Productivity Trends of New Zealand Electricity Distributors

Pacific Economics Group, LLC

Economic and Litigation Consulting

Productivity Trends of New Zealand Electricity Distributors

June 2014

Larry Kaufmann, Ph.D.
Senior Advisor

David Hovde, M.S.
Vice President

PACIFIC ECONOMICS GROUP

22 East Mifflin, Suite 302
Madison, Wisconsin USA 53703
608.257.1522 608.257.1540 Fax

Table of Contents

1. INTRODUCTION AND SUMMARY

1.1 Introduction

The electricity distribution businesses (EDBs) in New Zealand are subject to Part 4 of the Commerce Act 1986 (The Act), as amended by the Commerce Amendment Act 2008. In 2009, the Commerce Commission (the Commission) set a default price-quality paths (DPP) for the EDBs that determines allowed changes in electricity distribution prices for the 2010-2015 period. The DPP must comply with a number of requirements specified in the legislation. In particular, Paragraph 53P of the Act says that:

- The Commission must set only one rate of change in prices for each type of regulated service (subsection five), unless the Commission decides that an alternative rate of change is needed to minimize undue financial hardship to the supplier or price shock to consumers, or as an incentive for a supplier to improve its quality of supply (subsection eight)
- The rate of change must be based on the long-run average productivity improvement achieved by suppliers operating in the industry in New Zealand, or by suppliers in comparable countries (subsection six)
- The selected rate of change may take into account the effects of inflation in the prices of inputs used by suppliers in the industry (subsection seven)

In 2012, the Commission reset the DPP for the April 1, 2013 to March 31, 2015 period. The DPP was reset to reflect a set of changes in regulatory rules, requirements and processes collectively known as "input methodologies." Effectively, the input methodologies establish a "building block" framework for setting allowed revenues for EDBs over a multi-year regulatory period. The Act continues to mandate a price path with a rate of change based on long-run productivity improvement, but the price path *per se* no longer has any material impact on the magnitude of allowed revenues for EDBs over the price control period.

However, the 2012 reset also established a formula for setting EDBs' allowed operating expenditures (opex) that requires forecast changes in the industry's *opex*

productivity. This formula updates an initial level of EDB opex to reflect the impact of changes in the scale of EDB output, opex input prices, and forecast partial factor productivity (PFP) trends of opex inputs in the electricity distribution industry. Projected changes in opex PFP can therefore have a direct impact on EDBs' allowed revenue. In its March 2014 *Process and Issues* paper, the Commission indicated that it plans to use a similar approach for setting EDBs' allowed opex for the 2015-2020 period.

Pacific Economics Group (PEG) was hired by New Zealand's Electricity Networks Association (ENA) to estimate total factor productivity (TFP) and opex PFP and capital PFP trends for New Zealand's electricity distribution industry. The industry's opex PFP trend can be used to project future changes in opex PFP, which will directly impact EDBs' allowed revenues in the upcoming price controls. The industry's TFP trend will provide an empirical foundation for the productivity-based rate of change formula, which will impact EDBs' recovery of allowed costs in each year of the plan but not overall allowed costs.

Following a brief summary of the study, our report is organized as follows:

- Chapter Two presents details on the data and indexing methods used to develop productivity and related index-based results
- Chapter Three presents the results of PEG's TFP, opex PFP and related indexes for NZ's electricity distribution industry
- Chapter Four reports multi-factor productivity (MFP) and CPI data from Statistics New Zealand and uses these data to compute TFP and input price trends for the New Zealand economy
- Chapter Five summarizes our main findings and conclusions

1.2 Summary of Results

1.2.1 Productivity

A TFP index is the ratio of an overall output quantity index to an overall input quantity index. The growth trend of a TFP trend index is the difference between the trends in overall output and input quantity indexes. The TFP index developed for this study measured the TFP growth trend for New Zealand's electricity distribution industry.

An opex PFP index is the ratio of an overall output quantity index to an index of O&M inputs. The growth trend of an opex PFP index is the difference between the trends in the output quantity index and the O&M input quantity index. The opex PFP index developed for this study measured the O&M PFP growth trend for New Zealand's electricity distribution industry.

PEG considered two different specifications for the output quantity index. The first measured trends in the number of customers served, total volumes delivered, and (non-coincident) peak demands of New Zealand's EDBs. This is the same output quantity index used in PEG's previous TFP work for the NZ EDBs and similar to the output quantity specifications used in many electricity distribution TFP studies. The second option measured trends in the number of customers served and total km of distribution line. The Commission has indicated that these two outputs will be used to quantify the 'scale effects' of EDB output on forecast opex, so PEG's alternate output specification is consistent with the outputs the Commission intends to use when projecting allowed opex under the price controls.

The input quantity index in our TFP analysis summarizes trends in the amounts of capital and O&M inputs that the EDBs used. By definition, the input quantity in PEG's opex PFP analysis measures changes in EDBs' opex inputs only.

1.2.2 Productivity and Input Price Research for EDBs

We calculated the TFP and opex PFP trends for New Zealand's EDBs using Tornqvist indices. We computed TFP and opex PFP using both the three-output (customers, kWh deliveries and peak demand) and two-output (customers and km of line) specifications discussed above. The sample period was 2001 - 2012.

Using the three-output specification, we estimate the EDBs' TFP grew at an average annual rate of -1.34% over the 2001-2012 period. Output quantity grew at an average rate of 1.60% per annum. The input quantity index grew more rapidly, at an average rate of 2.93% per annum. Within the input quantity index, capital inputs grew at an average annual rate of 2.77 % per annum over the sample period. O&M inputs increased somewhat more rapidly, at an average rate of 3.17% per annum.

Using the two-output specification, PEG estimates the EDBs' TFP grew at an average annual rate of -1.80% over the 2001-2012 period. Output quantity grew at an average rate of 1.13% per annum. The input quantity index was identical to that used in the alternate TFP specification and grew at an average rate of 2.93% per annum.

Opex PFP growth is equal to the change in overall output quantity minus the change in opex inputs. PEG estimates that opex inputs grew at an average annual rate of 3.17% over the 2001-2012 period. Because the three-output quantity index grew by 1.60% per annum over this period, we estimate that the opex PFP trend was -1.58% per annum using the three output quantity specification (*i.e.* 1.60% - 3.17% = -1.58%, when rounded to decimal points). The two-output quantity index grew by 1.13% per annum over the 2001-2012 period, so PEG estimates that the opex PFP trend was -2.04% per annum using the two-output quantity specification (*i.e.* 1.14% - 3.17% = -2.04%).

Capital PFP growth is equal to the change in output quantity minus the change in capital inputs. PEG estimates that capital inputs grew at an average annual rate of 2.77% over the 2001-2012 period. Capital PFP growth was therefore -1.17% per annum over the sample period using PEG's three-output specification and -1.63% per annum using PEG's two-output specification.

PEG also computed industry input price indexes. We estimate that industry input prices grew at an average rate of 2.32% over the 2001-2012 period. Capital input prices increased by 2.04% per annum over this period, while O&M input prices increased at an average rate of 2.69% per annum.

1.2.3 Productivity and Input Price Research for the NZ Economy

PEG also examined data on MFP trends developed by Statistics New Zealand (StatsNZ). The StatsNZ data show that MFP for the broadest available measure of the New Zealand economy grew at an average rate of 0.32% per annum over the same 2001-2012 period that PEG used to estimate the EDBs' TFP trend.

The input price trend for the NZ economy is equal to inflation in the NZ economy plus the long-run trend in NZ MFP. Annual growth in the NZ CPI averaged 2.60% over the 2001-2012 period. If we use 0.32% as the long-run MFP trend of the New Zealand

economy, the long-run input price trend for the economy is equal to 2001-2012 average CPI inflation of 2.60% plus 0.32%, or 2.92% per annum.

1.2.4 Recommendations

PEG estimates the EDBs' opex PFP trend is between -1.58% (the estimate from our three-output specification) and -2.04% (from the two-output specification). The opex PFP forecast is part of an opex adjustment formula that includes a scale effects term, which the Commission intends to calibrate using the same outputs in PEG's two-output specification. This adjustment formula would internally inconsistent, and incompatible, if different outputs were used for different components of the same formula. All elements of this formula should be internally consistent, so PEG's recommended opex PFP trend is based on the two-output specification and equal to -2.04%.

In the 2003 and 2009 reviews, the Commission calculated the "X factor" in the EDBs' rate of change formula as the sum of the TFP differential and the input price differential. The TFP differential is equal to the growth in industry TFP minus the growth in economy-wide TFP. The input price differential is equal to the economy-wide input price trend minus the industry input price trend. In principle, it remains valid to compute the X factor for a rate of change formula in this manner even though the X factor *per se* does not directly impact the EDBs' allowed revenues.

A reasonable estimate of the EDBs' long-run TFP trend is between -1.34% (the estimate from our three-output specification) and -1.80% (the estimate from our two-output specification). The economy-wide MFP trend for New Zealand is 0.32%. This implies that a reasonable estimate of the TFP differential for NZ's electricity distribution industry is between -1.66% and -2.12%.

The input price trend for the NZ economy is 2.92%. PEG's estimated input price trend for NZ's EDBs is 2.32%. This implies that the input price differential is 0.60%. The value for the X factor used in the rate of change formula should therefore be between -1.06% (*i.e.* a -1.66% TFP differential plus a 0.60% input price differential) and -1.52% (*i.e.* a -2.12% TFP differential plus a 0.60% input price differential).

The TFP estimate in the rate of change formula should have the same output specification used to project opex PFP. If this is not the case, the empirical parameters in the Commission's ratemaking formulae will be internally inconsistent. PEG's preferred TFP differential and X factor are therefore derived from the two-output specification, and we recommend a -1.52% value for the X factor in the rate of change of formula.

We note that negative TFP and opex PFP trends are consistent with the theory of incentive regulation and a number of recent regulatory decisions. A negative productivity estimate should not be interpreted as evidence that NZ's electricity distribution industry is becoming "less efficient;" it simply means that the inputs needed for EDBs to provide service have been growing more rapidly than their outputs.[1] This trend is clearly evident for the EDBs, which registered negative TFP growth in each of the last ten years for which data are available. Negative productivity trends have also become more pronounced since 2006. Because PEG's recommendations about the magnitudes of continuing productivity declines are based on long-term 2001-2012 trends, they are less negative than the EDBs' recent experience and may turn out to be conservative.

[1] Further discussion of the meaning and interpretation of negative productivity factors is provided in Section 4.2 of PEG's August 2014 report, *Review of Economic Insights' Report Electricity Distribution Productivity Analysis: 1996-2013*.

2. DATA AND METHODOLOGICAL ISSUES

This chapter presents an overview of the data and methods used to calculate TFP and related trends for New Zealand's EDBs. We begin by discussing data issues. We then provide a relatively non-technical discussion of the methods employed for index calculation.

2.1 Data

2.1.1 Data Sources and Sample Period

The primary source of data used in our productivity research is the Economic Insights (EI) dataset. PEG used the EI data for the sample period from 1998 through 2008. We supplemented this dataset with 2009-2012 Information Disclosure data that were compiled by PricewaterhouseCoopers (PwC) and provided to PEG.[1] Because PEG noticed some anomalies with reported km of line data for some EDBs, we requested km data from PwC that were recorded on a consistent definitional basis over time.[2]

PEG also relied on MFP, CPI, producer price index (PPI), labor cost index, and capital goods price data collected by Statistics New Zealand. The MFP and CPI data are used to develop the economy-wide components of the TFP and input price differentials. PEG used the capital goods price index, labor cost index and PPI in the computation of the industry input price index, as explained further in Section 2.3.2.

The sample period for our analysis was 2001 through 2012. Although PEG had EDB data for 1999-2000, these were anomalous years for New Zealand's electricity distribution industry because of the ongoing impacts of industry restructuring and the

[1] It should be noted that, during the sample period, United Networks was sold to Vector, Unison and Powerco. Because it was impossible to determine from available data what assets, cost and outputs of United Networks were allocated to the purchasing companies, PEG aggregated the data for all four of these EDBs and treated it as a consolidated entity over the entire sample period.

[2] In particular, PEG noticed apparent anomalies in reported km of line data for Orion and Vector. In 2008, the Commission clarified that its definition of circuit km should exclude street lighting and communications circuit. In order to assess the potential impact of this clarification on reported km of line, the Commission asked the EDBs to provide transitional disclosures that presented historical data (back to 2005) using the refined definition. While not all EDBs provided these transitional disclosures, both Orion and Vector did, and PwC and PEG used these data to develop a new km series that was recorded on a more internally consistent basis over time than the km of line data reported in the Information Disclosures.

1998 power outage in Auckland's central business district. Both were one-time, unusual events that affected EDBs' reported 1998-2000 data. PEG believes conditions from 1999-2000 are not representative of or relevant to the industry's current experience, and measured cost trends could be distorted if these years are included in the analysis. A twelve year, 2001-2012 sample is also more than sufficient for calculating the industry's long-run TFP trend, so PEG chose 2001-2012 as the sample period.

2.1.2 Choices and Definitions of Outputs and Inputs

PEG considered two different specifications for the output quantity index. The first was a weighted average of growth in three output quantity subindexes: the number of customers, total delivery volumes (GWh), and non-coincident demands (GW). These output choices correspond to the billing determinants for the EDBs, or the services which actually generate the EDBs' allowed revenues. This is the same output quantity index used in PEG's previous TFP work for the NZ EDBs and similar to the output quantities used in many electricity distribution TFP studies.

The second option measured trends in the number of customers served and total km of distribution line. This Commission has indicated that these two outputs will be used to quantify the 'scale effects' of EDB output on forecast opex. PEG's alternate output specification is therefore consistent with the output specification the Commission intends to use for other elements of the formula that will set allowed opex under the price controls.

In both specifications, PEG used relative cost elasticities to weight outputs. These cost elasticities were estimated in a recent econometric cost study that PEG conducted for electricity distributors in Ontario.[3] Since the "input methodologies" approach for establishing the 2015-2020 controls is focused on setting prices to recover

[3] These cost elasticities are presented in Table 8 of the November 2013 PEG report, *Productivity and Benchmarking Research in Support of Incentive Rate Setting in Ontario: Final Report to the Ontario Energy Board*. In that table, the cost elasticity for customer numbers is 0.4077; the cost elasticity for peak demand is 0.1942; the cost elasticity for retail kWh deliveries is 0.0712; and the cost elasticity for average km of line is 0.3090. The cost elasticity shares for the three-output specification are therefore (.4077/(.4077+.1942+/0712)) = 0.606 for customers; (.1942/(.4077+.1942+/0712)) = 0.289 for peak demand; and (.0712/(.4077+.1942+/0712)) = 0.106 for kWh deliveries. The cost elasticity shares for the two-output specification are (.4077/(.4077+.3090)) = 0.569 for customers and (.3090/(.4077+.3090)) = 0.431 for km of line.

allowed costs, it is appropriate to use cost elasticity-based weights (rather than revenue weights) that reflect the impact of the respective outputs on electricity distribution costs for constructing the output quantity index.

We divided inputs into two categories: operation and maintenance (O&M) expenses and capital inputs. We describe the measurement of input costs and quantities in section 2.3.2.

2.2 Indexing Methods

PEG calculated TFP, opex PFP and capital PFP using the Törnqvist index form.[4] PEG and many other researchers have used Törnqvist indices to estimate TFP growth. With the Törnqvist form, the annual growth rate of the overall input quantity index is determined by the formula:

$$\ln\left(Input\ Quantities_t \Big/ Input\ Quantities_{t-1}\right) = \sum_j \frac{1}{2}\cdot\left(S_{j,t} + S_{j,t-1}\right)\cdot\ln\left(X_{j,t} \Big/ X_{j,t-1}\right). \qquad [1]$$

Here in each year *t*,

$Input\ Quantities_t$ = Input quantity index

$X_{j,t}$ = Input quantity subindex for input category *j*

$S_{j,t}$ = Share of input category *j* in applicable total cost.

It can be seen that the growth rate of the index is a weighted average of the growth rates of the quantity subindexes. Each growth rate is calculated as the logarithm of the ratio of the quantities in successive years.

Annual growth rate of the Törnqvist output quantity index is given by the formula:

$$\ln\left(Output\ \text{Quantities}_t \Big/ \text{Output Quantities}_{t-1}\right) = \sum_j \frac{1}{2}\cdot\left(S_{k,t} + S_{k,t-1}\right)\cdot\ln\left(Y_{k,t} \Big/ Y_{k,t-1}\right). \qquad [2]$$

Here in each year *t*,

$Output\ Quantities_t$ = Output quantity index

$Y_{k,t}$ = Output quantity subindex for output category *k*

$S_{k,t}$ = Share of output category *k* in applicable total cost.

[4] The Tornqvist is one of two "superlative" index forms that are used in most productivity research; the other is the Fisher Ideal form. In practice, these two forms typically lead to almost identical TFP index results, as Economic Insights has acknowledged in its most recent reports to the Commission.

In both instances, the growth rate of the index is a weighted average of the growth rates of the quantity subindexes. Each growth rate is calculated as the logarithm of the ratio of the quantities in successive years. For the output quantity index, weights are equal to the share of each quantity subindex's share of the sum of cost elasticities for output subindexes. For the input quantity indexes, weights are equal to the average shares of each input in the EDBs' aggregate applicable total cost during these years.

The annual growth rate in the TFP index is given by the formula

$$\ln\left(TFP_t / TFP_{t-}\right) = \ln\left(Output\ Quantities_t / Output\ Quantities_{t-1}\right) - \ln\left(Input\ Quantities_t / Input\ Quantities_{t-1}\right). \quad [3]$$

The annual growth rate in PFP is analogous, except the only input quantity included in the second term on the right-hand side of [3] is opex inputs for opex PFP and capital inputs for capital PFP.

We estimated productivity trends for New Zealand's EDBs for the 2001-2012 period. Since the index formulas involve annual growth rates, some method is needed to calculate trends from the annual growth rates. The trend in each TFP index was computed using the formula

$$\text{trend TFP}_t = \frac{\sum_{t}^{2012}_{2001} \ln\left(TFP_t / TFP_{t-1}\right)}{11} \quad [4]$$

$$= \frac{\ln\left(TFP_{2012} / TFP_{2001}\right)}{11}$$

It can be seen that the trend is the average annual growth rate during the years of the sample period. The reported trends in other indexes that appear in this report are computed analogously.

2.3 Indexing Details

2.3.1 Scope

The applicable total cost of electricity distribution was calculated as power distribution O&M expenses plus the cost of plant ownership. O&M cost figures were drawn directly from the EI dataset and the Information Disclosure Statements. Capital cost was determined using a capital service price methodology. Under this approach, the cost of capital is the product of a capital quantity index and the price of capital services. This method has a solid basis in economic theory and is well established in the scholarly literature.

2.3.2 Input Quantity and Price Subindexes

The input quantity index was constructed as a weighted average of input quantity subindexes for capital and O&M inputs. Growth in each input quantity subindex must be expressed in real, inflation-adjusted terms. Each input quantity subindex must therefore be "deflated" by an associated input price subindex.

The approach to quantity trend measurement taken in each case relies on the theoretical result that the growth rate in the cost of any class of input *j* is the sum of the growth rates in appropriate input price and quantity indexes for that input class. Thus,

$$growth\ Input\ Quantities_j = growth\ Cost_j - growth\ Input\ Prices_j . \qquad [5]$$

The quantity subindex for O&M was the ratio of the O&M expenses to an opex input price index. PEG's opex input price index is identical to the index the Commission is using to measure input price changes when projecting the EDBs' allowed opex. This input price index is equal to a weighted average of the change in the all industries labor cost index and the all industries PPI, with a 60% weight applied to the labor cost index and a 40% weight applied to the PPI.

A simplified service price approach was chosen to measure capital cost. This approach has a solid basis in economic theory and is widely used in scholarly empirical work.[5] In the application of the general method used in this study, the cost of a given class

[5] See Hall and Jorgensen (1967) for a seminal discussion of the service price method of capital cost measurement.

of utility plant *j* in a given year *t* ($CK_{j,t}$) is the product of a capital service price index ($WKS_{j,t}$) and an index of the capital quantity at the end of the prior year (XK_{t-1}).

$$CK_{j,t} = WKS_{j,t} \cdot XK_{j,t-1}. \quad [6]$$

Each capital quantity index is constructed using inflation-adjusted data on the value of utility plant.

In constructing indexes, we took the value of each EDB's RAB in 2004 as the benchmark or starting year. This is the year of the most recent revaluation of the EDBs' capital stock. The following formula and data were used to compute subsequent, and prior, values of the capital quantity index:

$$XK_{j,t} = (1 - d) \cdot XK_{j,t-1} + \frac{VI_{j,t}}{WKA_{j,t}}. \quad [7]$$

Here, the parameter *d* is the depreciation rate and VI_t is the value of gross additions to utility plant. The asset-price index (WKA_t) was equal to the capital goods price index for all industries.

The depreciation rate for each company was measured as 3.09%, which is approximately equal to the EDBs' value of regulatory depreciation divided by RAB over the sample period. PEG also used a geometric depreciation formulation, which has ample support in the empirical literature and is used by respected government agencies to measure capital.[6] Under geometric decay, the rate of depreciation is constant in all sample years.

The full formula for a capital service price index is:

$$WKS_t = r_t \cdot WKA_{j,t-1} + d \cdot WKA_{j,t}. \quad [8]$$

The two terms in this formula correspond to the return to capital and depreciation. This is sometimes referred to as the "return on" and the "return of" capital. The term r_t is the return to capital. We assumed a 4% real return to capital, which is identical to what StatsNZ assumes when it calculates multi-factor productivity trends for the NZ economy.[7] The term d_t is the regulatory depreciation rate, equal to 3.09%, as described above.

---

[6] Hulten, Charles and Wykoff, Frank (1981), "The Measurement of Economic Depreciation," in *Depreciation, Inflation and the Taxation of Income from Capital*, The Urban Institute Press, 81-125.

[7] Statistics New Zealand, *Productivity Statistics: Sources and Methods*, Tenth Edition, p. 30.

2.3.3 Productivity Indexes

The growth rate in each EDB's TFP index was the difference between the growth rates in the industry's output and input quantity indexes. Growth in the output quantity index was either the weighted average of growth in the number of customers, power delivery volumes, and non-coincident peak demands, or a weighted average of the growth in customer numbers and km of line, depending on the output specification. In either case, weights were equal to each output's relative cost elasticity. The growth rate in each input quantity index was a weighted average of the growth rates in quantity subindexes for capital and O&M inputs. The weights were based on the shares of these input classes in total electricity distribution cost.

PEG also decomposed the TFP indices into opex PFP and capital PFP indices. The growth rate in opex PFP is equal to the growth in output quantity (either the three-output or two-output specification) minus the growth in opex inputs. The growth in capital PFP is equal to the growth in output quantity (either the three-output or two-output specification) minus the growth in capital inputs.

2.3.4 Input Price Indexes

PEG also developed input price indexes for the electricity distribution industry as part of our work. This was computed as a cost-share weighted average of the growth in input price subindexes for capital and O&M inputs. The capital input price subindex was the capital service price presented in equation [8]; the opex inpt price subindex was a weighted average of the all industries' labor cost and producer price indices, as described in Section 2.3.2.

3. SUMMARY OF EDB RESULTS

This chapter will briefly summarize the results of PEG's research on TFP and related trends for New Zealand's electricity distribution industry.

3.1 Output Quantities

Table One presents information on the output quantity index and component subindexes for the three-output specification. It can be seen that the overall output quantity index grew at an average annual rate of 1.60% over the 2001-2012 period. Output quantity is somewhat variable, with growth rates ranging from 2.62% in 2007 to 0.09% in 2011.

The number of customers served grew by an average of 1.30% over the sample period. This is both the smallest and most stable growth rate of the component subindexes. Annual customer growth ranged from 0.47% to 2.07% over 2001-2012, although it is clearly slowing over time. In the last three years, customer growth was 0.87% in 2010, 0.55% in 2011, and 0.47% in 2012, which are the three lowest growth rates in the sample period.

Delivery volumes increased by 1.44% per annum over the 2001-2012 period. Volumes were more variable than customer numbers, with growth rates that ranged from 4.52% in 2003 to -0.80% in 2011. Changes in peak demand were also variable, although demand actually displays a relatively rapid growth rate of 2.29% over the sample period.

Table Two provides analogous information for PEG's two output (customers and km of line) specification. These are the same two outputs the Commission is using to capture 'scale effects' when projecting the EDBs' allowed opex. This output measure grew at an average rate of 1.14% per annum over the sample period. As discussed, customers grew by 1.30% per annum. Total km of line grew more slowly, at 0.82% per annum. The growth in km was fairly steady over time, growing at an average rate of 0.90% in the 2001-2006 period and slowing only modestly to 0.76% growth per annum in the 2006-2012 period.

Table 1

Output Quantity Trends for Electricity Distributors, 2001-2012

(3-Output Specification)

Year	Output Quantity Index		Total Customers		Volumes		Maximum Demand	
	Index	Growth	Level	Growth	Level	Growth	Index	Growth
2001	1.000		1,748,370		26,239		5,159	
2002	1.020	1.97%	1,779,370	1.76%	26,216	-0.09%	5,324	3.2%
2003	1.041	2.02%	1,813,030	1.87%	27,429	4.52%	5,415	1.7%
2004	1.054	1.23%	1,851,000	2.07%	27,972	1.96%	5,369	-0.8%
2005	1.081	2.58%	1,875,120	1.29%	29,176	4.22%	5,634	4.8%
2006	1.095	1.32%	1,904,630	1.56%	29,728	1.87%	5,673	0.7%
2007	1.124	2.62%	1,928,570	1.25%	30,322	1.98%	6,011	5.8%
2008	1.140	1.36%	1,950,460	1.13%	30,350	0.09%	6,133	2.0%
2009	1.148	0.75%	1,979,790	1.49%	29,901	-1.49%	6,122	-0.2%
2010	1.170	1.85%	1,997,010	0.87%	31,041	3.74%	6,320	3.2%
2011	1.171	0.09%	2,007,930	0.55%	30,795	-0.80%	6,261	-0.9%
2012	1.192	1.78%	2,017,290	0.47%	30,754	-0.13%	6,637	5.8%
Average Annual Growth Rate								
2001-2012		1.60%		1.30%		1.44%		2.29%
2001-2006		1.82%		1.71%		2.50%		1.90%
2006-2012		1.41%		0.96%		0.57%		2.61%

Table 2

Output Quantity Trends for Electricity Distributors, 2001-2012

(2-Output Specification)

Year	Output Quantity Index		Total Customers		Total km of Line	
	Index	Growth	Level	Growth	Level	Growth
2001	1.000		1,748,370		137,652	
2002	1.019	1.92%	1,779,370	1.76%	140,340	1.93%
2003	1.026	0.66%	1,813,030	1.87%	139,598	-0.53%
2004	1.038	1.14%	1,851,000	2.07%	139,602	0.00%
2005	1.056	1.74%	1,875,120	1.29%	142,101	1.77%
2006	1.072	1.45%	1,904,630	1.56%	143,958	1.30%
2007	1.083	1.05%	1,928,570	1.25%	145,027	0.74%
2008	1.094	0.98%	1,950,460	1.13%	146,095	0.73%
2009	1.114	1.88%	1,979,790	1.49%	148,869	1.88%
2010	1.125	0.95%	1,997,010	0.87%	150,391	1.02%
2011	1.124	-0.08%	2,007,930	0.55%	149,611	-0.52%
2012	1.132	0.73%	2,017,290	0.47%	150,698	0.72%
Average Annual Growth Rate						
2001-2012		1.13%		1.30%		0.82%
2001-2006		1.38%		1.71%		0.90%
2006-2012		0.92%		0.96%		0.76%

3.2 Input Quantities

Table Three presents information on overall changes in the input quantity index. It can be seen that overall input quantity increases by an average 2.93% per annum over the 2001-2012 period. Tables Four and Five provide more detail on the changes in capital and O&M inputs, respectively. These tables decompose changes in the cost of each input into changes in input quantity and changes in input price. The changes in input quantity figures are relevant for when computing the TFP differential component of the X factor, while the changes in input price are used to compute the input price differential.

In Table Four, it can be seen that capital inputs increased at an average annual rate of 2.77% over the 2001-2012 period. Capital inputs have increased in each sample year, but there is a discernible acceleration in capital spending in the latter years. Capital inputs increased at an average rate of 3.55% per annum over the 2006-2012 period, which is nearly double the 1.82% annual growth in capital quantity over the 2001-2006 period.

In contrast, O&M inputs have grown at a relatively constant rate. Table Five shows that O&M inputs grew at an average rate of 3.26% per annum over the 2001-2006 period. O&M input growth slowed only slightly to 3.10% per annum over the 2006-2012 period. O&M input growth over the entire sample period averaged 3.17% per annum.

All else equal, the relatively constant growth of opex inputs over time means the Commission can have a high degree of confidence that past opex PFP trends will be a good proxy for opex PFP trends going forward. This is true even though the change in opex can vary significantly from year to year. EDB data show these year-to-year fluctuations have largely balanced out over the last two observed quinquennia, with the result that the trend in opex inputs the first half of the 2001-2012 sample period is quite similar to the trend in the second half.

Table 3

Input Quantity Trends for Electricity Distributors, 2001-2012

Year	Input Quantity Index		Capital Quantity		O&M Quantity	
	Index	Growth	Index	Growth	Index	Growth
2001	1.000		5,028		2,435	
2002	1.005	0.46%	5,087	1.16%	2,422	-0.54%
2003	1.030	2.51%	5,147	1.18%	2,531	4.43%
2004	1.066	3.40%	5,194	0.91%	2,712	6.88%
2005	1.110	4.06%	5,320	2.40%	2,887	6.27%
2006	1.129	1.66%	5,507	3.46%	2,866	-0.73%
2007	1.172	3.74%	5,706	3.55%	2,983	3.99%
2008	1.210	3.19%	5,925	3.76%	3,056	2.43%
2009	1.244	2.80%	6,166	3.98%	3,094	1.21%
2010	1.289	3.54%	6,381	3.43%	3,210	3.68%
2011	1.323	2.63%	6,597	3.32%	3,265	1.70%
2012	1.381	4.28%	6,816	3.27%	3,452	5.59%
Average Annual Growth Rate						
2001-2012		2.93%		2.77%		3.17%
2001-2006		2.42%		1.82%		3.26%
2006-2012		3.36%		3.55%		3.10%

Table 4

Capital Quantity, Price, and Cost Trends for Electricity Distributors, 2001-2012

Year	Capital Quantity		Capital Price Index		Capital Cost	
	Index	Growth	Index	Growth	Index	Growth
2001	5,028.3		75.207		378,165	
2002	5,086.8	1.16%	76.182	1.29%	387,526	2.45%
2003	5,147.2	1.18%	76.838	0.86%	395,499	2.04%
2004	5,194.0	0.91%	79.568	3.49%	413,273	4.40%
2005	5,320.1	2.40%	82.049	3.07%	436,507	5.47%
2006	5,507.2	3.46%	85.062	3.61%	468,453	7.06%
2007	5,706.2	3.55%	87.402	2.71%	498,732	6.26%
2008	5,924.8	3.76%	90.344	3.31%	535,275	7.07%
2009	6,165.7	3.98%	93.074	2.98%	573,863	6.96%
2010	6,380.9	3.43%	92.808	-0.29%	592,198	3.15%
2011	6,596.5	3.32%	93.127	0.34%	614,316	3.67%
2012	6,815.9	3.27%	94.084	1.02%	641,268	4.29%
Average Annual Growth Rate						
2001-2012		2.77%		2.04%		4.80%
2001-2006		1.82%		2.46%		4.28%
2006-2012		3.55%		1.68%		5.23%

Table 5

O&M Quantity, Price, and Cost Trends for Electricity Distributors, 2001-2012

Year	O&M Quantity		O&M Price Index		O&M Cost	
	Index	Growth	Index	Growth	Index	Growth
2001	2,435		107.62		262,028	
2002	2,422	-0.54%	108.83	1.12%	263,538	0.57%
2003	2,531	4.43%	109.90	0.98%	278,188	5.41%
2004	2,712	6.88%	111.94	1.84%	303,536	8.72%
2005	2,887	6.27%	115.85	3.43%	334,449	9.70%
2006	2,866	-0.73%	121.20	4.51%	347,362	3.79%
2007	2,983	3.99%	125.33	3.35%	373,835	7.34%
2008	3,056	2.43%	133.39	6.23%	407,677	8.67%
2009	3,094	1.21%	134.79	1.04%	416,988	2.26%
2010	3,210	3.68%	137.29	1.84%	440,659	5.52%
2011	3,265	1.70%	141.83	3.25%	463,020	4.95%
2012	3,452	5.59%	144.61	1.94%	499,252	7.53%
Average Annual Growth Rate						
2001-2012		3.17%		2.69%		5.86%
2001-2006		3.26%		2.38%		5.64%
2006-2012		3.10%		2.94%		6.05%

3.3 Input Price Trends

Table Six presents information on input price trends for the EDBs. It can be seen that the overall input price index grew by 2.32% per annum. Capital input prices grew at an average annual rate of 2.04% over the 2001-2012 period. O&M input prices grew somewhat less rapidly, at an average rate of 2.69%.

3.4 Productivity Trends

Table Seven presents information on TFP trends for the EDBs using the three-output specification. It can be seen that TFP declined at an average rate of 1.34% per annum over the 2001-2012 period. Output quantity grew by 1.60% per year and input quantity increased by an average 2.93% per annum over the entire sample period.

The declining TFP trend is more pronounced in later years of the sample. In 2001-2006, TFP declined at an average annual rate of 0.60% per annum. In 2006-2012, the TFP decline was 1.95% per annum. The main reason TFP declined more rapidly in later years was faster input quantity growth, although slowing output growth also contributed. The increase in capital spending led input quantity to grow by 3.36% per annum in 2006-2012 compared with 2.42% per annum in 2001-2006. Output quantity slowed more modestly, from 1.82% average growth in 2001-2006 to 1.41% per annum in 2006-2012.

Table 8 presents analogous information on TFP trends using the two-output specification. TFP declined by an average of 1.80% per annum over the entire sample period. The measured TFP decline for the two-output specification is lower than that for the three-output specifications because the two-output growth was 0.43% per annum less rapid in 2001-2006 and 0.49% per annum less rapid in 2006-2012.

Tables 9 and 10 present associated opex PFP trends for the three-output and two-output specifications, respectively. Table 9 shows that opex PFP declined by an average of 1.58% per annum over the 2001-2012 period. The average annual rate of PFP decline was 1.44% in 2001-2006 and 1.69% in 2006-2012. The relative stability of opex PFP decline reinforces the conclusion from Table 5 that the EDBs' past opex PFP trends will be a good proxy for opex PFP trends that can be expected for the industry going forward.

Table 6

Input Price Index Trends for Electricity Distributors, 2001-2012

Year	Input Price Index		Capital Input Price		O&M Price	
	Index	Growth	Index	Growth	Index	Growth
2001	640,193		75.207		107.620	
2002	648,044	1.22%	76.182	1.29%	108.830	1.12%
2003	653,951	0.91%	76.838	0.86%	109.900	0.98%
2004	672,523	2.80%	79.568	3.49%	111.940	1.84%
2005	694,574	3.23%	82.049	3.07%	115.850	3.43%
2006	722,895	4.00%	85.062	3.61%	121.200	4.51%
2007	744,790	2.98%	87.402	2.71%	125.330	3.35%
2008	779,601	4.57%	90.344	3.31%	133.390	6.23%
2009	796,549	2.15%	93.074	2.98%	134.790	1.04%
2010	801,456	0.61%	92.808	-0.29%	137.290	1.84%
2011	814,291	1.59%	93.127	0.34%	141.830	3.25%
2012	825,943	1.42%	94.084	1.02%	144.610	1.94%
Average Annual Growth Rate						
2001-2012		2.32%		2.04%		2.69%
2001-2006		2.43%		2.46%		2.38%
2006-2012		2.22%		1.68%		2.94%

Table 7

Total Factor Productivity Trends for Electricity Distributors, 2001-2012

(3-Output Specification)

Year	Total Factor Productivity		Output Quantity Index		Input Quantity Index	
	Index	Growth	Index	Growth	Index	Growth
2001	1.000		1.000		1.000	
2002	1.015	1.50%	1.020	1.97%	1.005	0.46%
2003	1.010	-0.49%	1.041	2.02%	1.030	2.51%
2004	0.988	-2.17%	1.054	1.23%	1.066	3.40%
2005	0.974	-1.48%	1.081	2.58%	1.110	4.06%
2006	0.971	-0.34%	1.095	1.32%	1.129	1.66%
2007	0.960	-1.12%	1.124	2.62%	1.172	3.74%
2008	0.942	-1.83%	1.140	1.36%	1.210	3.19%
2009	0.923	-2.06%	1.148	0.75%	1.244	2.80%
2010	0.908	-1.69%	1.170	1.85%	1.289	3.54%
2011	0.885	-2.54%	1.171	0.09%	1.323	2.63%
2012	0.863	-2.50%	1.192	1.78%	1.381	4.28%
Average Annual Growth Rate						
2001-2012		-1.34%		1.60%		2.93%
2001-2006		-0.60%		1.82%		2.42%
2006-2012		-1.95%		1.41%		3.36%

Table 8

Total Factor Productivity Trends for Electricity Distributors, 2001-2012

(2-Output Specification)

Year	Total Factor Productivity		Output Quantity Index		Input Quantity Index	
	Index	Growth	Index	Growth	Index	Growth
2001	1.000		1.000		1.000	
2002	1.015	1.46%	1.019	1.92%	1.005	0.46%
2003	0.996	-1.85%	1.026	0.66%	1.030	2.51%
2004	0.974	-2.26%	1.038	1.14%	1.066	3.40%
2005	0.952	-2.31%	1.056	1.74%	1.110	4.06%
2006	0.950	-0.21%	1.072	1.45%	1.129	1.66%
2007	0.924	-2.69%	1.083	1.05%	1.172	3.74%
2008	0.904	-2.21%	1.094	0.98%	1.210	3.19%
2009	0.896	-0.92%	1.114	1.88%	1.244	2.80%
2010	0.873	-2.59%	1.125	0.95%	1.289	3.54%
2011	0.850	-2.71%	1.124	-0.08%	1.323	2.63%
2012	0.820	-3.55%	1.132	0.73%	1.381	4.28%
Average Annual Growth Rate						
2001-2012		-1.80%		1.13%		2.93%
2001-2006		-1.03%		1.38%		2.42%
2006-2012		-2.44%		0.92%		3.36%

Table 9

O&M Productivity Trends for Electricity Distributors, 2001-2012

(3-Output Specification)

Year	O&M Productivity		Output Quantity Index		O&M Input Quantity Index	
	Index	Growth	Index	Growth	Index	Growth
2001	1.000		1.000		1.000	
2002	1.025	2.51%	1.020	1.97%	0.995	-0.54%
2003	1.001	-2.41%	1.041	2.02%	1.040	4.43%
2004	0.946	-5.65%	1.054	1.23%	1.114	6.88%
2005	0.912	-3.69%	1.081	2.58%	1.186	6.27%
2006	0.931	2.04%	1.095	1.32%	1.177	-0.73%
2007	0.918	-1.37%	1.124	2.62%	1.225	3.99%
2008	0.908	-1.07%	1.140	1.36%	1.255	2.43%
2009	0.904	-0.47%	1.148	0.75%	1.271	1.21%
2010	0.887	-1.83%	1.170	1.85%	1.318	3.68%
2011	0.873	-1.61%	1.171	0.09%	1.341	1.70%
2012	0.841	-3.81%	1.192	1.78%	1.418	5.59%
Average Annual Growth Rate						
2001-2012		-1.58%		1.60%		3.17%
2001-2006		-1.44%		1.82%		3.26%
2006-2012		-1.69%		1.41%		3.10%

Table 10

O&M Productivity Trends for Electricity Distributors, 2001-2012

(2-Output Specification)

Year	O&M Productivity		Output Quantity Index		O&M Input Quantity Index	
	Index	Growth	Index	Growth	Index	Growth
2001	1.000		1.000		1.000	
2002	1.025	2.47%	1.019	1.92%	0.995	-0.54%
2003	0.987	-3.77%	1.026	0.66%	1.040	4.43%
2004	0.932	-5.74%	1.038	1.14%	1.114	6.88%
2005	0.891	-4.52%	1.056	1.74%	1.186	6.27%
2006	0.910	2.18%	1.072	1.45%	1.177	-0.73%
2007	0.884	-2.94%	1.083	1.05%	1.225	3.99%
2008	0.871	-1.45%	1.094	0.98%	1.255	2.43%
2009	0.877	0.67%	1.114	1.88%	1.271	1.21%
2010	0.853	-2.74%	1.125	0.95%	1.318	3.68%
2011	0.838	-1.77%	1.124	-0.08%	1.341	1.70%
2012	0.799	-4.86%	1.132	0.73%	1.418	5.59%
Average Annual Growth Rate						
2001-2012		-2.04%		1.13%		3.17%
2001-2006		-1.88%		1.38%		3.26%
2006-2012		-2.18%		0.92%		3.10%

Opex PFP growth has become only somewhat more negative over time because of slowing output growth.

Table 10 shows that opex PFP declined by an average of 2.04% per annum using the two-output specification. The more rapid decline in opex PFP using the two-output measure is due to slower measured growth in output. However, as with the three-output specification, opex PFP is relatively constant over time, and changes only modestly (from -1.88% per annum to -2.18%) from the first half to the second half of the 2001-2012 sample period.

Tables 11 and 12 present capital PFP trends for the three-output and two-output specifications, respectively. Table 11 shows that capital PFP grew by -1.17% per annum over the 2001-2012 period. Capital PFP was flat (i.e. zero growth) in the 2001-2006 period, as capital inputs and overall output each grew at a 1.82% annual rate. In 2006-2012, capital growth nearly doubled to 3.55% per annum while output growth slowed to 1.41%. Capital PFP therefore declined by -2.14% per annum in 2006-2012.

Table 12 presents analogous results for the two-output specification. Because measured output growth was slower, capital PFP declined at a more rapid 1.63% per annum rate. Capital PFP declined at average rates of 0.44% and 2.63%, respectively, in the 2001-2006 and 2006-2012 periods.

Table 11

Capital Productivity Trends for Electricity Distributors, 2001-2012

(3-Output Specification)

Year	Capital Productivity		Output Quantity Index		Capital Quantity Index	
	Index	Growth	Index	Growth	Index	Growth
2001	1.000		1.000		1.000	
2002	1.008	0.81%	1.020	1.97%	1.012	1.16%
2003	1.017	0.84%	1.041	2.02%	1.024	1.18%
2004	1.020	0.33%	1.054	1.23%	1.033	0.91%
2005	1.022	0.18%	1.081	2.58%	1.058	2.40%
2006	1.000	-2.14%	1.095	1.32%	1.095	3.46%
2007	0.991	-0.93%	1.124	2.62%	1.135	3.55%
2008	0.967	-2.40%	1.140	1.36%	1.178	3.76%
2009	0.937	-3.24%	1.148	0.75%	1.226	3.98%
2010	0.922	-1.58%	1.170	1.85%	1.269	3.43%
2011	0.893	-3.24%	1.171	0.09%	1.312	3.32%
2012	0.879	-1.49%	1.192	1.78%	1.356	3.27%
Average Annual Growth Rate						
2001-2012		-1.17%		1.60%		2.77%
2001-2006		0.00%		1.82%		1.82%
2006-2012		-2.14%		1.41%		3.55%

Table 12

Capital Productivity Trends for Electricity Distributors, 2001-2012

(2-Output Specification)

Year	Capital Productivity		Output Quantity Index		Capital Quantity Index	
	Index	Growth	Index	Growth	Index	Growth
2001	1.000		1.000		1.000	
2002	1.008	0.77%	1.019	1.92%	1.012	1.16%
2003	1.002	-0.52%	1.026	0.66%	1.024	1.18%
2004	1.005	0.24%	1.038	1.14%	1.033	0.91%
2005	0.998	-0.65%	1.056	1.74%	1.058	2.40%
2006	0.978	-2.01%	1.072	1.45%	1.095	3.46%
2007	0.954	-2.50%	1.083	1.05%	1.135	3.55%
2008	0.928	-2.78%	1.094	0.98%	1.178	3.76%
2009	0.909	-2.10%	1.114	1.88%	1.226	3.98%
2010	0.887	-2.48%	1.125	0.95%	1.269	3.43%
2011	0.857	-3.40%	1.124	-0.08%	1.312	3.32%
2012	0.835	-2.54%	1.132	0.73%	1.356	3.27%
Average Annual Growth Rate						
2001-2012		-1.63%		1.13%		2.77%
2001-2006		-0.44%		1.38%		1.82%
2006-2012		-2.63%		0.92%		3.55%

4. NZ MFP AND INPUT PRICES

PEG also examined data on MFP trends developed by Statistics New Zealand (StatsNZ). Table 13 presents data on the NZ MFP trend as well as PEG's measured TFP growth for the EDBs under both output specifications. The StatsNZ data show that MFP for the broadest available measure of the New Zealand economy grew by 0.32% over the same 2001-2012 period that PEG used to estimate the EDBs' TFP trend. Over the entire sample period, the TFP differential between the NZ electricity distribution industry and the NZ economy is -1.66% with the three-output specification and -2.12% with the two-output specification.

The input price trend for the NZ economy is equal to inflation in the NZ economy plus the long-run trend in NZ MFP. Table 14 shows the details of the NZ input price trend calculation. Annual growth in the NZ CPI averaged 2.60% over the 2001-2012 period. If we use 0.32% as the long-run MFP trend of the New Zealand economy, the long-run input price trend for the economy is equal to 2001-2012 average CPI inflation of 2.60% plus 0.32%, or 2.92% per annum. This compares to PEG's measured input price trend for the EDBs of 2.32%. The input price differential (the trend growth in input prices for the economy minus trend growth in input prices for the industry) is therefore 0.60%.

Table 13

Productivity Trends for New Zealand Industries, 2001-2012

Year	TFP: 3 Output Specification		TFP: 2 Output Specification		New Zealand Economy		Productivity Differential	
	Index	Growth	Index	Growth	Index	Growth	3 Output	2 Output
2001	1.000		1.000		1030			
2002	1.015	1.50%	1.015	1.46%	1037	0.68%	0.82%	0.78%
2003	1.010	-0.49%	0.996	-1.85%	1052	1.44%	-1.93%	-3.29%
2004	0.988	-2.17%	0.974	-2.26%	1053	0.10%	-2.27%	-2.36%
2005	0.974	-1.48%	0.952	-2.31%	1060	0.66%	-2.14%	-2.97%
2006	0.971	-0.34%	0.950	-0.21%	1068	0.75%	-1.09%	-0.96%
2007	0.960	-1.12%	0.924	-2.69%	1071	0.28%	-1.40%	-2.97%
2008	0.942	-1.83%	0.904	-2.21%	1072	0.09%	-1.92%	-2.30%
2009	0.923	-2.06%	0.896	-0.92%	1034	-3.61%	1.55%	2.69%
2010	0.908	-1.69%	0.873	-2.59%	1046	1.15%	-2.84%	-3.75%
2011	0.885	-2.54%	0.850	-2.71%	1055	0.86%	-3.39%	-3.56%
2012	0.863	-2.50%	0.820	-3.55%	1067	1.13%	-3.63%	-4.68%
Average Annual Growth Rate								
2001-2012		-1.34%		-1.80%		0.32%	-1.66%	-2.12%
2001-2006		-0.60%		-1.03%		0.72%	-1.32%	-1.76%
2006-2012		-1.95%		-2.44%		-0.02%	-1.94%	-2.43%

Table 14

Input Price Trends for the New Zealand Economy, 2001-2012

Year	Consumer Price Index		New Zealand Economy MFP		New Zealand Input Price	
	Index	Growth	Index	Growth	Index	Growth
2001	877.9		1030		1.000	
2002	901.4	2.64%	1037	0.68%	1.034	3.32%
2003	917.2	1.74%	1052	1.44%	1.067	3.17%
2004	938.2	2.26%	1053	0.10%	1.093	2.36%
2005	966.7	2.99%	1060	0.66%	1.133	3.65%
2006	999.3	3.31%	1068	0.75%	1.180	4.06%
2007	1023.0	2.35%	1071	0.28%	1.212	2.63%
2008	1063.5	3.88%	1072	0.09%	1.261	3.98%
2009	1086.0	2.09%	1034	-3.61%	1.242	-1.52%
2010	1111.0	2.28%	1046	1.15%	1.285	3.43%
2011	1155.8	3.95%	1055	0.86%	1.348	4.81%
2012	1168.0	1.05%	1067	1.13%	1.378	2.19%
Average Annual Growth Rate						
2001-2012		2.60%		0.32%		2.92%
2001-2006		2.59%		0.72%		3.31%
2006-2012		2.60%		-0.02%		2.59%

5. CONCLUSIONS AND RECOMMENDATIONS

PEG estimates the EDBs' opex PFP trend is between -1.58% (the estimate from our three-output specification) and -2.04% (from the two-output specification). The opex PFP forecast is part of an opex adjustment formula that includes a scale effects term, which the Commission intends to calibrate using the same outputs in PEG's two-output specification. This adjustment formula would be internally inconsistent if different outputs were used for different components of the same formula. Because all elements of this formula should be internally consistent, PEG's recommended opex PFP trend is derived from the two-output specification and is equal to -2.04%.

In the 2003 and 2009 reviews, the Commission calculated the "X factor" in the EDBs' rate of change formula as the sum of the TFP differential and the input price differential. In principle, it remains valid to compute the X factor for a rate of change formula in this manner even though the X factor *per se* does not directly impact the EDBs' allowed revenues. A reasonable estimate of the EDBs' long-run TFP trend is between -1.34% (the estimate from our three-output specification) and -1.80% (the estimate from our two-output specification). The economy-wide MFP trend for New Zealand is 0.32%. This implies that a reasonable estimate of the TFP differential for NZ's electricity distribution industry is between -1.66% and -2.12%.

The input price trend for the NZ economy is 2.92%. PEG estimates that the input price trend for NZ's electricity distribution industry is 2.32%. This implies that the input price differential is 0.60%. The value for the X factor used in the rate of change formula should therefore be between -1.06% (*i.e.* a -1.66% TFP differential plus a 0.60% input price differential) and -1.52% (*i.e.* a -2.12% TFP differential plus a 0.60% input price differential).

The TFP estimate used in the rate of change formula should have the same output specification that is used to project opex PFP. If this is not the case, the empirical parameters in the Commission's ratemaking formulae will be internally inconsistent. PEG's preferred TFP differential and X factor is therefore derived from the two-output specification, and our recommended value for the X factor in the rate of change formula is equal to -1.52%.

We note that negative TFP and opex PFP trends are consistent with the theory of incentive regulation and a number of recent regulatory decisions. A negative productivity estimate should not be interpreted as evidence that NZ's electricity distribution industry is becoming "less efficient;" it simply means that the inputs needed for EDBs to provide service have been growing more rapidly than their outputs. This trend is clearly evident for the EDBs, which registered negative TFP growth in each of the last ten years for which data are available. Negative productivity trends have also become more pronounced since 2006. Because PEG's recommendations about the magnitudes of continuing productivity declines are based on long-term 2001-2012 trends, they are less negative than the EDBs' recent experience and may turn out to be conservative.

REFERENCES

Hall, R. and D. W. Jorgensen (1967), "Tax Policy and Investment Behavior", *American Economic Review*, 57, 391-414.

Hulten Charles R and Wykoff, Frank C (1981), "The Measurement of Economic Depreciation," in *Depreciation, Inflation and the Taxation of Income from Capital* ed. C. Hulten, Washington DC: The Urban Institute Press, 81-125.

Kaufmann, Lawrence et. al, (2013), *Productivity and Benchmarking Research in Support of Incentive Rate Setting in Ontario: Final Report to the Ontario Energy Board*.

Statistics New Zealand, *Productivity Statistics: Sources and Methods*, Tenth Edition.

Törnqvist, L. (1936), "The Bank of Finland's Consumption Price Index", *Bank of Finland Monthly Bulletin*, 10, pages 1-8.