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Attention: Networks Benchmarking Team

28 February 2025

AER consultation – Quantonomics memorandum 2024

Evoenergy supports the AER's examination of, and consultation on, options to improve the performance of its benchmarking models and address statistical performance issues. We welcome the opportunity to provide feedback on Quantonomics' Memorandum on *Electricity Distribution Opex Cost Function: Potential Misspecification Issues*. Evoenergy engaged Frontier Economics (Frontier) to provide expert advice on these issues. A memo outlining Frontier's findings is attached.

The findings outlined in the Quantonomics memo are an important step towards improving the AER's benchmarking models. We encourage the AER to take an open, holistic and consultative approach to determining necessary model changes, including addressing model mis-specification, reviewing the approach to rolling forward opex in assessing base year efficiency, and consideration of the historical benchmarking periods currently in use.

Importantly, Quantonomics identifies that the econometric models are likely to be mis-specified due to:

- The assumption of a common time-trend for distribution network service providers (DNSPs) in Australia, New Zealand, and Ontario; and
- The assumption of constant efficiency over time.

Quantonomics provides analysis to demonstrate that efficiency outcomes differ for DNSPs in Australia, New Zealand, and Ontario. Notably, differences may relate to catch-up efficiency, driven by incentives created by the extent to which benchmarking is used to set regulatory allowances between jurisdictions.

Evoenergy encourages the AER to recognise that some Australian DNSPs, including Evoenergy, have made significant opex efficiency improvements over time, and those advancements should be accounted for in the benchmarking models. It is important to reflect time varying inefficiencies among different Australian DNSPs, as well as between other jurisdictions, in benchmarking analysis to ensure that the AER uses robust and accurate models as tools to assesses efficiency, particularly when informing efficient opex allowances. Evoenergy considers that the AER should explore options to identify models that allow for time-varying inefficiency and result in improved statistical performance. The Frontier memo provides additional evidence of time varying inefficiency between Australian DNSPs and identifies options worthy of further exploration by the AER and Quantonomics for addressing the issues relating to the AER's assumption of constant efficiency over time.

In addition to exploring options for incorporating time varying inefficiency in the benchmarking models, Evoenergy considers that the AER should simultaneously reconsider the approach adopted in the opex roll forward model (RFM). The current RFM estimates the average efficient opex over the benchmarking period and then rolls that estimate forward from the middle of the period to the base year. If the AER adopts time varying inefficiency models, it would be possible to estimate the efficiency of each DNSP close to the base year. The AER should explore whether that information, or the estimated cost function itself, could be used to produce a more reliable estimate of efficient base year opex.

Evoenergy supports Frontier's recommendation that the AER should consider a move to a 10-year rolling benchmarking period to inform opex efficiency, which would ensure that the estimated cost function is more reflective of recent and relevant data. Restricting the sampling period to the most recent 10 years may improve the ability of the models to estimate the efficient frontier because the models would not need to contend with a structural break in the data that likely occurred when the AER began to apply benchmarking when making revenue determinations. This approach may also improve the statistical performance of the AER's benchmarking models.

Evoenergy understands that the potential improvements discussed, including allowing for efficiency to vary over time, would represent a fundamental change to benchmarking. Therefore, we consider it necessary for the AER to ensure adequate time to thoroughly consider and consult on the relevant issues and proposed improvements, and welcome opportunities for continuing engagement with the AER on this important benchmarking development work. It may therefore be more appropriate for the AER to target the incorporation of the outcomes of this consultation in the 2026 Annual Benchmarking Report rather than the 2025 Annual Benchmarking Report.

Given the highly technical nature of these issues, we would be happy to facilitate discussion between Frontier and Quantonomics to discuss the findings.

Should you have any questions or wish to discuss our response, please contact Gillian Symmans, Group Manager Regulatory Reviews and Policy, at

[redacted]

Yours sincerely

[redacted]

Megan Wilcox
General Manager Economic Regulation

Memo

To:	Evoenergy
From:	Dinesh Kumareswaran, Dr James Key (Frontier Economics)
Date:	27/02/2025
Subject	Response to AER's Phase 1 consultation on potential mis-specification issues – electricity distribution opex cost functions

Introduction

In November 2024, the Australian Energy Regulator (AER) published alongside its 2024 Annual Benchmarking Report for electricity Distribution Network Service Providers (DNSPs) a memorandum prepared by Quantonomics,[1] which commenced a two-phase review into potential mis-specification issues affecting the econometric models that the AER uses to benchmark DSNSP's operating expenditure (opex).

- **Phase 1** of the review investigates one potential source of mis-specification within the existing econometric models – the imposition of a common time-trend for all three jurisdictions within the AER's benchmarking sample (Australia, New Zealand and Ontario).
- **Phase 2** of the review, as we understand it, will investigate a second potential source of mis-specification – the assumption that DNSPs' level of inefficiency remains constant over the historical benchmarking period.

The key findings in the Quantonomics memorandum are the following:

- The common time trend assumption is likely to be a source of model mis-specification, which can result in biased estimates of the relationship between output quantities and costs;[2]
- A model that allows jurisdiction-specific time trends (the JTT model) and a model that allows a separate time trend for Australia (the ATT model) outperform the existing econometric models in a number of ways (i.e., by producing more "credible" efficiency scores, achieving convergence for models that previously did not converge, and producing fewer monotonicity violations);[3]
- The existing models, and the JTT and ATT models presented in the Quantonomics memorandum, assume that the inefficiency of each DNSP remains constant over time.

1 Quantonomics, *Electricity Distribution Opex Cost Function: Potential Misspecification Issues*, 21 November 2024 (Quantonomics memorandum)

2 Quantonomics memorandum, p. 39.

3 Quantonomics memorandum, sections 3.7 and 4.

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However, there is evidence that the efficiency of Australian DNSPs has changed over time. A failure to account for this may be an additional source of model mis-specification;[4] and

- Given this second mis-specification problem, there may be benefit in exploring time-varying inefficiency models that can better disentangle the effects of frontier shift and catch-up efficiency for the Australian DNSPs.[5]

Evoenergy has asked us to assess the analysis and conclusions presented in the Quantonomics memorandum, and to recommend areas for focussed investigation in Phase 2 of the AER's consultation process.

Our main conclusions

The following are our key conclusions, having reviewed the Quantonomics memorandum:

- Quantonomics has presented compelling evidence that the existing econometric models are mis-specified in two ways:
  - The models assume that there is a common time-trend for DNSPs in Australia, New Zealand and Ontario. This would be a reasonable assumption if (a) DNSPs in these three jurisdictions have achieved a similar level of catch-up efficiency over time, and (b) the effect on opex of changes in operating environment factors (OEFs)—e.g., changes in regulatory obligations—has been the same in all three jurisdictions. However, this does not appear to be the case. When this assumption is relaxed, the estimated time trends for Australia, New Zealand and Ontario are found to differ, both economically and statistically.
  - The models assume that the inefficiency of each DNSP remains constant over time. However, there is convincing evidence that some Australian DNSPs have achieved significant catch-up efficiency over time. Because the models impose a constant inefficiency assumption, the improvement in efficiency of some Australian DNSPs is likely captured by the time trend for Australia in the JTT and ATT models presented in the Quantonomics memorandum.
- The mis-specification of the models essentially results in an omitted variables problem. This results in mis-estimation of the inefficiency of individual DNSPs, the rate of technical efficiency, and the other cost function elasticities. Consequently, the existing models are not fit-for-purpose. They certainly should not be relied on by the AER anymore to set opex allowances for individual DNSPs.
- Of the two sources of mis-specification, the second (i.e., constant inefficiency assumption) is likely to be the more serious problem. Once that mis-specification is corrected, one would expect any differences in time trend to account for differences in OEF changes that have not been accounted for by the models.
- Quantonomics has recommended the AER explore time-varying inefficiency models. We support that recommendation. In our view, given the strong evidence that some Australian DNSPs have achieved significant catch-up efficiency (particularly since the AER began benchmarking DNSPs' opex formally in 2014), this is necessary if the AER wishes to have models that are capable of benchmarking DNSPs' opex reliably.
- There are many time-varying inefficiency models that have been developed in the literature. The AER should explore these models as part of Phase 2 of its consultation. Many of the

4 Quantonomics memorandum, p. 42.

5 Quantonomics memorandum, p. 48.

models in the literature are sufficiently flexible to support a wide range of specifications that may better fit the data than the existing models.

- There are existing software packages—e.g., the *sfpanel* package—that could be a useful starting point for the exploration of suitable time-varying inefficiency models.

Key takeaways from Quantonomics' memorandum

Quantonomics has made a major contribution to the development of the AER's econometric benchmarking models by identifying, and providing convincing evidence for, two sources of model mis-specification:

1. The assumption of a common time-trend for DNSPs in Australia, New Zealand and Ontario; and
2. The assumption of constant efficiency over time.

The Quantonomics memorandum focuses primarily on the first of these issues, and seeks to address that mis-specification by allowing for jurisdiction-specific time trends.

In our view, the constant efficiency assumption is by far the more serious of the two problems.

Whilst the JTT and ATT models perform better than the existing models in a number of respects, they do not address the second source of mis-specification. Indeed, the reason why the estimated time trends differ between jurisdictions in the JTT and ATT models may be because the time trends are capturing the differing effects of catch-up efficiency (in addition to other effects such as frontier shift and missing OEFs) between jurisdictions.

As the Quantonomics memorandum acknowledges, there is evidence of material catch-up by at least some Australian DNSPs in response to the AER's introduction of formal benchmarking analysis in 2014, which the JTT and ATT models do not account for:

> *…the design of both the current models and the models presented in this memo implicitly assume that inefficiency of each DNSP does not vary over time (i.e. the U_i term in equation 4.1 is assumed to be constant over time). This might have been a reasonable assumption at the commencement of the AER's benchmarking program. However, there is evidence that Australian DNSPs' inefficiency has varied over time, as indicated in the upward trend in the distribution TFP results since 2015, which is mainly due to opex productivity. The current models, and models in section 2 and 3 do not, however, enable us to separate the effects of time-varying inefficiency from technical change (or from changes over time in omitted OEFs), which are currently all conflated in $\lambda.t$. This may be a source of potential misspecification. This will be desirable if we want to ascertain the changes in efficiency scores over time.*[6]

The primary benefit of the JTT and ATT models is that they allow the second mis-specification problem to be identified more clearly. The apparently weak efficiency performance of the New Zealand DNSPs, combined with the common time trend restriction, largely masked the issue. Relaxing the common time trend assumption allowed the time trend for each jurisdiction to reflect the effect of average catch-up in that jurisdiction—suggesting significant positive catch-up efficiency in Australia, and negative catch-up efficiency in New Zealand.

[6] Quantonomics memorandum, p. 42.

The JTT and ATT models should not, in their current forms, be employed by the AER because (as acknowledged by Quantonomics) they do not properly address the model mis-specification arising from the constant efficiency assumption. As a result, the models will continue to mis-estimate the efficiency of each DNSP, the rate of frontier shift and the other elasticities in the model.

In our view, the AER's focus now should be to explore alternative model specifications that allow properly for time-varying inefficiency, rather than implementing the JTT or ATT models. If the AER can identify reliable time-varying inefficiency models, it may find that there is little need for jurisdiction-specific time trends.[7]

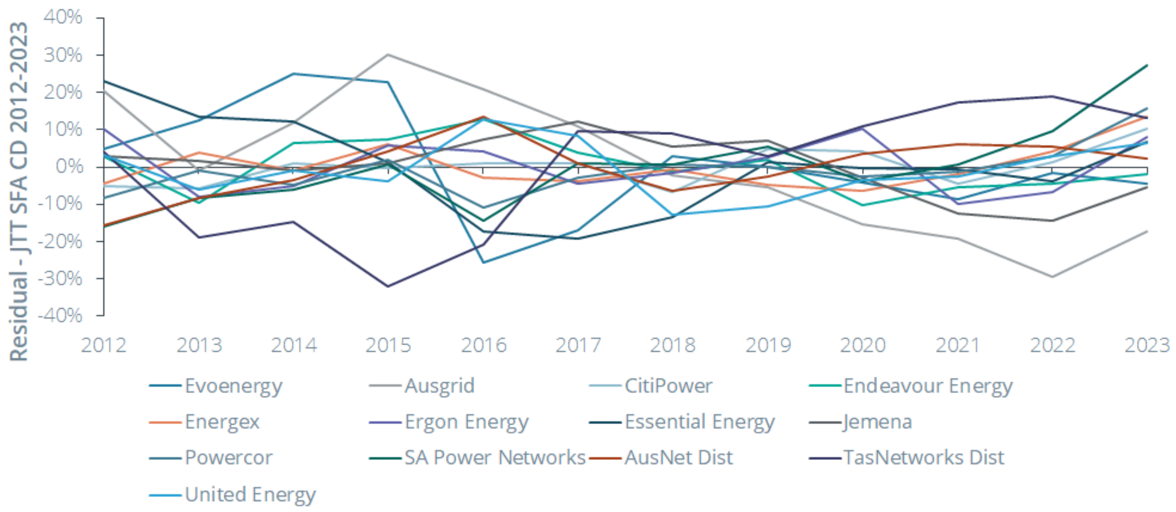
Further evidence of model mis-specification

As noted above, Quantonomics concludes that the existing econometric models (and the JTT and ATT models) may be mis-specified because the assumption of time-invariant inefficiency results in the models being unable to separate the effects of time-varying inefficiency from technical change over time.

One common way of investigating whether an econometric model has been mis-specified is to examine the residuals of the regression. Figure 1 plots the residuals from the JTT version of the SFA-CD model estimated over the short sample period (i.e., 2012 to 2023). The figure shows that the residuals from the regression are large for some DNSPs. This could be an indication of omitted relevant variables or model mis-specification.

Furthermore, the plotted residuals for some DNSPs exhibit a clear trend over time. This can be seen more easily in Figure 2, which plots the time trend in the residuals produced by the JTT version of the SFA-CD model estimated over the short sample period against the estimate of efficiency for each DNSP over the period.

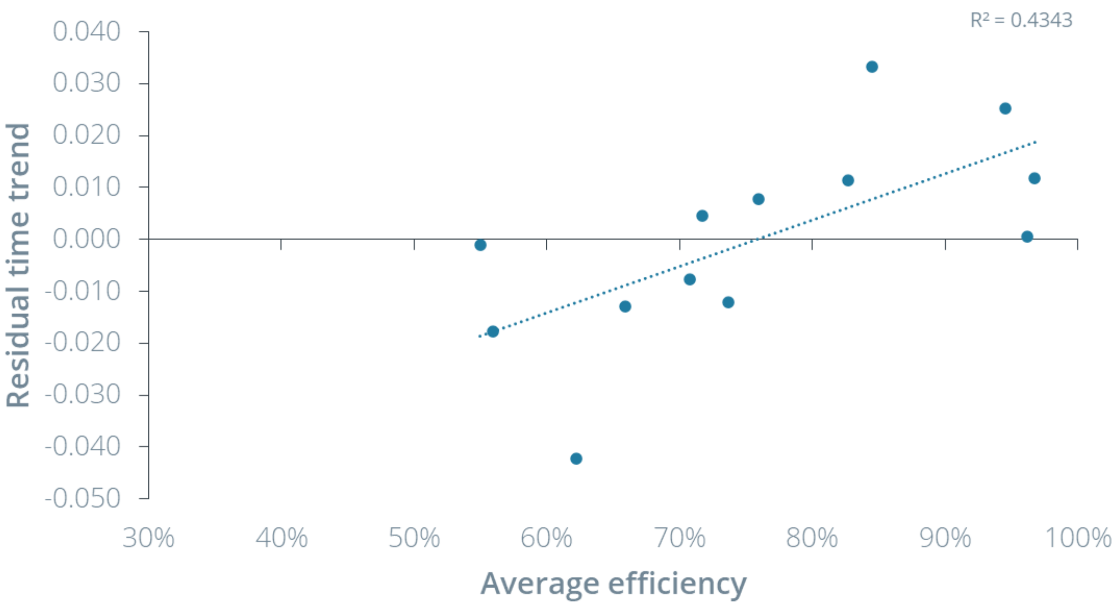
Figure 1: Residuals – JTT SFA-CD model



Source: Frontier Economics.

7 It seems plausible that the rate of change in technical efficiency is similar across jurisdictions. However, there may still be some benefit in allowing for jurisdiction-specific time trends if the effect of changing OEFs (e.g., changes in regulatory obligations) differs between Australia, New Zealand and Ontario.

Figure 2: Trend in residuals vs average efficiency – JTT SFA-CD model



Source: Frontier Economics.

If the model were well-specified, one would expect to see no relationship the trend in the residuals and estimated efficiency. However, the strong positive relationship presented in Figure 2 indicates that the JTT SFA-CD model suffers from a mis-specification problem. In other words, introducing jurisdiction-specific time trends, as the JTT models do, is not sufficient to fully address the mis-specification of the models.

We undertook further modelling to investigate whether the constant efficiency assumption may be a source of mis-specification, as Quantonomics hypothesises. Specifically, we estimated the JTT versions of the SFA-CD and SFA-TLG models (over the short benchmarking period 2012 to 2023) with one small change: we treated each of the seven Australian DNSPs that the AER has recently judged as *not* being reference DNSPs as its own panel in each year over the sample period.[8] This allows the model to derive a separate estimate of efficiency for each of those seven DNSPs in each year.

The six existing reference DNSPs were modelled in the usual way, thus maintaining the constant efficiency assumption in the standard models over the entire benchmarking period.[9] The rationale for treating the six reference DNSPs in this way is because, if they are indeed reference DNSPs (as the AER has judged them to be), they are already at the efficient frontier, so face no need to achieve any catch-up efficiency.

The estimated efficiencies over time for each DNSP, under these two models, are plotted in Figure 3 and Figure 4 below. The charts show that that the estimated efficiency score for each of the non-reference DNSPs generally improves over time. The two DNSPs with the lowest estimated scores in 2012 exhibit the largest improvement over the period to 2023. For example:

- In the SFA-CD model:

[8] These seven DNSPs are: Ausgrid, Evoenergy, Endeavour Energy, Energex, Ergon Energy, Essential Energy and Jemena.

[9] According to the AER, the six reference DNSPs at the current time are: AusNet, CitiPower, Powercor, SA Power Networks, TasNetworks and United Energy.

- Ausgrid's estimated efficiency score improves by 24.9 percentage points from 50.1% in 2012 to 75.0% in 2023; and
- Essential Energy's estimated efficiency score improves 14.7 percentage points from 53.0% in 2012 to 67.7% in 2023.

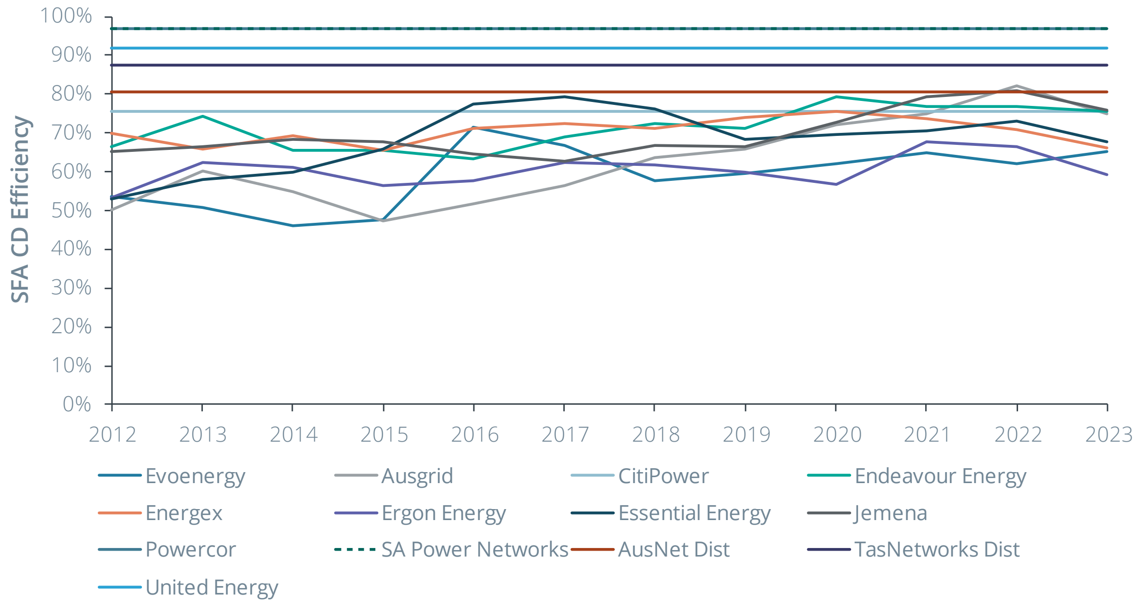
- In the SFA-TLG model:
  - Ausgrid's estimated efficiency score improves by 25.6 percentage points from 54.7% to 80.3% in 2023; and
  - Evoenergy's estimated efficiency score improves by 15.6 percentage points from 58.1% to 73.7% in 2023.

This finding is consistent with evidence from other sources (such as the AER's opex MPFP models) that:

- many DNSPs have achieved significant catch-up efficiency since the AER began using benchmarking analysis to make revenue determinations and to report on DNSP efficiency performance in the Annual Benchmarking Reports; and
- those DNSPs that have achieved the greatest catch-up efficiencies have been those that were judged to be the least efficient when the AER first began benchmarking.

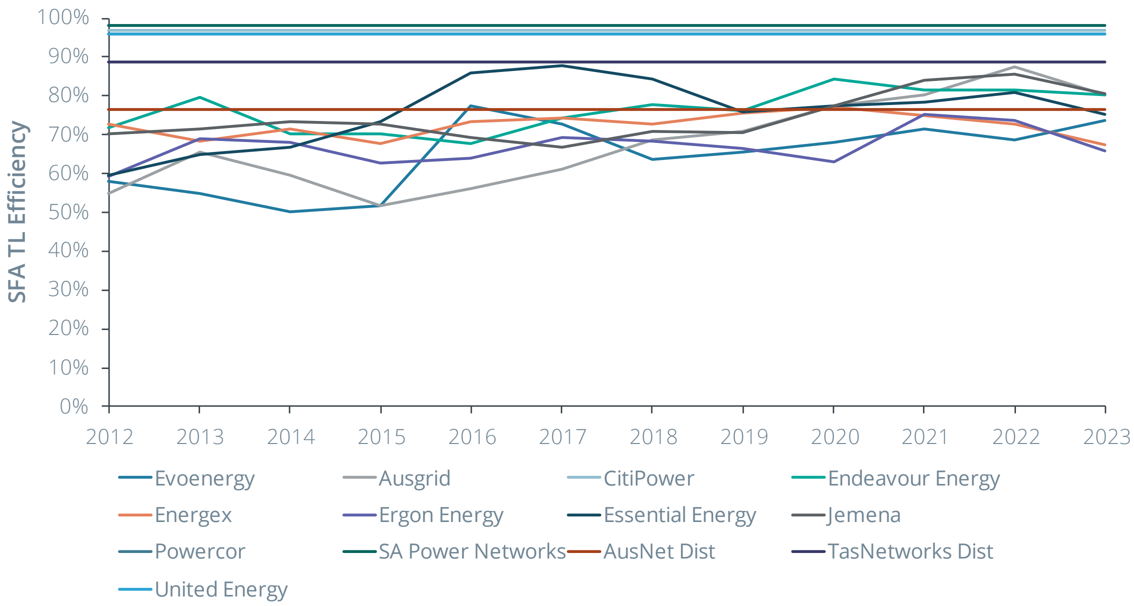
These findings should be viewed as a success by the AER. However, by the same token, it is important that the AER recognise that some DNSPs have made significant improvements over time. The existing models simply fail to do so, potentially resulting in opex allowances that are unreasonably low.

Figure 3: Estimated efficiencies over time – SFA-CD model



Source: Frontier Economics.

Figure 4: Estimated efficiencies over time – SFA-TLG model



Source: Frontier Economics.

Another striking finding is that the SFA-TLG model for the short period presented above exhibits only one monotonicity violation. By contrast, the JTT SFA-TLG model for the short period exhibits a total of 72 monotonicity violations. This dramatic difference suggests that most of the monotonicity violations that have plagued the existing econometric models are due to the constant efficiency assumption, which has resulted in mis-specification of those models in circumstances where the Australian DNSPs have achieved significant catch-up efficiency over time. Hence, properly addressing this source of model mis-specification may help address the problem of monotonicity violations that the AER has highlighted for many years.

For the avoidance of doubt, we are not proposing that the AER should adopt the respecified models presented in this section. We present these models purely as *prima facie* evidence in support of Quantonomics' tentative conclusion that the constant efficiency assumption is a likely source of model mis-specification, which in turn could distort the outcomes of the AER's benchmarking analysis.

Investigating time-varying inefficiency models

There are many time-varying inefficiency models that could be investigated

As noted above, Quantonomics has concluded that neither the existing models, nor the JTT and ATT models presented in the Quantonomics memorandum, are capable of accounting for time-varying inefficiency. We consider that this is likely to be a source of model mis-specification that could distort the results of the AER's benchmarking analysis, and that there would be benefit in exploring time-varying inefficiency models.

The Quantonomics memorandum mentions one example of such models, the Battese and Coelli (1992) model.[10] This model has a stochastic efficiency term:

$$U_{it} = \eta_{it} U_i,$$

where U_i is time invariant and has a truncated normal distribution and η_{it} depends on a uniform decay parameter η (i.e., a constant rate of change in inefficiency) that is common to all DNSPs in the sample.

However, many other well-known time-varying inefficiency models have been developed over the years, which could also be explored. One such example is the Battese and Coelli (1995) model,[11] where in each year the inefficiency U_{it} of each DNSP is drawn from a truncated normal distribution with a common, constant variance σ_U, and where the mean of the distribution μ_{it} is a linear function of a number of factors. These factors, which would need to be specified by the modeller, could include the country from which the DNSP is drawn, the identity of the DNSP, time trends, etc.

Another model is Kumbhakar (1990),[12] which is a more general version of Battese and Coelli (1992) in that each DNSP's inefficiency is specified as:

$$U_{it} = g(t).U_i,$$

where, once again, U_i is time invariant and has a truncated normal distribution, and $g(t)$ is a function (to be specified by the modeller) that determines the rate of change in inefficiency over time. For example, $g(t)$ may be specified as a decay function, or as sigmoid or spline functions (if there is reason to think that inefficiency has changed non-linearly over time).[13] For example, a two-knot spline function could potentially be adopted in the inefficiency term to distinguish explicitly between three distinct periods:

- The years prior to 2014, before the AER began performing benchmarking analysis;
- 2014 to 2020, during which time most the most dramatic catch-up efficiency gains to have been realised by the Australian DNSPs; and
- The years since 2020, where the catch-up efficiency gains appear to be more modest.

We have identified here only a handful of time-varying inefficiency models. The key point is that there is, in the literature, many examples of well-established time-varying inefficiency models that are worthy of exploration. Each will have its own strengths and weaknesses. We encourage the AER and Quantonomics to review and test different options for time-varying inefficiency models in Phase 2, and to allow stakeholders to submit their views on the appropriateness of different model specifications and their pros and cons.

There are established statistical packages that can implement a wide array of time-varying inefficiency models

The Quantonomics memorandum seems to suggest that a potential challenge in exploring suitable time-varying inefficiency models is the need for statistical software that can estimate

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10 Battese, G. E., Coelli, T. J. (1992), Frontier production functions, technical efficiency and panel data: With application to paddy farmers in India, *Journal of Productivity Analysis* 3, pp. 153–169.

11 Battese, G. E., Coelli, T. J. (1995), A model for technical inefficiency effects in a stochastic frontier production function for panel data, *Empirical Economics* 20, pp. 325–332.

12 Kumbhakar, S. C. (1990), Production frontiers, panel data, and time-varying technical inefficiency, *Journal of Econometrics* 46, pp. 201–211.

13 The $g(\cdot)$ function may also depend on non-time variables, subject to identification requirements.

these more complex cost functions. We note that Belotti et al (2013)[14] have developed the *sfpanel* package to implement a wide range of SFA models, including time-varying inefficiency specifications, using Stata, the statistical software that Quantonomics and the AER currently use to estimate the econometric benchmarking models. In fact, all three of the time-varying inefficiency models mentioned above (and a wide range of other SFA models) can be estimated using *sfpanel*. We present below indicative results using the *sfpanel* package, to demonstrate that it can be used to estimate time-varying inefficiency cost functions for DNSPs.

The *sfpanel* package is widely used by practitioners and researchers in the field, and supporting documentation explaining how it can be implemented is readily available.

The *sfpanel* package is, in our view, likely to be a useful tool that would help Quantonomics and the AER explore time-varying inefficiency models in Phase 2. It may be that some extensions to the underlying code may ultimately be needed to implement the models that would be most appropriate for the AER to adopt. However, there is no need to develop the required model code from scratch, or to avoid exploration of time-varying inefficiency models on the grounds that there is no 'off the shelf' software that could enable such investigation.

Illustrative implementation of time-varying inefficiency models using the *sfpanel* package

We first consider the ability of the *sfpanel* package to replicate the results of the *xtfrontier* package used by Quantonomics. To do this we compare examine the JTT SFA-TLG model estimates using the short period (2012 to 2023).[15] We note that the model used by Quantonomics is the time invariant model of Battese and Coelli (1988),[16] which is included as an option in the *sfpanel* package. As shown in Table 1 below, the *sfpanel* package is able to replicate the parameter estimates of the *xtfrontier* package.

Table 1: **Parameter estimates for JTT SFATLG (2012-2023) model**

	xtfrontier	*sfpanel*
ly1	0.6095	0.6095
ly2	0.2128	0.2128
ly3	0.1133	0.1133
ly11	-0.1075	-0.1075
ly12	0.1309	0.1309
ly13	-0.0013	-0.0013
ly22	0.1633	0.1633
ly23	-0.2873	-0.2873
ly33	0.2562	0.2562

14 Belotti, F., Daidone, S., Ilardi, G., Atella, V. (2013), Stochastic frontier analysis using Stata, *The Stata Journal* 13(4), pp. 719-758. Available at: https://journals.sagepub.com/doi/pdf/10.1177/1536867X1301300404

15 We use the dataset accompanying the Quantonomics memo.

16 Battese, G. E., Coelli, T. J. (1988), Prediction of firm-level technical efficiencies with a generalized frontier production function and panel data, *Journal of Econometrics* 38, pp. 387–399.

	xtfrontier	*sfpanel*
lz1	0.0470	0.0470
jur1_yr	-0.0312	-0.0312
jur2_yr	0.0284	0.0284
jur3_yr	-0.0048	-0.0048
jur2	-120.3363	-120.3363
jur3	-53.1337	-53.1337
_cons	72.9006	72.9006
/mu	0.0494	0.0494
/lnsigma2	-2.5245	-2.5245
/ilgtgamma	2.3220	2.3220
sigma2	0.0801	0.0801
gamma	0.9107	0.9107
sigma_u2	0.0729	0.0729
sigma_v2	0.0072	0.0072
N	732	732
LLH	656.4799	656.4799

Source: Frontier Economics.

We now present an alternative specification to the JTT model that allows for time-varying inefficiency, while retaining the translog specification for the short sample period. The model we present is not intended to be a recommendation to the AER. Rather, it is intended to be an illustrative example to demonstrate that it is feasible to estimate time-varying inefficiency SFA models using the *sfapanel* package. In other words, the model presented below should be viewed only as a 'proof of concept' of the types of time-varying inefficiency models that could be explored in Phase 2.

For illustrative purposes only, we do not allow for different cost function time trends for the three jurisdictions; as noted earlier the differences across jurisdictions in estimated frontier time trends likely reflect the catch-up to a substantial degree. Instead, we specify a single time trend in the frontier cost function, and allow for time trends in the efficiency effects model of Battese and Coelli (1995).

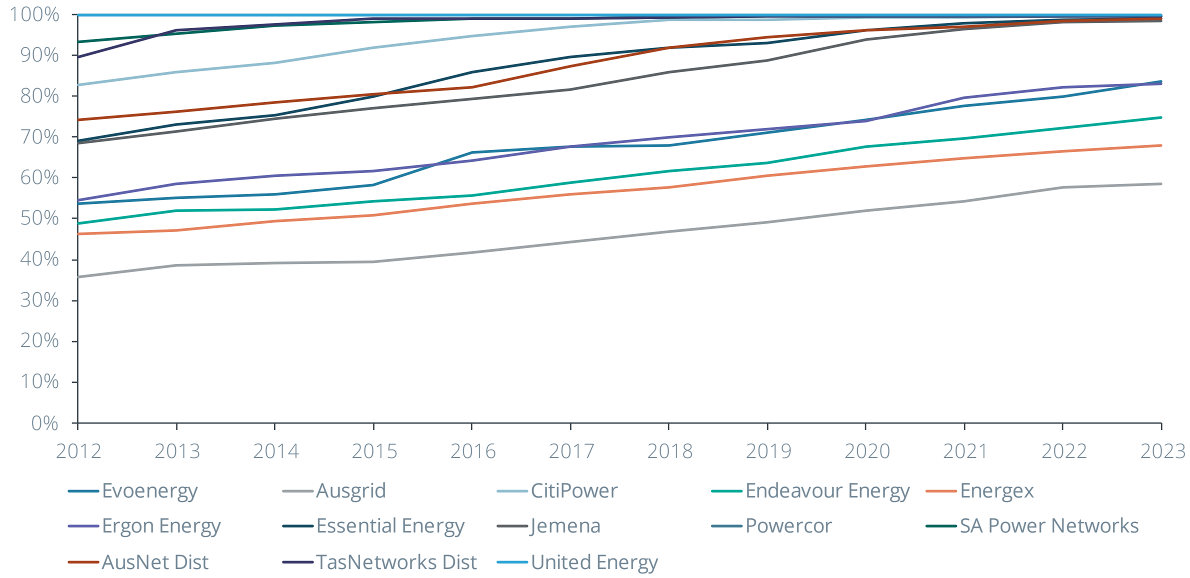
In this model, the inefficiency U_{it} of each DNSP is drawn from a truncated normal distribution with a common, constant variance σ_U, and where the mean of the distribution μ_{it} is a linear function of a number of factors. The factors we specify in this illustrative model are DNSP dummies, not only for Australian DNSPs but also each New Zealand and Ontario DNSP.[17] In addition, the mean of the

[17] We use 60 dummy variables plus a constant, as there are 61 distinct DNSPs in the short sample.

inefficiency distribution μ_{it} follows a time trend.[18] That is, the time trend of the inefficiency mean is allowed to be country specific.[19]

The resulting efficiency estimates for the Australian DNSPs improve relatively steadily over time, as shown in Figure 5.

Figure 5: Efficiency estimates: Battese and Coelli (1995) time-varying inefficiency



Source: Frontier Economics.

As shown in Table 2, this model yields a small negative time trend for the cost function, but the time trends for the inefficiency term exhibit substantial differences between the three jurisdictions.

Table 2: Parameter estimates: Battese and Coelli (1995) time-varying inefficiency

Parameter	Estimate
ly1	0.4732
ly2	0.2252
ly3	0.2045
ly11	0.5235
ly12	-0.1129
ly13	-0.3681
ly22	0.1986

[18] We do this by adding the following variables to the inefficiency term in the model: aus_yr = yr-2017.5 if the DNSP is in Australia; nz_yr = yr-2017.5 if the DNSP is in New Zealand; and ont_yr = yr-2017.5 if the DNSP is in Ontario.

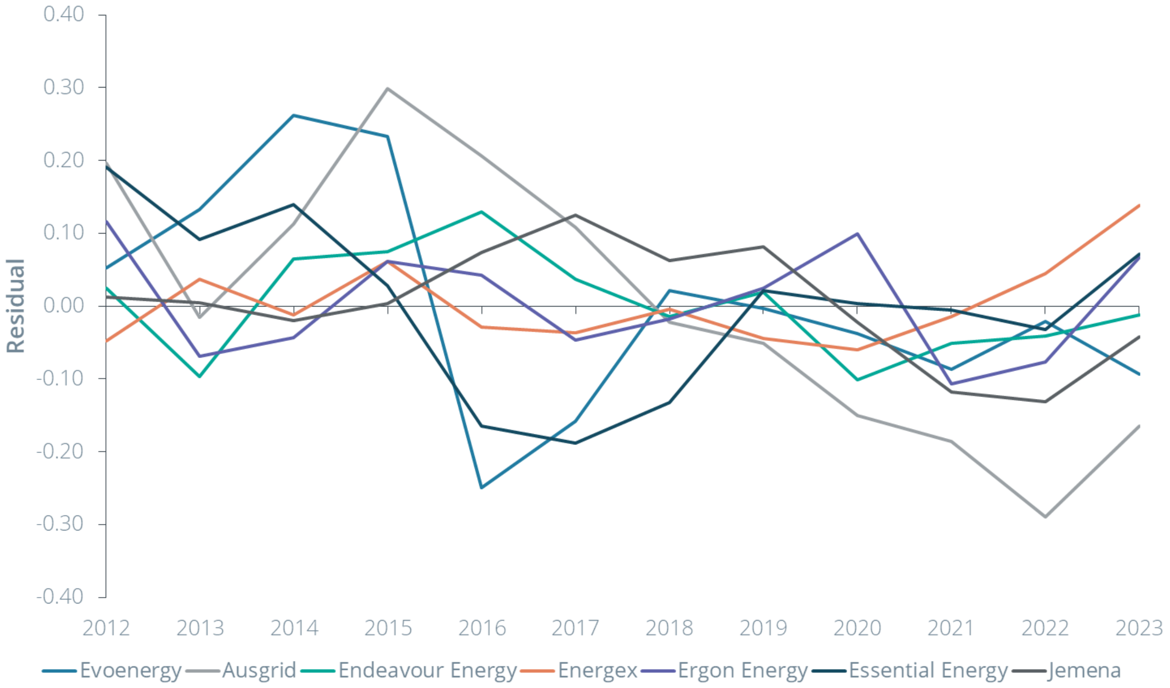
[19] We compare the year to the average of 2012 and 2023 to facilitate interpretation of the parameter estimates and to facilitate optimisation.

Parameter	Estimate
ly23	-0.0468
ly33	0.2291
lz1	0.0133
yr	-0.0006
jur2	-0.2632
jur3	-0.0443
_cons	11.3570
/mu: aus_yr	-0.0403
/mu: nz_yr	0.0329
/mu: ont_yr	-0.0047
/mu: _cons	0.2296
sigma_u2	0.0012
sigma_v2	0.0051
N	732
LLH	835.0186

Source: Frontier Economics.

As explained above, an analysis of the residuals from the regression can provide some insight into whether the models are likely to be mis-specified. First, examining the JTT SFA-TLG model, Figure 6 plots the residuals of the seven non-reference DNSPs over time. We focus on the non-reference DNSPs because, according to the AER, they have scope to catch up to the efficient frontier.

Figure 6: Residuals – JTT SFA-TLG model (non-reference DNSPs)

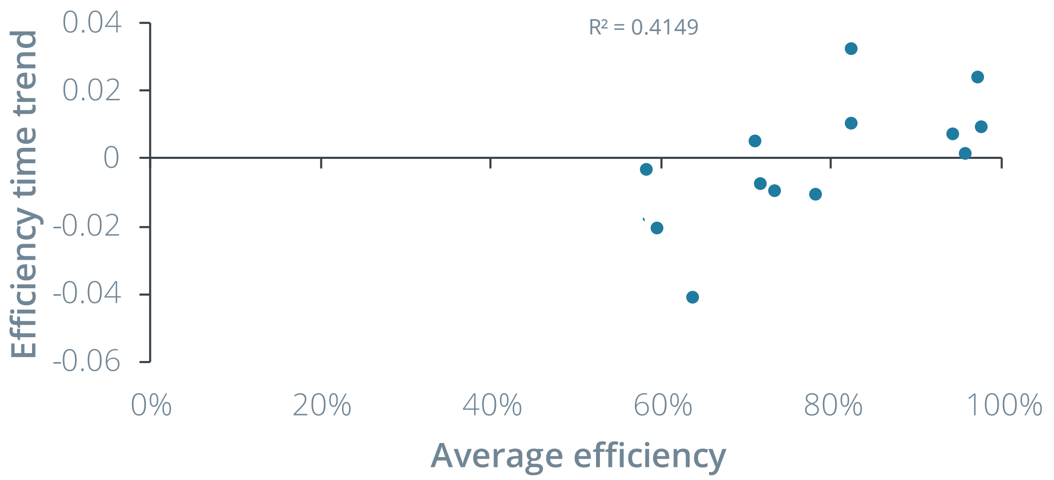


Source: Frontier Economics analysis

The figure shows a general downward trend in the residuals over time, consistent with an improvement in efficiency over the period.[20] This indicates that the model is likely mis-specified because an important effect remains unexplained.

Figure 7 plots the time trend in the residuals (for all DNSPs) derived from the JTT SFA-TLG model against the average efficiency over the period for each DNSP.

Figure 7: Residual pattern vs efficiency – JTT SFA-TLG model



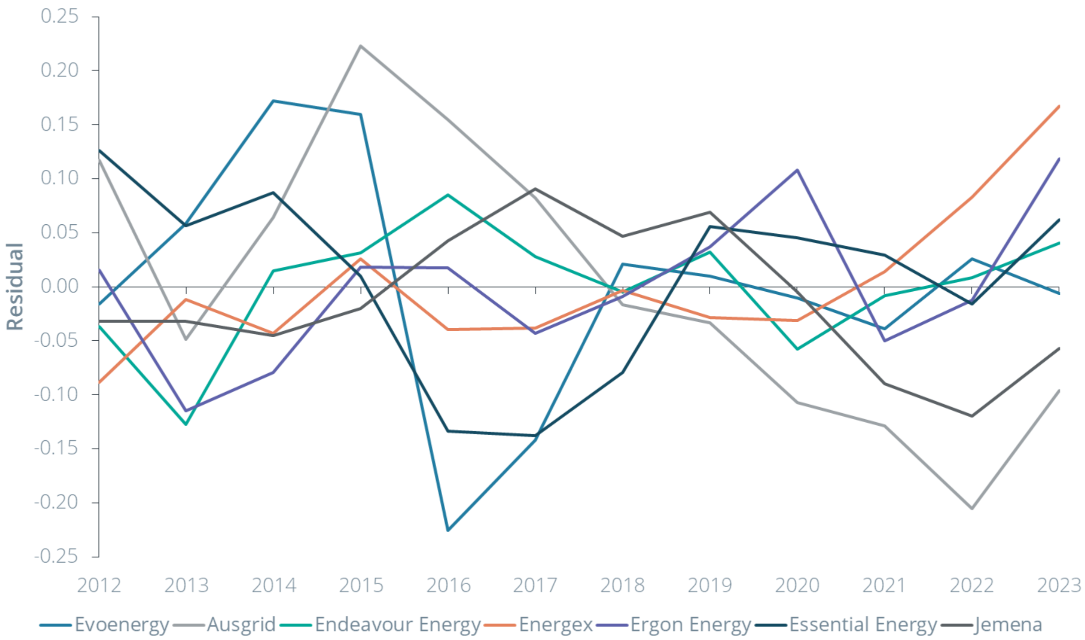
Source: Frontier Economics analysis

[20] A positive residual value indicates that the observed opex is greater than the fitted opex obtained from the estimated cost function (inclusive of estimated inefficiency), whereas a negative residual value indicates the observed opex is lower than the fitted opex obtained from the estimated cost function.

The figure shows a clear pattern: the DNSPs with low efficiencies over the period tend to have decreasing residuals over the period, consistent with improving efficiency. This also suggests that that the model is mis-specified.

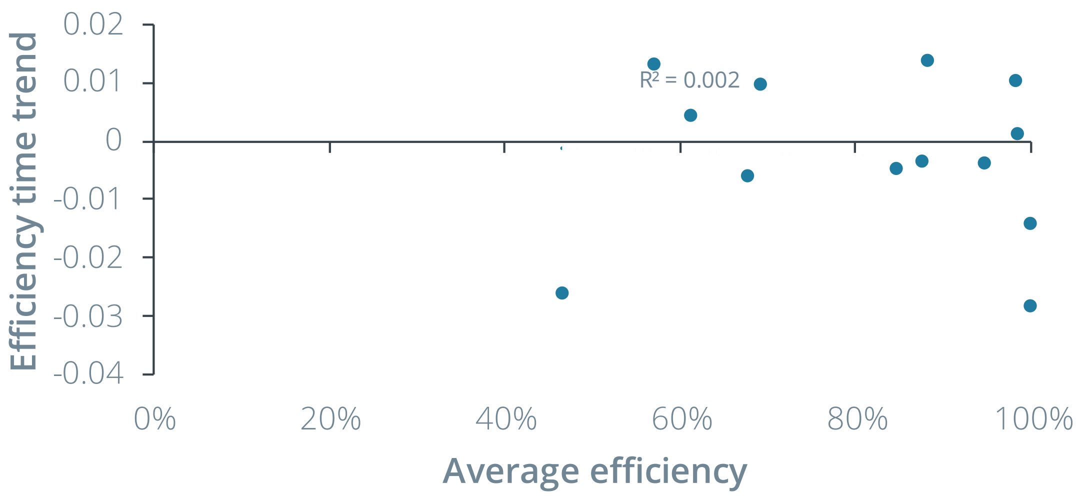
By contrast, Figure 8 and Figure 9 show that the residuals from the time-varying inefficiency model show no clear pattern over time. That is, the residuals alone indicate no evidence of model mis-specification once inefficiency is allowed to be time-varying.

Figure 8: Residuals – Battese and Coelli (1995) time-varying inefficiency (non-reference DNSPs)



Source: Frontier Economics analysis

Figure 9: Residual pattern vs efficiency – time varying inefficiency model



Source: Frontier Economics analysis

We observe that both models presented above exhibit monotonicity violations with respect to ratcheted maximum demand. Specifically, in the under the JTT specification of the SFA-TLG model, 46.1% of Australian DNSP observations have monotonicity violations for the ratcheted maximum demand output variable. This increases to 84.6% for the Battese and Coelli (1995) specification. This is likely due to the greater flexibility of the inefficiency term in the Battese and Coelli (1995) model. This underscores the fact that the time-varying inefficiency model presented above is simply for illustrative purposes. Further investigation is required to identify models that perform better statistically, while allowing for time-varying inefficiency.

Choice of historical benchmarking period

The existing models are currently estimated over two historical periods:

- The long period – using data from 2006 onwards; and
- The short period – using data from 2012 onwards.

The start of each of these periods is always anchored in the same year (i.e., either 2006 in the case of the long period, or 2012 in the case of the short period).

The conventional wisdom is that more data is better than less data, because more data improves the statistical reliability of the estimated relationships. However, it may be sensible to restrict the length of the sampling period if:

- There is good reason to suspect that there is a structural break in the data;
- There is sufficient data available after the break point to reliably estimate the models; and
- The estimated relationship in the data after the break point is likely to better reflect the current relationship between the dependent and explanatory variables.

In our view, all these conditions appear to be met in the current circumstances. It seems to us that there is no good reason for the AER's assessment of a DNSP's efficiency in 2025 to be influence by data on its costs in 2006, a full eight years before the AER began to benchmark DNSPs' opex.

We suggest that the AER do away with the two benchmarking periods and instead consider using a 10-year rolling estimation period. That is, for the 2026 Annual Benchmarking Report, the AER would use data from 2016 to 2025 (inclusive). This would exclude any years prior to the commencement of annual benchmarking analysis by the AER, or the AER's use of benchmarking to inform the setting of opex allowances.

Then, for the 2027 Annual Benchmarking, the AER would use data from 2017 to 2026 (inclusive), and so on. We note that a 10-year sampling period would include more data than the seven years of data the AER originally had when it first began benchmarking opex in 2014.

Such an approach would ensure that the estimated cost function—and the estimated efficiency scores—are more reflective of recent and relevant data.

One of the reasons the AER may have persisted in using relatively long sampling periods is a belief that more data may help reduce the number of monotonicity violations. However, as we have documented in recent reports, the number of monotonicity violations has been increasing over time.[21] This is likely because the degree to which the models have been forced to overfit the data, due to model mis-specification, has increased over time. Restricting the sampling period to the most recent 10 years may improve the ability of the models to estimate the efficient frontier because the models would not need to contend with a structural break in the data that likely occurred when the AER began to apply benchmarking when making revenue determinations. This, in turn, may reduce the number of monotonicity violations.

[21] For example: Frontier Economics, *AER benchmarking of DSNP opex*, 30 November 2023, Appendix A.

The use of a 10-year rolling sampling period would ensure the most recent performance of the DNSPs is reflected in the estimated efficiency scores.

Other considerations for Phase 2

There are two further issues that we recommend the AER consider as part of Phase 2:

- Firstly, we suggest that the AER consider alternative approaches to the existing method of rolling forward an estimate of efficient opex from the midpoint of the benchmarking period to the base year. The roll-forward approach may be appropriate if DNSPs did in fact maintain a constant level of efficiency over the benchmarking period. However, if efficiency does not remain constant over the period, then the roll-forward approach (which starts with an estimate of average efficiency over the period) is unlikely to properly account for the fact that a particular DNSP has become more or less efficient over time.

  If the AER adopts time-varying inefficiency models, then one alternative approach would be to adopt the most recent estimate of efficiency produced by that model for a particular DNSP, and use that estimate to roll forward an estimate of efficient opex in the base year. For instance, suppose a particular DNSP's base year is FY2028, and the AER is able to use time-varying inefficiency models to derive an efficiency score for FY2027 (the final year in the benchmarking sample period). Then the efficiency score for FY2027 could be used to derive an estimate of efficient opex in FY2027, which could then be rolled forward (using the estimated cost function) by just one year to the base year.

  An alternative approach could be to use the estimated cost function directly to predict the efficient level of opex in the base year directly. If the model is well-specified, and able to account for time-varying inefficiency properly, this would likely produce a better estimate of efficient opex in the base year than the existing roll-forward approach.

- As the Quantonomics memorandum explains, there is convincing evidence that efficiency outcomes differ for DNSPs in Australia, New Zealand and Ontario. It seems plausible that these differences relate substantially to catch-up efficiency, and may be driven by incentives created by the extent to which benchmarking is used to set regulatory allowances in the different jurisdictions. For example, in Australia, the AER uses benchmarking directly to set opex allowances. However, section 53P(10) the *Commerce Act 1986* prohibits the Commerce Commission from using comparative benchmarking on efficiency to set regulatory allowances for New Zealand DNSPs. Furthermore, of the 19 New Zealand EDBs in the AER's sample, eight are exempt from price-quality regulation altogether.[22] The Ontario Energy Board uses benchmarking analysis to set efficiency 'stretch' factors for cohorts of DNSPs.

  In this regard, the following observations by Quantonomics are striking:

> *The AER's opex partial factor productivity (PFP) index analysis of the Australian DNSP industry finds an average Opex PFP growth rate of 0.3 per cent per annum from 2006 to 2023, including a substantial decrease in the period up to 2012, and an equally substantial improvement after 2012 (Quantonomics 2024, 15). A recent study of productivity trends of the New Zealand electricity DNSP industry (CEPA 2024) finds that between 2008 and 2023, the average opex partial productivity as measured using econometric analysis fell by between 1.2 and 2.2 per cent per year. In 2013, Pacific*

[22] There are 13 DNSPs in New Zealand that are subject to information disclosure requirements, but which are exempt from price-quality regulation. Of these 13, Counties Energy Limited, Electra Limited, Mainpower New Zealand Limited, Northpower Limited, Scanpower Limited, The Power Company Limited, Waipa Networks Limited and WEL Networks Limited are included in the AER's benchmarking sample.

Economics Group (PEG) carried out a study of Rate Setting Parameters and Benchmarking for the Ontario Energy Board. It presented an output index and an Opex quantity index for 2002 to 2011 (PEG 2013:63,65). Between these two years, the Ontario electricity distribution industry's Opex PFP average rate of change was 0.0 per cent per annum.[23]

These observations are consistent with strong incentives for efficiency improvements by DNSPs (as a consequence of how the regulator uses benchmarking analysis) in Australia, weak incentives for efficiency improvements in New Zealand, and moderate incentives for efficiency improvements in Ontario.

If DNSPs in the different jurisdictions face different regulatory incentives to deliver catch-up efficiency, it may be very difficult to specify the cost functions to account for this properly (e.g., through the inclusion of separate jurisdictional time trends). Given the available evidence that DNSPs in the different jurisdictions have behaved very differently over time, it may now be appropriate for the AER to consider whether the benchmarking analysis should continue to use data on DNSPs from all three jurisdictions.

[23] Quantonomics memorandum, p. 2.

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