Memorandum

From: Denis Lawrence and Tim Coelli **Date:** 4 July 2017

To: Arek Gulbenkoglu, Toby Holder, Evan Lutton

CC:

Subject: Review of Frontier Economics report on TNSP economic benchmarking

We have been asked to review the Frontier Economics (FE 2017) report submitted to the AER by TransGrid as part of TransGrid's 2018–19 to 2022–23 revenue proposal. The FE report reviews the AER's 2016 TNSP economic benchmarking results.

FE (2017, p.4) claims that the analysis underlying the AER's TNSP economic benchmarking undertaken by Economic Insights 'contains a number of serious shortcomings'. FE (2017, p.6) goes on to claim that the annual benchmarking results are 'entirely unsuitable to be used to support regulatory decisions on the *relative efficiencies* of the TNSPs' (emphasis added).

Most of FE's criticisms relate to econometric issues. It should be noted that the AER's TNSP economic benchmarking uses index number methods and econometric estimation plays a relatively small part in the analysis, being confined to the derivation of output cost shares that feed into the index number calculations. It should also be noted that Economic Insights (2014b, p.2) stated that TNSP economic benchmarking is in its early days and, given its stage of development, should not be used for assessing TNSP relative efficiencies. Specifically, we stated:

> 'While economic benchmarking of distribution network service providers (DNSPs) is relatively mature and has a long history, there have been very few economic benchmarking studies undertaken of TNSPs. Economic benchmarking of transmission activities is in its relative infancy compared to distribution. As a result, in this report *we do not apply the above techniques to assess the base year efficiency of TNSPs*. We present an illustrative set of MTFP results using an output specification analogous to our preferred specification for DNSPs but *caution against drawing strong inferences about TNSP efficiency levels from these results*. However, output growth rates and opex input quantity growth rates can be calculated with a higher degree of confidence and used to forecast opex partial productivity growth for the next regulatory period which is a key component of the rate of change formula.' (emphasis added)

It should also be noted that AER (2016, pp.15–16) stated it does not use benchmarking to make efficiency adjustments because:

- there is only a very small sample of transmission businesses which limits the range of benchmarking techniques that can be applied (specifically, only index number methods can be used because more sophisticated econometric models are not tractable)

- economic benchmarking output measures require further refinement, and
- a better understanding of the impact of operating environment factors (OEFs) affecting TNSPs is needed.

The key findings of FE (2017) are, thus, of a so–called 'strawman' nature (ie criticising a proposition that does not reflect the purpose or focus of the economic benchmarking analysis). FE (2017) does not provide any practical suggestions for addressing the problems it claims to identify or for advancing the economic benchmarking of TNSPs. We note that the AER is currently undertaking a review of its TNSP economic benchmarking focused on finding practical ways to refine and further develop the analysis. The primary focus of the review is on improving the specification and measurement of TNSP outputs, particularly the voltage–weighted connections output, which has been the major issue raised by TNSPs themselves.

We turn now to each of the issues raised in FE (2017).

Issue: 'When the latest data is used, the AER model becomes inoperable'

FE (2017, pp.9–12) argues that the econometric model estimated for the years 2006–2014 and used to derive TNSP output cost shares in Economic Insights (2014b) becomes inoperable when revised data on the voltage–weighted connections output introduced in Economic Insights (2015) is used and when data is updated to include the 2014 and 2015 years. Specifically, FE argues that the cost function coefficient on the voltage–weighted connections output turns negative and/or insignificant if the model is re–estimated under these circumstances.

To understand the approach adopted it is necessary to first revisit the reason we derive output shares used in the index number methodology from a cost function model rather than directly from revenue observations. There has been general agreement that a 'functional' outputs approach is more appropriate than a 'billed' outputs approach for economic benchmarking used in a building blocks context. This is because NSP pricing structures have often evolved on the basis of convenience rather than on any strong relationship to underlying relative costs. As a result, observed revenue shares are of limited usefulness (in a building blocks context) in forming weights for index number economic benchmarking techniques that need to aggregate output quantities into a measure of total output. Rather, it is necessary to form output weights based on the weights implicitly used in building blocks determinations. These are generally taken to be cost–reflective output weights.

In keeping with the approach commonly adopted in network industry productivity studies using index number methods, estimates of the relevant cost–reflective output shares were formed from the first–order coefficients of a simple econometric cost function. However, the ability to form these estimates was significantly constrained by the small number of observations available at the time. We had only 40 observations available – 8 years for each of 5 TNSPs. At the best of times this would limit the sophistication of the cost function model that could be estimated. However, as noted in Economic Insights (2015), NSPs are very stable entities that exhibit limited time–series variation in cost/output relationships. In this case, our 40 observations were more akin to the explanatory power of 5 observations because the main variation in the data comes from the cross–sectional dimension.

To address small numbers of observations, previous index number productivity studies have estimated a very simple Leontief cost function developed by Lawrence and Diewert (2006) which is less flexible but also less observation–demanding than the translog functional form. In this case the Leontief cost function placed over 40 per cent weight on the voltage–weighted connections output, the output that was considered the least developed and settled of the TNSP outputs. A basic translog cost function, on the other hand, placed more even weight across the four outputs and was used instead (Economic Insights 2014b, p.9).

Contrary to what FE (2017) appears to assume to be the case, standard practice in functional output–based productivity index number studies has been to not update output shares annually. To do so would make it difficult to discern those changes due to genuine productivity improvement and those due to weight changes. Similarly, we note that regulators that make use of econometric models as their primary means of undertaking annual economic benchmarking typically do not update the parameters of their econometric models every year for the same reason (PEGR 2015, p.7).

The current review of TNSP economic benchmarking is considering changes to the output specification suggested by TNSPs. In particular, some TNSPs have advocated substituting the total number of downstream end–users for the current voltage–weighted connections output, the measurement of which has generated ongoing debate among stakeholders. If changes to the output specification are made as part of the review process then it will be necessary to re–estimate models from which output cost shares are derived.

Issue: 'Inconsistency in the information used in different aspects of the AER's analysis'

Following on from the first issue, FE (2017, p.13) claims that the TNSP economic benchmarking analysis has been inconsistent in its use of information in different parts of the analysis. It observes that the latest RIN information has not been used in the econometric model used to derive output cost shares while the latest RIN information is used in the index number methodology itself. However, as noted above, it is common practice in economic benchmarking of NSPs to not update parameter estimates annually so that those changes due to genuine productivity improvement can be separated from those due to weight changes or other parameter changes. This applies to both index number approaches and econometric cost function approaches.

Issue: 'The AER does not estimate separate output weights for opex, capital and total costs'

FE (2017, pp.13–15) criticises the use of total cost–based output cost shares in the economic benchmarking of TNSPs. It suggests instead that separate output weights should be used for opex partial productivity and capital partial productivity.

We disagree with FE's suggestion that a different output index should be used for partial productivity measures compared to that used for total factor productivity (TFP) measures and are not aware of any index–based economic benchmarking study that adopts this approach. Rather, adopting such an approach would break the internal consistency of the productivity index measures whereby the TFP index is effectively a weighted average of the relevant partial productivity indexes (where the weights are based on shares in total cost). FE appears to be confusing the approach adopted in productivity index measurement with that adopted in estimating an opex cost function where opex–specific output parameters are estimated and this is indeed what we do in our cost function efficiency analysis of DNSPs (Economic Insights 2014a).

Issue: Reliance on small sample

FE (2017, pp.16–17) claims that the use of an econometric model to estimate output cost shares for the TNSP economic benchmarking is at odds with statements in Economic Insights (2015) which note that the larger number of Australian DNSP observations available are inadequate to support robust estimation of cost functions to derive efficiency estimates.

It is precisely because of the small number of observations available for Australian TNSPs and the absence of comparable overseas data that we only use index number methods for TNSP economic benchmarking. Being a non–parametric method, index number analysis is not affected by only having a small number of observations. Information is required on output cost shares and this is derived from the estimation of very simple cost functions. While this information is not unimportant, it is secondary to data on output and input quantities which are the primary drivers of productivity measures. Furthermore, the sensitivity of productivity results to output cost shares estimates will depend on how closely related movements in output quantities are. As FE (2017, p.12) notes, in this case the correlations between the (logged) output quantities are all quite high so, all else equal, one would not expect the economic benchmarking results to be particularly sensitive to the estimated output cost shares.

We take issue with the FE (2017, p.16) statement that Economic Insights 'decided to rely on econometric analysis to support its benchmarking exercise for TNSPs without providing any caveat at all'. This is incorrect on both counts. Firstly, as noted above, we use an index number methodology for TNSP economic benchmarking and the output cost shares derived from a simple cost function only play a secondary role. Given the characteristics of the data the results are unlikely to be sensitive to those shares. And, it is untrue to say we have not provided a caveat. As quoted above, we extensively qualified our results and cautioned that they be used with care, and not for direct efficiency comparisons.

Issue: Violations of monotonicity conditions

FE's (2017, pp.17–19) claim that our use of output cost shares derived from a model that has some monotonicity violations contradicts the Economic Insights (2015, p.32) statement that such models are 'unsuitable for efficiency measurement' is of a 'strawman' nature and misguided. This is because we do not use a cost function model to measure efficiency in the case of TNSPs. Monotonicity violations would be a serious issue if the model was used for efficiency calculations where local elasticities are used as weights. But, in the index number methodology used, we only use mean output cost shares as output weights and all the mean elasticities satisfy monotonicity.

For the record, FE's (2017, p.19) claim that Economic Insights (2014a) rejected the use of the translog functional form because of monotonicity violations is not correct. This only applied to the stochastic frontier analysis (SFA) translog cost function. Our fixed effects translog model satisfied monotonicity conditions, performed as well as our SFA Cobb–Douglas model and its results are presented throughout our report.

Issue: Allowance for scale effects

FE (2017, p.21) claims that the TNSP economic benchmarking model does not adequately control for TNSP scale effects. It argues that the separate inclusion of the key system capacity variables of ratcheted maximum demand and line length on the output side does not mirror the ‘multiplicative’ inclusion of line capacity on the input side. It claims that this will potentially disadvantage large TNSPs relative to small TNSPs.

It should be noted that Economic Insights (2014b, p.8) has previously examined including a multiplicative measure of system capacity based on installed distribution transformer and line length on the output side. We did not favour this approach because increases over time in both transformer capacity and line length led to unrealistic rates of output growth and divergences between measured output levels for large and small NSPs. The measure of line capacity on the input side, on the other hand, involves multiplying line lengths by a constant MVA conversion factor applicable to the line’s voltage level and is thus a different situation.

The difference in the two cases can be seen considering a simple example. Consider a TNSP that has y MVA of transformer capacity, z MVA of ratcheted maximum demand and x circuit kilometres of line with a weighted average MVA rating of, say, 200. Under the multiplicative system capacity output approach the TNSP’s capacity output is yx MVA*kms while under the separate inclusion approach it is z MVAs and x kilometres. Its input measure is $200x$ MVAkms.

Now consider the situation of a TNSP of exactly twice the size. It has $2y$ MVA of transformer capacity, $2z$ MVA of ratcheted maximum demand and $2x$ circuit kilometres of line with a weighted average MVA rating of 200. All else equal and assuming constant returns to scale, the doubling of all variables should lead to its productivity remaining the same. Under the multiplicative system capacity output approach the larger TNSP’s capacity output is $2y2x=4xy$ MVA*kms while under the additive approach it is $2z$ MVAs plus $2x$ kilometres. Its input measure is $200(2x)=400x=2(200x)$ MVAkms. That is, under the multiplicative output approach the larger TNSP’s output is four times larger than the smaller TNSP’s output compared to its input which is twice as large. Under the separate inclusion approach, the larger TNSP’s output is double that of the smaller TNSP as required. Given that input has also doubled, productivity is the same for both TNSPs under the separate inclusion output approach as required but it is twice as high for the larger TNSP under the multiplicative approach.

This example disproves FE’s (2017, p.23) claim that the current output and input specifications do not adequately control for TNSP scale effects.

The above example assumes the same configuration of lines for the larger TNSP as for the smaller TNSP. If the larger TNSP was to configure its lines to use a higher proportion of very high MVA capacity lines then it would potentially have a higher share of its total MVAkms on the input side in these very high capacity lines. However, it remains necessary to convert circuit line lengths to a common unit so that the line input can be legitimately summed to an aggregate level for each TNSP. If this was not done, to use an aeroplane example, we would be counting a Cessna and a Jumbo jet equally in summing up the number of planes to form a proxy for total capital input quantity.

It should be noted that this issue is only potentially of relevance to benchmarking total productivity levels across TNSPs. Currently, only TNSP opex MPFP growth rates are used in the AER's TNSP regulatory determinations. As illustrated in the example above, a move to include a multiplicative measure of capacity on the output side as advocated by FE (2017) would distort measured productivity growth rates as well as distorting productivity level comparisons.

Issue: Size of implied economies of scale

FE (2017, p.29) argues that the simple translog cost function model we derive our output cost shares from produces unrealistically high estimates of diseconomies of scale with the sum of the first order output coefficients summing to around 1.3 (where 1 would reflect constant returns to scale, values greater than one reflect diseconomies of scale and values less than one reflect economies of scale). FE argues that this provides evidence that our output and input specification disadvantages large TNSPs. However, the comparable FE (2017, p.25) estimates calculated using their alternative 'multiplicative' output specification produce sums of first order output coefficients of between 0.56 and 0.78 which suggests implausibly high economies of scale effects and an output specification that is biased in favour of large TNSPs. Given the small sample size, little can be read into the implied economies of scale effects. In any case, we scale the elasticities to sum to one for input to the index number methodology. That is, we assume constant returns to scale for the TNSP economic benchmarking.

Issue: Controlling for operating environment factors

FE (2017, pp.29–31) criticise the TNSP economic benchmarking analysis for not including adjustment for operating environment factors (OEFs). We note that by including the main dimensions of network output we do include allowance for the main network density differences, a fact well illustrated by an earlier FE (2015) report.

As noted in the introduction to this memo, TNSP economic benchmarking is in its relative infancy and data collection and analysis to support allowance for a wider range of OEFs is still underway. This is one of the key reasons why we caution against using TNSP economic benchmarking for efficiency comparisons at this time. However, OEF differences are unlikely to change significantly over time and so not including allowance for more OEFs is not likely to have an impact on productivity growth results.

Issue: Total inputs price index

FE (2017, p.20) claims that our 'assessment of input prices (through the PRTC index) lacks any theoretical justification and produces implausible results'. We reject both these claims.

Firstly, the total input price index (PRTC) is only used to convert total costs to constant price or 'implicit quantity' terms to support estimation of the simple translog cost function from which the output cost shares are derived. The PRTC is formed by aggregating the TNSP–specific prices for opex and each of the three capital components – overhead lines, underground cables, and transformers and other capital. The price of opex is taken to be the aggregate of a labour price index and five producer price indexes. Because opex is, by definition, fully expended each year, we assume that the price of opex faced by the five TNSPs will be the same in any given year. However, this assumption is not reasonable for the three capital inputs which last in the order of 50 years and so different TNSPs may have capital stocks for each component of widely differing average ages. The input cost of each component for each TNSP will be the relevant annual user cost which is the sum of the return of capital plus the return on capital plus taxation liabilities. We are assuming one hoss shay physical depreciation for the TNSP assets so the quantity of each component for each TNSP can be proxied by its physical quantity. The input (ie annual user) price is then derived by dividing the annual user cost by its respective quantity proxy. The resulting opex and three capital input prices are then aggregated across all observations to form a total input price index.

It is to be expected that the resulting total input prices will vary across the five TNSPs reflecting differences in average asset age and differences in the asset composition of each of the components. FE's (2017, p.34) misunderstanding of this process is reflected in its comment that 'it seems unrealistic for some networks to procure inputs at half the cost of others'. A total input price index is a completely different concept to procurement (or new asset purchase) prices. To illustrate this, consider the analogy of the cost of using a car. To expect that actual capital *input* prices should be the same across different firms would be to expect the total annual cost per kilometre (ie including opportunity costs and depreciation) of using, say, a brand new $50,000 car to be the same as the total annual cost per kilometre of using, say, a 10 year old car worth $10,000. Clearly, the total price of using the new car will be considerably higher than that of using the 10 year old car. The sunk and largely immovable nature of TNSP assets will make differences across TNSPs in annual input usage prices even more the norm.

Issue: Spread in efficiency scores

FE's (2017, pp.35–36) final criticism is that the TNSP economic benchmarking produces spreads in efficiency scores that are 'too wide to be credibly driven by differences solely in managerial efficiency'. As noted above, the TNSP economic benchmarking efficiency scores currently only include allowance for differences in network densities and not for other OEFs. Extension of the analysis to include allowance for a wider range of OEFs will likely reduce the spread of efficiency scores considerably given the more heterogeneous nature of TNSPs compared to DNSPs. And, the specification of TNSP outputs in particular is currently being reviewed given the less mature stage TNSP economic benchmarking is at. For these reasons we have stressed that conclusions relating to relative efficiency levels should not be drawn from the TNSP economic benchmarking results at this stage. However, conclusions regarding productivity growth rates can be drawn with a higher level of confidence and the use of TNSP economic benchmarking in regulatory decisions to date has been confined to assessing productivity growth rates, as is appropriate.

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