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Subject: Total Factor Productivity Review - Framework and Issues paper, EMO0006 - Submission by Dr Keith Watts
Attachments: 090101 TFP paper Dr Keith Watts.pdf

Review Commissioner
Total Factor Productivity Review
Australian Energy Market Commission
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Attached is an unpublished paper on Total Factor Productivity in the Queensland Electricity Distribution Industry 1977-78 to 1991-92 which may inform some of the issues raised in the Framework and Issues Paper, specifically Issues 3, 4, 5-7, 14, 17, 20 and 21. Based on my research, I believe that any electric utilities connected to the National Electricity Grid (Queensland, New South Wales, Victoria, South Australia and Tasmania) could be good candidates for the application of the TFP methodology outlined in the paper.

Please refer to my 1996 PhD thesis on "Analysing Performance and Prospects of Government-Owned Enterprises in the Queensland Electricity Distribution Industry", available from the University of Queensland Library, for further information and the application of the TFP methodology to the prediction of performance of electric utilities. This may have good application to the concepts outlined in the issues paper.

Yours sincerely

Keith Watts

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TOTAL FACTOR PRODUCTIVITY IN THE QUEENSLAND ELECTRICITY DISTRIBUTION INDUSTRY 1977-78 to 1991-92

by Dr Keith Watts[1]

1. Introduction

Total factor productivity is one of the key performance indicators used in benchmark studies for electric utilities, and has been used for many years as a performance indicator for industry. Although not used as a comparative indicator in earlier years, it has been used extensively for this purpose following the work of Caves Christensen and Diewert (1982). Total factor productivity's strengths and weaknesses as a performance measure are summarised in Table 1.

Table 1: Strengths and Weaknesses of the Total Factor Productivity Measure

Strengths of TFP as a Performance Measure	**Weaknesses of TFP as a Performance Measure**	**Comments**
Provides a complete assessment of how an organisation is performing (Swan Consultants 1991, 4, 1992, 1)	Sensitive to measurement technique and assumptions (Forsyth 1987, 5).	Must make appropriate adjustments for differences in operating environments (Lawrence, Swan and Zeitsch 1991).
Capable of providing an assessment of performance trends	Failure to adjust for returns to scale yields an overstatement (or	Tornqvist methodology only suitable for an individual organisation

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Table 1: Strengths and Weaknesses of the Total Factor Productivity Measure		
Strengths of TFP as a Performance Measure	**Weaknesses of TFP as a Performance Measure**	**Comments**
(Swan Consultants 1992, 7). Best measure of overall performance (Forsyth 1992, 4).	understatement) of TFP growth. (Cowing, Small and Stevenson 1981, 165)	over time, or a group of similar organisations in a single time period (Lawrence, Swan and Zeitsch 1991, 184).
Takes account of changes in the various factors of production (Swan Consultants 1992, 1).	Can reflect changes in allocative efficiency as well as productive efficiency (Forsyth 1992, 4). Cannot allow for different conditions, technology and output mixes (Forsyth 1992, 10).	Overcomes the "only half the picture" syndrome that occurs when partial factor productivity measures such as labour productivity are used (Steering committee on National Performance Monitoring 1992, 4).
Can be used for inter-organisation performance comparison (Zeitsch, Lawrence and Salerian 1992, 2). The multilateral TFP technique provides a ready means of bench marking enterprises both domestically and relative to international best practice (Steering committee on National Performance Monitoring 1992, 5).		Must use translog multilateral methodology to achieve comparability. Where comparison with other organisations are required, must be careful to select comparable bench marking partners, or where not possible, make adjustments for differences in operating environments (Swan Consultants 1992, 8, 17).
Can be used for comparison of absolute productivity levels between firms as well as	Sensitive to the way the constituent output and input indices are constructed (Forsyth 1992, 4).	

Table 1: Strengths and Weaknesses of the Total Factor Productivity Measure		
Strengths of TFP as a Performance Measure	**Weaknesses of TFP as a Performance Measure**	**Comments**
over time (Lawrence, Swan and Zeitsch 1991, 183).		
TFP is the best measure of overall technical efficiency (Steering committee on National Performance Monitoring 1992, 5.)	TFP changes can reflect scale effects (Forsyth 1992, 4). Cannot distinguish pure productivity gains from efficiency gains from growth in the scale of operations. Says nothing about whether the same productivity could be achieved by producing at significantly different scales of operation (Forsyth 1992, 5).	
	Difficulty in measuring and weighting outputs for aggregation purposes (Forsyth 1992, 4).	May need to use surrogates for outputs which are difficult to measure. There are two ways like comparisons can be achieved. The first is to choose a bench marking partner with similar characteristics. The second is to adjust measured performance for differences in operating environments (Zeitsch, Lawrence and Salerian 1992, 2).
Can use change in total factor productivity as a comparison among		Absolute total factor productivity levels can be used for comparison

Table 1: Strengths and Weaknesses of the Total Factor Productivity Measure		
Strengths of TFP as a Performance Measure	**Weaknesses of TFP as a Performance Measure**	**Comments**
industries and at national and international level (Swan Consultants 1992).		provided that the translog multilateral method is used for their calculation (Lawrence, Swan and Zeitsch 1991).

This paper discusses the use of total factor productivity both from the individual utility viewpoint and as a comparative indicator for a number of utilities. Methods are also discussed by which calculations of total factor productivity for electric utilities may be refined to produce greater accuracy, and results are presented. The refinements include the calculation of an improved capital series by converting historical cost data to current cost, and adjusting the output for load factor to recognise the multi product nature of electricity on a time of day basis. Total factor productivity has been identified as one of the five output variables for use in analysing the performance of the Queensland electric distribution utilities. Total factor productivity indices and output and input indices for seven Queensland electric utilities for the 15-year period 1977-78 to 1991-92 were calculated by the author for use in the analysis of the performance of the seven utilities.

2. Tornqvist Methodology

The electricity industry database prepared by the author for this research includes a complete set of data to calculate total factor productivity for each utility for the fifteen-year period 1977-78 to 1991-92 using Tornqvist methodology (Steering Committee for National Performance Monitoring of Government Trading Enterprises 1992, 10). Also provided are the formulae to calculate the output, input and total factor productivity indices. The Tornqvist TFP index is

$$\mathrm{Ln}\left(\frac{TFP_t}{TFP_{t\_1}}\right) = \Sigma_i \mathrm{1over2}\left(R_{it}+R_{it\_1}\right) \mathrm{Ln}\left(\frac{Y_{it}}{Y_{it\_1}}\right) - \Sigma_j \frac{1}{2}\left(S_{jt}+S_{jt\_1}\right) \mathrm{Ln}\left(\frac{X_{jt}}{X_{jt\_1}}\right)$$

expressed in log-change form:

Here t and t-1 are adjacent time periods, there are I outputs Y, j inputs X, the output shares are denoted by R and the input shares by S (Steering Committee on National Performance Monitoring of Government Trading Enterprises 1992, 11[2]).

This formula was used to calculate output, input and TFP indices and trend growth rates, which showed that the identity for output growth rate held, and that the growth in inputs and total factor productivity jointly explained the growth in output[3].

Output growth rate = Input growth rate + TFP growth rate

Provided that there is no wish to compare performance among utilities, the Tornqvist methodology is sufficient to allow a utility to monitor its performance over a number of years, and to present its productivity performance for review by its stakeholders. However as soon as TFP performance is published, there is a natural tendency for comparison among others, and it is here that the methodology is inadequate.

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[2] To validate the spreadsheet formulae, the author used illustrative data provided in the technical guide (Steering Committee 1992, 18, 19). The trend growth rates were then calculated by regressing each index series against time (Trend) and a constant term.

[3] The two time periods were arbitrarily selected to illustrate the identity still held. There is no relationship likely between the TFP indices calculated for the two periods.

3. Translog Multilateral Index Methodology

A weakness in the Tornqvist methodology (Lawrence, Swan and Zeitsch in Johnson, Kreisler and Owen 1991, 184) is that the results cannot be reliably used to compare other organisations publishing similar results, be they electric utilities or any enterprises. This is because the method lacks characteristicivity (Freeman, Hoon Oum, Tretheway and Waters 1985, 252), or in other words it does not satisfy the technical property of transitivity (Lawrence, Swan and Zeitsch 1991, 184), since the results of the various index calculations are still dependent on the choice of the reference year, with half the weights for the averaging coming from the reference year, and half from the base year. Lawrence Swan and Zeitsch used a multilateral procedure originally proposed by Caves, Christensen and Diewert (1982), based on the translog (or transcendal logarithmic) production function (Kmenta 1990, 517), as set out below (Lawrence, Swan and Zeitsch 1991, 185), and this has been used by the author.

$$\mathrm{Ln}\left(\frac{TFP_t}{TFP_{t\_1}}\right) = \frac{\Sigma_i\left(R_{it} + \overline{R_i}\right)\left(\mathrm{Ln}\,Y_{it} - \overline{\mathrm{Ln}\,Y_i}\right)}{2}$$

$$- \frac{\Sigma_i\left(R_{it\_1} + \overline{R_i}\right)\left(\mathrm{Ln}\,Y_{it\_1} - \overline{\mathrm{Ln}\,Y_i}\right)}{2}$$

$$- \frac{\Sigma_j\left(S_{jt} + \overline{S_j}\right)\left(\mathrm{Ln}\,X_{jt} - \overline{\mathrm{Ln}\,X_j}\right)}{2}$$

$$+ \frac{\Sigma_J\left(S_{jt\_1} + \overline{S_j}\right)\left(\mathrm{Ln}\,X_{jt\_1} - \overline{\mathrm{Ln}\,X_j}\right)}{2}$$

$\overline{R_i}$ $\overline{S_j}$ are the revenue cost shares respectively averaged all firms all time periods.

$\overline{Ln\ Y_i}$ $\overline{Ln\ X_j}$ are the averages of the natural logarithms of output i input j respectively.

Here t and t-1 are two observations which may be adjacent in time or from two firms in the same time period.

To produce the output series for one firm over time, the following equation is used.

$$Ln\left(\frac{Y_{1978\_79}}{Y_{1977\_78}}\right) = \frac{\Sigma_i\left(R_{i78\_79} + \overline{R_i}\right)\left(Ln\ Qty_{i78\_79} - \overline{Ln\ Qty_i}\right)}{2} - \frac{\Sigma_i\left(R_{i77\_78} + \overline{R_i}\right)\left(Ln\ Qty_{i77\_78} - \overline{Ln\ Qty_i}\right)}{2}$$

R_i is the output revenue share and Qty_i is the output quantity of each output i. Where there is only one output, the values of the revenue shares are 1.0. In order to use all the indices in a single series the values of the output index are standardised on the value for one firm in the comparison.

A similar equation is used, with the values for revenue shares and quantities for the two firms substituted[4]. The estimation is then repeated for every firm in the comparison. The same approach is used to estimate the input indices, using the following equation:

[4] A nominal sum of $1000 each year has been entered for recoverable works for the other years for these four utilities. For the other three utilities, recoverable works is relatively small and is ignored.

$$\text{Ln}\left(\frac{X_{1978\_79}}{X_{1977\_78}}\right) = \frac{\Sigma_j\left(S_{j78\_79} + \overline{S_j}\right)\left(\text{Ln Qty}_{j78\_79} - \overline{\text{Ln Qty}_j}\right)}{2} - \frac{\Sigma_J\left(S_{j77\_78} + \overline{S_j}\right)\left(\text{Ln Qty}_{j78\_79} - \overline{\text{Ln Qty}_j}\right)}{2}$$

Again S_j is the input share and Qty_j is the input quantity of each j input. When standardising the input values, which must be against the same firm as used for the output values, the "standard" firm values and the other firm values are substituted for the time values. This is repeated for each firm in the comparison. The translog multilateral output, input and TFP indices have been used in the regression analysis rather than the Tornqvist indices.

4. Refining the TFP Model: Development of an Improved Capital Series

One of the major issues is the value of fixed assets. The only capital series available were total assets at historical cost, although depreciation was reported in notes to the accounts. To provide a calculation of total factor productivity as accurate as possible, current values of assets were required for each year, and the author devised a methodology for revaluing the assets referred to a revaluation to current values carried out by the utilities. The fixed assets of the utilities were revalued to current values at 30 June 1992, and a methodology was established by the utilities to maintain a revalued depreciated fixed assets series in the future using the following approach.

	Opening balance at 1 July
Plus	new assets constructed/acquired
Less	Depreciation
Less	Asset disposal
Plus	Revaluation for current year calculated on opening balance less sales/disposal plus half new assets

Closing balance at 30 June

This can be expressed in a different form, as follows, and it will be shown that the two are equivalent.

	Opening balance at 1 July
Plus	.5 new assets for the financial year
Less	Depreciation at current year values
Less	Asset disposal at current year values
Subtotal	Asset value at 31 December revalued to current year
Plus	0.5 new assets for the financial year[5]
	Closing balance at 30 June

The author has expressed the first expression in mathematical terms, as follows:

$$NFA_t = NFA_{t-1} + N_t - (S_t + D_t) + R_t$$

$$= r_t \times (NFA_{t-1} + (N_t/2) - (S_t + D_t))$$

NFA_t	Revalued net fixed assets at end year t
NFA_{t-1}	Revalued net fixed assets at end year t-1
N_t	New assets constructed/acquired in year t
S_t	Value of asset sales/disposals in year t
D_t	Depreciation in year t
R_t	Revaluation in year t

[5] Assuming that new assets are created at a constant rate throughout the year, the assets in service for the whole year are equivalent to 0.5 times the accumulated value of new assets created at year end.

r_t revaluation index, expressed as change on previous year in implicit price deflator for gross fixed capital expenditure, public enterprises, ABS Catalogue 5204.0 (ABS 1992, Table 3; ABS 1988, Table 3).

$= p_t/p_{t-1} - 1$

p_t implicit price deflator, year t

Hence $NFA_t = NFA_{t-1} \text{ x } (1+ r_t) + N_t \text{ x } (1+ r_t/2) - (S_t + D_t)(1+ r_t)$

The mathematical formula for the second expression is

$$NFA_t = (NFA_{t-1} + N_t/2 - S_t - D_t) \text{ x } (1+ r_t) + N_t/2$$

$$= NFA_{t-1} \text{ x } (1+ r_t) + N_t \text{ x } (1+ r_t/2) - (S_t + D_t)(1+ r_t)$$

which is the same as that derived for the first expression.

An alternative approach is to treat depreciation and assets sales as a constant stream of transactions throughout the year, and deduct half the depreciation and half the assets sales to calculate the new subtotal at 31 December for the purpose of calculating the revaluation in year t, instead of deducting the total depreciation and asset sales for the year to calculate the new subtotal at 31 December.

The formula for revaluation would then become -

R_t = revaluation in year t

$= r_t \text{ x } (NFA_{t-1} + (N_t/2) - (S_t + D_t)/2)$

and $NFA_t = NFA_{t-1} \times (1+ r_t) + (N_t - S_t + D_t) \times (1+ r_t/2)$

This alternative approach is preferred by the author because of the treatment of depreciation and asset sales as a constant stream of transactions during the year, which matches the situation in practice. It has the effect of slightly accelerating the devaluation of the asset series, and will therefore result in a slightly higher growth rate for capital inputs and the input index.

The alternative approach is used to calculate a revalued net fixed assets series for the whole fifteen-year period, adding an extra factor for the new level of depreciation on revalued assets. Under their revalued assets accounting practice, the utilities calculate depreciation by the application of the prime cost rate, for each class of asset, to the current full replacement value of non-current assets (pers. comm.). To apply this to the asset series for the past fifteen years would be extremely complex, and the author approximated depreciation on revalued assets by assuming a reducing-balance (Yorston, Smyth and Brown 1983, 91) or declining balance depreciation rate for the fifteen-year period of 5.8 per cent. This rate approximated the mean of effective declining balance depreciation rates estimated from one utility's five year forecast, the effective rates being 0.0566, 0.0576, 0.0589, 0.0606 and 0.06175 respectively[6].

The formula for depreciation on revalued assets in year t developed by the author is thus -

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[6]The method calculated depreciation on revalued assets for the 15-year period back to 1977-78 for the purpose of deriving user cost of capital. As a check, depreciation on revalued assets was calculated for 1992-93 and 1993-94 using the same formula and produced depreciation amounts very close to those calculated by the utility for budgeting and forecasting purposes. This confirmed the accuracy of the estimated rate and the formula used. Given the structure of, and the relationships within, the Queensland electricity supply industry, it is not unrealistic to assume that the depreciation rate used is appropriate for all the utilities.

$$D_t = (NFA_{t\_1} * d_t) + \left(\frac{N_t}{2} * \left(1 + \frac{r_t}{2}\right) * d_t\right)$$

d_t = effective declining balance depreciation rate

and using the alternative approach

$$NFA_{t\_1} = \frac{NFA_t - (N_t - S_t - D_t) * \left(1 + \frac{r_t}{2}\right)}{(1 + r_t)}$$

Substituting for D_t and transposing terms,

NFA_{t-1} $(1 - d_t/(1 + r_t))$

$= NFA_t/(1 + r_t) + S_t (1 + r_t/2)/(1+ r_t)$

$- (N_t (1 + r_t/2) (1+ d_t)) / (1+ r_t)$

$NFA_{t-1} = (NFA_t + S_t (1 + r_t/2)$

$- N_t \times (1 + r_t/2)(1 - d_t/2))/(1 + r_t - d_t)$

$N_t (1+ r_t/2)$ = revalued new assets

$S_t (1+ r_t)$ = revalued asset sales

$N_t (1 + r_t/2) (1 - d_t/2)$ = depreciated revalued new assets

Real $NFA_{t-1} = NFA_{t-1}$ / Implicit price deflator year t-1 (ABS 1992, Table 3; ABS 1988, Table 3)[7]

[7]Using the ABS Catalogue 5204.0 series for implicit price deflator, gross fixed capital expenditure, public enterprise.

This series is the real capital stock series for the utility, the quantity of capital used in each year.

User cost of capital is obtained by adding the opportunity cost of capital to the calculated depreciation on revalued assets. Opportunity cost of capital is nominal fixed assets at historical cost multiplied by the real interest rate, the latter taken as the Government ten-year bond rate less the inflation rate.

5. Refining the TFP Model: Adjusted Output

Initially a simplistic approach was taken to treat the output of the utilities as simply kilowatt-hours sold, without any consideration of the quality or time of day aspects.

A refinement was then added to include recoverable works as a second output for those utilities which, since 1989-90, had reported significant recoverable works on transmission lines on behalf of the generating utility. This coincided with a change in organisation arrangements, which saw the main transmission maintenance in each utility's area of supply being carried out by that utility for the generating utility, on a cost plus basis, with the staff located in each board's area being transferred to that utility. In the last two years of the series, the volume of recoverable work is sufficiently large as to be separately reported in the accounts, and to affect productivity. The quantity of recoverable works is implicitly derived using the implicit price deflator for gross fixed capital expenditure, public enterprises (ABS 1992, Table 3; ABS 1988, Table 3)[8]. No data are available on recoverable works other than those undertaken for the generating utility, but even they were so small as to have negligible

[8] Using ABS Catalogue 5204.0 Table 3.

effect on the total factor productivity results. A nominal sum of $1000 per annum was allowed for each utility.

A second refinement added[9] was to adjust the quantity of electricity sales for load factor, to recognise that higher load factors mean better use of capacity of the system and thus higher productivity, which was not being captured using the simplistic kilowatt-hours sold output measure. The adjustment follows the technique used by Forsyth *et al* to adjust output in measuring airline efficiency (Forsyth *et al* 1986, 68) as shown in the equation below. The formulation used by Forsyth *et al* (1986, 77) is

$$Y = y^a A^b S^c L^d$$

where y denotes the raw output tonne-kilometres available, A denotes aircraft size, S denotes average flight stage length and L denotes the average load factor. The subscripts reflect the estimated orders of magnitude of the various adjustments to the raw output. Here a single adjustment is proposed, the ratio of the individual utility system load factor[10] to the overall network system load factor with an exponent of 1.0. The adjustment formulation is simply $Y = y^1 R_L{}^1$ where R_L is the load factor ratio.

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[9] A further refinement has been identified which adjusts the input factor requirements for distribution area customer density (Zeitsch, Lawrence and Salerian 1992, 6). No attempt has been made to apply this refinement in the total factor productivity calculations presented here because six out of the seven electric utilities studied have similar customer densities. It would be of value to apply the methodology in a future study to refine the prediction equations. Other possible refinements include taking account of consumer costs and benefits in the energy conversion chain, as well as the direct costs and benefits to electric utilities. These have not been taken to account in this research.

[10] System load factor, %. System load factor is actual annual electricity sales divided by the product of the maximum electrical demand and the number of hours in a year (the electricity that would be sold if electricity was used at a constant rate throughout the year equal to the maximum electrical demand). It is a utilisation measure.

System Load $Factor_t^*$ is the utility system load factor averaged over all utilities for each time period, as measured from the observations of the entire system.

To illustrate the effect of this adjustment, the unadjusted and adjusted electricity sales, translog multilateral output and TFP indices for one utility are shown in Table 2.

Table 2 Illustrative Effect on Total Factor Productivity of Adjustment on Electricity Sales Output for Product Mix Based on Load Factor, One Utility

Year	Elec Sales GWh	Adjusted Elec Sales GWh	Multi-lateral Output Index, No Adjustment	Adjusted Multi-lateral Output Index	Multi-lateral TFP Index, No Adjustment	Adjusted Multi-lateral TFP Index
77-78	4886.2	5260.3	1	1	1	1
79-79	5151.6	5148.3	1.054	0.979	1.013	0.94
79-80	5629.9	6204.2	1.152	1.179	1.039	1.063
80-81	5977.8	6495	1.223	1.235	1.058	1.067
81-82	6333.7	7066.3	1.296	1.343	1.095	1.135
82-83	6588.9	6830.2	1.348	1.298	1.095	1.054
83-84	6706.2	6420.5	1.372	1.221	1.107	0.984
84-85	6972.6	6553.5	1.427	1.246	1.153	1.006
85-86	7545.1	7498.8	1.544	1.426	1.199	1.107
86-87	8010.8	7927.4	1.639	1.507	1.234	1.135
87-88	8536.1	8196.9	1.747	1.558	1.265	1.128
88-89	9253.1	9584.7	1.894	1.822	1.289	1.24
89-90	9765.3	9563.5	2.005	1.818	1.309	1.187
90-91	10249	9811.7	2.098	1.865	1.344	1.195
91-92	10594	10890.7	2.168	2.07	1.349	1.288

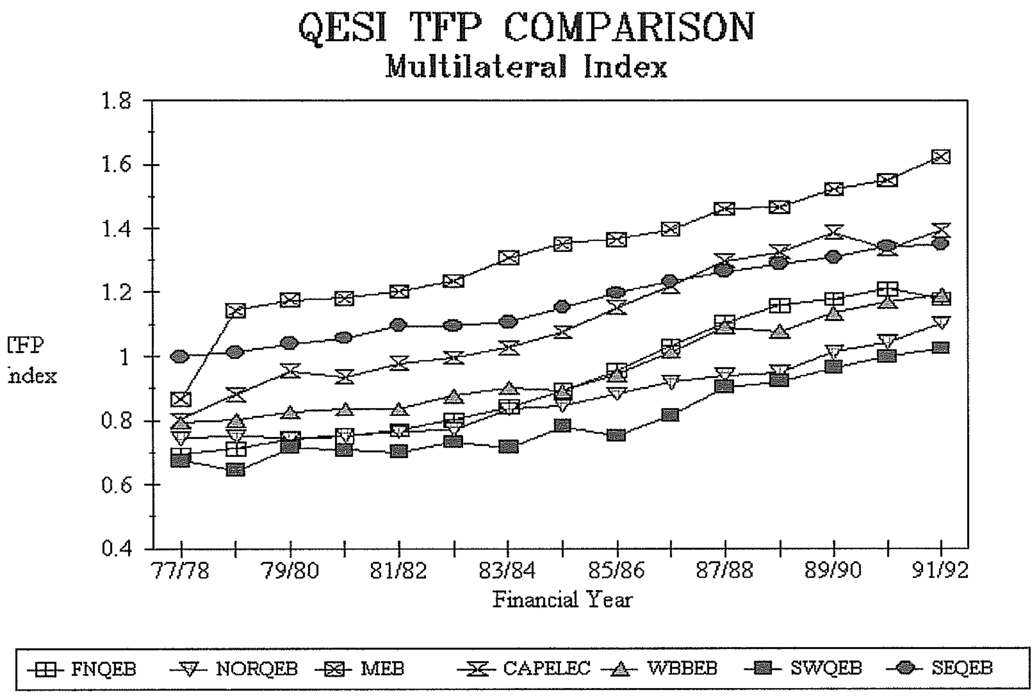

Figure 1. Comparative Translog Multilateral Total Factor Productivity Indices Standardised on SEQEB, Unadjusted Output, 7 Utilities

Figures 1 and 2 show the comparative translog multilateral total factor productivity indices over the 15-year period for the seven utilities, standardised on one utility, for both unadjusted and adjusted output. These two figures show the quite large differences produced by the product mix adjustment, using load factor as the adjusting factor; the relative total factor productivities of the utilities have changed and the spread is greater. Higher load factor means lower maximum electrical demand relative to total electricity sales, so that the utilities which have load factors in excess of the State mean, perhaps having invested in maximum demand control, or marketed off-peak electricity successfully, or have attracted industrial customers operating multiple shifts, or all three, are now showing higher productivity increases than those which have not. This quite logically reflects the benefits from demand control and industrialisation.

This second refinement captures the effect of the multi product nature of electricity in a time-of-day sense. Other market segmentations possible are on customer class, to capture the value-added effect as a product differentiation, and on reliability level, to capture the product difference between high-reliability electricity, such as might be attractive to a large manufacturer or a refinery or a customer where continuous electricity supply was critical to the process, and normal-reliability electricity, such as would be acceptable to domestic or small commercial customers. These suggest other refinements that could be applied to adjust the output measure, possibly using the Forsyth methodology as in the second refinement, though no attempt has been made to explore them in the thesis.

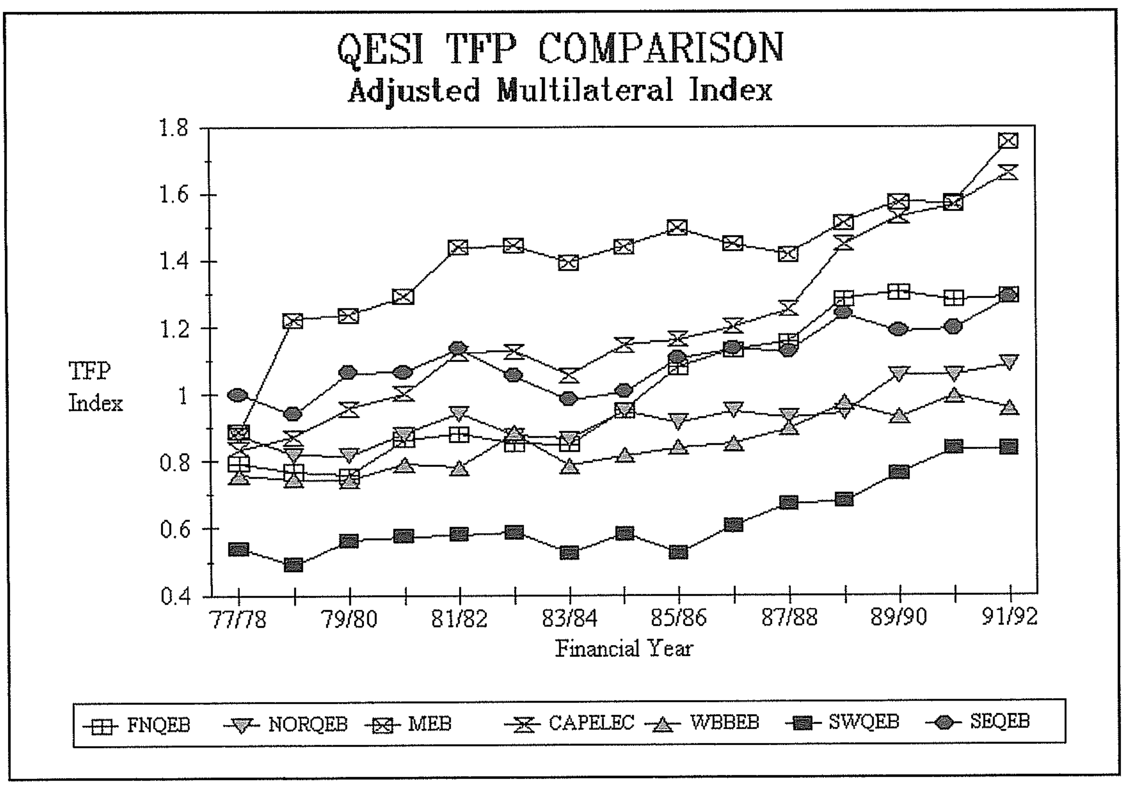

Figure 2. Comparative Translog Multilateral Total Factor Productivity Indices Standardised on SEQEB, Adjusted Output, 7 Utilities

It is interesting to note the use that total factor productivity trends can serve in aiding utility managements to monitor productivity changes. Table 3 sets out the 15-year trends on total factor productivity for the seven Queensland electric utilities, and also the trends for the seven years 1977-78 to 1983-84 and the eight years 1984-85 to 1991-92. These two periods were chosen to explore the change in TFP trends following the substantial change in industrial relations that occurred in early 1985. The trends were calculated using linear regression techniques. Similar trends are available for input and output indices, which can be used to isolate the contributions due to growth in output from efficiency improvements affecting growth in inputs, although this has not been discussed here.

Table 3 Total Factor Productivity Trends, Queensland Electricity Distribution Utilities, 1977-78 to 1991-92

Utility	Fifteen-Year TFP Trend 1977-78 to 1991-92: Annual Percentage Change	Seven-Year TFP Trend 1977-78 to 1983-84: Annual Percentage Change	Eight-Year TFP Trend 1984-85 to 1991-92: Annual Percentage Change
SEQEB	1.6%	0.08%	2.79%
SWQEB	3.18%	1.07%	6.58%
WBBEB	1.16%	0.06%	2.2%
CAPELEC	4.52%	4.9%	5.88%
MEB	2.9%	6.55%	2.3%
NORQEB	1.7%	0.08%	2.38%
FNQEB	4.42%	2.0%	4.19%

It will be seen that except for MEB, all the utilities showed an increase in the TFP trend for the eight years following the 1985 industrial unrest. The impact was greater in the utilities which were experiencing relatively small trends in TFP change in the first seven-year period.

6. Summary

The paper has presented the methodology for and results of calculating total factor productivity of the seven electric distribution utilities in Queensland. Total factor productivity using translog multilateral methodology, which permits direct comparison of total factor productivity across the seven utilities, is calculated and has been used in a model for analysing the performance of the electric utilities. Methods of correcting for the current value of assets and the time of day value of electricity sold are presented, together with results calculated. These corrected total factor productivity data are used in the calculation of the performance analysis model. A distinct change in the trends in TFP growth is evident following the significant industrial unrest which occurred in early 1985. This change suggested that a closer examination of the two periods is warranted.

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