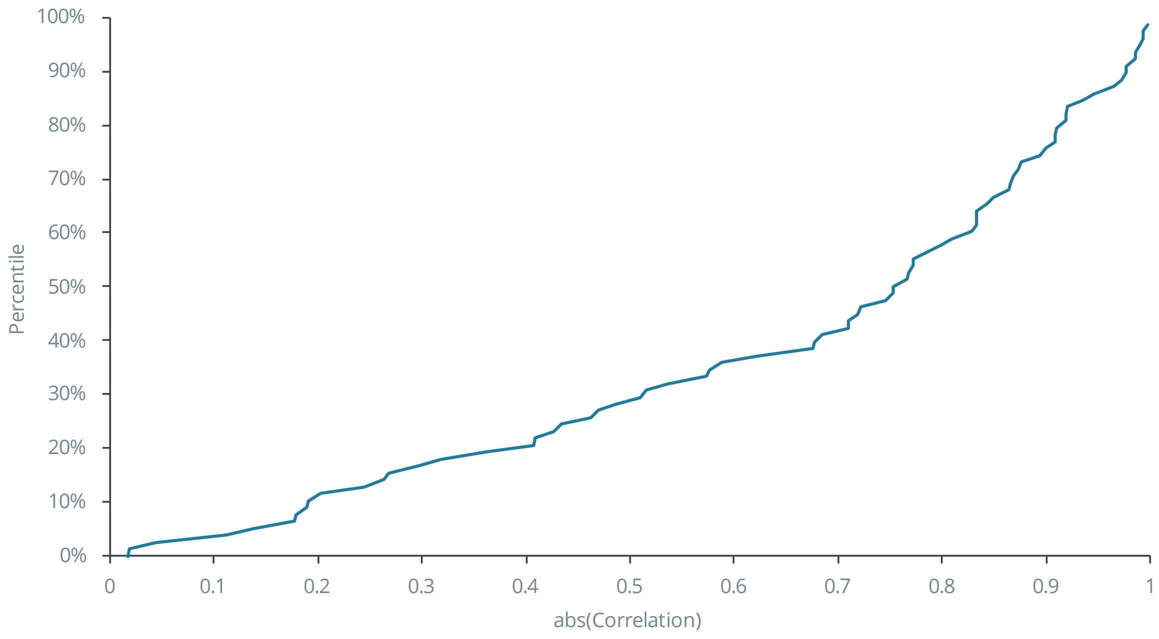
Source: Frontier Economics analysis of DNSP consolidated benchmarking data (2023)

Similarly high pairwise correlations between output variables are evident for all the other DNSPs (see the correlograms presented in the Appendix to this report).

Figure 1 plots the cumulative distribution of pairwise correlations between output variables across all DNSPs. The figure shows that the distribution is very skewed towards a high degree of correlation between output variables. For example:

- 58% of pairwise correlations are greater than 0.70 (in absolute value); and
- 41% of pairwise correlations are greater than 0.80 (in absolute value).

Figure 1: Cumulative distribution of pairwise correlations between output variables across all DNSPs



Source: Frontier Economics analysis of DNSP consolidated benchmarking data (2023)

These very high degrees of correlation between output variables means that the Leontief cost functions that the AER estimates, to derive non-reliability output weights, likely suffer from a serious multicollinearity problem, where the elasticities for individual output variables cannot be estimated reliably. This is because when two or more output variables are highly correlated with one another, the statistical model cannot disentangle the individual effect of each variable on the input variable. In some cases, the true effect of a particular output variable may be overestimated by the model, and in other cases the true effect may be underestimated.

Since the estimated output variables are a function of the estimated elasticities from the Leontief cost function, errors in the estimation of the elasticities will flow through as errors in the estimates of individual output weights.

This problem is likely to be exacerbated by the fact that the individual DNSP cost functions are estimated with relatively few observations.

The AER's approach is to calculate a weighted average of the estimated output weights across DNSPs to arrive at set of overall estimates for the industry as whole. This averaging process will not ameliorate the effect of multicollinearity on the estimated output weights.

As a consequence of the multicollinearity problem, the output weights used to construct the PIN models are unlikely to be reliable. However, the MPFP and MTFP indices are highly sensitive to the weights adopted. This means that some DNSPs may appear to be very strong performers on these indices when in fact they are not, and vice versa.

We recognise that there is no straightforward solution to the multicollinearity problem, if the AER wishes to retain all the output variables specified in the Leontief cost function. In these circumstances, the AER should be explicit that multicollinearity is a serious limitation, and that the PINs presented in its Annual Benchmarking Report may be distorted as a result, warranting due caution.

1.5.3 Non-linearity of opex over time

CEPA interprets the time trend term in the Leontief cost function as a measure of technical progress, and suggests that it is unclear that a time trend should be included at all because the rationale for allowing for technical progress in the cost function for DNSPs is unclear.

However, the time trend term may be picking up other effects that are not accounted for by the other explanatory variables in the model—such as the effect over time of the AER's regulatory framework (and in particular, the AER's benchmarking of DNSPs) on opex.

CEPA goes on to *assume* that opex changes linearly over time (keeping the outputs constant).[5] Indeed, this assumption is one of the underpinnings of CEPA's recommendation of a linearised time trend specification in the Leontief model.

However, in reality, the opex that has actually been incurred by individual DNSPs has not evolved linearly over time. This is because some DNSPs appear to have responded very strongly to the AER's regulatory framework (including its benchmarking analysis) by reducing opex very materially—in some cases within a very short period of time. Evoenergy and Ausgrid are two such examples.

This means that a linearised time trend is very unlikely to result in well-fitted models. A similar mis-specification problem arises in the case of the AER's econometric benchmarking models. The resulting output weight estimates are likely to be highly unreliable. The AER should give serious consideration to model specifications that recognise DNSP opex has changed non-linearly over time.

[5] CEPA, Review of the AER's estimated non-reliability output weights used in the TFP and MTFP benchmarking models, pp. 20-21.

Appendix: Correlation matrices for output Leontief output variables

Table 3: Ausgrid output correlations

	Energy delivered	RM Demand	CustNum	CircLen
Energy delivered	1			
RM Demand	-0.7103	1		
CustNum	-0.9083	0.7220	1	
CircLen	-0.9348	0.8334	0.9764	1

Source: Frontier Economics analysis of DNSP consolidated benchmarking data (2023)

Table 4: CitiPower output correlations

	Energy delivered	RM Demand	CustNum	CircLen
Energy delivered	1			
RM Demand	-0.7106	1		
CustNum	-0.7721	0.9106	1	
CircLen	-0.6780	0.8279	0.9652	1

Source: Frontier Economics analysis of DNSP consolidated benchmarking data (2023)

Table 5: Endeavour Energy output correlations

	Energy delivered	RM Demand	CustNum	CircLen
Energy delivered	1			
RM Demand	-0.5766	1		
CustNum	-0.4073	0.8684	1	
CircLen	-0.4335	0.8932	0.9978	1

Source: Frontier Economics analysis of DNSP consolidated benchmarking data (2023)

Table 6: Energex output correlations

	Energy delivered	RM Demand	CustNum	CircLen
Energy delivered	1			
RM Demand	0.4700	1		
CustNum	0.1886	0.7878	1	
CircLen	0.2027	0.8488	0.9863	1

Source: Frontier Economics analysis of DNSP consolidated benchmarking data (2023)

Table 7: Ergon Energy output correlations

	Energy delivered	RM Demand	CustNum	CircLen
Energy delivered	1			
RM Demand	-0.0181	1		
CustNum	-0.1910	0.7722	1	
CircLen	0.1374	0.7531	0.7528	1

Source: Frontier Economics analysis of DNSP consolidated benchmarking data (2023)

Table 8: Essential Energy output correlations

	Energy delivered	RM Demand	CustNum	CircLen
Energy delivered	1			
RM Demand	0.8089	1		
CustNum	0.8736	0.9185	1	
CircLen	0.2684	0.2633	0.3175	1

Source: Frontier Economics analysis of DNSP consolidated benchmarking data (2023)

Table 9: Jemena Electricity Networks output correlations

	Energy delivered	RM Demand	CustNum	CircLen
Energy delivered	1			
RM Demand	-0.2979	1		
CustNum	-0.5736	0.6759	1	
CircLen	-0.5357	0.7193	0.9929	1

Source: Frontier Economics analysis of DNSP consolidated benchmarking data (2023)

Table 10: Powercor output correlations

	Energy delivered	RM Demand	CustNum	CircLen
Energy delivered	1			
RM Demand	0.7994	1		
CustNum	0.8338	0.8327	1	
CircLen	0.8433	0.8653	0.9936	1

Source: Frontier Economics analysis of DNSP consolidated benchmarking data (2023)

Table 11: SA Power Networks output correlations

	Energy delivered	RM Demand	CustNum	CircLen
Energy delivered	1			
RM Demand	-0.4094	1		
CustNum	-0.9003	0.6846	1	
CircLen	-0.8636	0.7679	0.9775	1

Source: Frontier Economics analysis of DNSP consolidated benchmarking data (2023)

Table 12: AusNet Services Distribution output correlations

	Energy delivered	RM Demand	CustNum	CircLen
Energy delivered	1			
RM Demand	0.0444	1		
CustNum	-0.1784	0.8755	1	
CircLen	-0.1769	0.9082	0.9857	1

Source: Frontier Economics analysis of DNSP consolidated benchmarking data (2023)

Table 13: TasNetworks Distribution output correlations

	Energy delivered	RM Demand	CustNum	CircLen
Energy delivered	1			
RM Demand	-0.1119	1		
CustNum	-0.0171	0.5152	1	
CircLen	-0.3634	0.4271	0.9187	1

Source: Frontier Economics analysis of DNSP consolidated benchmarking data (2023)

Table 14: United Energy Distribution output correlations

	Energy delivered	RM Demand	CustNum	CircLen
Energy delivered	1			
RM Demand	-0.2440	1		
CustNum	-0.7663	0.6228	1	
CircLen	-0.7455	0.5878	0.9729	1

Source: Frontier Economics analysis of DNSP consolidated benchmarking data (2023)

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