NERA
ECONOMIC CONSULTING

Opex Partial Factor Productivity for DPP3

Electricity Network Association

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Executive Summary

Overview

The New Zealand Commerce Commission (NZCC) is in the process of formulating a draft determination for the Default Price Path (DPP) for the Electricity Distribution Businesses (EBDs), to run from 1 April 2020 to 31 March 2025 (DPP3). As part of this decision, the NZCC will set allowances for operational expenditure (opex), which will be determined using a "step and trend" approach. In other words, opex allowances will be equal to:

(1) A "base year" level of opex, equal to actual opex in a selected year before the beginning of DPP3;

(2) Any "step change" adjustments to reflect known differences in operating conditions during DPP3 relative to the base year; and

(3) An annual "trend", equal to estimated changes in opex productivity, input price inflation, and scale effects (referred to by some regulators as "output growth").

In the previous decision for DPP2, the NZCC had assumed opex partial factor productivity of -0.25% per year and companies were therefore allowed an additional 0.25% in opex each year to reflect this declining productivity. In the recent draft determination for DPP3, the NZCC proposes to shift to a 0 per cent productivity assumption. This appears to be based on a view that historical studies provide limited information on future productivity and a concern with setting a negative partial factor productivity assumption.

The Electricity Network Association (ENA) has commissioned NERA to:

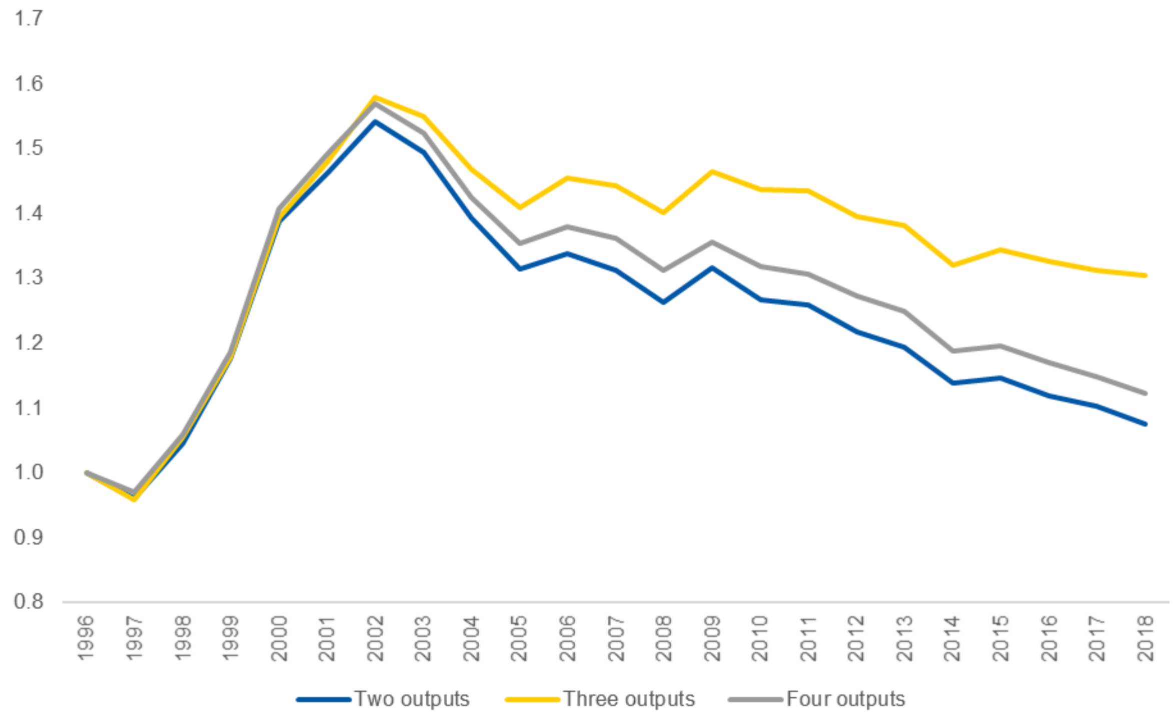
- Describe recent EDB trends using the Economic Insights (EI) methodology implemented in 2014 for DPP2, but updated to include improvements in that approach and EDB specific methodologies used by the AER in its recent productivity decision;
- Review the Commission's rationale for setting a 0% partial productivity assumption in the DPP3 Draft Determination; and
- Comment on the interrelationship between the partial factor productivity assumption and the scale factor approach to forecasting opex.

In this report, we present the ranges of productivity implied by the NZCC's 2014 decision extended through to 2018 and by the econometric approaches implemented in Australia. We then first assess whether the updated evidence suggests there is a change in evidence that would warrant a change in approach at DPP3 (assuming the DPP2 approach is correct). Next, we more generally assess the appropriateness of the assumption adopted at DPP2 against the evidence and consider what an appropriate assumption would be for DPP3. In particular, we discuss the relationship between the scale factors used to forecast opex and the productivity assumption, and what this implies for setting the productivity assumption. Because of the mechanistic way that opex is trended forwards in the DPP, the "productivity" assumption is more accurately characterised as a residual factor that captures opex productivity for measured outputs and changes in opex in relation to unmeasured outputs. Therefore, as discussed in the rest of this report, we recommend the Commission relabel the partial factor productivity factor to the be "residual opex factor".

Productivity index analysis shows the trend of negative measured productivity has continued

Regarding the productivity index analysis, we have updated EI's 2014 analysis to include the most recent information disclosed by EDBs. Graphs of the relevant indices for the entire industry are shown in Figure X.1.

Figure X.1: Industry Wide Opex Partial Factor Productivity Indices



Source: NERA analysis, EI 2014, NZCC information disclosures.

In addition to the compound growth figures presented by EI, we have also calculated the annual percentage change in productivity using our preferred approach of regression time trends. Compound growth rates only use the start and end point as inputs and thus essentially ignore any information on long-term trends given by intermediate data points. Regression time trends incorporate all the data points.

Table X.1 below presents a summary of our productivity index analysis. This table contains ranges for productivity growth calculated using the following windows:

- The 2014 EI/NZCC preferred window (2004 – 2014);
- The 2014 EI/NZCC preferred window extended through to 2018 (2004-2018); and
- The full data period (1996 – 2018)

Table X.1: Opex Partial Factor Productivity index trends

Measurement window/method	Industry	Non-Exempt
NZCC/EI 2004 - 2014		
NZCC/EI 2014 (cont-compounded)	-1.40% to -0.45%	-1.64% to -0.80%
NERA (cont-compounded)	-2.03% to -1.07%	-1.85% to -1.04%
NERA (log-trend)	-1.60% to -0.66%	-1.24% to -0.46%
NZCC/EI update - 2004 - 2018		
Continuously Compounded	-1.85% to -0.85%	-1.55% to -0.68%
Log-Trend	-1.74% to -0.83%	-1.43% to -0.67%
Full series - 1996 - 2018		
Continuously Compounded	0.33% to 1.20%	0.58% to 1.31%
Log-Trend	-0.22% to 0.73%	0.02% to 0.82%

Source: NERA analysis and EI 2014

This shows that extending the 2014 analysis through to today still results in negative measured productivity. Note that our 2004-2014 results differ from EI's due to some data corrections we have made to the 2013/14 data which are explained in the appendices of our report.[1] While using the entire window results in marginally positive productivity (as it did in 2014), like EI in 2014 we do not place much weight on this calculation.

In general, our preferred approach to measuring productivity is to use the longest window available. However, when selecting the 2004-2014 window in 2014, EI noted structural changes in the electricity distribution industry and suggested that a more recent window was preferable. Based on this they examined the "past decade". As is evident in Figure X.1, there was sharp rise in productivity between 1996 and 2002 but productivity has been on a consistent decline since. This early period is likely driven by the corporatisation (and in some cases privatisation) of lines companies that occurred in the early 1990s and is therefore unlikely to be repeated going forward. Given these NZ specific circumstances, the sheer magnitude of the rise pre-2002 and the persistent pattern since, we agree with EI that it is preferable to exclude this early period and focus on more recent data. We have accordingly focused our summary results on simply extending the EI preferred window of 2004-2014 through to 2018 (i.e. 2004-2018). In any event, our sensitivity analysis indicates that estimated productivity is not particularly sensitive to the start and end date chosen, so long as data prior to 2002 is not included. Furthermore, our preferred method of calculating productivity growth using regression trends instead of compound growth figures places less weight on the start and endpoints chosen, thus mitigating this issue somewhat.

Econometric cost function analysis also estimates negative productivity

Regarding the cost function regression trend analysis, in an analysis for the AER, EI estimated an econometric cost function for electricity distributors in Australia, New Zealand and Canada over the period 2006 to 2017. This analysis assumes opex is a function of: Ratcheted Maximum Demand, Customer Numbers, Circuit Length, and the proportion of lines that have been underground. Rather than constructing an index, this analysis econometrically estimates the relationship between these outputs and opex. Part of this analysis involves estimating a country specific time trend which is

[1] As already discussed, because continuously compounded growth rates take the first and last year as the final input, a change to the final of data can have a large impact on the calculated growth rate.

essentially an estimate of opex productivity. EI used various functional forms and estimation techniques which we describe in the body of the report. These different methods give an estimated range for productivity of -2.3% to -2.8%.

Another aspect of the econometric cost functions is that they estimate the relationship between the proportion of lines that are undergrounded and opex. In Australia, the AER took this as an alternative measure of productivity on the basis that EDBs would continue to underground lines in the future. This involved calculating historical averages of changes in undergrounding (on either an industry or firm specific basis) and using this as a forecast of future undergrounding. Combining this forecast with the undergrounding coefficient from the cost function regressions gives an estimate of future opex reductions due to undergrounding. This gives a range of annual opex reductions of 0.02% to 1.07% (i.e. positive productivity). However, the undergrounding coefficients come from the same regressions that estimate an annual decline in productivity of -2.3% to -2.8%. That is to say, the undergrounding coefficient shouldn't be viewed in isolation, but instead offset against the time trend to give a *net* productivity figure. Combining these effects still results in *net* negative productivity.

The NZCC's econometric models used to estimate the scale factors can also be modified to include a time trend in the same manner as the EI/AER econometric cost models. Making this modification gives a statistically significant productivity estimate of -3.08% for total opex if outliers are excluded (as occurs in the regressions the Commission uses) and -1.97% if the whole sample is used.

Given a continuation of the trends observed at the time of DPP2, the Commission's proposed change in approach is not based on a change in evidence

At the time of DPP2, despite a range of measured productivity of -0.45% to -1.40%, the Commission exercised its judgement to set a partial factor productivity assumption of -0.25%. As shown in Table X.1, measured productivity remains materially negative once the measurement window is extended to 2018. Over the period of DPP2, measured productivity is between -1% and -2.1%, as shown in Table X.2 below.

Table X.2: Measured productivity over DPP2 (2015-2018)

Output specification	Continuously compounded	Log-trend
Two outputs	-2.1%	-2.0%
Three outputs	-1.0%	-1.0%
Four outputs	-2.1%	-2.1%

Source: NERA analysis

On this basis, it is not clear what has driven a change in approach from setting a negative factor to setting a factor equal to zero. While the Commission is right to say the analysis should be forward looking, no evidence has been presented that the forward-looking picture is different now compared to the time DPP2 was set.

Persistent negative measured productivity suggests the Commission's opex trend approach is likely to undercompensate EDBs

The Commission's logic for setting a factor of -0.25% at DPP2, despite measured productivity that was materially more negative, (-1.4 % to -0.45%) was based on three factors:

- Historical step changes in expenditure may mean that measured productivity is understated;

- A negative productivity assumption may create perverse incentives, and negative productivity is expected to be the exception and is typically not a feature of workably competitive markets; and
- The electricity distribution overseas (in particular the US) has experienced positive productivity.

We addressed these factors conceptually in our previous report to the Commission in this process.[2] In the draft determination for DPP3 the Commission has largely adopted a similar position, with the focus on perceived problems with setting a negative factor and citing the approach taken by other regulators as support for its position.[3] For completeness we again address each factor in turn, including, where relevant, the new data and analysis presented in this report:

- **Step-changes:** It is unlikely that negative measured productivity can be attributed to one-off step changes – measured productivity has been persistently declining since approximately 2002 (i.e. the last 17 years). Step changes would likely present as one-off changes in the level of costs, which would result in one-off reductions in productivity rather than a continued trend of declining productivity. Furthermore, for this concern to result in a non-negative productivity factor being set despite negative *measured* productivity requires a belief that the Commerce Commission will be able to accurately make allowances for all step changes over DPP3. In this regard we note the Commission's draft decision not to allow for any step changes over DPP3 and our previous point that the Commission's approach to step changes is unlikely to deal with persistent misspecification of the opex forecasting model.
- **Negative measured productivity:** The productivity measure is only a reliable measure of productivity to the extent that it captures all the outputs EDBs are producing. If EDBs are producing outputs that are not included in the productivity measure, and these outputs (and their associated opex) are growing over time, then *measured* productivity will be negative, even if the expenditure is efficient and EBDs are achieving productivity gains. If the productivity measure is incomplete, then it is misleading to refer to it as "productivity" - it instead functions as a residual that measures the *net* impact of changes in unmeasured outputs and productivity (with respect to measured and unmeasured outputs) on costs.[4] We return to this issue below, but note now that concerns expressed about a negative "productivity" assumption make strong implicit assumptions that the underlying models used for opex forecasting and productivity measurement are an accurate representation of the services provided by EDBs.
- **Overseas evidence:** Measured productivity in Australia and Canada is negative according to the data considered by the AER in Australia. Furthermore, as shown in our previous report, measured opex productivity in the United States has switched to being negative since ~2000. Furthermore, while the Commerce Commission cites the positive productivity assumptions used in Australia, Great Britain and Canada, it doesn't recognise that the opex allowances are set in a different manner in these jurisdictions. In Great Britain, Australia and Canada, EDBs provide an opex forecast, which bears similarities with New Zealand's CPP process.[5,6] To the extent that these

[2] NERA, *Economic considerations for forecasting productivity in the DPP*, 31 January 2019.

[3] NZCC, *Default price-quality paths for electricity distribution businesses from 1 April 2020 – Draft decision – Reasons paper*, 29 May 2019, para. A124

[4] I.e. 1% negative measured "productivity" could be the result of achieving a 1% productivity improvement with respect to opex associated with line length and ICPs and 2% increase in opex associated with growth in outputs besides line length and ICPs. That 2% increase in opex could also incorporate productivity gains with respect to those unmeasured outputs.

[5] The proposal of course needs to be accepted by the regulator in question. We briefly describe each regulator's approach and the similarities/differences with the DPP in the body of this report.

[6] In Great Britain, Distribution Network Operators (DNOs) submit a total expenditure (totex) forecast which is assessed by Ofgem. DNOs provide a breakdown of costs into opex and capex. Ofgem approves a totex allowance which incorporates expected productivity growth.

processes result in opex allowances that consider all the outputs EDBs will deliver, then a productivity adjustment is actually accounting for expected productivity.

The DPP on the other hand is a mechanistic roll forward of historic costs for two outputs. As already discussed, the evidence suggests this model is missing something. If opex allowances were instead determined by a bottom up forecast of the costs associated with delivering the totality of the outputs EDBs expected to deliver, then an adjustment to this cost forecast for productivity would accurately be described as a "productivity" adjustment. This is not the context of the DPP.

In our view, the evidence continues to support a negative opex partial factor productivity assumption, likely at a greater level than that set by the Commission for DPP2, as we discus below.

Given the mechanistic way opex is forecast in the DPP, the partial factor productivity assumption should be relabelled the residual opex factor

Jorgenson and Griliches, academics amongst the founding fathers of productivity analysis, have described productivity estimates as the "residual" or the "Measurement of Our Ignorance".[7] As noted above, measured productivity is actually a residual that measures the *net* impact of changes in unmeasured outputs and productivity (with respect to measured and unmeasured) on costs. That is to say, we can decompose measured opex productivity into two components:

Measured Opex PFP = productivity for measured outputs + changes to opex due to changes and productivity in unmeasured outputs.

Viewed this way, concerns about negative measured productivity implicitly assume that the second term on the right-hand side of the equation above is close to zero. Given the persistent negative measured productivity (both index analysis and econometric cost functions), this seems unlikely to be the case.

In a framework like the DPP where opex is forecast in a mechanistic way,[8] the productivity assumption is capturing *any* effect on opex not driven by changes in line length, ICPs or input prices. Given the simplicity of the model, it should not be surprising that there are other factors that drive opex which the model does not explain. Because of this, in our view, the productivity assumption should be re-labelled the "residual opex factor",

Reframing the opex partial factor productivity assumption in this way should make clear that a negative assumption is not necessarily an assumption of negative productivity. Rather it would be an assumption that the growth of unmeasured outputs exceeds the productivity achieved for opex driven by line length and ICPs. That is to say, setting a negative residual factor would be recognition that the Commission's model is necessarily an incomplete abstraction of reality, rather than a belief that the EBDs are becoming less efficient over time.

Internal consistency with the Commission's scale factors suggests a residual opex factor materially less (i.e. more negative) than -0.25%

The Commission forecasts opex using essentially the same two output model (line length and ICP numbers) we have demonstrated is likely to be persistently missing something, as evidenced by negative measured productivity for the last ~16 years. Indeed, the most negative end of our range of

[7] Jorgenson, D.W. and Griliches, Z. (1967), The explanation of productivity change, Review of Economic Studies, vol. 34 (3) p.249

[8] In a less mechanistic framework where EDBs could provide an opex proposal/forecast that captured all the outputs they believe they need to produce, the issue we describe is less relevant and the conversation returns to a discussion of "productivity".

productivity estimates is from the two output model. Table X.3 shows the various point estimates of the residual opex factor using the two output model (line length and ICP growth) and our base case measurement window (2004-2018, with the exception of the Commission's regression model, for which we use the same window as the Commission.)

Table X.3: Measured productivity using the two output model consistent with the Commission's scale factors

Measurement method and window	Residual opex factor
Productivity index: Continuous compounded growth (2004-2018)	-1.85%
Productivity index: Logarithmic regression growth (2004-2018)	-1.74%
NZCC scale factor model time trend (2013 to 2018 – including outliers)	-1.97%
NZCC scale factor model time trend (2013 to 2018 – excluding outliers)	-3.08%

Source: NERA analysis

This suggests a range between -1.74% and -3.08%. As a cross check, the amount by which actual opex has deviated from the forecast over DPP2 is 4.6% over 3 years, i.e. 1.53% per year. Note that this deficit is after opex allowances have been increased by -0.25%. Therefore, the actual deficit, before the residual opex adjustment of -0.25%, would have been ~1.78% per year. This suggests the bottom end of our range of -1.74% would have been unlikely to have overcompensated EDBs over the first three years of DPP2.

We agree with the Commission's statement in the draft determination that any analysis of productivity should be forward looking. However, historical analysis indicating a persistent pattern over a long period of time can have informative value when forecasting the future. It is also not clear what the Commission envisages a forward-looking productivity study would look like, particularly in the context of the DPP where the productivity term is actually a residual capturing productivity and the effect of unmeasured outputs. In this regard, we understand that the EDBs will be providing evidence to the Commission about factors which have driven costs besides line length and ICP growth in the past and other factors which they expect will cause opex to increase in the future.

If these pressures are likely to continue over DPP3, compensating EDBs solely on the basis of line length and ICP growth is likely to undercompensate EDBs for the costs they need to efficiently incur. Importantly the DPP2 residual opex figure of -0.25% would significantly undercompensate EDBs if the scale factor model continues to under forecast EDB opex requirements. Therefore, we recommend the Commission sets a residual opex factor significantly less (more negative) than -0.25%. The evidence considered in this report would support a factor between -1.74% and -3.08%.

1. Introduction

The New Zealand Commerce Commission (NZCC) in the process of formulating a draft determination for the Electricity Distribution Businesses (EBDs) of New Zealand, to run from 1 April 2020 to 31 March 2025. As part of this decision, the NZCC will set allowances for operational expenditure (opex), which will be determined using a "step and trend" approach. In other words, opex allowances will be equal to:

(1) A "base year" level of opex, equal to actual opex in a selected year before the beginning of DPP3;

(2) Any "step change" adjustments to reflect known differences in operating conditions during DPP3 relative to the base year; and

(3) An annual "trend", equal to estimated changes in opex productivity, input price inflation, and scale effects (aka output growth).

In the previous decision for DPP2, the Commission assumed opex partial factor productivity of -0.25% per year and companies were therefore allowed an additional 0.25% in opex each year to reflect this declining productivity. In a recent consultation for DPP3, the Commission proposes to shift to a 0 per cent productivity assumption.

The Electricity Network Association (ENA) has commissioned NERA to:

- Describe recent EDB trends using the Economic Insights (EI) methodology implemented in 2014 for DPP2, but updated to include improvements in that approach and EDB specific methodologies used by the AER in its recent productivity decision; and
- Review the Commission's rationale for setting a 0% partial productivity assumption in the DPP3 Draft Determination; and
- Comment on the interrelationship between the partial factor productivity assumption and the scale factor approach to forecasting opex.

In this report, we present the ranges of productivity implied by the Commission's 2014 decision extended through to 2018 and by the econometric approaches implemented in Australia. We then compare each of these approaches and the resulting productivity figures against a set of criteria we have developed to reflect the purpose of Part 4 regulation under the Commerce Act. Having done that, we assess whether the evidence suggests there is a case for a change the in partial productivity factor approach at DPP3 and more generally, the appropriateness of the assumption made at DPP2 and proposal for DPP3.

This report proceeds as follows:

- Section 2 provides relevant background on the Commission's approach to opex forecasting under the DPP and the role of the productivity assumption. We also briefly discuss the approach taken by other regulators to productivity and forecasting opex and set out the criteria we have developed for assessing productivity measures;
- Section 3 describes the results of our update of the Economic Insights 2014 productivity index analysis and econometric cost function analysis of productivity;
- Section 4 describes the interrelationship between the outputs used in the productivity measure and the scale factors; and
- Section 5 concludes.

2. Approach to opex forecasting in the DPP

In this section we provide a brief overview of the role of the productivity assumption in the DPP, the interrelationship between productivity and the scale factors, discuss the criteria that should be used when measuring productivity and summarise the approach to opex allowances and productivity used in Great Britain, Canada and Australia, since the Commission has referenced their positive productivity assumptions in support of setting a productivity factor of zero.

2.1. General approach to opex allowances and productivity under the DPP

For DPP3, the Commission intends to set opex allowances using the same general "base-step-trend" approach as used during DPP2. This approach mechanistically takes a **base** year of opex (year four of the previous five year price control), adjusts for any **step** changes and then **trends** that level forward for three factors:

- **Changes in input prices**: This is referred to by some regulators as "real price effects" (RPEs) and acknowledges that the inputs used by EDBs may become more/less expensive in *real* terms over time;[9]
- **Changes in network scale**: This is also referred to as "output growth" by some regulators to recognize scale is more than just the physical size of the network. This factor reflects that opex may increase due to EDBs expanding output over time. I.e. "EDBs are spending more because they are doing more"; and
- **Partial factor productivity for opex**: This factor recognises that over time, industry wide changes in productivity can result in more (or less) output per unit of input.[10] Under incentive regulation, efficiencies are passed through to consumers with a lag. The productivity factor "pre-emptively" passes through an assumed level of industry wide productivity change to the revenue allowance immediately. The Commission justifies this approach on the basis that industry-wide productivity changes would be competed away in a workably competitive market.[11]

This general approach is implemented in the now familiar formula:

Box 1: Formula for forecasting opex under the DPP

$$\begin{aligned} opex_t = opex_{t-1} \times & \\ & (1 + \Delta \text{ due to network scale effects}) \times \\ & (1 + \Delta \text{ input prices}) \times \\ & (1 - \Delta \text{ partial productivity for opex}) \pm \\ & \text{step changes} \end{aligned}$$

The step change allowance is intended to adjust the base year of opex for additional expenditures that are not included in the base year, or remove expenditures in the base that are not expected to occur in the future.

[9] For example, a tightening of the labour market may result in real wages for specialised labour rising over time.

[10] NZCC, *Default price-quality paths for electricity distribution businesses from 1 April 2020 – Draft decision – Reasons paper*, 29 May 2019, para.A117.
From here: NZCC (2019)

[11] NZCC (2019), para. A120.

2.2. Approach used in DPP2

In arriving at the -0.25% annual productivity assumption used in DPP2, the Commission relied partly on the Economics Insights' "Electricity Distribution Industry Productivity Analysis: 1996–2014" study.[12] This study used observations from 1996 to 2014, and calculated productivity growth using 3 different outputs specifications:

Table 2.1: EI 2014 Study Output Specifications

Description	Components and Weights
2 outputs	Circuit length (54%) and customer nos. (46%)
3 outputs	Customer nos. (29%), energy (22%) and system capacity (kVA*kms) (49%)
4 outputs	Circuit length (47%), customer nos. (23%), energy (15%) and ratcheted maximum demand (15%)

Source: EI 2014

The commission requested EI to provide estimates for the electricity distribution industry as a whole, and for the subset group of non-exempt EDB's. Economic Insights estimated that the industry long-term trend in operating expenditure partial productivity was between -1.4% and -0.45% between 2004 – 2014.[13] EI argued that, under normal conditions, one would seek the longest period possible to form an estimate of the long run growth rate. However, they considered that there is evidence from other countries that significant changes in market conditions have occurred recently, driven by the introduction of more energy-efficient appliances and buildings, and the increasing penetration of solar photo voltaic panels. Therefore, they use results from the "last decade" (2004-2014) as the basis of their recommendations.[14]

Despite measured productivity being in the range of -1.4% - 0.45%, the Commission set the productivity factor at -0.25% because it considered that:

- Historical step changes in expenditure may mean that measured productivity is understated;
- A negative productivity assumption may create perverse incentives, and negative productivity is expected to be the exception and not typically a feature of workably competitive markets; and
- The electricity distribution overseas (in particular the US) has experienced positive productivity.[15]

With respect to the scale factors, the Commission used the following:

- Network opex: change in circuit length (0.44), change in ICP numbers (0.49);
- Non-network opex: change in ICP numbers (0.82).

Regarding step changes, no step changes were allowed for in DPP2.[16]

[12] Economic Insights (EI), *Electricity Distribution Industry Productivity Analysis: 1996–2014*, 30 October 2014. From here on: Economic Insights (2014)

[13] New Zealand Commerce Commission (NZCC), *Default price-quality paths for electricity distributors from 1 April 2015 to 31 March 2020 - Low cost forecasting approaches*, 28 November 2014, para. 3.27. From here on: NZCC (2014)

[14] Economic Insights (2014), p. ii-iii.

[15] NZCC (2014)., para. 3.32.3.

[16] NZCC (2014), para.3.39.

2.3. Approach proposed in the DPP3 draft determination

For DPP3, the Commission has proposed to set the opex partial productivity factor at 0%.[17] Some of the alternatives considered were to:

- repeat the EI historical study,
- preserve the -0.25% parameter used in DPP2; or
- conduct a forward-looking productivity study.

However, the Commission does not consider a historical productivity assessment is appropriate, on the basis that past productivity changes may not be an accurate predictor of future productivity. In the same vein, it is sceptical of negative rates, as they "may entrench declines in partial productivity and weaken incentives to improve efficiency"[18]. The Commission also does not consider using a high positive factor is appropriate either, as this would have the effect of "passing gains onto consumer in anticipation of their discovery, which is not the purpose of the productivity factor."[19] That is to say, the Commission did not want to set what some regulators refer to as a "stretch factor". The Commission therefore argued that a forward-looking study would be the best option, but considers that the resource intensity of such a study makes it an impractical option.

In reaching a draft decision to set the productivity factor at 0%, the Commission has essentially relied on precedent from Australia, Great Britain and Canada, who have respectively set non-negative productivity factors of 0.8%-1.1%, 0.5% and 0% per year. The Commission argues that a 0% assumption would result in the EDBs and consumers sharing any possible industry-wide efficiency changes and would prevent entrenching productivity gains or declines before they are made.[20]

With respect to the scale factors, the Commission proposes to use the following (with opex elasticities in brackets):

- Network opex: change in circuit length (0.4727), change in ICP numbers (0.4514);
- Non-network opex: change in circuit length (0.6520), change in ICP numbers (0.2118).

Regarding step changes, the Commission currently proposes to make no allowances for step changes, except for a negative step change to account for Fire and Emergency New Zealand (FENZ) levies which will now be treated as a pass-through.[21]

2.4. Approaches adopted by other regulators to productivity and opex allowances

Given the Commission has placed some weight on the productivity assumptions adopted in the Great Britain, Australia and Canada, we provide a very brief over view of the approach to forecasting costs and accounting for expected productivity in each of these jurisdictions.

[17] NZCC (2019), para. A118

[18] NZCC (2019), para. A124

[19] NZCC (2019), para. A125

[20] NZCC (2019), para. A126

[21] NZCC (2019), para. A44.

Table 2.1: Comparison of approach to opex forecasting and productivity assumption in NZ, Australia, Great Britain and Canada

Jurisdiction	Approach to forecasting opex	Measurement approach for opex productivity assumption
New Zealand DPP	Historic opex mechanistically rolled forward for growth in line length, ICPs, input prices and a partial factor productivity adjustment.	For DPP2 the Commission examined historical productivity index analysis, which gave a range of -1.4% to -0.45% and exercised its judgement to set an assumption of -0.25%.
Australia	EDBs prepare a bottom up expenditure forecast/proposal which the AER can accept if it meets the "expenditure objective". The standard process for Australian EDBs is thus similar to the New Zealand CPP. As part of the assessment of the proposal, the AER develops an alternative forecast using the base-step-trend approach, which is similar to the DPP but uses more outputs. This is not however, in theory, deterministic of the end opex allowance.	Index and econometric approaches yielded negative productivity over long time periods. AER instead adopted a holistic approach which looked at other methodologies which give positive numbers.[22]
Great Britain	EDBs provide totex forecasts, based on their business plans, which are benchmarked against each other. Superior business plans can be "fast tracked".	Long term productivity trends taken from other sectors[23] given substantial "catch up" likely for privatized utilities.
Canada	Three options available for distributors:[24] ▪ **4th Gen IR**: a "forward test year", being the first year of the next regulatory period, is forecast by the EDBs, reviewed by the regulator and then rolled forward for inflation and productivity ▪ **Custom IR**: similar to the CPP, an individualized forecast of costs over the regulatory period is prepared and assessed by the regulator. ▪ **Annual IR**: for firms with stable costs, current costs are rolled forward with no set review cycle.	Long term (~10 year) productivity index analysis[25]

Source: NERA analysis of regulator decisions and documents.

This table demonstrates that in the jurisdictions which the Commission has cited, EDBs have a greater ability to propose opex, rather than a mechanistic roll forward of historic costs determining future

[22] AER, *Forecasting productivity growth for electricity distributors: Final Decision*, March 2019

[23] Ofgem uses the EU KLEMS database which covers the time period 1970- 2007. It uses a weighted average of productivity growth from a wide range of industries, including Construction, Manufacture of Chemicals and Chemical Products, Manufacture of Electrical & Optical Equipment, Manufacture of Transport Equipment, Sale, Maintenance & Repair of Moter Vehicles/Motorcycles; Retail Sale of Fuel, Transport & Storage, and Financial Intermediation.

[24] Ontario Energy Board, *Renewed Regulatory Framework for Electricity Distributors: A Performance-Based Approach,* 18 October 2012, pg.13

[25] Ontario Energy Board, *Rate Setting Parameters and Benchmarking under the Renewed Regulatory Framework for Ontario's Electricity Distributors*, 4 December 2013, pg.17

opex allowances. The Ontario Energy Board's 4th Generation price cap bears the closest resemblance to the DPP. However, even there the base year is a forecast based on the distributor's business plan.

2.5. Appraisal criteria for productivity measures

In our previous report submitted during this process on the topic of productivity,[26] we set out four criteria that we had suggested the AER use in similar circumstances to achieve its saturator objective, on the basis that the purpose of Part 4 regulation under the Commerce act shared similar goals. We repeat these criteria now for convenience:

- **Approach captures underlying trends in productivity for DNSPs**: Any productivity assumption must reflect the productivity improvement that would be attainable by an efficient EDB. In other words, any measure of productivity should be electricity network specific and not pick up cyclicality/noise.
- **Approach separates productivity from catch-up**: Measured historical productivity may include inefficient firms "catching-up" to the frontier, rather than technological progress by efficient firms. Catch-up is unlikely to be replicable going forward, so the productivity adjustment should only reflect improvements in efficiency by efficient firms.
- **Approach is objective and stable over time:** The approach adopted for measuring productivity should not be highly sensitive to start and end years and should demonstrate longer-term productivity trends. The approach should also be credible such that it can continue to use the approach in subsequent price control periods. Changing approaches frequently will risk perceptions of cherry-picking and could systematically deny cost recovery over time.
- **Approach does not limit incentives to reduce costs:** The productivity adjustment should not introduce perverse incentives which would encourage EDBs to make business decisions with a view to influencing their current or future productivity targets. For example, if the opex PPF was set by reference to very recent, short term improvements in productivity, this would blunt the incentive to improve efficiency as this improvement would immediately be clawed back.[27]

In its final decision on the forecasting opex productivity growth, the AER adopted the following factors for assessing each source of information on productivity:[28]

- Reflects a reasonable estimate of the underlying productivity growth achievable by an electricity distribution business, independent from cyclical events and one-off factors (such as step changes) and taking into account any issues with the estimation approach
- Estimates the shift in the efficiency frontier, and the extent to which it excludes catch-up effects
- Does not create any perverse incentives for distribution businesses to not pursue productivity gains if relied upon deterministically
- Reflects the most recent available data
- Is based on a transparent methodology

As the AER notes, these criteria are largely consistent with our own.[29] The key difference is the AER has essentially split our "objective and stable" criteria into the factors relating to using recent data and

[26] NERA, *Economic considerations for forecasting productivity in the DPP*, 31 January 2019. See section 2.2.

[27] Put another way, the productivity adjustment would begin to counteract the Incremental Rolling Incentive Scheme (IRIS) if it becomes too closely linked to recent efficiency gains.

[28] AER, *Forecasting productivity growth for electricity distributors: Final Decision*, March 2019, p.26.

[29] AER, *Forecasting productivity growth for electricity distributors: Final Decision*, March 2019, p.26

having a transparent methodology. As mentioned above, taking a short term, but very recent measurement window could lead to erroneous conclusions. So while we agree that the most recent data should generally be incorporated, we do not think this should per se be its own criteria separate as it is picked up by our other criteria. Therefore, we don't see the AER's factors as being substantively different to our own criteria, so we continue to use our criteria in this report.

As will become clear in the rest of this report, given the mechanistic nature of the DPP and the long time series of data available for NZ EBDs, the primary concern in the present context is whether the chosen measure of productivity is consistent with the scale factors and whether it is actually measuring "productivity" or picking up other factors driving opex.

3. Empirical analysis of EDB opex productivity

In this section we empirically analyse EDB productivity using two methods: The productivity index analysis conducted by EI in 2014 and econometric cost function time trend analysis.

3.1. Update of 2014 Opex Partial Factor Productivity Analysis

3.1.1. Overview of analysis

In this section we present our replication and extension of the 2014 opex partial factor productivity analysis conducted by EI for the Commission.

We have replicated the 2014 EI study commissioned by the Commission and, we have also updated it to cover the years 2014 to 2018. Our overall approach to update the dataset has been to track down the data series used by EI in the information disclosures published by the Commission, and cross check them with the 2013 numbers in the EI dataset. In practice, this means we have calculated our own set of numbers for 2013, to cross check they match with EI, and from there we have extended the series until 2018. From 2013 onwards, the dataset does not necessarily match the ID numbers, as in some instances EI have spliced have series from the pre-input methodologies (IMs) ID data onto the post-IM ID data to give a consistent series from 1996-2014. This affects variables such as system capacity, ratcheted maximum demand, opex and customer numbers. A detailed description of the replication of all the variables can be found in Appendix B and C.

Having extended the dataset to 2018, we replicated the calculations of the opex partial factor productivity growth using the same output specifications used by EI in 2014, which we repeat in Table 3.1 below.

Table 3.1: Output weights used in productivity indices

Model Specification	Outputs	Weight
Two outputs	Circuit Length	46%
	Customer Nos.	54%
Three outputs	Energy	22%
	Customer Nos.	29%
	System Capacity	49%
Four outputs	Energy	15%
	Circuit Length	47%
	Customer Nos.	23%
	Ratcheted Maximum Demand	15%

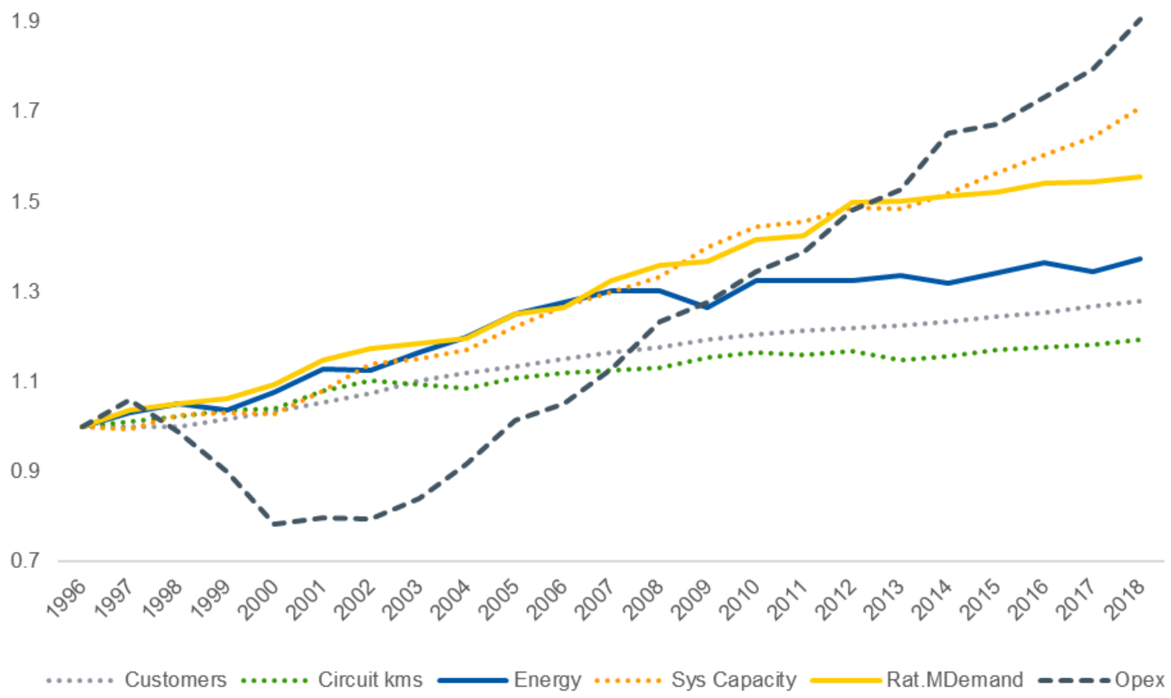
Source: EI 2014.

Consistent with EI and the AER’s recent practice, we use a Tornqvist index to calculate the indices, as opposed to the fisher index EI used in 2014. This makes little difference to the results, as set out in Appendix D. As we describe in more detail below, we then calculate productivity trends using both compound growth rates and log regression trends and consider various estimation windows.

3.1.2. Industry Level Productivity Analysis

We begin by examining trends in the individual output measures that make up the PFP index, as well as opex itself. Figure 3.1 extends Figure 4 from our previous report to 2018 and to also includes opex. This demonstrates the same decoupling in ~2006 of ratcheted maximum demand and system capacity[30] from energy delivered that we observed in our previous report. Extending the data series to 2018 also reveals a decoupling of system capacity from ratcheted maximum demand in ~2014. These trends are largely similar if only non-exempt EDBs are examined, except the apparent decoupling of system capacity from ratcheted maximum demand is no longer present (see Figure E.1).

Figure 3.1: Distribution Industry Output Components Quantity Indices, 1996 - 2018



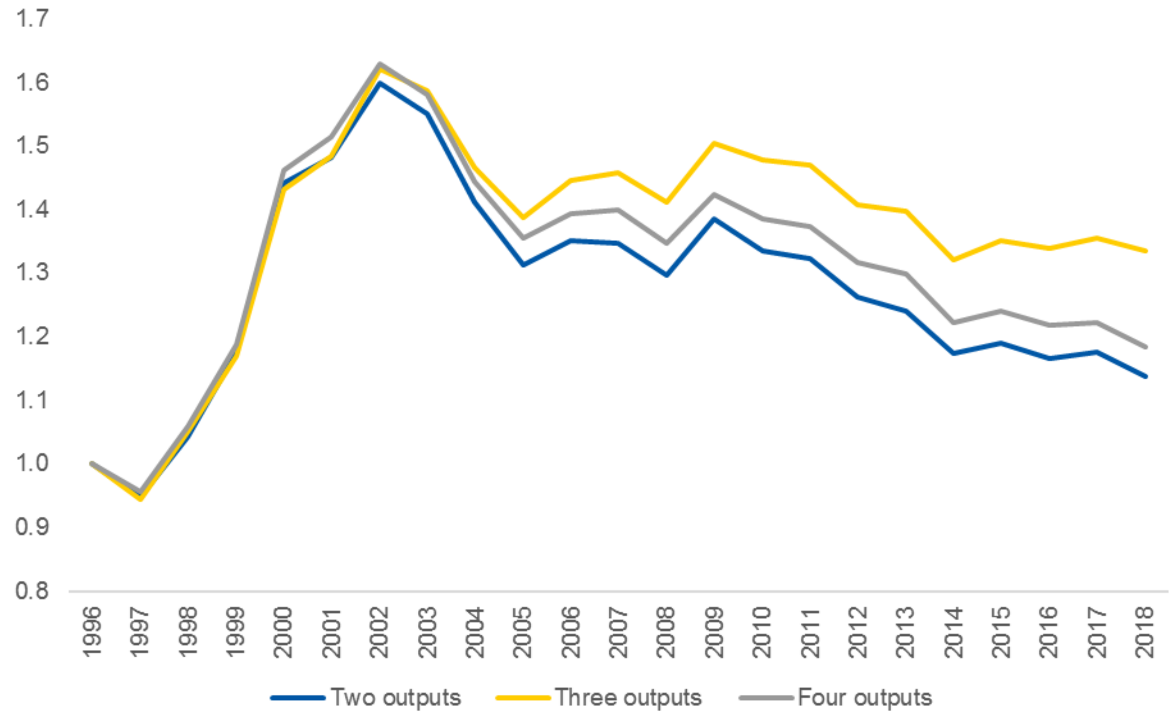
Source: NERA analysis, EI, NZCC ID database.

The overriding observation from this figure is that since ~2002, opex has been growing at a greater rate than outputs related to the physical characteristics of the network. In the context of constructing a partial factor productivity index, this will show up as negative measured productivity as any growth in opex unrelated to growth in the outputs selected is assumed to be inefficient.

This is shown in Figure 3.2 below, which plots, at the industry level, the different PFP indices defined by EI. This figure shows that since 2002, there has been a persistent decline in measured productivity across each of the three output specifications.

[30] Which is defined as transformer capacity multiplied by line length.

Figure 3.2: Distribution Industry Opex Productivity Indices (1996-2018)



Source: NERA analysis, EI, NZCC ID database

Table 3.2: Industry EBD productivity trends

Measurement window and method	Two-output specification	Three-output specification	Four-output specification
Continuous Compounding Growth			
1996-2018	0.33%	1.20%	0.52%
1996-2004	4.15%	4.80%	4.43%
2004-2018	-1.85%	-0.85%	-1.71%
Logarithmic Regression Growth			
1996-2018	-0.22%	0.73%	-0.03%
1996-2004	6.09%	6.69%	6.32%
2004-2018	-1.74%	-0.83%	-1.61%

Source: NERA analysis, EI, NZCC ID database

In terms of calculating “measured productivity”, which is the annual percentage change in the productivity index, we have taken two approaches:

- **Compound growth rates:** the annual percentage change is calculated by measuring the change between a start and an end date.
- **Regression time trends:** the productivity index is regressed against a time variable to give an econometric estimate of the productivity time trend.

Our preferred approach is to use regression time trends. Compound growth rates only use the start and end point as inputs and thus essentially ignore any information on long-term trends given by intermediate data points. This is particularly important if the series contains outliers. Because of the weight placed on the start and end points, the choice of time period can have a large effect on the calculated trend when using compound growth rates. Regression time trends on the other hand incorporate all the data points into the analysis (for the time period selected) and will therefore place less weight on outliers appearing at the start or end of the series.

For our main results we have calculated productivity trends for three time periods:

- The 2014 EI/NZCC preferred window extended through to 2018 (2004-2018); and
- The full data period (1996 – 2018)
- The “first half” of the data set (1996 – 2004);

The results of this analysis are shown in Table 3.2. As a generalisation, this shows that if “recent” data is used (2004-2018), then measured productivity is materially negative, whereas if data from the first half of the dataset is included, then measured productivity is generally positive or close to zero.

Interestingly, if the entire time period is used, the two-output (line length and ICP numbers) productivity index, which is consistent with commissions scale factors, gives measured productivity of -0.22% using our preferred regression trend method. This similar to the -0.25% assumption the Commission set at DPP2. This small negative trend is however primarily driven by the inclusion of pre 2002 data, which appears to be a period of unusually high measured productivity, which has not been repeated for the last 16 years.[31]

Because the productivity trend is sensitive to the time period chosen, we have conducted sensitivity analysis with respect to the length of the time period and time period chosen. We have done this by doing three calculations:

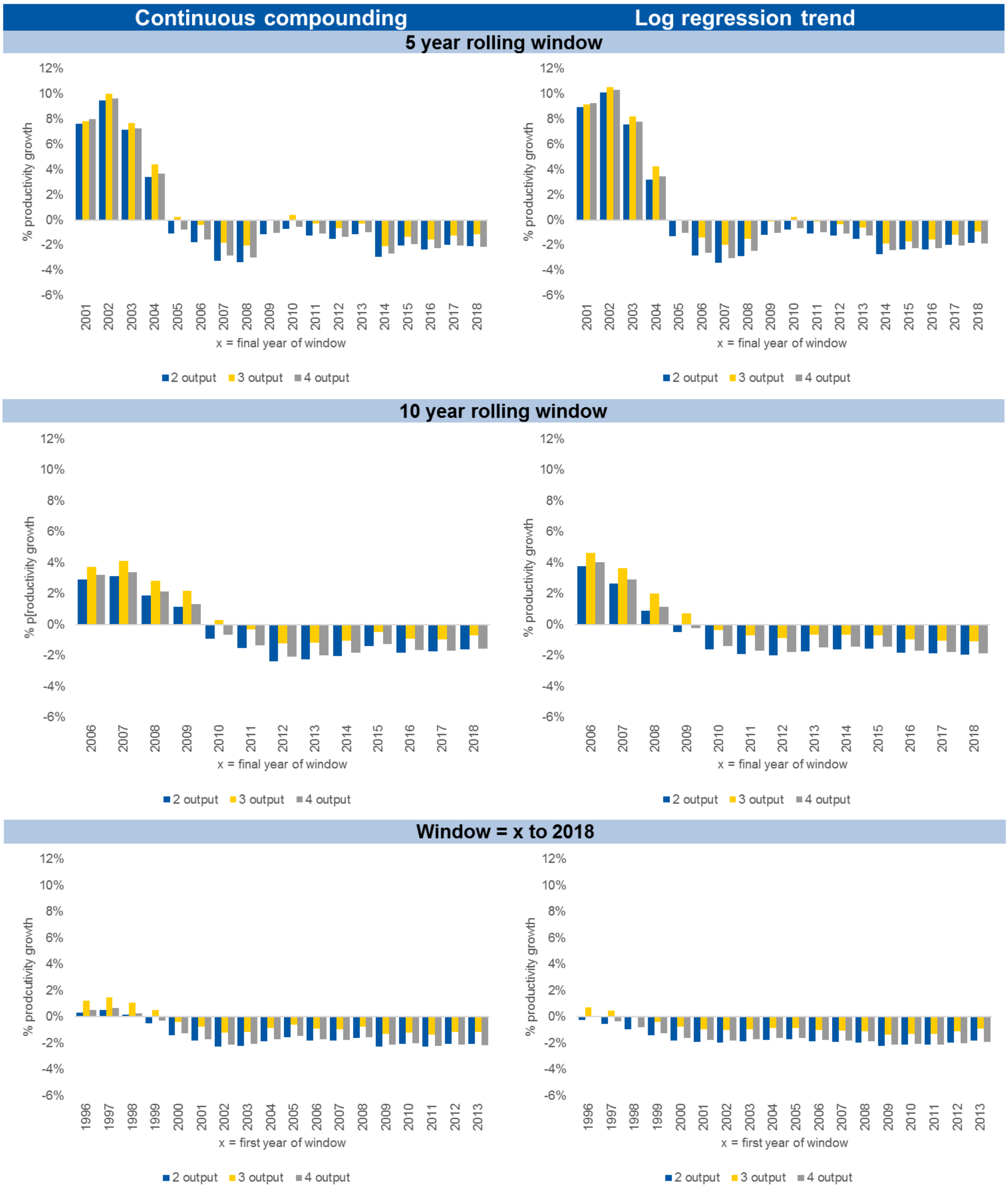
- Rolling 5 year windows;
- Rolling 10 year windows; and
- Fixing the end point at 2018 and using different start dates (and therefore terms) back to the start of the data series.

This analysis is shown in Figure 3.3 and demonstrates that:

- Longer measurement windows result in less variation in the results;
- The regression trend series are less sensitive to the time-period chosen; and
- Measured productivity is negative unless data before ~2000 is included in the sample period.

[31] Given EDBs were corporatized and in some cases privatised in the early 1990s, this period of positive productivity may be driven by “catch up” during the period. Put another way, the period may represent structural changes in the electricity which resulted in productivity gains unlikely to be repeated going forward.

Figure 3.3: Industry EDB productivity sensitivity to measurement window



Source: NERA analysis, EI, NZCC ID database.

3.1.3. Summary of Productivity Index Analysis

Table 3.3 below presents a summary of our productivity index analysis, including both the industry level results presented above and the non-exempt results from Appendix E. This table contains ranges for productivity growth calculated using the following windows:

- The 2014 EI/NZCC preferred window (2004 – 2014);
- The 2014 EI/NZCC preferred window extended through to 2018 (2004-2018); and
- The full data period (1996 – 2018)

This shows that extending the 2014 analysis through to today still results in negative measured productivity. Note that our 2004-2014 results differ from EI's due some data corrections we have made to the 2013/14 data which are explained in the appendices of our report.[32] While using the entire window results in marginally positive productivity (as it did in 2014), like EI in 2014 we do not place much weight on this calculation.

In general, our preferred approach to measuring productivity is to use the longest window available. However, when selecting the 2004-2014 window in 2014, EI noted structural changes in the electricity distribution industry and suggested that a more recent window was preferable.[33] Based on this they examined the "past decade". As is evident in Figure 3.2, there was sharp rise in productivity between 1996 and 2002 but productivity has been on a consistent decline since. We thus agree with EI that it is preferable to exclude this early period and focus on more recent data. We have accordingly focused our summary results on simply extending their window by taking a window of 2004-2018. In any event, as already discussed above, our sensitivity analysis indicates that estimated productivity is not particularly sensitive to the start and end date chosen, so long as data prior to 2002 is not included. Furthermore, our preferred method of calculating productivity growth using regression trends instead of compound growth figures places less weight on the start and endpoints chosen, thus mitigating this issue somewhat.

Table 3.3: Summary of opex Partial Factor Productivity index trends

Measurement window/method	Industry	Non-Exempt
NZCC/EI 2004 - 2014		
NZCC/EI 2014 (cont-compounded)	-1.40% to -0.45%	-1.64% to -0.80%
NERA (cont-compounded)	-2.03% to -1.07%	-1.85% to -1.04%
NERA (log-trend)	-1.60% to -0.66%	-1.24% to -0.46%
NZCC/EI update - 2004 - 2018		
Continuously Compounded	-1.85% to -0.85%	-1.55% to -0.68%
Log-Trend	-1.74% to -0.83%	-1.43% to -0.67%
Full series - 1996 - 2018		
Continuously Compounded	0.33% to 1.20%	0.58% to 1.31%
Log-Trend	-0.22% to 0.73%	0.02% to 0.82%

Source: NERA analysis and EI 2014

[32] As already discussed, because continuously compounded growth rates take the first and last year as the final input, a change to the final year of data can have a large impact on the calculated growth rate.

[33] Economic Insights (2014)

3.2. Econometric Approaches to Opex Productivity

In its annual benchmarking reports which it provides for the AER, EI econometrically estimates the drivers of efficient opex for Australian DNSPs, using four econometric models which arise from the combination of two functional forms and two estimation techniques:

- Two models assume a Cobb-Douglas functional form, which assumes that the elasticity of costs to output level is not dependent on the scale of outputs. The other two models assume a translog functional form, which allows elasticity estimates to change with scale.
- Two models are estimated using stochastic frontier analysis (SFA), which estimates the drivers of opex for the efficient frontier. The other two models are estimated using least squares estimation (LSE), which estimates the drivers of opex across the entire sample.

In order to calibrate the relationships between cost drivers and opex, EI includes data from 18 EDBs in New Zealand and 37 companies in the Canadian province of Ontario. In the annual benchmarking reports, EI controls for level differences between the jurisdictions by including NZ- and Ontario-specific dummy variables, but otherwise assumes that the relationships between the jurisdictions are the same. Under such a specification, the time trend would capture changes in productivity across the entire sample, including New Zealand. These models also include the proportion of lines that are undergrounded as an explanatory variable. If undergrounding is expected to continue into the future, all other things being equal, ongoing opex would fall as these lines incur lower maintenance costs.

The Commerce Commission has also estimated econometric models for the purposes of estimating the scale factors it applies. These models do not include time trends but can easily be modified to do so.

In the remainder of this section we discuss:

- The econometric cost function time trend results (section 3.2.1);
- The econometric cost function undergrounding coefficient (section 3.2.2); and

3.2.1. Time Trend in Econometric Cost Functions

In the context of the AER's most recent productivity decision, and because the parameter of interest was the time trend itself, EI amended its core models to include separate time trends for the different jurisdictions. In other words, insofar as the Australia-specific time trend captures changes in productivity in Australia, the New Zealand-specific time trend captures changes in productivity in New Zealand.

EI considered models estimated from 2006 to 2017; 2011 to 2016; 2011 to 2017; and 2012 to 2017. These truncated windows were specifically adopted in Australia because of concerns that step changes due to new reliability and bush fire requirements were distorting the results.

For the context of this report, we consider only the fullest window for the application to New Zealand, because the step changes which may make the earlier period non-comparable in Australia do not apply to New Zealand. Because the EI dataset only goes as far back as 2006, we do not need to worry about distortions caused by the pre 2002 New Zealand data.

We provide the productivity estimates applicable to New Zealand derived from the 2006-2017 models in Table 3.4 below, equal to the negative coefficient on the New Zealand-specific time trend.[34]

[34] Because the econometric models measure cost as a function of drivers, a positive time trend indicates increasing costs in the absence of changes to other drivers, potentially indicating decreasing productivity.

Table 3.4: Econometric Time Trend Productivity Estimates for New Zealand using AER's cross country dataset (2006 – 2017)

		Estimation Technique	
		SFA	**LSE**
Functional Form	**Cobb-Douglas**	-2.3%***	-2.6%***
	Translog	-2.3%***	-2.8%***

*Significance: *** = 1%, ** = 5%, * = 10%*
Source: NERA replication of EI[35]

EI's productivity analysis for the AER therefore suggests that productivity in New Zealand has grown at a rate between 2006 and 2017 of -2.3 to -2.8% per year. The coefficients from the truncated windows assessed by EI (but not considered here) show an annual average growth in productivity of -1.9% to -2.7% per year, indicating that the use of the full period does not materially bias the results.

The Commerce Commission's econometric models used to determine the scale factors do not include a time trend, but this is easily added to their regressions. The Commission's econometric advisor at the time of DPP2 noted that:[36]

> *…at this stage it would be difficult to incorporate time effects into the econometric models for opex in a way that could be applied in forecasting. Incorporating time effects would become important if it was found that, in addition to drivers for opex currently included in the econometric models, there was a systematic time effect on opex –for example, a time trend or a finding that there has been a fixed structural shift in opex in recent years. Therefore the appropriate response is to maintain a 'watching brief' on this issue, undertaking further investigation in the future when extra years of data will be available*

The Commission's draft decision on the scale factors uses the regressions with outliers excluded. Adding a time trend and repeating the Commission's process to exclude outliers gives the results in Table 3.5 below.

Table 3.5: NZCC econometric models with time trend included (2013-2018) – Outliers excluded

Model	Lines	ICPs	Time	R^2
Total opex	0.3505***	0.5524***	0.0308***	0.9529
Network opex	0.4556***	0.4599***	0.0299**	0.8991
Non-network opex	0.2146***	0.6482***	0.0191	0.9003

*Significance: *** = 1%, ** = 5%, * = 10%*
Source: NERA analysis of NZCC econometric models

While the disaggregated Non-network opex time trend is not statistically significant, the total opex and Network opex trends are statistically significant and suggest measured productivity growth of -3.08%. and -2.99% respectively.[37]

In the case where outliers are not excluded, the results of adding a time trend are shown in Table 3.6 below.

[35] EI, *Memorandum to AER Opex Team: Forecast Opex Productivity Growth*, 4 February 2019, p.13.

[36] Jeff Borland, *Comments on NZCC approach for forecasting opex*, 26 June 2015, p. 10.

[37] I.e. the total opex regression indicates all other things being equal, total opex has increased by 3.08% over time.

Table 3.6: NZCC econometric models with time trend included (2013-2018) – full sample

Model	Lines	ICPs	Time	R^2
Total opex	0.3598***	0.5343***	0.0197**	0.9495
Network opex	0.5268***	0.4230***	0.0246*	0.9053
Non-network opex	0.2091***	0.6419***	0.0138	0.8930

*Significance: *** = 1%, ** = 5%, * = 10%*
Source: NERA analysis of NZCC econometric models

In this case, the time trend for both of the disaggregated opex measures are not statistically significant, but the time trend for total opex is. This regression suggests a fall in productivity -1.97%.

3.2.2. Undergrounding Approach

The AER's productivity decision also links DNSPs' opex allowances to changes in the share of the network which is underground, on the basis that underground networks incur lower opex costs. In particular, EI's econometric models (as described in Section 3.2 above) include a coefficient on the natural logarithm of the share of a company's lines which are underground. While the AER uses data series starting in 2012 for the time trend analysis, it used the full 2006 to 2017 data series for estimating the productivity gains associated with undergrounding.[38]

In all econometric models, the coefficient is negative, consistent with the hypothesised relationship between underground share and opex. The AER then multiplies these coefficients by each company's average undergrounding growth rate between 2006 and 2017. The AER's approach assumes that each company will continue to move its network underground at the same rate over the coming reset, thereby yielding continued opex savings defined by the product of this rate and the coefficient.

In its core benchmarking models, EI defines the undergrounding variable as the natural logarithm of the underground share, so the coefficient on the variable represents the change in opex associated with a one *per cent* change in the share (e.g. an increase in the share from 50 per cent to 51 per cent is a two per cent change, and a one *percentage point* change). In a submission we wrote on behalf of a set of DNSPs, we criticised this functional form, which had been the sole basis for the AER's undergrounding approach in the draft decision.

We argued that a one *percentage point* increase in the undergrounding share may have a similar effect on opex, irrespective of whether the company increases from 10 to 11 per cent, or 90 to 91 per cent underground. We therefore proposed that the variable should be defined in its linear form, and that the coefficient should measure the opex savings associated with a one percentage point increase in undergrounding.

In its final decision, the AER acknowledged our proposal and presented its approach under both a logarithmic form and a linear form. In other words, it presented eight coefficients (three models + the average across the models, with each model estimated under two forms of the undergrounding variable), which it then multiplied each company's undergrounding growth, estimated as appropriate as the average percentage point or per cent growth per annum.

Because the coefficients are calibrated using data from New Zealand and Ontario, the coefficients are no more applicable to Australia than they are to New Zealand, and the Commission could

[38] AER, *Final decision paper – Forecasting productivity growth for electricity distributors,* March 2019, p. 47.

theoretically apply this approach directly, so long as it applies it to undergrounding rates specific to New Zealand EDBs.

Using data on the 18 EDBs EI presents in its dataset for the AER, we have estimated the equivalent growth rates (using both per cent and percentage point growth) and multiplied by each of EI's eight coefficients. We present the *industry-wide* implied productivity growth rate in Table 3.7, for the 18 EDBs included in the AER dataset.

Table 3.7: Industry-wide Productivity Growth

	Log UG Share	Linear UG Share
SFA C-D	0.22%	0.14%
LSE C-D	0.27%	0.24%
LSE TL	0.24%	0.22%
Average	0.24%	0.20%

Source: NERA analysis on data from EI

The AER calculated separate productivity growth rates for each company, based on each company's undergrounding growth rate. The EI dataset allows us to do so, but for the sake of brevity, we present only the minimum and maximum company-specific growth rates in Table 3.8 and Table 3.9 and below.

Table 3.8: Minimum Firm-specific Productivity Growth

	Log UG Share	Linear UG Share
SFA C-D	0.08%	0.03%
LSE C-D	0.10%	0.06%
LSE TL	0.09%	0.05%
Average	0.09%	0.05%

Source: NERA analysis on data from EI

Table 3.9: Maximum Firm-specific Productivity Growth

	Log UG Share	Linear UG Share
SFA C-D	0.84%	0.40%
LSE C-D	1.02%	0.72%
LSE TL	0.92%	0.63%
Average	0.93%	0.58%

Source: NERA analysis on data from EI

The undergrounding approach therefore assumes company-specific productivity growth of between 0.03% and 1.02% per annum. Note that the undergrounding coefficients should not be viewed in isolation given that the same econometric models include a time trend which suggests annual *decreases* in productivity of over 2 per cent across the industry. However, it may be appropriate to use the results from this approach *in combination with* the results of the time trend analysis, which would capture both the opex savings companies can expect to achieve through increased undergrounding as well as ongoing increases in opex costs driven by other factors captured by the time trend. Alternatively, rather than as a measure of "productivity", undergrounding could be included in the scale factors separately as an output.[39]

[39] I.e. the line length variable could be split into overhead and underground line length.

4. Interrelationship between the productivity factor and the scale factors

Both the scale factors and measurement of productivity rely on an assumed set of outputs. The scale factors measure how opex changes with changes in assumed outputs, while measured productivity measures the extent to which an assumed outputs are produced using more or less opex over time.

The EI 2014 productivity study used three different output specifications to measure productivity, which involved combinations of:

- Circuit length;
- Customer numbers (ICPs);
- Energy
- System Capacity; and
- Ratcheted Maximum Demand.

With respect to the scale factors, the Commission is currently proposing to use:

- Circuit length;
- Customer numbers (ICPs);

If different outputs are used to measure productivity and estimate scale factors, then erroneous conclusions may be drawn about measured productivity, due simply to using different outputs for each measure. For example, consider a firm that produces three outputs: A, B and C. If A, B & C are used for scale growth, but only A & B are used for productivity, if C grows more slowly than A & B, then the productivity measure may erroneously show positive productivity as opex would be growing more slowly than the outputs used to measure productivity. Likewise, if C grew faster than A & B, then measured productivity would be deteriorating.

Even if consistent outputs are used for the productivity measure, if EDBs are incurring expenditure unrelated to changes in line length and ICPs, then this will be both uncompensated for by the scale factors and show as negative measured productivity. Because of this, we think it is more accurate to characterise measured productivity as a residual factor that captures both changes in productivity with respect to the measured outputs and changes in opex due to changes in the level and productivity of unmeasured outputs. I.e. measured productivity has two components, as set out below:

Measured Opex PFP = productivity for measured outputs + changes to opex due to changes and productivity in unmeasured outputs.

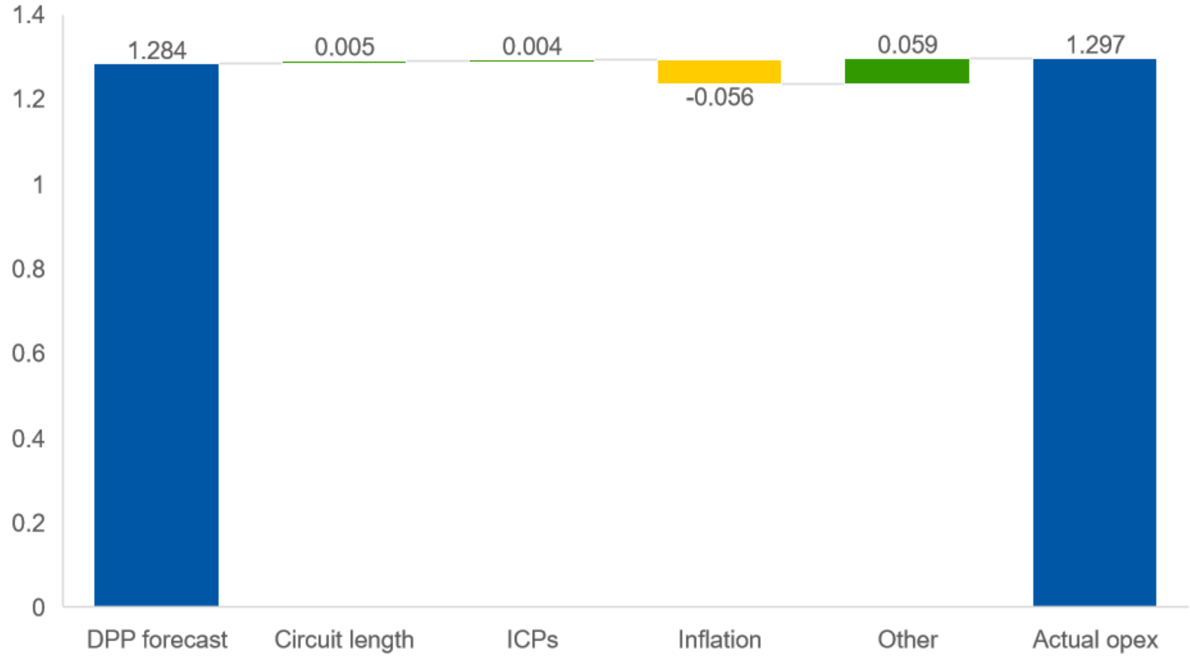
As a result of this, and other factors, Jorgenson and Griliches, academics amongst the founding fathers of productivity analysis, have described productivity estimates as the “residual” or the “Measurement of Our Ignorance”.[40]

In this regard we note that over the first 3 years of DPP2, the Commission has found that there has been approximately $59m of unexplained opex, as shown by Figure 4.1 below. This difference amounts to 4.6% over the period to date, or 1.53% per year. We note that the forecast also includes

[40] Jorgenson, D.W. and Griliches, Z. (1967) The explanation of productivity change, Review of Economic Studies, vol. 34 (3) p.249.

the -0.25% negative partial productivity allowance. Therefore, had the allowance been set at 0% this unexplained level of opex would have been even higher.

Figure 4.1: Deviations between DPP allowance and actuals, 2016–2018 ($b)



Source: DPP draft determination reasons paper, Figure A1.

The Commission gives four possible explanations for this difference:

- productivity growth being lower than forecast, or individual distributors becoming less efficient;
- econometric drivers deviating from actuals;
- any step changes not accounted for; and/or
- random variation in the level of opex.

None of these explanations explicitly acknowledge that the Commission's model may simply be an incomplete abstraction of reality and therefore be missing outputs provided by EDBs unrelated to changes in line length and ICPs. Step changes are meant to deal with changes in opex that occur 'outside the model', but as we have already noted, the Commission's approach to step changes is geared towards one-off changes in the level of costs (as implied by the name "step change").

A simple model is not a problem if its limitations are recognized. Problems arise when simple models are used in deterministic ways that don't recognise their limitations. In the present context, there is a risk of false precision. For example, while the Commission notes that its opex models explain 90-94% of the variation in opex[41], it doesn't acknowledge that the unexplained segment may not simply be noise, but could be a systematic bias in the model. The persistent negative measured productivity shown in Section 3 may be evidence of a systematic bias in the scale factors.

[41] NZCC (2019), para. A71 & A72

5. Conclusions and Recommendations

In a framework like the DPP where opex is forecast in a mechanistic way,[42] the productivity assumption is capturing *any* effect on opex not driven by changes in line length, ICPs or input prices. Given the simplicity of the model, it should not be surprising that there are other factors that drive opex which the model does not explain. Because of this, in our view, the productivity assumption should be re-labelled the "residual opex factor" which captures both productivity in the measured outputs and changes in opex due to changes and/or productivity in unmeasured outputs.

Reframing the opex partial factor productivity assumption in this way should make clear that a negative assumption is not necessarily an assumption of negative productivity. Rather it would be an assumption that the growth of unmeasured outputs exceeds the productivity achieved for opex driven by line length and ICPs. That is to say, setting a negative residual factor would be recognition that the Commission's model is necessarily an incomplete abstraction of reality, rather than a belief that the EBDs are becoming less efficient over time.

The Commission forecasts opex using essentially the same two output model (line length and ICP numbers) we have demonstrated is likely to be persistently missing something, as evidenced by negative measured productivity for the last ~16 years. Indeed, the most negative end of our range of productivity estimates is from the two output model. Table 5.1 shows the various point estimates of the residual opex factor using the two output model (line length and ICP growth) and our base case measurement window (2004-2018, with the exception of the Commission's regression model, for which we use the same window as the Commission.)

Table 5.1: Measured productivity using the two output model consistent with the Commission's scale factors

Measurement method and window	Residual opex factor
Productivity index: Continuous compounded growth (2004-2018)	-1.85%
Productivity index: Logarithmic regression growth (2004-2018)	-1.74%
NZCC scale factor model time trend (2013 to 2018 – including outliers)	-1.97%
NZCC scale factor model time trend (2013 to 2018 – excluding outliers)	-3.08%

Source: NERA analysis

This suggests a range between -1.74% and -3.08%. As a cross check, the amount by which actual opex has deviated from the from the forecast over DPP2 is 4.6% over 3 years, i.e. 1.53% per year. Note that this deficit is after opex allowances have been increased by 0.25%. Therefore, the actual deficit, before the residual opex factor adjustment of -0.25%, would have been ~1.78% per year. This suggests the bottom end of our range of -1.74% would have been unlikely to have overcompensated EDBs over the first three years of DPP2.

We understand that the EDBs will provide context on increased obligations and factors which have driven costs increases and will continue to do so over DPP3. If these pressures are likely to continue over DPP3, compensating EDBs solely on the basis of line length and ICP growth is likely to undercompensate EDBs for the costs they need to efficiently incur. Importantly the DPP2 residual opex factor figure of -0.25% would significantly undercompensate EDBs if the scale factor model

[42] In a less mechanistic framework where EDBs could provide an opex proposal/forecast that captured all the outputs they believe they need to produce, the issue we describe is less relevant and the conversation returns to a discussion of "productivity".

continues to under forecast EDB opex requirements. Therefore, we recommend the Commission sets a residual opex factor significantly less (more negative) than -0.25%. The evidence considered in this report would support a factor between -1.74% and -3.08%.

Appendix A. Distribution Industry and Non-Exempt EDB's Opex Partial Productivity Indexes, 1996-2018.

Table A.1: Industry Opex Partial Productivity Indexes, 1996-2018

Year	Two-output specification	Three-output specification	Four-output specification
1996	1.0000	1.0000	1.0000
1997	0.9604	0.9584	0.9691
1998	1.0449	1.0553	1.0582
1999	1.1757	1.1776	1.1860
2000	1.3883	1.3933	1.4079
2001	1.4624	1.4812	1.4925
2002	1.5423	1.5794	1.5696
2003	1.4943	1.5501	1.5231
2004	1.3938	1.4685	1.4248
2005	1.3139	1.4098	1.3542
2006	1.3380	1.4541	1.3792
2007	1.3122	1.4436	1.3616
2008	1.2631	1.4006	1.3115
2009	1.3164	1.4637	1.3553
2010	1.2676	1.4364	1.3173
2011	1.2579	1.4345	1.3073
2012	1.2175	1.3960	1.2726
2013	1.1931	1.3810	1.2489
2014	1.1379	1.3199	1.1877
2015	1.1453	1.3432	1.1961
2016	1.1177	1.3270	1.1699
2017	1.1028	1.3131	1.1487
2018	1.0755	1.3034	1.1216

Source: NERA analysis, EI, NZCC ID database.

Table A.2: Non-exempt EDB's Opex Partial Productivity Indexes, 1996-2018.

Year	Two-output specification	Three-output specification	Four-output specification
1996	1.0000	1.0000	1.0000
1997	0.9486	0.9439	0.9571
1998	1.0438	1.0507	1.0588
1999	1.1767	1.1705	1.1880
2000	1.4415	1.4319	1.4622
2001	1.4815	1.4837	1.5146
2002	1.5999	1.6207	1.6291
2003	1.5516	1.5867	1.5801
2004	1.4125	1.4661	1.4448
2005	1.3124	1.3873	1.3553
2006	1.3513	1.4454	1.3944
2007	1.3469	1.4586	1.3992
2008	1.2977	1.4114	1.3477
2009	1.3859	1.5042	1.4240
2010	1.3361	1.4787	1.3862
2011	1.3232	1.4703	1.3728
2012	1.2620	1.4087	1.3178
2013	1.2411	1.3968	1.2983
2014	1.1736	1.3213	1.2230
2015	1.1902	1.3520	1.2405
2016	1.1649	1.3389	1.2172
2017	1.1752	1.3547	1.2222
2018	1.1362	1.3334	1.1830

Source: NERA analysis, EI, NZCC ID database.

Appendix B. Replication and Extension of EI 2014 dataset

This section describes the procedure taken to replicate and extend the operational expenditure (opex) partial productivity indices done originally by EI for the New Zealand Commerce Commission (NZCC), as part of their report entitled "Electricity Distribution Industry Productivity Analysis: 1996 – 2014".[43] The replication includes the indices both at the industry and non-exempt EDB level, with the additional extension from 2013 till 2018.

B.1. Datasets used.

The datasets used are:

(1) The EI 2014 NZ dataset: "Economic Insights NZ EDB Database excl Orion Jun2014.xls," available as part of the .zip file with the data from the proposed default price-quality paths for electricity distributors, from the 1 April 2015 study.[44]

(2) The EI 2018 Australian dataset "DNSPData AusNZOnt 1Nov2018x BM.xls," available as part of the .zip file with the data from the Australian Energy Regulator (AER) Annual Benchmarking Report 2018.[45]

(3) "Performance summaries for electricity distributors – Year to 31 March 2018," available at the NZCC webpage.[46]

(4) "Electricity-distributors-information-disclosure-data-20132018-23-October-2018.xlsm," available at the NZCC webpage.[47]

(5) Labour Cost Index (LCI), All Sectors Combined and Industry Group (ANZSIC06) (Base: June 2009 qtr (=1000)) (Qrtly-Mar/Jun/Sep/Dec). Electricity, gas, water and waste services, and all industries combined time series, available at Stats N.Z. Infoshare webpage.[48]

(6) Producers Price Index (PPI), Inputs (ANZSIC06) - NZSIOC level 1, Base: Dec. 2010 quarter (=1000) (Qrtly-Mar/Jun/Sep/Dec). Electricity, gas, water and waste services, and all industries combined time series, available at Stats N.Z. Infoshare webpage.[49]

B.2. Extending the dataset to 2018.

The series for the years 1996-2012 is sourced from the original EI dataset (1). For the years 2013 to 2018, the time series are extended using variables from both NZCC datasets (3 & 4), as per below:

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[43] Economic Insights, *Electricity Distribution Industry Productivity Analysis: 1996-2014*, 30 October, 2014.

[44] Economic Insights, *Productivity Analysis – Data and Analysis File*, 11 July, 2014.

[45] AER, *Economic Insights DNSP - Economic Benchmarking Results for the AER - 12 November 2018*, 12 November, 2018.

[46] NZCC, *Performance Summaries for Electricity Distributors – Year to 31 March 2018*, 08 November, 2018.

[47] NZCC, *Electricity Distributors' Information Disclosure Data 2013–2018 – 23 October 2018*, 07 November, 2018.

[48] Stats NZ, *Labour Cost Index – LCI, All Sectors Combined and Industry Group (ANZSIC06)(Base: June 2009 qtr (=1000)) (Qrtly-Mar/Jun/Sep/Dec)*, accessed on 6 May, 2019. http://archive.stats.govt.nz/infoshare/SelectVariables.aspx?pxID=d5b4ee0a-c93b-4dcf-abaf-7cc5117f4344.

[49] Stats NZ, *Producers Price Index – PPI, Table: Inputs (ANZSIC06) - NZSIOC level 1, Base: Dec. 2010 quarter (=1000) (Qrtly-Mar/Jun/Sep/Dec)*, accessed on 6 May, 2019. http://archive.stats.govt.nz/infoshare/SelectVariables.aspx?pxID=d8e0c6c8-c5f9-468d-8ecb-c4497ae10fa3.

- **Circuit length**: From the database (3), under selection “Total circuit length (km),” and schedule “9e(ii).”
- **Customer Numbers:** From the database (3), under selection “Average no. of ICPs in disclosure year.” Starting 2013, the number of customers is obtained by scaling the previous year figure by the implicit growth rate in the performance summary records, between the observation and previous year.
- **Energy**: Sourced from the database (3), under selection “Electricity entering system for supply to consumers” and schedule “9e(ii).”
- **System capacity**: Following EI methodology, the system capacity is measured by transformer capacity multiplied by circuit length, or kVA*kms.[50] Due to the EDB’s reporting transformer capacity inconsistently, two data series were combined, with the appropriate series being matched based on the previous numbers in the EI 1996-2013 dataset (1).[51] This series comes from the dataset (3), and are under the descriptions “Distribution transformer capacity (EDB owned)" and "Total distribution transformer capacity", network "All", and schedule "SCHEDULE 9e: REPORT ON NETWORK DEMAND."
- **Ratcheted Maximum Demand**: From database (3), under selection “Maximum coincident system demand” and schedule “9e(ii).” Ratcheted demand is just the maximum demand experienced by the EDB up to the relevant point in time.[52]
- **Opex**: The data is sourced from (4), under “Operational expenditure”, subcategory “Actual”, and section "3(i): Regulatory Profit". In the next appendix, we describe an issue we had reconciling our opex calculations with the original EI database. Additionally, a weighted-averaged opex price index is also built based on the labour cost index (LCI) (5) and the producers price index (PPI) (6).[53]
- **Revenue:** Calculated using description values from (4) and the EI definition of “deemed revenue”, for years 1996 to 2014:[54]

    Deemed revenue = Line charge revenue + Other regulated income (other than gains / (losses) on asset disposals) - Non-exempt EDB electricity lines service charge payable to Transpower - Avoided transmission charge

  Starting 2015, the charge “Non-exempt EDB electricity lines service charge payable to Transpower” is substituted by the charge “Electricity lines service charge payable to Transpower”. All the revenue entries are under schedule "SCHEDULE 3: REPORT ON REGULATORY PROFIT."

[50] See Economic Insights (2014), p. 7.

[51] Economic Insights (2014), p. 9.

[52] It is worth mentioning that the series for Vector starts again in 2009, due to the separation of Wellington Electricity.

[53] EI uses a 62% weight for the LCI, and 38% for the PPI.

[54] This definition was provided to us by EI.

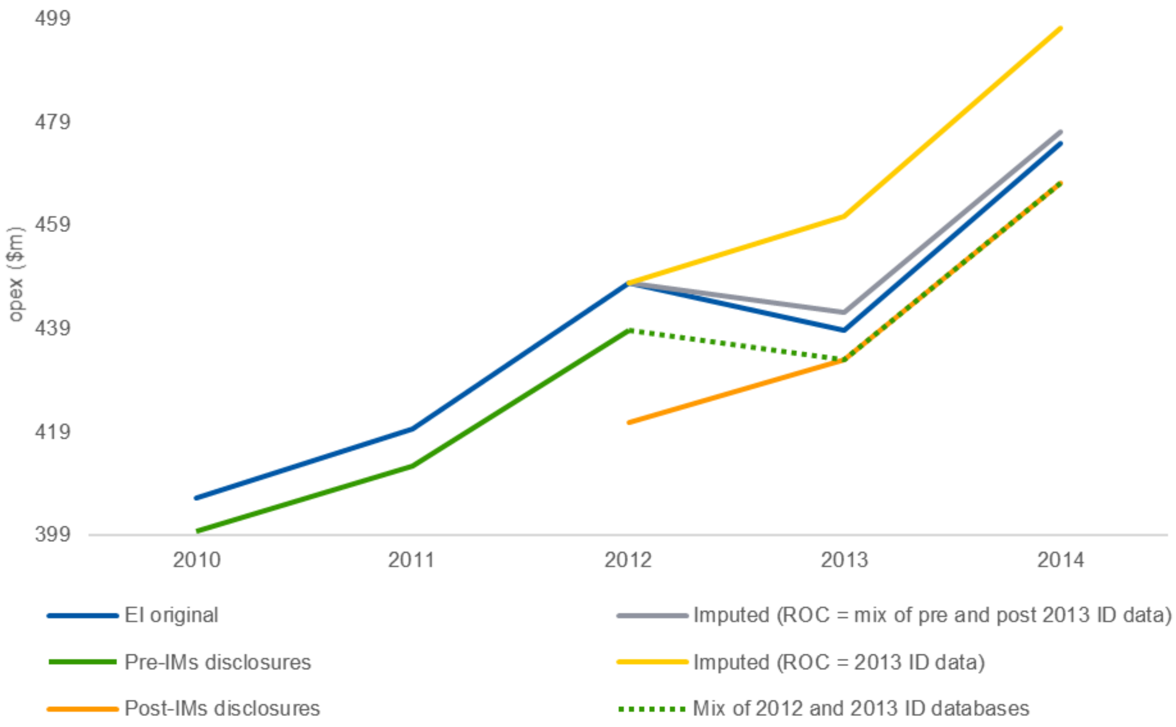
Appendix C. Opex reconciliation

As described in EI (2014),[55] EI's opex series for EDBs scales the 2008 figures for changes in the subsequently disclosed opex figures. This is because of a change in the reported opex categories that occurred in 2008. However, in attempting to replicate the EI figures, it appears they have not accounted for a change to the ID opex figures that occurred with the introduction of the input methodologies in 2013.

The "post-IMs" disclosures include a retrospective disclosure figure for 2012 which is lower than the figure contained in the "pre-IMs" disclosures. Therefore, using the pre-IMs figure for 2012 and the post-IMs figure for 2013 suggests that opex fell, whereas using the post-IMs figures shows a moderate increase in opex between 2012 and 2013. This is demonstrated in Figure C.1 below which shows, for the industry as a whole: the pre-IM disclosures, the post-IMs disclosures, EI's imputed series, an imputed series that scales EI's 2012 figure using either the post-IM disclosure data or the pre-IMs disclosure for 2012 and the post-IM disclosures for 2013 onwards.

This suggests that EI's imputed series incorrectly declines between 2012 and 2013 due to combining two different opex series to calculate the rate of change. Calculating the rate of change just using post-IM data results in opex increasing between 2012 and 2013.

Figure C.1: Replication of EI's imputed opex series



Source: NERA analysis, EI, NZCC ID database.

[55] Economic Insights (2014)

Appendix D. Replication of EI 2014 Index Results

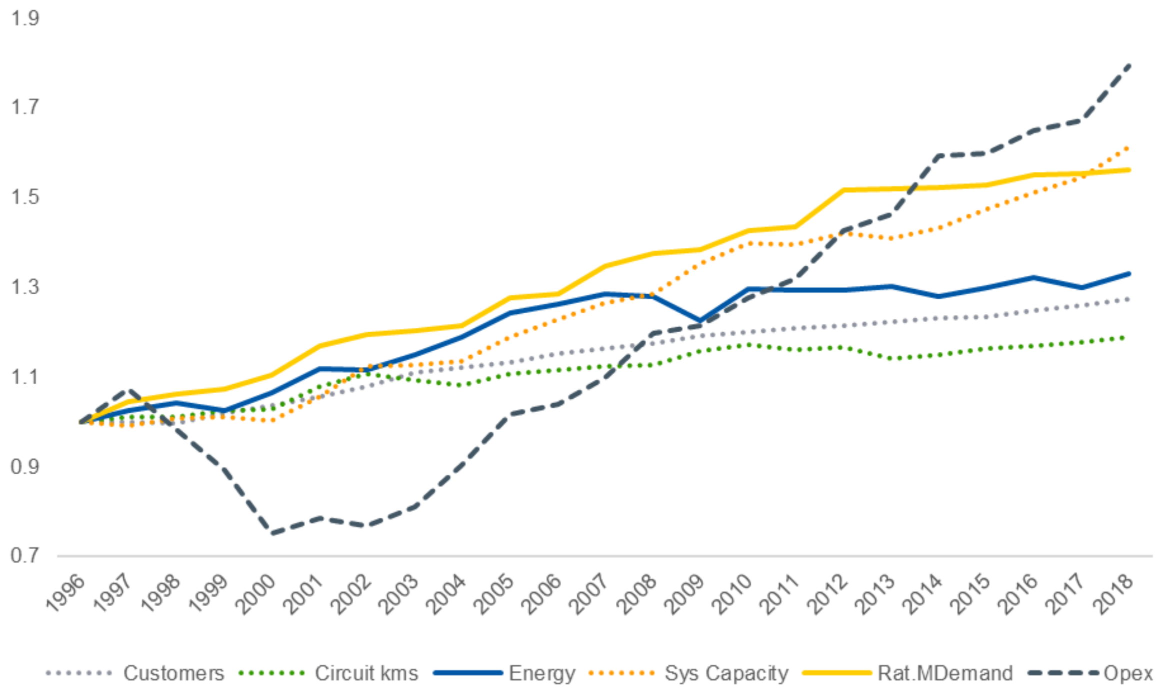
As noted above, our results largely replicate the indices calculated by EI. This is demonstrated by Figure D.1 below.

Figure D.1: Comparison of EI 2014 and NERA industry level productivity index calculations

As can be seen from Figure D.1, other than 2013 and 2014, our results track EI's with minor variation. This is likely attributable to our use of the Tornqvist index (following EI's more recent practice) as compared to the Fisher index which EI used in 2014. The large difference in the series in 2013 and 2014 is likely attributable to the issue described in Appendix C. I.e. incorrect splicing of the pre and post input methodologies (IM) series resulting in a drop in opex (and therefore increase in productivity) between 2012 and 2013.

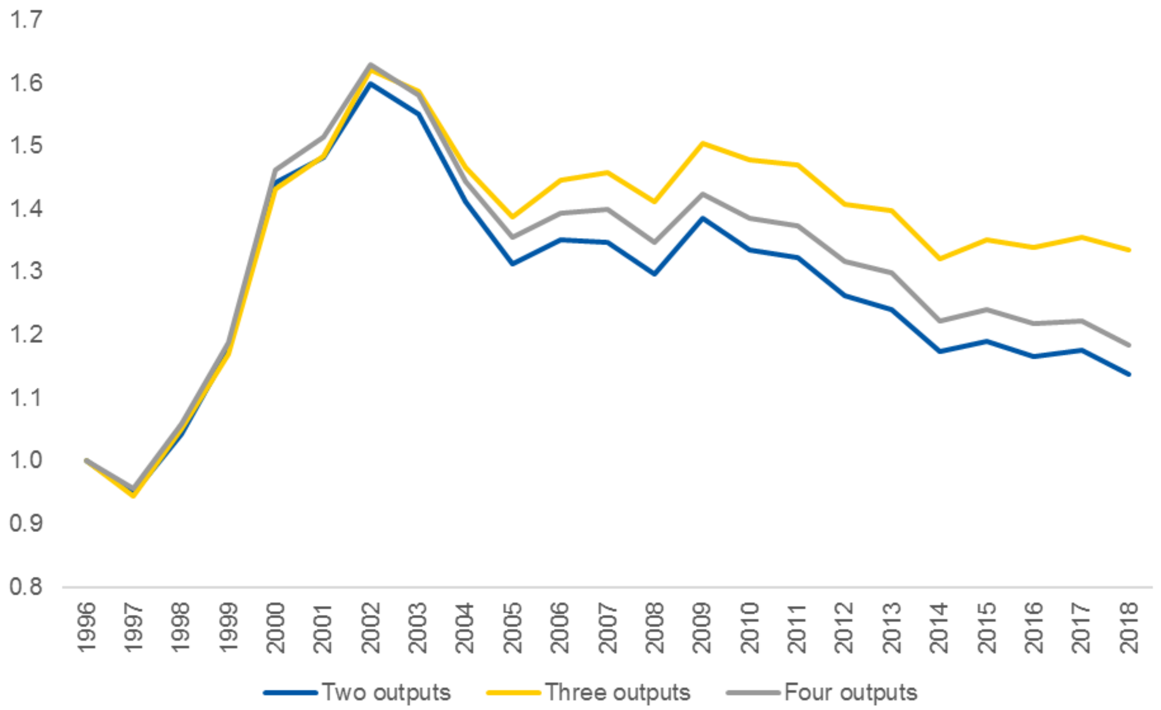
Appendix E. Non-Exempt PFP analysis

Figure E.1: Non-Exempt EDB Opex and Output Components Quantity Indices



Source: NERA analysis, EI, NZCC ID database.

Figure E.2: Non-Exempt EDB's Opex Productivity Indices



Source: NERA analysis, EI, NZCC ID database.

Table E.3: Non-Exempt EBD productivity trends

Measurement window and method	Two-output specification	Three-output specification	Four-output specification
Continuous Compounding Growth (1996-2018)	0.58%	1.31%	0.76%
Continuous Compounding Growth (1996-2004)	4.32%	4.78%	4.60%
Continuous Compounding Growth (2004-2018)	-1.55%	-0.68%	-1.43%
Logarithmic Regression Growth (1996-2018)	0.02%	0.82%	0.20%
Logarithmic Regression Growth (1996-2004)	6.57%	6.99%	6.80%
Logarithmic Regression Growth (2004-2018)	-1.43%	-0.67%	-1.32%

Source: NERA analysis, EI, NZCC ID database.

Figure E.3: Non-Exempt EDB productivity sensitivity to measurement window

Source: NERA analysis, EI, NZCC ID database.

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