Performance Measurement and Regulation of Network Utilities

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Chapter 8

Regulating Electricity Networks: The ABC of Setting X in New Zealand, Denis Lawrence and Erwin Diewert

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8. Regulating Electricity Networks: The ABC of Setting X in New Zealand

Denis Lawrence and Erwin Diewert

1. INTRODUCTION

The New Zealand Commerce Commission has recently implemented a new form of electricity network regulation. Price path thresholds have been put in place which set a maximum change in real output prices that each distribution lines business is allowed without triggering further investigation. The X-factors in the thresholds are made up of three components: a B factor reflecting industry-wide total factor productivity (TFP) growth, a C_1 factor reflecting comparative productivity performance and a C_2 factor reflecting comparative profitability. The X-factors have been set using the results of quantitative modelling using multilateral TFP and cost function methods.

In this chapter we report the results of the productivity study undertaken for the Commission and used as the basis for setting X-factors. The study covers 29 distributors over an eight year period and reports TFP levels and growth rates. We derive an output specification that attempts to adjust for differing customer and energy densities. The challenge is to attribute weights to the output components given that revenue for each is unobservable.

The following section of the chapter sets the regulatory background for the Commission inquiry, while section 3 reviews the rationale for using productivity results in forming the parameters of CPX-X regulation. Section 4 discusses measurement problems encountered in electricity network productivity studies, particularly the specification of outputs and capital inputs. Section 5 reviews the data used in the current study and discusses the unusual characteristics of the New Zealand distribution system. In section 6 we present estimates of distribution industry TFP. Based on this information we then derive the implied B factors for distribution lines businesses. In section 7 we investigate the performance of the 28 distribution lines businesses existing in 2003 using multilateral TFP indexes. This permits the businesses to be allocated to three broad C_1 factor groups based on relative productivity performance. We then examine post-tax residual rates of return as a means of allocating the businesses to three profitability or C_2 groupings before forming overall C factor estimates for each business taking account of both relative productivity and relative profitability. Finally conclusions are drawn in section 8.

2. ELECTRICITY NETWORK REFORM IN NEW ZEALAND

In the mid-1980s electricity generation and transmission in New Zealand was undertaken by a government department and 60 electricity supply authorities undertook distribution and supply (or retailing). These authorities comprised:

- 38 electric power boards;
- 21 municipal electricity departments; and
- one government owned authority.

All 60 organisations were statutory monopolies.

Reform of the electricity industry commenced in 1987 with the establishment of the Electricity Commission of New Zealand (ECNZ) as a state owned enterprise undertaking generation and transmission. Transpower was established as a subsidiary of ECNZ in 1988 solely responsible for transmission functions. In 1994 Transpower was separated from ECNZ as a state owned enterprise.

Reform of the distribution and supply businesses began in 1990 with the appointment by government of commercial directors to the electric power boards (with the existing board members becoming elected trustees). In 1992 establishment plans were prepared for all 60 businesses resulting in a diverse range of ownership structures including trusts, majority private shareholding and local government.

Initially there was no formal regulation of the network businesses. However there was a requirement for distribution and transmission businesses to supply compulsory Disclosure Data on a range of indicators commencing with the 1994–95 financial year. These data were gazetted within six months of the end of the financial year to allow public inspection. This was intended to allow stakeholders to monitor lines business activities and performance as a form of light-handed regulation.

In 1999 distribution and retail businesses were formally separated. Generation businesses were not allowed to own distribution businesses but they were allowed to own retail businesses. The separation of distribution and retail businesses improved the quality of the available Disclosure Data by eliminating the scope for businesses to 'cost shift' between the two activities. Further refinements were introduced at this time to improve the quality of reported data.

More formal network regulation was foreshadowed in 2001 with the introduction of amendments to the Commerce Act. Under Part 4A of the New Zealand Commerce Act, the Commission is required to set thresholds for the declaration of control in relation to New Zealand electricity distribution businesses. The thresholds are, in effect, a screening mechanism to identify lines businesses whose performance may warrant further examination through a post-breach inquiry and, if required, control by the Commission.

In December 2003 the Commission announced the thresholds to apply to the then 28 individual distributors from April 2004 using the analysis reported in this chapter. The threshold X factors comprise a B factor representing average productivity growth in the industry, a C_1 factor representing relative productivity performance and a C_2 factor representing relative profitability performance. As with any study of network productivity performance, the first task is to specify exactly what the network firm's outputs are. The approach adopted includes throughput, network line capacity and customer dimensions. This builds an allowance for customer and energy density differences into the output specification (see sections 4 and 5). Weights are allocated to the output components based on the econometric estimation of a simple cost function (reported in section 7).

The B factor representing average industry productivity growth is calculated using standard Fisher indexes for aggregate industry level data (reported in section 6 of the paper). The C_1 factors representing relative productivity performance are formed from estimates of multilateral TFP reported in section 7. Relative efficiency scores are also derived from the econometric cost function estimates. These provide a check on the multilateral TFP results but are not used in forming the C_1 factors. The rationale for the C_1 factors is that distributors having relatively low TFP levels should be able to make easy 'catch-up gains' and thus achieve better than average TFP growth. They hence have positive C_1 factors. Distributors having high TFP levels, on the other hand, will have difficulty matching average TFP growth as they are already close to best practice. They will hence be allocated negative C_1 factors.

Finally C_2 factors representing relative profitability performance of each distributor are formed from residual rates of return calculated from the database (also reported in section 7). The rationale for the C_2 factor is that distributors earning relatively high rates of return should be set a higher X factor than would otherwise apply to bring them closer to average profitability. They hence have positive C_2 factors while distributors with low rates of return are allocated a negative C_2 factor to help bring them closer to the average. The C_1 and C_2 factors are both seen as temporary measures given the diverse range of ownership structures and starting points for the distributors. In the longer run the objective is to move to having the thresholds based solely on industry TFP growth as reflected in the B factor.

3. THE USE OF PRODUCTIVITY IN THRESHOLD SETTING

The principal objective of CPI–X regulation is to mimic the outcomes that would be achieved in a competitive market (Christensen Associates, 1997). Competitive markets normally have a number of desirable properties. The process of competition leads to industry output prices reflecting industry unit costs, including a normal rate of return on the market value of assets after allowing for the risk. Because no individual firm can influence industry unit costs, each firm has a strong incentive to maximise its productivity performance to achieve lower unit costs than the rest of the industry. This outcome allows the firm to keep the benefit of new, more efficient processes that it may develop until such times as they are generally adopted within the industry. This process leads to the industry operating as efficiently as possible at any point in time with the benefits of productivity improvements being passed on to consumers relatively quickly.

Because infrastructure industries such as electricity transmission and distribution networks are often subject to increasing returns to scale (and, hence, decreasing average costs over the likely range of market demand), competition is normally limited and incentives to minimise costs and provide the cheapest and best possible quality service to users are not strong. The use of CPI–X regulation in such industries attempts to strengthen the incentive to operate efficiently by imposing similar pressures on network operators to the process of competition. It does this by constraining the operator's output price to track the level of estimated efficient unit costs for the industry. The change in output prices is 'capped' as follows:

$$\Delta P = \Delta W - X \pm Z \tag{8.1}$$

where Δ represents the proportional change in a variable, P is the maximum allowed output price, W is a price index taken to approximate the industry's input prices, X is the estimated productivity change for the industry and Z represents relevant changes in external circumstances beyond managers' control which the regulator may allow for. There are several alternative ways of choosing the index W. Perhaps the best way of doing this is to use a specially constructed index which weights together the prices of inputs by their shares in industry costs. However this price information is often not readily or objectively available, particularly in regulatory regimes that have yet to fully mature. A commonly used alternative is to choose a generally available price index such as the consumer price index or GDP deflator.

In choosing a productivity growth rate to base X on, it is desirable that the productivity growth rate be external to the individual firm being regulated and reflect industry trends at a national or international level (Shleifer, 1985). This way the regulated firm is given an incentive to match (or better) this productivity growth rate while having minimal opportunity to 'game' the regulator by acting strategically. The latter can be a problem with the 'building blocks' method for setting X (see, for example, ACCC, 2005) which relies more heavily on information on the firm's own costs and likely best practice for that firm.

While the CPI–X framework can provide incentives to reduce costs, it may need to be accompanied by measures to stop firms from achieving those cost reductions by reducing quality. This may take the form of an 'S' factor introduced to provide incentives to maintain or improve quality (so that the formula becomes CPI–X + S) or the setting of minimum service standards.

The framework that underlies the CPI–X approach can be illustrated as follows. We start with the index number definition of TFP growth:

$$\begin{aligned}\Delta TFP &\equiv [Y^1/Y^0]/[X^1/X^0] \\ &= \{[R^1/R^0]/[P^1/P^0]\}/\{[C^1/C^0]/[W^1/W^0]\} \\ &= \{[M^1/M^0][W^1/W^0]\}/[P^1/P^0]\end{aligned} \tag{8.2}$$

where the superscripts represent different time periods, Y^t is aggregate output, X^t is aggregate input (as distinct from the X factor representing productivity change), R^t (C^t) is revenue (cost) in period t, M^t is the period t markup and $R^t = M^t C^t$. As a normal return on assets (after allowing for risk) is included in the definition of costs, a firm earning normal returns will have a markup factor of one while a firm earning excess returns will have a markup of greater than one. Rearranging the above equation gives:

$$P^1/P^0 = \{[M^1/M^0][W^1/W^0]\}/\ \Delta TFP \tag{8.3}$$

where W^1/W^0 is the firm's input price index (which includes intermediate inputs). Equation (8.3) is approximately equal to:

$$\Delta P = \Delta M + \Delta W - \Delta TFP. \tag{8.4}$$

Thus, the admissible rate of output price increase ΔP is equal to the rate of increase of input prices ΔW less the rate of TFP growth ΔTFP provided the regulator wants to keep the monopolistic markup constant (so that $\Delta M = 0$). Equation (8.3) or its approximation (8.4) is the key equation for setting up an incentive regulation framework: the term W^1/W^0 would be an input price index of the target firm's peers and the term ΔTFP would be the average TFP growth rate for the target firm's peers. The markup growth term could be set equal to zero under normal circumstances but if the target firm was making an inadequate return on capital due to factors beyond its control, this term could be set equal to a positive number. On the other hand, if the target firm was making excessive returns, then this term could be set negative. This effectively sets a 'glide path' to bring firms closer to earning a normal or average rate of return.

The next issue to be considered in operationalising (8.4) is the choice of the price index to best reflect changes in the industry's input prices, W. The most common choice for this index is the consumer price index (CPI). But this is actually an index of output prices for the economy rather than input prices for the industry under consideration. Normally we can expect the economy's input price growth to exceed its output price growth by the extent of economy-wide TFP growth (since labour and capital ultimately get the benefits from productivity growth). We assume that the markup factors for the economy as a whole are one in each period (and, hence, ΔM_E is always zero) so that the counterpart to equation (8.2) applied to the entire economy becomes:

$$P_E^1/P_E^0 = [W_E^1/W_E^0]/\ \Delta TFP_E \qquad (8.5)$$

where the E subscript refers to the overall economy level. Substituting the rate of change of the CPI for the economy-wide output price index on the left hand side of (5) and rearranging terms leads to the following identity:

$$1 = [CPI^1/CPI^0]\ \Delta TFP_E/[W_E^1/W_E^0]. \qquad (8.6)$$

Substituting the right-hand side of (8.6) into (8.2) produces the following equation:

$$\begin{aligned} P^1/P^0 &= \{[CPI^1/CPI^0]\Delta TFP_E/[W_E^1/W_E^0]\}\{[M^1/M^0][W^1/W^0]\}/\ \Delta TFP \\ &= [CPI^1/CPI^0][\Delta TFP_E/\Delta TFP]\{[W^1/W^0]/[W_E^1/W_E^0]\}[M^1/M^0]. \qquad (8.7) \end{aligned}$$

Approximating the terms in (8.7) by finite percentage changes leads to the following:

$$\Delta P = \Delta CPI + \Delta M + [\Delta W - \Delta W_E] - [\Delta TFP - \Delta TFP_E] \qquad (8.8)$$

so that the X factor is defined as:

$$X \equiv [\Delta TFP - \Delta TFP_E] - [\Delta W - \Delta W_E] - \Delta M. \qquad (8.9)$$

This is a more general version of the so-called 'differential of a differential' formula developed by Bernstein and Sappington (1999). What equation (8.9) tells us is that the X factor can effectively be decomposed into three terms. The first differential term takes the difference between the industry's TFP growth and that for the economy as a whole, while the second differential term takes the difference between the firm's input prices and those for the economy as whole. Thus, taking just the first two terms, if the regulated industry has the same TFP growth as the economy as a whole and the same rate of input price increase as the economy as a whole then the X factor in this case is zero. If the regulated industry has a higher TFP growth than the economy then X is positive, all else equal, and the rate of allowed price increase for the industry will be less than the CPI. Conversely, if the regulated industry has a higher rate of input price increase than the economy as a whole then X will be negative, all else equal, and the rate of allowed price increase will be higher than the CPI. As noted above, the markup growth term could be set equal to zero under normal circumstances but if the target firm was making excessive returns, then this term could be set negative (leading to a higher X factor).

In the New Zealand thresholds setting context, setting the B factor involves a similar process to that for setting the general X described above.

The differential productivity or 'C' factor approach has usually been adopted where industry-wide data are used to determine the productivity growth rate and input price growth rate in determining the X factor for a number of firms in the industry. The differential productivity factor is then used to tailor the regulatory regime to the circumstances of each particular firm. The approach distinguishes between productivity levels and growth rates. Normally firms at the forefront of industry performance have high productivity levels but low productivity growth rates. This is because they have removed almost all unnecessary slack and are only able to increase productivity at the rate of technological change for the industry.

Conversely, laggard firms normally have low productivity levels but are potentially capable of high productivity growth rates. This is because they can make some easy gains by removing the slack from their operations to mimic the operations of the industry's best performers. Consequently they can achieve productivity growth far in excess of the rate of technological change for the industry for an interim period while they catch up to the productivity levels of the best performing firms. As a result of this catch-up process, the best performing firms in the industry will, ironically, not be able to match the average productivity level growth rates for the industry (although they have superior productivity levels) while laggard firms will be able to outperform the industry average productivity growth rate.

In a regulatory context, if a firm is operating far below best practice (after allowing for operating environment and service quality differences) then a positive differential factor may be applied to allow for the fact that the firm should be able to make some easy 'catch-up' gains and exceed the average industry productivity growth rate. This ensures the firm's consumers receive some of the initial catch up benefits. In subsequent regulatory periods we would expect the firm to move closer to average industry productivity performance and so the size of the differential productivity factor would diminish. Conversely, for a firm already close to best practice, a negative differential factor may be set to allow for the fact that this firm is unlikely to be able to match industry average productivity growth performance as it cannot make easy catch up gains and is instead only able to grow its productivity at the rate of technological change.

4. MEASUREMENT ISSUES

Measuring the productivity of electricity lines businesses to facilitate setting appropriate X factors presents a number of challenges. In this section we examine a number of difficult measurement issues including how to define lines business output and how to measure capital inputs.

4.1. Measuring Lines Business Outputs

The main challenge in calculating TFP for a lines business is the specification of exactly what the outputs of a lines business are and how to measure their quantity and value. Distribution output can be measured from either a 'supply side' or a 'demand side' perspective. At the simplest level, the output would be the amount of energy 'throughput' and its value would be the distributor's total revenue. This approach essentially treats the distribution system in an analogous fashion to a pipeline and was a common approach of early studies of electricity distribution using TFP or other comprehensive indicators (Lawrence *et al.*, 1991; Jamasb and Pollitt, 2003). It simply concentrates on the demand for the final product delivered by the distribution network. However there are other important dimensions to a distributor's output that need to be taken into account. These include the reliability and quality as well as the quantity of the electricity supply and the coverage and capacity of the

system (that is the fact that the system is there to meet the highest potential peak as well as actual day-to-day demand).

A number of distributor representatives in Australia have drawn the analogy between an electricity distribution system and a road network. The distributor has the responsibility of providing the 'road' and keeping it in good condition but it has little, if any, control over the amount of 'traffic' that goes down the road. Consequently they argue it is inappropriate to measure the output of the distributor by a volume of sales or 'traffic' type measure. Rather the distributor's output should be measured by the availability of the infrastructure it has provided and the condition in which it has maintained it – essentially a supply side measure.

This way of viewing the output of a network industry can be extended to a number of public utilities. For instance, Henscher *et al.* (1992) measured the output of public transport providers using both a 'supply side' and a 'demand side' measure of output. The supply side measure of a passenger train system, for instance, was measured by the number of seat-kilometres the system provides while the demand side output was measured by the number of passenger-kilometres. In the case of public transport this distinction is often drawn because suppliers are required to provide transport for community service obligation and other non-commercial reasons. Using the supply side measure looks at how efficient the supplier has been in providing the service required of it without disadvantaging the supplier as happens with the demand side measure because of low levels of patronage beyond its control.

Tasman Asia Pacific (2000a,b) further advanced the output specification by combining the key elements of the demand and supply models to form a comprehensive output measure which contained three components – throughput, network line capacity and the number of connections. The connection component recognises that some distribution outputs are related to the very existence of customers rather than either throughput or system line capacity. This measure includes customer service functions such as call centres and, more importantly, connection related capacity (for example having more residential customers requires more small transformers and poles). The three-output specification has the advantage of incorporating key features of the main density variables (customers per kilometre and sales per customer).

A fourth dimension to the output of a lines business is the quality of supply which encompasses reliability (the number and duration of interruptions), technical aspects such as voltage dips and surges and customer service (for example the time to answer calls and to connect or reconnect supply). Reliability is likely to be the most important of these service quality attributes and the one for which the most data are available. However previous attempts to include reliability measures as a fourth output have proven unsuccessful due to the way reliability is measured. As both the frequency and duration of interruptions are measured by indexes where a decrease in the value of the index represents an improvement in service quality, it would be necessary to either include the indexes as 'negative' outputs (that is a decrease in the measure represents an increase in output) or else to convert them to measures where an increase in the converted measure represents an increase in output. Most indexing methods cannot readily incorporate negative outputs and inverting the measures to produce an increase in the measure equating to an increase in output leads to non-linear results. Measuring reliability by the time on supply each year rather than the time off supply effectively produces a constant as the time off supply is such a small proportion of the total time. Given these difficulties we omit service quality as an explicit output. In common with most jurisdictions, New Zealand regulates reliability separately from prices (Commerce Commission, 2003). It does this by setting a separate reliability threshold.

Of the three outputs that can readily be included, energy throughput is measured by kWh of energy delivered. The line capacity of the system is measured by the number of MVA kilometres (megavolt-ampere) formed by summing the product of line length for each voltage capacity and a conversion factor based on the voltage of the line. This measures not only the length of line but also its overall capacity. Finally the connections output is measured by the number of connections or customers.

To aggregate the three measured outputs into a total output index using indexing procedures, we have to allocate a weight to each output. For most industries which produce multiple outputs the output weights used are the revenue shares. However in this case we cannot observe separate amounts being paid for the output components. In this case we can either make some arbitrary judgements about the relative importance of the output components or we can draw on econometric evidence by using the relative shares of cost elasticities derived from a cost function (see section 7).

4.2. Capital Inputs and Depreciation

There are a number of different approaches to measuring both the quantity and cost of capital inputs. The quantity of capital inputs can be measured either directly in quantity terms (for example using a measure of line length) or indirectly using a constant dollar measure of the value of assets.

Some analysts such as Kaufmann (2004) have argued that measuring the quantity of capital by the deflated asset value method provides a better estimate of total input as it better reflects the quality of capital and can include all capital items, not just lines and transformers. There are two potential problems with this approach. Firstly it is better suited to more mature systems

where the asset valuations are very consistent over time and across organisations. If the asset valuation process is still being bedded down, as it is in New Zealand, then the estimated quantity of capital inputs is likely to be artificially variable using this approach. Secondly, approaches using the capital stock to reflect the quantity of inputs usually incorporate some variant of either the declining balance or straight line approaches to measuring depreciation. Electricity lines business assets tend to be long lived and to produce a relatively constant flow of services over their lifetime. Consequently, their true depreciation profile is more likely to reflect the 'one hoss shay'[1] or 'light bulb' assumption than that of a declining balance. That is, they produce the same service each year of their life until the end of their specified life rather than producing a given percentage less service every year. In these circumstances it is better to measure the quantity of capital input by the physical quantity of the principal assets. This approach is also invariant to different depreciation profiles that may have been used by different lines businesses. In this study we use direct physical asset measures to proxy the quantity of capital inputs wherever possible.

5. DATA

The data source for this study is the official electricity lines business Disclosure Data required under the *Electricity (Information Disclosure) Regulations 1994* and *1999*. These data were first required for the 1995 March year and included physical, service quality and financial information. Legal (as opposed to reporting) separation of distribution and retail activities occurred during the 1999 financial year, and the disclosure data requirements were revised at this time.

Despite the wide range of items now reported in the Disclosure Data, the consistency and quality of the data is variable, particularly in the earlier years. Several variables normally required for productivity analyses are not reported. For instance there are effectively no useful labour data. There are coverage gaps in years where distributors have amalgamated due to a requirement that data only has to be provided for entities existing at the end of the financial year. Some corrections were made to improve the consistency and coverage of the database.

Eight data years covering 1996–2003 are used to calculate trend rates of aggregate industry level productivity growth used to derive B factor estimates. The 1995 data were discarded due to apparent teething problems with providing Disclosure Data in the first year and the absence of optimised deprival value (ODV) capital valuation estimates. A number of assumptions are made to address data problems surrounding the 1999 financial year. The changes introduced in 1999 have generally improved the quality of the data available. We use the five data years 1999–2003 to derive multilateral TFP estimates used to derive C factor productivity groupings.

5.1. Output and Input Definitions

The distribution productivity analyses reported generally contain three outputs and five inputs.

Output quantities

Throughput The quantity of the distributor's throughput is measured by the number of kilowatt hours of electricity supplied. This is similar to the output measures used in most early TFP studies of electricity supply (Lawrence *et al.*, 1991).

System line capacity The quantity of the distributor's system capacity is measured by its total megavolt-ampere (MVA) kilometres. The MVA-kilometres measure provides a more representative measure of system capacity than either line length alone or the simpler kilovolt-kilometres measure. Low voltage distribution lines were converted to system capacity in MVA-kilometres using a factor of 0.4, 6.6kV high voltage distribution lines using a factor of 2.4, 11kV high voltage distribution lines using a factor of 4.0, 22kV high voltage distribution lines using a factor of 8.0, 33kV high voltage distribution lines using a factor of 15.0, 66 kV lines using a factor of 35.0, and 110 kV lines using a factor of 80.0. These factors are based on a review of the factors used in our initial report by Parsons Brinckerhoff Associates (2003). They have been tailored specifically to reflect New Zealand operating conditions and the fact that the effective capacity of an individual line depends not only on the voltage of the line but also on a range of other factors, including the number, material and size of conductors used, the allowable temperature rise as well as limits through stability or voltage drop.

Connections Connection dependent and customer service activities are proxied by the distributor's number of connections.

Output weights

To aggregate a diverse range of outputs into an aggregate output index using indexing procedures, we have to allocate a weight to each output. For most industries which produce multiple outputs these output weights are taken to be

the revenue shares. However in this case we cannot observe separate amounts being paid for the different output components. As discussed in section 4.1, in this case we can either make some arbitrary judgements about the relative importance of the output components in costs or we can use the estimated output cost shares derived from an econometric cost function. We have chosen to rely on New Zealand based empirical evidence wherever possible in this study and use the output cost shares derived from the econometric cost function reported in section 7.2. Given the small number of observations available for each distributor, a weighted average of the output cost shares is formed using the share of each observation's estimated costs in the total estimated costs for all distributors and all time periods. This produces an output cost share for throughput of 22 per cent, for system line capacity of 32 per cent and for connections of 46 per cent. While the output shares could be expected to vary somewhat between distributors in reality, using a common share based on the weighted average for all observations produces the most robust estimate in this case.

Input quantities

Operating expenditure The quantity of the distributor's operating expenses (OpEx) is derived from the Disclosure Data by deflating the sum of the grossed up values of direct costs per kilometre and indirect (or overhead and shared) costs per customer by the Statistics New Zealand index of labour costs for the electricity, gas and water sector. The grossed up values of direct costs per kilometre and indirect costs per customer are used as the value of operating costs because these measures best reflect the purchases of actual labour, materials and services used in operating the lines business and exclude rebates. The index of labour costs for the electricity, gas and water sector is used as the price of operating expenditure as it directly measures the price of a major component of operating expenditure.

Overhead (OH) network The quantity of poles and wires input in the overhead network is proxied by the distributor's overhead MVA-kilometres calculated using the same factors as listed above.

Underground (UG) network The quantity of underground cables input is proxied by the distributor's underground MVA-kilometres.

Transformers The quantity of transformer inputs is proxied by the kilovolt-amperes (KVA) of the distributor's installed transformers.

Other assets The quantity of other capital inputs such as computers and control systems, and so on, is proxied by their ODV where the share of total ODV attributable to these assets is estimated for the average of distributors having disaggregated ODV information in each of four groups (rural high density, rural low density, urban high density and urban low density). The shares of other assets in total ODV range from 2 to 4 per cent. The price of other assets is assumed to remain unchanged over the period in line with the replacement cost unit values used in the ODV asset valuation at the time.

Input weights

The value of total costs is formed by summing the estimated value of operating expenditure and 12.5 per cent of total ODV. We follow NZIER (2001) in assuming a common depreciation rate of 4.5 per cent and an opportunity cost rate of 8.0 per cent for capital assets. Disaggregated ODV data has been formed for all but three distributors. To allocate ODV to the four asset classes we take the weighted average shares for the distributors that have this data in each of four groups (rural high density, rural low density, urban high density and urban low density) and apply these shares to all distributors in the respective group. This strategy was adopted to minimise risks as little confidence can be placed in the disaggregated asset data for several of the distributors. Input weights were then formed from the share of the cost of each of the five inputs in total cost.

5.2. Data characteristics

The key characteristics of the output and input data for the 29 distributors included in the analysis are reported in Table 8.1 for 2002.

Table 8.1 Key output and input characteristics, 2002

	Units	Average	Minimum	Maximum
Deemed revenue	$NZm	35.17	2.66	299.43
Energy	GWh	957.20	44.53	6 873.04
Customer numbers	'000	61.33	4.11	505.06
Line length	km	4 962.28	241.00	30 022.00
Transformers	MVA	517.16	27.82	3 887.57
Energy density	kWh/cust	16 129.17	10 026.00	25 745.00
Customer density	cust/km	11.34	3.44	35.58

The key feature of Table 8.1 is that the 29 distributors have a wide range of characteristics and a skewed distribution within that range. The five largest distributors in terms of throughput in 2002 accounted for around 65.0 per cent of energy delivered while the smallest business in terms of throughput accounted for only 0.3 per cent of energy delivered. New Zealand has an unusually large number of very small distributors. The range of customer densities observed also highlights that operating environments vary considerably from sparse rural to dense urban.

6. INDUSTRY PRODUCTIVITY AND THE B FACTOR

In this section we use the Fisher TFP index method to calculate the productivity performance of distribution as a whole for the eight years 1996 to 2003. We then examine evidence on input price changes before deriving implied B factors for distribution.

6.1. The Fisher TFP Index

TFP is defined as the change in total output quantity divided by the change in total input quantity between two periods,

$$TFP = \Delta Y / \Delta X \tag{8.10}$$

where ΔY is the proportional change in the quantity of total output between the current and base periods and ΔX is the corresponding proportional change in the quantity of total inputs.

To operationalise this concept we need a way to combine changes in diverse outputs and inputs into measures of change in total outputs and total inputs. To aggregate changes in these diverse components into a total change, index number methodology essentially takes a weighted average of the changes in the components. Different index number methods take this weighted average change in different ways (Diewert and Nakamura, 2003). Alternative index number methods can be evaluated by examining their economic properties or by assessing their performance relative to a number of axiomatic tests. The index number which performs best against these tests and which is being increasingly favoured by statistical agencies is the Fisher ideal index (Diewert, 2004), given by:

$$Y_F^t = \left[\left(\sum_{i=1}^{m} P_i^B Y_i^t / \sum_{j=1}^{m} P_j^B Y_j^B\right)\left(\sum_{i=1}^{m} P_i^t Y_i^t / \sum_{j=1}^{m} P_j^t Y_j^B\right)\right]^{0.5} \qquad (8.11)$$

where:

- Y_F^t is the Fisher ideal output index for observation t;
- P_i^B is the price of the ith output for the base observation;
- Y_i^t is the quantity of the ith output for observation t;
- P_i^t is the price of the ith output for observation t; and
- Y_j^B is the quantity of the jth output for the base observation.

In this case we have three outputs (so $m = 3$) and seven years (so $t = 1, \ldots, 7$).

Similarly, the Fisher ideal input index is given by:

$$X_F^t = \left[\left(\sum_{i=1}^{n} W_i^B X_i^t / \sum_{j=1}^{n} W_j^B X_j^B\right)\left(\sum_{i=1}^{n} W_i^t X_i^t / \sum_{j=1}^{n} W_j^t X_j^B\right)\right]^{0.5} \qquad (8.12)$$

where:

- X_F^t is the Fisher ideal input index for observation t;
- W_i^B is the price of the ith input for the base observation;
- X_i^t is the quantity of the ith input for observation t;
- W_i^t is the price of the ith input for observation t; and
- X_j^B is the quantity of the jth input for the base observation.

In this case we have five inputs (so $n = 5$) and seven years (so $t = 1, \ldots, 7$).

The Fisher ideal TFP index is then given by:

$$TFP_F^t = Y_F^t / X_F^t . \qquad (8.13)$$

The Fisher index can be used in either the unchained form denoted above or in the chained form used in this study where weights are more closely matched to pair-wise comparisons of adjacent period observations, thus minimising any inaccuracy from changing composition over time. Denoting the Fisher output index between observations i and j by $Y_F^{i,j}$, the chained Fisher index between observations 1 and t is given by:

$$Y_F^{1,t} = 1 \times Y_F^{1,2} \times Y_F^{2,3} \times \ldots \times Y_F^{t-1,t} . \qquad (8.14)$$

6.2. Aggregate Distribution Productivity

Our model of aggregate distribution TFP involves the three outputs and five inputs defined in section 5.1. The outputs are energy delivered in kilowatt hours, system line capacity in MVA-kilometres and connection numbers. The five inputs are operating costs, overhead lines capital, underground lines capital, transformer capital and other capital items.

TFP results for the aggregate distribution industry are presented in Figure 8.1 and Table 8.2 using the chained Fisher indexing method and the eight years of available data from 1996 to 2003.

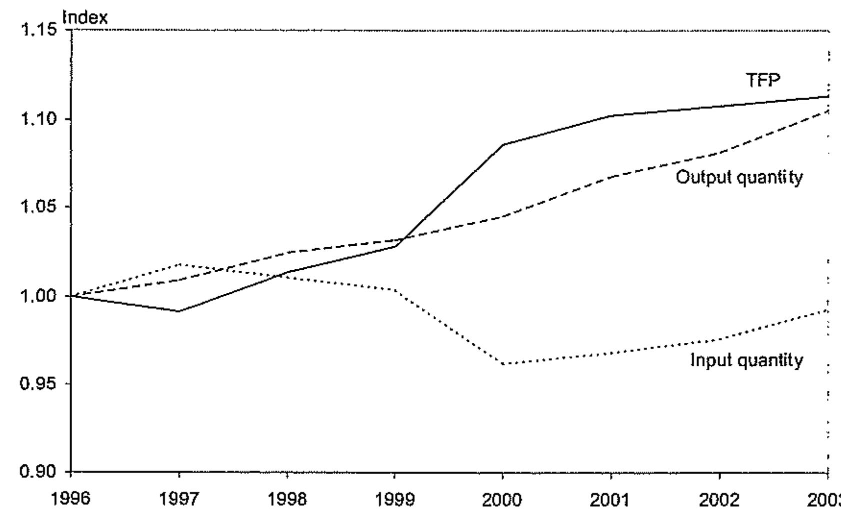

Figure 8.1 Aggregate distribution output, input and TFP indexes, 1996–2003

Output quantity increases steadily over the period although somewhat more rapidly after 2000. Input quantities were initially relatively flat through to 1999 before falling somewhat in 2000 and again remaining relatively flat for the last three years. The TFP index increased by 3.0 per cent between 1996 and 1999. The TFP index then increased by 5.6 per cent in 2000 and by another 2.5 per cent through to 2003, the latter driven mainly by increased output quantities. For the eight-year period aggregate distribution TFP increased at a trend annual rate of around 2.0 per cent.

In Table 8.2 and Figure 8.2 we present the five aggregate distribution partial productivities – the output quantity index divided by the relevant input quantity index. The partial productivity of operating costs has increased by around one third between 1996 and 2003 while the partial productivities of transformers, overhead lines and other capital have all increased by over 5.0 per cent.

Table 8.2 Aggregate distribution TFP and partial productivity indexes, 1996–2003

	Quantity indexes			Partial productivities				
	Outputs	Inputs	TFP	OpEx	O/H lines	U/G lines	T' formers	Other
1996	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1997	1.009	1.018	0.992	0.979	1.003	0.977	1.021	0.945
1998	1.024	1.011	1.014	1.055	1.001	0.953	1.017	0.936
1999	1.031	1.004	1.028	1.103	1.000	0.916	1.040	0.967
2000	1.045	0.962	1.086	1.271	1.026	0.890	1.058	0.987
2001	1.067	0.969	1.102	1.296	1.032	0.916	1.073	0.963
2002	1.081	0.976	1.107	1.336	1.036	0.901	1.055	0.956
2003	1.105	0.993	1.113	1.333	1.051	0.894	1.059	1.052

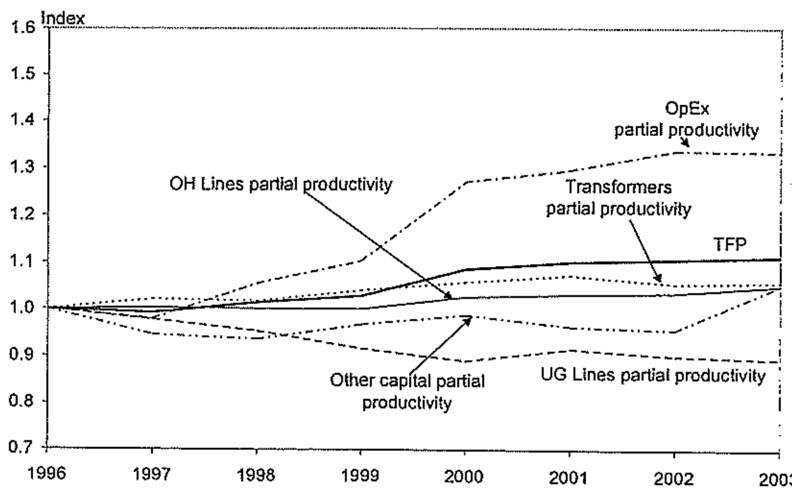

Figure 8.2 Aggregate distribution partial productivity indexes, 1996–2003

The partial productivity of underground lines has decreased by 10.0 per cent reflecting the increasing use of undergrounding. TFP is essentially a weighted average of these five partial productivities and lies above the four capital partial productivities but below operating expenditure partial productivity.

TFP lies closer to the capital partial productivities reflecting the relative weights used in constructing the TFP index.

6.3. Input Price Changes

As well as information on the difference between the productivity performances of the electricity industry and the economy as a whole, we also require information on the difference between the electricity industry's and the economy's input price growth rates to derive the B factor. There was considerable debate regarding what was a suitable index of changes in distribution input prices, and data from official sources often conflicted.

A strong case can be made that unless there is clear-cut evidence of a statistically significant difference in rates of input price increase then the price differential term should be set at zero. In light of the conflicting information coming through from the official statistics and the fact that the implicit input price index derived from the database is close to the all industries capital price index (and this is a capital intensive industry), we adopt the approach of minimising risks by setting the price differential to zero.

6.4. B Factor Conclusions

Based on the review of available information for the lines businesses and for the economy, we can now draw conclusions on the appropriate size of the B factor for distribution. In terms of the two productivity components, we have the preferred annual growth rate for TFP in the New Zealand economy of 1.1 per cent per annum using the trend rate derived from the indexes reported in the Treasury update (Black *et al.*, 2003) of Diewert and Lawrence (1999). For the distribution lines businesses we have derived a trend annual TFP growth rate of 2.1 per cent per annum from the adjusted Disclosure Data. The estimate of a 2.1 per cent per annum TFP growth rate for the industry for the seven-year period 1996 to 2002 is likely to be lower than that which could be expected over the next several years as economies from the recent split up of UnitedNetworks are realised.

Substituting these data in equation (8.9), and ignoring the markup component for now, we obtain the following for distribution:

$$\begin{aligned} B &= [(\Delta TFP - \Delta TFP_E) - (\Delta W - \Delta W_E)] \\ &= [(2.1\% - 1.1\%) - (0\%)] \\ &= 1.0\%. \end{aligned} \tag{8.15}$$

A B factor of 1.0 per cent would be appropriate for the distribution lines businesses.

7. DISTRIBUTOR PRODUCTIVITY AND C FACTORS

As well as the industry productivity growth related B factor, we use a number of additional considerations in arriving at distributors' X factors. These distributor-specific considerations are represented by a C factor for each distributor reflecting the distributor's comparative productivity performance (taking account of differences in distributors' operating environments) and relative profitability. Those distributors performing better than the industry average on productivity levels and those earning low rates of return would be set less onerous overall X factors compared to those performing near the industry average. Those performing worse than the industry average on productivity levels and those earning high rates of return would be set more onerous overall X factors compared to those performing near the industry average.

The overall X factor for a given distributor is made up of an amalgam of its B and C factors. The B factor is common to all distributors and the C factors are to be determined for broad groups of distributors.

We proceed with a two stage analysis. The first stage allocates distributors to three groupings based on relative productivity performance while the second stage allocates distributors to three groupings based on profitability considerations. We then form overall C factor groupings by summing the relative productivity and profitability components.

7.1. Multilateral TFP

For benchmarking purposes we need to extend the time series indexing methods discussed in the earlier sections to include analysis of productivity levels as well as growth rates. The reasons for this can be illustrated using Figure 8.3 where the efficiency performance of two similar utilities is plotted relative to a best practice frontier. Utility A is initially performing at close to best practice efficiency as reflected by its closeness to the best practice frontier while Utility B is initially well below best practice efficiency. Say we are reviewing the utilities at time t_1 and setting price caps for the period through to t_2. Because Utility A is close to best practice initially it will have limited options for efficiency improvement and so its productivity growth rate will consist of small movements towards the frontier plus movement of the frontier due to technical change which will be relatively slow in industries like electricity distribution. Utility B, on the other hand, has the potential to make large catch-up changes to its operations and so could achieve a much higher productivity growth rate than Utility A although it is starting from a much lower productivity level.

If Utility B had a low productivity growth rate in the period up to t_1 getting only to point C then in the absence of yardstick competition (Shleifer, 1985) we would have no way of distinguishing Utilities A and B. Extrapolating the low productivity growth rate would be appropriate for Utility A but inappropriate for Utility B. Rather, Utility B should be set a higher X factor to provide it with an incentive to move closer to the frontier. If, on the other hand, Utility B had had a higher growth rate in the period up to t_1 getting to point D then extrapolating this growth rate in setting the X factor would be appropriate. However setting an X factor of that magnitude would be inappropriate and indeed unachievable for Utility A. Only by examining the utilities' productivity levels as well as their growth rates can we set appropriate X factors for them.

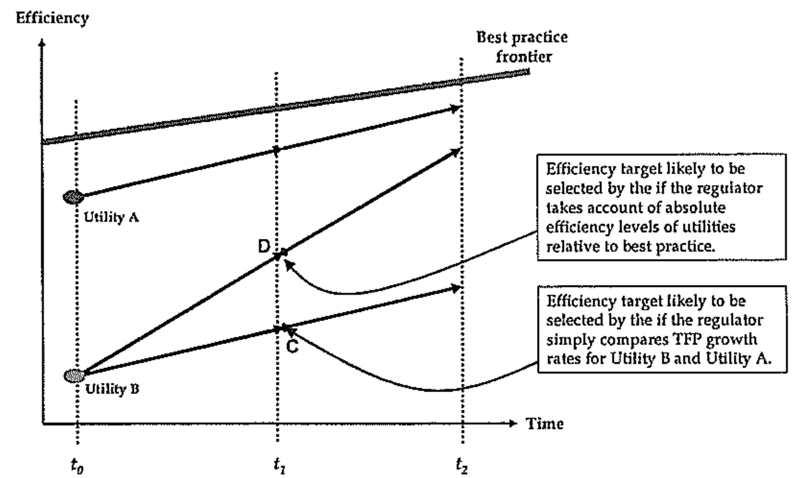

Figure 8.3 Efficiency levels and growth rates

Traditional measures of TFP have enabled comparisons to be made of rates of change of productivity between organisations but have not enabled comparisons to be made of differences in the absolute levels of productivity in combined time series, cross-section data. This is due to the failure of conventional TFP measures to satisfy the important technical property of transitivity. This property states that direct comparisons between observations *m* and *n* should be the same as indirect comparisons of *m* and *n* via any intermediate observation *k*.

Caves *et al.* (1982) developed the multilateral translog TFP (MTFP) index measure to allow comparisons of the absolute levels as well as growth rates of productivity. It satisfies the technical properties of transitivity and characteristicity which are required to accurately compare TFP levels within panel data (see Lawrence *et al.*, 1991).

The Caves, Christensen and Diewert (CCD) multilateral translog index is given by:

$$\begin{aligned}\log\ (TFP_m / TFP_n\ ) = & \sum_i (R_{im} + R_i^*)\ (\log Y_{im} - \log Y_i^*)/2 \\ & -\sum_i (R_{in} + R_i^*)\ (\log Y_{in} - \log Y_i^*)/2 \\ & -\sum_j (S_{jm} + S_j^*)\ (\log\ X_{jm} - \log X_j^*)/2 \\ & +\sum_j (S_{jn} + S_j^*)\ (\log X_{jn} - \log X_j^*)/2 \end{aligned} \qquad (8.16)$$

where R_i^* (S_j^*) is the revenue (cost) share averaged over all utilities and time periods and $\log Y_i^*$ ($\log X_j^*$) is the average of the log of output i (input j). In the application reported in the following section we have three outputs (throughput, system line capacity and connections) and, hence, i runs from 1 to 3. We have five inputs (operating expenses, overhead lines, underground cables, transformers and other capital) and, hence, j runs from 1 to 5. The Y_i and X_j terms are the output and input quantities, respectively, described in section 6.1. The R_i and S_j terms are the output and input weights, respectively, from section 5.1.

With the index number MTFP approach there is scope to capture density related operating environment conditions by the specification of multiple outputs. For example, in previous studies, output specifications that focus on energy delivered have tended to favour dense urban distributors while output specifications that have focused on the network's capacity as measured by MVA-kilometres have tended to favour low density rural distributors (Tasman Asia Pacific, 2000a,b). Incorporating both the energy delivered and network capacity measures of distribution output leads to a more even-handed treatment of urban and rural distributors. By choosing multiple outputs such as energy delivered, MVA-kilometres and connection numbers, it is possible to incorporate aspects of density such as customers per kilometre and energy delivered per customer into the MTFP measure directly in an analogous fashion to how this is captured in multiple output econometric cost functions (see Tasman Asia Pacific, 2000a,b; and Pacific Economics Group, 2000a,b).

7.2. MTFP Results

The database we used in section 6 to calculate the overall distribution industry productivity performance was formed by aggregating the individual data for the 29 distributors for the years 1996 to 2002 and for the 28 full-year equivalent distributors in 2003. In this section we use the same data from the distributors but for the five years 1999 to 2003 and look at individual distributor results. We use the shorter time period in this analysis because it avoids problematic individual distributor data issues associated with the 1999 accounting changes and only recent information is used to determine distributor productivity rankings.

The main decision we have to make again relates to how to weight the three outputs together. As described in section 5.1, we use the weighted average estimated output cost shares derived from running econometric Leontief cost functions using the eight-year database.

We present the MTFP results in Table 8.3. Index values and ranks are shown for each of the five years 1999 to 2003 and for the average of the five years. The index values indicate the productivity level relative to the performance of Alpine Energy in 1999. The results are invariant to this choice of the 'base' observation. The distributors are listed by decreasing MTFP level for the average of the five years.

A mixture of urban and rural based distributors with both high and low (energy) density are found to have the highest MTFP levels for the average of the five years. We define rural distributors as those having less than 13 connection points per kilometre while low density distributors have an average consumption of less than 16 000 kilowatt hours per customer. The urban low density distributor Electricity Invercargill has the highest productivity level in each of the five years. This is followed by the urban high density distributor Nelson Electricity, the rural low density Waipa Networks and the rural high density Horizon Energy. The two large urban distributors, Vector and UnitedNetworks, also have MTFP levels in the top third of the sample.

The distributors with the lowest average MTFP levels over the five years also reflect a mixture of distributor types. The rural high density distributors, Electricity Ashburton and Buller Electricity, have the lowest MTFP levels followed by four rural low density distributors (Eastland Network, Westpower, Marlborough Lines and MainPower) and the urban high density Aurora Energy (formerly Dunedin Electricity).

Table 8.3 MTFP indexes using 3 outputs, average cost function weights, 1999–2003

	1999	Rk	2000	Rk	2001	Rk	2002	Rk	2003	Rk[1]	Mean	Rk
Elec Invercargill	1.401	1	1.441	1	1.508	1	1.603	1	1.781	1	1.547	1
Nelson Electricity	1.262	2	1.363	2	1.318	2	1.404	2	1.201	4	1.309	2
Waipa Networks	1.227	3	1.221	3	1.296	3	1.296	3	1.239	3	1.256	3
Horizon Energy	0.987	16	1.143	6	1.257	4	1.201	6	1.254	2	1.168	4
Vector	1.093	5	1.168	4	1.165	6	1.251	4	1.104	9	1.156	5
Network Tasman	0.989	14	1.154	5	1.145	7	1.227	5	1.161	6	1.135	6
Northpower	1.105	4	1.111	8	1.171	5	1.126	7	1.159	7	1.134	7
Scanpower	1.038	9	1.136	7	1.106	9	1.123	8	1.100	10	1.100	8
UnitedNetworks	0.981	17	1.089	9	1.111	8	1.115	9			1.074[2]	9
OtagoNet	1.005	12	1.023	15	1.071	10	1.078	10	1.175	5	1.070	10
Orion NZ	1.065	7	1.032	13	1.059	11	1.047	11	1.050	14	1.051	11
Alpine Energy	1.000	13	1.033	12	1.037	13	1.040	12	1.067	13	1.035	12
Network Waitaki	1.077	6	1.040	11	1.041	12	1.013	16	1.001	17	1.034	13
Powerco	1.053	8	1.026	14	0.986	19	1.007	19	1.097	11	1.034	14
Electra	0.987	15	1.046	10	1.031	15	1.012	17	1.012	16	1.018	15
Unison	0.957	18	1.008	16	0.986	18	1.028	13	1.067	12	1.009	16
Counties Power	1.023	10	0.971	21	0.999	17	1.010	18	0.973	20	0.995	17
WEL Networks	0.926	20	0.987	19	1.008	16	1.016	15	1.000	18	0.987	18
Top Energy	1.011	11	0.991	18	0.970	21	0.987	20	0.977	19	0.987	19
The Power Co	0.937	19	0.954	22	0.983	20	0.966	21	0.946	24	0.957	20
The Lines Co	0.762	28	1.005	17	1.034	14	1.018	14	0.962	21	0.956	21
Centralines	0.827	24	0.974	20	0.950	23	0.950	22	1.047	15	0.950	22
Aurora Energy	0.912	21	0.954	23	0.959	22	0.946	23	0.952	23	0.944	23
MainPower	0.889	22	0.927	24	0.946	24	0.923	24	0.942	25	0.925	24
Marlborough	0.878	23	0.853	25	0.873	26	0.847	26	0.868	26	0.864	25
Westpower	0.791	26	0.784	28	0.875	25	0.824	27	0.842	27	0.823	26
Eastland Network	0.702	29	0.817	26	0.766	29	0.859	25	0.959	22	0.821	27
Elec Ashburton	0.778	27	0.789	27	0.812	28	0.797	28	0.765	28	0.788	28
Buller Electricity	0.817	25	0.734	29	0.834	27	0.712	29	0.674	29	0.754	29

Notes:

1. For 2003 rankings UnitedNetworks was assumed to have same MTFP as in 2002 to facilitate greater comparability of rankings of firms ranked below it. Hence, 2003 rankings go to 29, not 28.
2. Four year average for UnitedNetworks.
   Rk stands for 'rank'.

Scale of operations does not appear to be a major determinant of average MTFP levels with the smallest distributor in terms of throughput (Scanpower) appearing near the top of the list and the second smallest distributor (Buller Electricity) appearing near the bottom. The five largest distributors (UnitedNetworks, Vector, Orion, Powerco and Aurora Energy) are spread across the top, middle and bottom thirds of the sample.

The MTFP results reported in Table 8.3 provide the best measure of individual distributor productivity performance given information currently available. It may be possible to refine these estimates in future if more direct information on cost allocation between outputs becomes available.

7.3. Cost Function Estimation

The sophistication of the cost function model we are able to estimate is limited by the number of observations we have for each distributor and the range of variables available. In particular we have no information on the price individual distributors pay for their operating expenses, and have assumed they face a common price given by the Electricity, Gas and Water labour cost index.

To overcome these problems we estimate a multi-output Leontief cost function. This functional form assumes that distributors use inputs in fixed proportions for each output. We include the three outputs of throughput, system line capacity and connections. We include four of the five inputs used earlier: operating expenses, overhead lines, underground lines and transformers. We exclude the other capital item which only makes up between two and three per cent of total costs to conserve degrees of freedom. To improve the statistical properties of the model we change to measuring system line capacity by a transformer capacity and line length based measure rather than the line length and voltage based measure used earlier. This change reduces the potential for linear dependence between the system line capacity output quantity and the overhead line and underground cable input quantities. We retain the line length and voltage based measure for the overhead and underground lines capital input quantities.

The Leontief cost function is given by:

$$C(y^t, w^t, t) = \sum_{i=1}^{4} w_i^t [\sum_{j=1}^{3} (a_{ij})^2 y_j^t (1 + b_i t)] \qquad (8.17)$$

where w_i is an input price, y_j is an output and t is a time trend representing technological change. The input/output coefficients a_{ij} are squared to ensure the non-negativity requirement is satisfied, that is increasing the quantity of any output cannot be achieved by reducing an input quantity. This means we have to use non-linear regression methods. To conserve degrees of freedom we impose a common rate of technological change for each input across the three outputs but this can be either positive or negative.

The estimating equations are the four input demand equations:

$$x_i^t = \sum_{j=1}^{3} (a_{ij})^2 y_j^t (1 + b_i t); \quad i = 1,..,4; \; j = 1,2,3; \; t = 1,..,7, \qquad (8.18)$$

where the i's represent the four inputs, the j's the three outputs and t the seven years, 1996 to 2002.

The input demand equations are estimated separately for each of the 29 distributors using the non-linear regression facility in Shazam (White, 1997) and data for the years 1996 to 2002. Given the limited number of observations and the absence of cross-equation restrictions, each input demand equation is estimated separately. This leads to a total of 116 regressions,[2] the results of which are reported in Meyrick and Associates (2003a).

From the estimated equations we can derive information on each distributor's rate of productivity change and its relative efficiency. The period t productivity change estimate for a distributor is equal to (the negative of) the amount of cost reduction due to the passage of one period:

$$\begin{aligned} Tech^t &= -[\partial C(y^t, w^t, t)/\partial t]/C(y^t, w^t, t) \\ &= -[\sum_{i=1}^{4} w_i^t [\sum_{j=1}^{3} (a_{ij})^2 b_i y_j^t]]/\{\sum_{i=1}^{4} w_i^t [\sum_{j=1}^{3} (a_{ij})^2 y_j^t (1+b_i t)]\}. \end{aligned} \quad (8.19)$$

The efficiency of a particular distributor in a particular year can be derived by comparing its estimated cost for that year with a 'benchmark' cost using a numeraire observation's technology (or estimated parameters) but the distributor's actual output quantities:

$$E_n^t = C(b, y_n^t, w_n^t, t)/C(n, y_n^t, w_n^t, t) \quad (8.20)$$

where b is the benchmark observation and n is the distributor whose efficiency we are calculating. Thus, if distributor n can produce its output quantities at lower cost using its own technology than it could using the benchmark distributor's technology then E will be greater than one and n will be more efficient than the benchmark. Conversely, if n could produce its output quantities more cheaply using the benchmark distributor's technology than it can using its own then E will be less than one and n will be less efficient than the benchmark.

A problem with equation (8.20) is that the efficiency scores and rankings are likely to vary depending on which observation we choose as the benchmark or numeraire. To overcome this problem we take the benchmark to be a weighted average of the technologies of all the observations in the sample where the weights are given by the share of the observation's estimated cost in the total cost for all distributors and all time periods:

$$E_n^t = [\sum_{b,t} s_b^t C(b, y_n^t, w_n^t, t)]/C(n, y_n^t, w_n^t, t) \quad (8.21)$$

where:

$$s_b^t = C(b, y_b^t, w_b^t, t)/\sum_{b,t} C(b, y_b^t, w_b^t, t). \quad (8.22)$$

Equations (8.21) and (8.22) use an analogous idea to the multilateral TFP method in that the benchmark is taken to be a weighted average of all observations' technologies. This means the efficiency scores will be invariant provided the sample is not changed.

We can also derive the output cost shares for each output and each observation as follows:

$$h_j^t = \{\sum_{i=1}^{4} w_i^t [(a_{ij})^2 y_j^t (1+b_i t)]\}/\{\sum_{i=1}^{4} w_i^t [\sum_{j=1}^{3} (a_{ij})^2 y_j^t (1+b_i t)]\}. \quad (8.23)$$

We then form a weighted average of the estimated output cost shares using equation (8.22) to form an overall estimated output cost share. This process produces output cost share estimates of 22 per cent for throughput, 32 per cent for system line capacity and 46 per cent for connections. This procedure produces more robust and stable estimates of the cost shares given the limited number of observations available than the alternative of running one set of regressions on the aggregated data.

The cost function efficiency scores are presented in Meyrick and Associates (2003a). They span a wider range than the corresponding three-output MTFP indexes but the ranking of distributors is broadly similar. While they are not used in forming the threshold factors, the econometric cost function efficiency results broadly confirmed the findings of our preferred MTFP results despite being derived from a different methodology.

7.4. Profitability Considerations

Given that this is effectively the first time the New Zealand lines businesses have been regulated and they are starting from a wide range of circumstances, we now proceed to allocate distribution businesses a second C factor component based on their profitability. The rationale for this is that if a business is currently earning 'high' profits, it can sustain a higher level of real price reduction than that indicated solely by its relative productivity performance, all else equal. Conversely, if a business is currently earning a 'low' return then there is an arguable case for easing the tightness of its threshold based purely on productivity considerations to allow it to return to earning normal rates of return. It is envisaged that the profitability component would be purely temporary and only apply for the first one or two regulatory periods until the businesses get to reasonable starting points. From then on incentive regulation would only contain the productivity factor.

While it would be desirable to also include a service quality component in the C factor, more work is required on better understanding the complex relationship between observed service quality levels and current input levels.

Profitability issues are often addressed separately from productivity issues by the setting of an upfront adjustment or 'P_0' factor separately from the X factor. While the X factor is based on relative productivity considerations as usual, the P_0 adjustment is applied as an additional adjustment in the first year of the regulatory period to bring the business's profitability back to 'normal' levels. P_0 adjustments have been the subject of much controversy in other countries as evidenced by the appeal in 2000 against the Victorian regulator's decision in Australia. By sometimes placing a large adjustment burden on the distributor in a short space of time there is a risk that this process can place undue financial distress on the lines business and endanger the ongoing security of supply. They also assume that the regulator has full information which is rarely the case.

A more reasonable approach is to set a 'glide path' where prices are adjusted over several years to bring the business closer to earning a normal return. The overall X factor that a business is set will then consist of two components: the usual productivity-based component plus an additional component aimed at gradually eliminating excess profits or restoring normal returns, as the case may be.

The range of ownership types and associated objectives complicates assessing the profitability of New Zealand lines businesses. The businesses can be broadly divided into three groups: commercial businesses that issue dividends to shareholders in the normal way; trusts which offer 'dividends' to their consumers/owners in the form of explicit rebates which may take the form of line charge holidays; and trusts which provide a 'return' to their consumers/owners implicitly in the form of lower prices. This makes assessing profitability against normal commercial criteria such as the rate of return difficult. However we do not have enough information to attempt to adjust for ownership influences. Instead we assess businesses on the basis of pre-rebate prices. This is equivalent to treating the explicit trust rebates as a form of dividend to 'shareholders'.

We assess distributor profitability on the basis of a relatively simple post-tax residual rate of return measure. This was derived by subtracting operating expenses, tax-equivalent payments and estimated depreciation from 'deemed' revenue. The tax-equivalent payments deducted are actual taxes paid plus 33 per cent of subvention payments plus the interest tax shield. Subvention payments are payments from one business entity to another in the same tax group (for example subsidiary to parent company) while the interest tax shield is an adjustment to correct for the tax implications of debt rather than equity

funding. The residual rates of return are calculated relative to the ODV asset valuation.

The tax adjusted residual rates of return derived from our database are presented in Table 8.4 for the years 2000 to 2003 and the average of these four years. With the exception of Powerco, Unison and Vector, for which 2003 deemed revenue data are neither available nor readily able to be estimated, distribution businesses have been ranked on their average tax adjusted residual rates of return for the average of the four-year period. The three businesses involved in the acquisition of United Networks have been ranked on their average tax adjusted residual rates of return for the three-year period from 2000 to 2002 instead.

We divide the businesses into three groups – high, medium and low rates of return – with approximately one third of the businesses in each group. This also corresponds with breakpoints in the list of tax adjusted residual rates of return. This leads to businesses with low rates of return being those with a tax adjusted residual rate of return of less than 6.0 per cent and those with high rates having tax adjusted residual rates of return in excess of 8.1 per cent.

The distributors earning the highest residual rates of return include a mixture of listed businesses, trusts, consumer trusts and council owned entities. Nelson Electricity has the highest residual rate of return. The businesses in the low rate of return group are all trusts plus the former consumer cooperative OtagoNet.

7.5. C and X Factor Recommendations

We are now in a position to assemble the information presented in the preceding sections on productivity levels and profitability to form recommendations for C factors. In doing this we have adopted targets that minimise likely risks in light of the relatively small amount of information we have to work with.

Given the capital intensive nature of electricity lines businesses and the longevity of the assets involved, it is unrealistic to expect lines businesses to be able to remove large productivity gaps in a short space of time. Rather, a timeframe of a decade, or two five-year regulatory periods, is likely to be necessary for businesses performing near the bottom of the range to lift themselves into the middle of the pack. This timeframe would allow sufficient time for asset bases to be adjusted significantly, new work practices to be adopted and bedded down and for amalgamations and rationalisations to be implemented and consolidated. It is, However reasonable to expect profitability levels to be adjusted over a shorter period, say one regulatory period of five years. This should allow sufficient time for adjustment in a sustainable fashion without incurring the risk of financial stress or failure resulting from large P_0 adjustments.

For productivity adjustments we form the distributors into three groups with high, medium and low productivity levels. In 2003 the high productivity group (excluding Electricity Invercargill) was 15 per cent more productive on average than the middle productivity group which was in turn around 15 per cent more productive than the low productivity group. Using the distribution B factor of 1.0 per cent derived in section 6 for the middle group and a 10 year timeframe, the average productivity of the bottom group would have to increase by 2.5 per cent annually to reach the same average productivity level as the middle group after 10 years. Conversely, the high productivity group would have to change its average TFP by -0.5 per cent annually to reach the same average productivity level as the middle group after 10 years. This implies overall X factors of -0.5, 1.0 and 2.5 per cent per annum for the three groups or C factors of -1.5, 0.0 and 1.5 per cent per annum, respectively. Given the need to minimise risks due to the mixed quality of the available data and residual uncertainties, we reduce the range of C factors to -1, 0 and 1 per cent. This range also allows the high productivity group to maintain its absolute productivity levels while the other groups catch up.

For a similar spread of tax adjusted residual rates of return, the same range of C factors (-1, 0 and 1 per cent) would imply adjustment of average residual returns for the low and high return groups, respectively, to the average of the medium return group over less than 10 years. This is because the rate of return component will usually make up less than half of total annual costs. Therefore, a 1 per cent change in total revenue has a magnified effect on the residual rate of return.

To recap, distributors performing near the industry average on all counts would receive a C factor of zero while those achieving high productivity levels (taking their density characteristics into account) and low rates of return would be set the less onerous C factor components of -1 per cent. Distributors achieving low productivity levels taking their density characteristics into account and high rates of return would be set the higher C factor components of 1 per cent. Those achieving, say, high productivity and high profitability would receive offsetting C factor components of -1 and 1 per cent, respectively, leading to an overall C factor of zero.

We use the information from the multilateral TFP indexes using three outputs and the cost function based output cost shares to allocate initial C factors based on the average productivity levels estimated for the five years 1999 to 2003.[3] For clarity, we will refer to these as C_1 components. We then proceed to derive C_2 components based on relative profitability by using the tax adjusted residual rate of return information.

The X factors resulting from using aggregate distribution industry TFP and input price estimates relative to those for the economy as a whole to derive the B factor and the MTFP scores in conjunction with the tax adjusted residual rate of return estimates to derive C factors are presented in Table 8.5. For three distributors the C factor components sum to -2. When combined with the B factor of 1, this means these three distributors would be allowed to increase their real prices by 1 per cent per annum to restore their profitability levels. No distributors have both low productivity and high profitability groupings leading to 2 being the largest X factor recommended.

There is a mixture of business types in each of the three broad X factor groups with urban and rural businesses appearing in each of the low, middle and high X factor groups.

The Commission accepted the above recommendations which are set out in more detail in Meyrick and Associates (2003b) with the new price thresholds regime came into effect from the start of April 2004.

8. CONCLUSIONS

In this chapter we have illustrated some of the practical measurement issues encountered in assessing electricity network productivity performance. While we believe the solution presented represents the best use of the limited data we had to work with in this instance, electricity networks remain one of the many 'hard to measure' industries where further research will lead to ongoing refinements in productivity measurement. Given the trend toward greater use of incentive regulation in network industries, improving productivity measurement in these industries should have a high priority.

The thresholds announced by the Commission for the five years from April 2004 use the recommendations reported in Table 8.5 based on the analysis reported in this chapter. With respect to future regulatory resets, the priority for work in this area in New Zealand is improving the quality and quantity of relevant data available. This involves requiring the disclosure of data on the price and quantity of all major outputs and inputs, including labour and broad asset categories. It also includes gaining more accurate information on the allocation of costs between the major output types. Greater effort will be required to ensure businesses report data in a consistent manner both across businesses and over time.

Table 8.4 Tax adjusted residual rate of return estimates, 2000–2003

	2000 (%)	2001 (%)	2002 (%)	2003 (%)	4 yr-average (%)
High return					
Nelson Electricity	13.90	15.53	18.20	13.23	15.2
UnitedNetworks	11.68	11.84	12.95		*12.2
Counties Power	6.41	10.61	13.45	9.92	10.1
The Lines Company	9.01	9.31	11.72	9.81	10.0
Powerco	8.00	10.79	10.19		*9.7
WEL Networks	9.19	8.86	9.22	11.30	9.6
Network Tasman	6.01	10.02	10.96	9.87	9.2
Centralines	2.17	14.38	10.13	9.86	9.1
Horizon Energy	7.66	9.39	10.40	8.36	9.0
Electra	9.58	8.49	9.05	7.70	8.7
Medium return					
Alpine Energy	5.57	7.31	9.30	10.23	8.1
Scanpower	7.84	7.25	7.54	8.98	7.9
Marlborough Lines	9.01	10.44	5.63	5.95	7.8
Electricity Invercargill	5.93	7.05	8.33	9.30	7.7
MainPower	6.25	7.32	7.18	8.97	7.4
Orion New Zealand	8.45	7.24	6.40	6.33	7.1
Eastland Network	6.80	5.30	6.60	6.49	6.3
Vector	8.79	4.61	5.21		*6.2
Low return					
Unison	5.56	4.02	6.31		*5.3
Aurora Energy	4.80	4.97	4.95	5.13	5.0
Top Energy	3.90	4.16	5.35	5.23	4.7
Network Waitaki	3.46	5.75	4.29	2.34	4.0
Westpower	1.77	4.29	4.96	4.57	3.9
Electricity Ashburton	3.55	4.48	4.34	3.04	3.9
Northpower	4.31	1.89	2.54	3.03	2.9
OtagoNet	1.55	3.22	1.88	3.25	2.5
Buller Electricity	2.31	4.47	0.90	1.56	2.3
Waipa Networks	3.27	3.74	0.30	-0.14	1.8
The Power Company	0.29	1.35	1.12	2.33	1.3

Note: * Three-year average

Table 8.5 X-factor recommendations

ELB	B	C_1	C_2	$C= C_1+ C_2$	$X= B+C$	ELB	B	C_1	C_2	$C= C_1+ C_2$	$X= B+C$
Centralines	1	0	1	1	2	Network Tasman	1	−1	1	0	1
Counties Power	1	0	1	1	2	Orion New Zealand	1	0	0	0	1
Eastland Network	1	1	0	1	2	United Networks[1]	1	−1	1	0	1
Electra	1	0	1	1	2	Westpower	1	1	−1	0	1
MainPower	1	1	0	1	2	Elec Invercargill	1	−1	0	−1	0
Marlborough Lines	1	1	0	1	2	Network Waitaki	1	0	−1	−1	0
Powerco	1	0	1	1	2	Scanpower	1	−1	0	−1	0
The Lines Company	1	0	1	1	2	The Power Company	1	0	−1	−1	0
WEL Networks	1	0	1	1	2	Top Energy	1	0	−1	−1	0
Alpine Energy	1	0	0	0	1	Unison	1	0	−1	−1	0
Aurora Energy	1	1	−1	0	1	Vector	1	−1	0	−1	0
Buller Electricity	1	1	−1	0	1	Northpower	1	−1	−1	−2	−1
Elec Ashburton	1	1	−1	0	1	OtagoNet	1	−1	−1	−2	−1
Horizon Energy	1	−1	1	0	1	Waipa Networks	1	−1	−1	−2	−1
Nelson Electricity	1	−1	1	0	1						

Note: UnitedNetworks included for information only.

NOTES

1. This is a well known term in the field and refers to assets that produce a constant quantity of service flow over their lives and then fall to bits (as opposed to assets that progressively produce a lower quantity of service flow every year).
2. Separate regressions were considered more appropriate than using pooled data which would place disproportionate weight on the few large firms given the skewed size distribution of the firms.
3. The conservative approach of using average productivity levels was considered appropriate to minimise the possible impact of year-to-year fluctuations in the data.

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