MODELS, METHODS + APPLICATIONS OF ECONOMETRICS
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DATA:
1986-87
60 DISTRIBUTORS
3.3 Million population
19 TWh sales.

per capita
annual consumption: 6 MWh Ontario: 14 MWh

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Economies of Scale in the New Zealand Electricity Distribution Industry

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Introduction

The New Zealand electricity industry is currently undergoing a process of deregulation, and there is considerable interest in its future structure. This industry is divided into three horizontal layers, dealing with the generation, high-voltage transmission, and final distribution of electricity. Although a few distributors generate a significant proportion of their requirements, there has been no trend towards vertical integration. Generation and transmission are currently under the control of the Electricity Corporation of New Zealand (ECNZ), from whom the various regional Electricity Supply Authorities (ESAs) purchase bulk electricity, and transmit it from ECNZ's substations to the end users.[1] This study focuses on these ESAs and examines whether there are economies of scale in the distribution of electricity in New Zealand.

At the time of our sample there were 60 ESAs in New Zealand,[2] a mountainous country comprising two principal islands, with a population of approximately 3.3 million people. Some 70 percent of the population live in the North Island (44,281 square miles), the Auckland metropolitan area accounting for 840,000 people, while in the South Island (58,093 square miles) the largest urban centre is Christchurch (population 300,000). Constitutionally, the ESAs are of two types – Electric Power Boards (EPBs), which are independent statutory bodies run by boards elected from the area over which the ESA has a franchise; and the Municipal Electricity Departments (MEDs), which are the trading arms of territorial local government and are managed by committees of the relevant local council. Each ESA has an area franchise and an associated obligation to supply electricity without discrimination. Only licensed firms may distribute electricity. Strictly, these franchises do not exclude the operation of competitors, but in practice only one franchise has been issued for each area.

Debate over the scale of electricity distributors in New Zealand has raged for years. The geographical features of the country are unusually relevant, but given the number of consumers and the relatively small annual output (19,444 GWh in 1986/87), it is not surprising that the appropriateness of 60 or so ESAs has been questioned. A Royal Commission headed by Stanton (1959) concluded that the (then 83) ESAs were technically efficient, but would be improved by amalgamations. So 26 supply areas were recommended, but without explicit reference to (economic) scale economies.

The latter were explored to some extent by Jones (1987) and with respect to the Christchurch region by McCutcheon et al. (1987). None of these studies employs any formal econometric analysis.

Several technical and organizational factors influence economies of scale in electricity distribution. Organizational economies may arise at the firm level as a result of staff specialization and staff control costs. Below some size a firm may not be able to employ the optimal resources, while beyond some other size the firm faces increasing costs in controlling these resources. Organizational economies can arise from increasing the specialization of managerial staff – the benefits of a larger firm depend on the gains from having this expertise "in house" in terms of cost and firm-specific knowledge gained. Conversely, organizational diseconomies may develop beyond a certain firm size, perhaps because of increasing communication problems, the difficulty of maintaining consistent objectives, and the potential for managerial "slack."

The principal technical economies are in distribution equipment, which lead to economies of density, economies in capacity expansion, and economies in the provision of capacity to meet peak requirements. An increase in equipment capacity leads to a less than proportionate rise in equipment cost. Larger capacity equipment also yields lower system costs as higher voltage operation lowers system energy losses. These factors contribute to economies of density. As the number of customers, and energy demand, rises for a given area, average cost falls. Supply security can also be improved when density rises. Several low-voltage networks can be interconnected with open switches to provide different flow paths, so that a fault that might otherwise cut off supply can be bypassed. Such benefits are exhausted at a certain scale of operation by the requirement to keep separate the networks supplied by each ECNZ substation. All of this points to the potential for scale economies in this industry – the extent to which such economies are in fact present or are exhausted is, of course, an empirical issue.

Econometric studies of scale economies in electricity industry in other countries focus primarily on generation rather than distribution, and reflect the vertically integrated nature of this industry elsewhere, see for example Christensen and Greene (1976), Betancourt and Edwards (1987), and Sing (1987). Other relevant studies include those of Neuberg (1977), Heuttner and Landon (1978), Aivazian et al. (1987), and some of the material discussed by Weiss (1975). A typical finding is that the average cost curves exhibit extensive "flat" regions – i.e. there is a wide range of outputs consistent with essentially constant returns to scale.

In this paper we use a Translog cost model and cross-section data for the 1986/87 financial year to estimate economies of scale in the distribution of electricity in New Zealand. The ESAs have a statutory obligation to supply electricity and are price takers in the purchase of bulk electricity from ECNZ (this being their major operating cost). An econometric model of cost, rather than production, is appropriate given that the firms are cost minimizers rather than profit maximizers.[3] The model and data used are described in the next two sections. The fourth section discusses the results; and our conclusions are given in the final section.

The Model

Costs for the firms in this industry are of the form

$$C = f(Y, P, I), \tag{1}$$

where C denotes total cost, Y is output, $\mathbf{P}$ is a vector of n input prices, and $\mathbf{I}$ is a vector of m additional industry-specific variables. In formulating such a relationship, it is assumed that output and input prices are exogenous, and that (for a given technology) firms adjust input levels so as to minimize costs of production. Given the comments at the end of the last section, and our use of cross-section data, such assumptions seem reasonable in this case. In common with other related studies, we use the Translog function (e.g. Christensen et al. (1971, 1973)) to formalize (1):

$$\begin{aligned}\ln C = {} & \alpha_0 + \alpha_y \ln Y + \tfrac{1}{2}\gamma_{yy}(\ln Y)^2 + \sum_{i=1}^{n} \gamma_{yi} \ln Y \ln P_i \\ & + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n} \gamma_{ij} \ln P_i \ln P_j + \sum_{i=1}^{n} \alpha_i \ln P_i + \sum_{k=1}^{m} \beta_k \ln I_k \\ & + \frac{1}{2}\sum_{k=1}^{m}\sum_{g=1}^{m} \beta_{kg} \ln I_k \ln I_g + \sum_{k=1}^{m} \beta_{ky} \ln I_k \ln Y \\ & + \sum_{k=1}^{m}\sum_{i=1}^{n} \theta_{ki} \ln I_k \ln P_i, \end{aligned} \tag{2}$$

where $\gamma_{ij} = \gamma_{ji}$ and $\beta_{kg} = \beta_{gk}$. The attractions of this functional form are that it is flexible enough to represent quite general production structures; it imposes no restrictions on factor substitutability; and it allows economies of scale to vary with output. To ensure that (2) is consistent with a well-behaved production function, it must be homogeneous of degree one in input prices, which implies

$$\begin{aligned} & \sum_{j=1}^{n} \gamma_{ij} = \sum_{i=1}^{n}\sum_{j=1}^{n} \gamma_{ij} = \sum_{i=1}^{n} \gamma_{ij} = 0, \\ & \sum_{i=1}^{n} \gamma_{yi} = 0, \quad \sum_{i=1}^{n} \alpha_i = 1, \quad \sum_{i=1}^{n} \theta_{ki} = 0; \quad k = 1, \ldots, m. \end{aligned} \tag{3}$$

The symmetry of the γ_{ij} terms follows from Young's theorem, given that the cost function is continuously twice differentiable. If X_i is the quantity of input i, applying Shephard's lemma, the associated input cost share equations are

$$S_i = (P_i X_i / C) = \alpha_i + \gamma_{yi} \ln Y + \sum_{j=1}^{n} \gamma_{ij} \ln P_j + \sum_{k=1}^{m} \theta_{ki} \ln I_k, \qquad i = 1, \ldots, n. \tag{4}$$

Adding normally distributed error terms, our full model comprises equation (2) and the equations (4). The model is estimated by joint maximum likelihood (ML), with all of the mentioned parameter restrictions imposed. The well-known singularity of the contemporaneous error covariance matrix associated with such allocation models is allowed for in the usual way – one of the share equations is dropped from the system, the coefficient estimates being invariant to the choice of this equation. Our primary interest is the measurement of scale economies. As is conventional, such economies are defined in terms of the relationship between cost and output along the expansion path. That is, with fixed input prices (and industry-specific variables)

and costs minimized at each output level. Specifically, we define them as the ratio of average to marginal costs:

$$\text{SCALE} \equiv (\partial \ln C / \partial \ln Y)^{-1} = \left[\alpha_y + \gamma_{yy} \ln Y + \sum_{i=1}^{n} \gamma_{yi} \ln P_i + \sum_{k=1}^{m} \beta_{ky} \ln I_k\right]^{-1}, \tag{5}$$

so there are scale economies (diseconomies) if SCALE is greater (less) than unity. The requirement that SCALE declines monotonically, as Y increases, holds if and only if $\gamma_{yy} > 0$. Given estimates of the parameters, and fixing the values of input prices and the industry-specific variables, setting (5) to unity and solving for Y allows the calculation of the output level at which such a firm's average cost is minimized. Dividing this output level into the total value of industry output suggests the number of such firms that are consistent with average cost minimization.

Data

Our sample comprises 60 cross-section data points for the 1986/87 financial year; the latest available. Output is defined as total retail sales of electricity (kWh). The sample is characterized by a conglomeration of ESAs with small output – 52 of the 60 firms had an annual output of 500 GWh or less. Of the remainder, one (Auckland) had an output nearly seven times as great as this, more than ten times the average output, and only slightly less than the combined outputs of the next three largest ESAs.[4]

Total cost is the simple sum of four input costs; those associated with labor, capital, electricity purchased, and other. The last of these is measured as total reported expenditure in the year in question, less expenditures on labor, capital, and on purchasing and (if applicable) generating electricity, less expenditures relating to the retailing of appliances. Accordingly, these "other" costs essentially relate to maintenance and operation, administration, loan interest, and depreciation. In the case of labor, total salaries and wages were adjusted to exclude amounts associated with any electricity generation or appliance sales, or capitalized in particular capital projects. Figures for the historic value of each ESA's assets were inflated and depreciated to allow for a life of 30 years for most distribution equipment. Different capital items were treated separately with respect to depreciation rates and method of depreciation (diminishing value or straight line). This breakdown distinguished between distribution equipment; distribution and transmission buildings; public lighting; land; offices, stores, and workshops; loose tools, plant, and furniture; motor vehicles; and other capital items. Aggregate capital figures were then constructed. The cost of purchasing electricity includes that associated with purchases from ECNZ, plus any from firms involved in cogeneration or from other ESAs. Generation costs (in the few cases, where relevant) were excluded from the analysis to ensure comparability across ESAs. A commensurate value was calculated and included in total electricity costs in such cases. Such values were calculated taking account of the structure of the bulk supply tariff, which distinguishes between winter zone and anytime demands; between day and night energy rates; and between location in the North and South Islands.

Input prices were defined as follows. The prices of labor and "other" inputs are the associated expenditures divided by the number of employees. Three possible definitions of the price of capital inputs were considered: total capital value divided by circuit kilometers of distribution line; the value of capital divided by the combined amount of circuit kilometers of distribution line plus kVA transformer capacity, expressed as circuit kilometer "equivalents"; a constant capital price across ESAs.[5] Two alternative measures of the price of electricity purchased were considered: total electricity cost divided by total electricity purchased and generated (cents/kWh); and constant values of 2.8084 cents/kWh for South Island ESAs, and 3.4318 cents/kWh for North Island ESAs, reflecting the average energy components in the wholesale electricity tariff.

Finally, we consider up to five industry-specific variables. Two of these are dummy variables for the "type" of ESA ($\ln(I_1) = 1$, EPB; $= 0$, MED); and for ESA location ($\ln(I_2) = 1$, North Island; $= 0$, South Island). We also considered the load factor (I_3) and density. Two possible measures of the latter were considered – I_4 = number of consumers per square kilometer of licensed area; or I_4 = number of consumers per circuit kilometer of distribution line. Also considered was a regional dummy variable ($\ln(I_5) = 1$, urban; $= 0$, rural). Further details of the data and their construction are given by Wyatt et al. (1989).

Results

Joint ML estimation and the other computations were undertaken with the TSP package (Hall et al. 1988). Equation (2) was constrained to avoid the multicollinearity that would otherwise arise because $\ln(I_i) = (\ln(I_i))^2$ $(i = 1, 2, 5)$. Not all of β_1, β_2, β_5, β_{11}, β_{22}, and β_{55} are identifiable in our model and so the relevant terms were coded as $1.5\beta_i \ln(I_i)$ $(i = 1, 2, 5)$. When all of the industry-specific variables (however defined) were included in the model, the results were economically implausible: the estimates of γ_{yy} were negative. A sequence of nested model tests revealed the load factor to be the main source of this problem,[6] although when it is removed from the model we were still unable to obtain plausible results with a significant rural–urban effect. Accordingly, we discarded these two regressors. A formal model-selection procedure was then used to determine the final specification of the model. Akaike's information criterion (AIC) was used to discriminate between the non-nested specifications that arise with the alternative definitions of density and the prices of capital and electricity purchased. With the variable definitions fixed, a sequence of nested likelihood ratio tests (LRTs) was used to determine whether the model should be simplified further by deleting other industry-specific variables. These asymptotic tests were applied in the manner described by Mizon (1977) so as to control their true size.

This procedure favored the first of the measures of density and electricity price, and the second measure of capital price. With these definitions, the results of our LRTs appear in table 23.1. Two non-nested specifications cannot be rejected, so the final selection is again based on AIC, resulting in the retention of density and the "type" of ESA as the industry-specific variables. The lack of significance of the North–South dummy apparently reflects the fact that the electricity purchase price variable is already capturing the relevant effects. The ML estimates of the model's parameters appear in table 23.2.

Table 23.1 Tests of nested hypotheses

Model specification tests

Industry-specific variables included				
Maintained hypothesis	*Restricted hypothesis*	LRT[a]	v	AIC
(I_1, I_2, I_4)	(I_1, I_2)	N.A.[b]	—	—
(I_1, I_2, I_4)	(I_2, I_4)	11.97	7	−16.97
(I_2, I_4)	I_2	N.A.[b]	—	—
(I_2, I_4)	I_4	20.26[c]	6	—
(I_1, I_2, I_4)	(I_1, I_4)	8.76	7	−17.03
(I_1, I_4)	I_4	23.46[c]	6	—
(I_1, I_4)	I_1	N.A.[b]		

Homotheticity test[d]

Maintained hypothesis	*Restrictions*	LRT	v
See table 23.2	$\gamma_{y1} = \gamma_{y2} = \gamma_{y3} = 0$	20.40[c]	3

[a] LRT is asymptotically χ^2 with v degrees of freedom.
[b] Not acceptable. Estimated coefficients conflict with prior economic theory.
[c] Significant at the 1 percent level or higher.
[d] Homogeneity restrictions are nested within homotheticity restrictions, so the former are rejected. Testing separately for homogeneity also leads to rejection: LRT = 21.86 ($v = 6$).

Each variable enters the model in several forms. The overall significance of the industry-specific variables has been established via the LRTs. Individually, many of the parameters are also significant. Signing the parameters is not trivial. The relevant issue is the sign of the partial derivative of C with respect to the variable of interest. Equivalently, we can sign the associated elasticity, which is more easily derived, given the form of (2). For example, we expect $\partial \ln C/\partial \ln Y$ $(= 1/\text{SCALE})$ and $\partial \ln C/\partial \ln P_i$ $(= S_i)$ $(i = 1, \ldots, 4)$ to be positive; and in the case of "density", $\partial \ln C/\partial \ln I_4 < 0$. The anticipated sign for the ESA "type" dummy variable is ambiguous. Using the estimated parameters from table 23.2, we have evaluated each of these derivatives at each point in the sample. There are no exceptions to the anticipated signs, and the estimated shares are all positive fractions. Given the imposition of the restriction $\sum_i \gamma_{yi} = 0$, homotheticity of the underlying production function would imply $\gamma_{y1} =$ $\gamma_{y2} = \gamma_{y3} = 0$. Adding the additional restrictions $\gamma_{yy} = \beta_{1y} = \beta_{4y} = 0$ implies homogeneity of the production function. Homotheticity and homogeneity are both rejected by LRTs (see table 23.1), and so are not imposed in the following analysis. Ordering the data by increasing value of output, there is no evidence of heteroskedasticity in the residuals. However, to be conservative, all reported standard errors and tests are based on White's (1980) heteroskedasticity-consistent covariance matrix estimator.

Estimated scale economy measures appear in table 23.3. These are obtained from (5) in two ways – first, as is conventional, $\overline{\text{SCALE}}$ is calculated with all variables except output fixed (here, to their sample means); and secondly, SCALE is calculated at each individual sample point.[7] The latter figures are interesting, but the former are of primary importance and only on these can cross-firm comparisons be based. The point estimates of $\overline{\text{SCALE}}$ suggest there are economies of scale in this industry

Table 23.2 Maximum likelihood estimates

Parameter	Estimate (asymptotic "t"-value)	Parameter	Estimate (asymptotic "t"-value)
α_0	7.775 (0.93)	α_1	−0.060 (−0.16)
α_y	0.661 (0.75)	α_2	−1.170 (−2.91)
γ_{yy}	0.031 (0.58)	α_3	2.155 (4.68)
γ_{y1}	−0.004 (−0.51)	β_1	−0.148 (−0.08)
γ_{y2}	−0.018 (−1.59)	β_4	0.267 (0.46)
γ_{y3}	0.023 (2.05)	β_{44}	0.001 (0.02)
γ_{22}	0.197 (8.01)	β_{14}	−0.068 (−0.88)
γ_{32}	−0.168 (−7.17)	β_{1y}	−0.037 (−0.24)
γ_{42}	−0.013 (−0.42)	β_{4y}	−0.002 (−0.06)
γ_{33}	0.183 (4.64)	θ_{11}	−0.010 (−0.39)
γ_{43}	−0.000 (−0.02)	θ_{12}	0.150 (3.20)
γ_{41}	−0.018 (−0.83)	θ_{13}	−0.126 (−3.33)
		θ_{41}	0.002 (0.41)
		θ_{42}	−0.028 (−3.09)
		θ_{43}	0.024 (2.90)

Equation:	ln C	S_1	S_2	S_3
R^2	0.964	0.661	0.485	0.433

Note: Estimates of remaining parameters are derivable from the homogeneity and symmetry restrictions. Asymptotic "t"-values (in parentheses) are standard normally distributed. The asymptotic standard errors on which these are based are calculated using White's heteroskedasticity-consistent covariance matrix estimator.

– numerically, all of these values exceed unity, except for that of Auckland, the ESA with by far the largest output. The Wald test is used to test the hypothesis of unitary economies of scale. In fact, we test if the reciprocal of SCALE (from (5)) is unity. The hypothesis of interest is formulated in this equivalent way to minimize the distortion of the true size of the Wald test (from the nominal size chosen) in finite samples. This choice is based on the results of Gregory and Veall (1985) and Phillips and Park (1988). The results obtained appear in table 23.3, where we see that for 26 cases the $\overline{\text{SCALE}}$ estimates are significantly greater than unity. No such estimate is significantly less than unity – even at the level of output experienced by the

Table 23.3 Scale economy measures

	Supply authority	Output (10^9 kWh)	$\overline{SCALE}$	SCALE
1	Ashburton	0.158	1.090 (3.85)**	1.093 (1.35)
2	Auckland	3.426	0.988 (0.01)	1.016 (0.02)
3	Bay of Islands	0.194	1.082 (3.11)*	1.080 (1.12)
4	Bay of Plenty	0.402	1.057 (0.70)	1.067 (0.43)
5	Bluff	0.017	1.177 (1.41)	1.146 (1.36)
6	Buller	0.082	1.114 (3.43)*	1.117 (1.46)
7	Cambridge	0.087	1.112 (3.56)*	1.119 (1.42)
8	Central Canterbury	0.427	1.055 (0.61)	1.066 (0.50)
9	Central Hawkes Bay	0.082	1.114 (3.44)*	1.101 (1.59)
10	Central Waikato	0.486	1.050 (0.44)	1.061 (1.05)
11	Christchurch	1.475	1.014 (0.01)	1.012 (0.01)
12	Dannevirke	0.070	1.120 (3.08)*	1.124 (2.11)
13	Dunedin	0.731	1.037 (0.15)	1.018 (0.02)
14	Egmont	0.191	1.082 (3.17)*	1.086 (2.03)
15	Franklin	0.248	1.073 (2.06)	1.075 (1.83)
16	Hamilton	0.136	1.095 (4.10)**	1.082 (2.77)*
17	Hawkes Bay	0.565	1.045 (0.30)	1.058 (0.65)
18	Horowhenua	0.257	1.072 (1.91)	1.094 (2.28)
19	Hutt Valley	0.967	1.027 (0.07)	1.058 (0.71)
20	Invercargill	0.216	1.078 (2.65)	1.073 (5.03)**
21	Kaiapoi	0.022	1.166 (1.57)	1.162 (1.45)
22	King Country	0.086	1.112 (3.54)*	1.092 (1.20)
23	Manwatu-Oroua	0.306	1.066 (1.32)	1.076 (1.43)
24	Marlborough	0.178	1.085 (3.46)*	1.091 (1.04)
25	Napier	0.076	1.117 (3.26)*	1.122 (2.64)
26	Nelson	0.109	1.103 (4.00)**	1.105 (6.30)**
27	New Plymouth	0.272	1.070 (1.71)	1.050 (0.22)
28	North Auckland	0.417	1.055 (0.64)	1.062 (0.64)
29	North Canterbury	0.198	1.081 (3.03)*	1.082 (0.78)
30	Otago	0.157	1.090 (3.86)**	1.079 (0.78)
31	Otago Central	0.204	1.080 (2.90)*	1.083 (0.61)
32	Palmerston North	0.180	1.085 (3.42)*	1.072 (2.91)*
33	Port Hills	0.079	1.115 (3.36)*	1.106 (3.48)*
34	Poverty Bay	0.207	1.080 (2.84)*	1.083 (1.15)
35	Riccarton	0.049	1.134 (2.42)	1.147 (1.57)
36	Rotorua	0.285	1.068 (1.55)	1.080 (1.65)
37	South Canterbury	0.260	1.072 (1.87)	1.079 (0.68)
38	Southland	0.424	1.055 (0.62)	1.046 (0.14)
39	Taranaki	0.250	1.073 (2.03)	1.078 (0.98)
40	Tararua	0.046	1.136 (2.33)	1.134 (1.69)
41	Tasman	0.297	1.067 (1.42)	1.080 (0.76)
42	Taumarunui	0.021	1.169 (1.53)	1.140 (1.94)
43	Taupo	0.162	1.089 (3.78)*	1.058 (0.10)
44	Tauranga MED	0.056	1.128 (2.65)	1.120 (1.55)
45	Taurange EPB	0.349	1.061 (0.98)	1.075 (1.69)
46	Te Awamutu	0.102	1.106 (3.89)**	1.111 (2.02)
47	Thames Valley	1.062	1.024 (0.05)	1.029 (0.08)
48	Thames-Coromandel	0.030	1.154 (1.82)	1.115 (1.51)
49	Timaru	0.120	1.100 (4.09)*	1.108 (3.43)*
50	Wairarapa	0.195	1.082 (3.08)*	1.089 (1.43)
51	Wairoa MED	0.019	1.171 (1.49)	1.159 (1.42)

continued

Table 23.3 (*continued*)

	Supply authority	*Output* (10^9 kWh)	$\overline{SCALE}$	*SCALE*
52	Wairoa EPB	0.038	1.144 (2.07)	1.130 (1.55)
53	Waitaki	0.146	1.092 (4.01)**	1.100 (1.35)
54	Waitemata	1.280	1.019 (0.02)	1.030 (0.16)
55	Waitomo	0.113	1.102 (4.04)**	1.097 (1.39)
56	Wanganui-Rangatikei	0.351	1.061 (0.97)	1.060 (0.55)
57	Wellington	0.837	1.032 (0.10)	1.020 (0.04)
58	West Coast	0.118	1.100 (4.09)**	1.113 (1.08)
59	Whakatane	0.038	1.143 (2.08)	1.130 (1.63)
60	Whangarei	0.092	1.109 (3.69)*	1.104 (2.80)*
	Average	0.324	1.088	1.087

Note: $\chi^2_{(1)}$ Wald-test values appear in parentheses. These are calculated using White's heteroskedasticity-consistent covariance matrix estimator.
* Significantly different from unity at 10 percent level.
** Significantly different from unity at 5 percent level.

Auckland ESA, there is no significant evidence that scale economies have been exhausted. This reinforces the earlier comment that there is evidence of scale economies in New Zealand electricity distribution.

The average cost (AC) curve implied by our estimated Translog model appears in figure 23.1, evaluated with all variables other than output set to their sample means. It exhibits the typical "flat" region mentioned in the first section: AC is minimized ($\overline{\text{SCALE}} = 1$) at an annual output of 2,315 GWh, but casual observation suggests that any output in the range 500–3,500 GWh is essentially consistent with minimum AC. In 1986/87, total output for the industry was 19,444 GWh, so we see that eight or nine "typical" ESAs with equal output would have ensured AC minimization. Taking account of the flat section of the AC curve suggests that up to 39 such ESAs would not have been inconsistent with this objective. This number can be formalized by noting that the asymptotic standard error associated with the AC-minimizing number of "typical" firms (8.4) is 19.855, so a 90 percent confidence interval puts an upper bound of 41 on this number of ESAs.

As a sensitivity test of our results we respecified the model to include only three input costs: the cost of electricity was discarded, as being largely beyond the control of ESAs, total cost was redefined accordingly, and the complete analysis was replicated. The preferred model specification used the second definitions of density and capital price, and the North–South dummy variable was retained. Our broad conclusions were unaltered: average cost was minimized at 1,748 GWh per year, implying 11 firms in the industry; a 90 percent confidence interval on this number of firms allows for up to 40 ESAs without departing significantly from AC-minimization; more than half of the $\overline{\text{SCALE}}$ and SCALE estimates were significantly greater than unity, and only one was numerically (but not significantly) less. Full details are given by Wyatt et al. (1989).[8]

Finally, we consider the (Allen) partial elasticities of substitution between the four factor inputs, which for the Translog model are defined as $\sigma_{ii} = (\gamma_{ii} + S_i^2 - S_i)/S_i^2$; $i = 1, \ldots, 4$, and $\sigma_{ij} = (\gamma_{ij} + S_iS_j)/S_iS_j$; $i, j = 1, \ldots, 4$; $i \neq j$.

We also consider the cost (price) elasticities of factor demand: $\eta_{ij} = S_j\sigma_{ij}$; $i, j = 1, \ldots, 4$. (These formulas are given by Berndt and Wood (1975).)

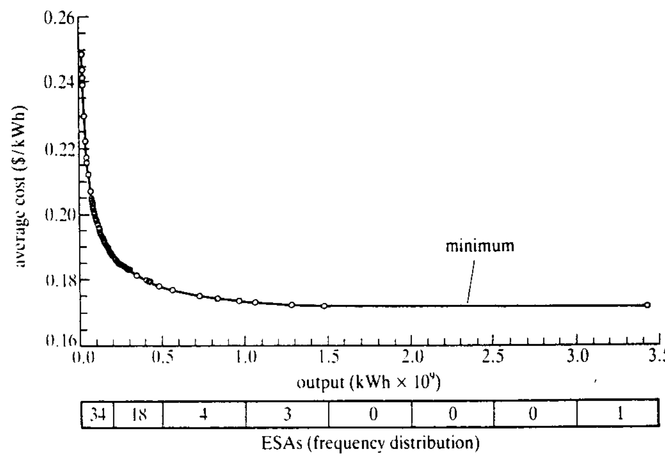

Figure 23.1 Estimated TRANSLOG AC curve

Estimates of these elasticities, together with asymptotic standard errors, appear in table 23.4. These estimates are reported for the firms with the largest and smallest output levels in our sample, to summarize the extent to which the results depend on the sample values. With one exception (labor when output is at its maximum), all inputs are own-price responsive. However, these responses are generally not significant – the only significant own-cost elasticities are for capital and for labor when output is small.

As is frequently the case in studies of the energy sector, capital and labor are found to be substitutes, and significantly so for small output levels. The signs of the other elasticities suggest that while the labor and "other" inputs are complements, all other pairs of factors are substitutable to some degree. However, none of these effects is statistically significant.

Conclusions

This paper uses a Translog cost model to estimate economies of scale in electricity distribution in New Zealand. We find evidence that the number of firms currently in the industry is greater than that consistent with average cost minimization. Our results indicate that, at the output levels associated with more than a third of the firms in our sample, there are significant scale economies, and that these economies are not (significantly) exhausted even at the highest sample value. Not surprisingly, the number of Electricity Supply Authorities in New Zealand has attracted attention over the years. Our results show this attention to be justified – with figure 23.1 in mind, and calculating the total industry cost with eight identical firms operating at AC-minimizing output, we find that would be a 15.5 percent reduction in this total

Table 23.4 Estimated elasticities

Partial elasticities of factor substitution (σ_{ij})

(i, j)	Labor max	Labor min	Capital max	Capital min	Electricity max	Electricity min	Other max	Other min
Labor	15.76	−4.10*						
	(14.05)	(1.31)						
Capital	0.19	0.64*	−0.10	−0.26*				
	(0.75)	(0.33)	(0.07)	(0.14)				
Electricity	−0.43	0.69	0.10	0.06	−0.31	−0.34		
	(3.20)	(0.70)	(0.13)	(0.13)	(0.43)	(0.22)		
Other	−10.12	−2.54	0.58	0.36	0.97	0.98	−6.46	−6.14
	(13.48)	(4.29)	(1.00)	(1.52)	(1.50)	(1.12)	(17.74)	(19.28)

Cost elasticities of factor demand (η_{ij})

(i, j)	Labor max	Labor min	Capital max	Capital min	Electricity max	Electricity min	Other max	Other min
Labor	0.52	−0.44*	0.12	0.27*	−0.13	0.29	−0.50	−0.12
	(0.46)	(0.14)	(0.46)	(0.14)	(0.97)	(0.30)	(0.66)	(0.20)
Capital	0.01	0.07*	−0.06	−0.11*	0.03	0.03	0.03	0.02
	(0.02)	(0.04)	(0.04)	(0.06)	(0.04)	(0.05)	(0.05)	(0.07)
Electricity	−0.02	0.07	0.06	0.03	−0.09	−0.15	0.05	0.05
	(0.11)	(0.08)	(0.08)	(0.05)	(0.13)	(0.09)	(0.07)	(0.05)
Other	−0.33	−0.28	0.36	0.15	0.29	0.41	−0.32	−0.29
	(0.44)	(0.46)	(0.62)	(0.64)	(0.45)	(0.47)	(0.87)	(0.91)

Note: "max" and "min" relate to firms with the largest and smallest outputs in the sample. Figures in parentheses are asymptotic standard errors based on White's heteroskedasticity – consistent covariance matrix estimator.

* Significant at the 10 percent level.

cost relative to that which prevailed in our 1986/87 sample. Even reducing the number of firms from 60 to 40 implies an 8 percent reduction in total industry cost on this basis.[9]

Such figures must be treated cautiously. Our model has been specified carefully but it cannot capture the full detail of this industry. The firms in it are not homogeneous. Each has its individual features, which of course preclude the attainment of the hypothetical situations just described. We offer no prescription for the amalgamation of Supply Authorities. Clearly, there are important geographic, technical, and social constraints that would have to be taken into account. Since this study was undertaken, several major changes to the New Zealand electricity distribution industry have been announced and the final impact of these changes is unclear. Subject to the constraints noted, our results suggest the likely future shape of the industry if Supply Authorities were to rationalize their activities in a more competitive environment.

Notes

The second author is now with Transpower New Zealand Ltd. This paper is based on work undertaken in the preparation of the more general report by Wyatt et al. (1989). We would like to thank Patrick Caragata for suggesting this study and for his ongoing support during

its execution. We are also grateful to Max Brown and Andrew Duncan for their substantial input, to Judith Giles for numerous helpful discussions, and to the New Zealand Ministries of Energy and Commerce for supporting this study. We would like to thank members of the Electricity Supply Association of New Zealand for their many helpful comments and suggestions during the course of our research, and the referee for several constructive comments on an earlier draft. This paper is the responsibility of the authors, and any views expressed should not be attributed to their employers.

1. Six major industrial users purchase bulk electricity direct from the national grid. They are excluded from this study.
2. Recently, this number has been reduced to 52, and negotiations for further amalgamations are in progress.
3. Recent changes to the industry include the potential for ESAs to bargain directly with ECNZ over the price of bulk electricity and changes to taxation arrangements for ESAs. In addition, the New Zealand Government has recently announced that ESAs will be corporatized, so in future they should be more profit-oriented.
4. All of our analysis was repeated with the Auckland observation excluded from the sample. The numerical estimates changed only slightly from those reported below, and none of the conclusions was altered.
5. In this case the implications of the estimation results are, of course, independent of the figure chosen.
6. There is evidence of multicollinearity, in terms of both the simple and multiple correlations between this variable and the other regressors.
7. As the estimate of γ_{yy} in table 23.2 is positive, the $\overline{\text{SCALE}}$ estimates decrease monotonically with increasing output. This is not the case for SCALE, of course.
8. That paper also reports some tentative, and only partially successful, attempts to model the ESAs as dual-output firms, supplying both "energy" (in kWh) and "power" (in kW). This was motivated by the peak-load problem and the ESAs' limited ability to smooth their loads. The aggregate scale economy estimates obtained were totally consistent with those reported here.
9. In the case of our three-input model these industry cost savings are estimated to be 21 percent and 17.5 percent respectively.

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24

Long-run Equilibrium Estimation and Inference: A Nonparametric Application

V. B. Hall and R. G. Trevor

Introduction

Phillips (1991a) has demonstrated that the long-run parameters of a continuous-time error correction model (ECM) involving nonstationary variables can be estimated from a corresponding discrete-time ECM. He derives theoretical results for a first-order stochastic differential equation system, driven by quite general stationary errors. The vector of variables is integrated of order one (an I(1) process), with the multiple long-run relationships being given by the cointegrating vectors. This theoretical work is an extension of the Phillips (1991c) results for a discrete-time ECM with a single cointegrating relationship.

He suggests frequency domain procedures of the type due to Hannan (1963) for estimation and inference, anticipating they would provide significant computational advantages over methods traditionally used for continuous-time models.[1] In particular, he considers the very significant problems associated with temporal aggregation (see for example Bergstrom (1984)), the problems of selecting short-run dynamics, and the complexities of nonlinear estimation would not arise. This is due to the generality afforded by the nonparametric treatment of regression errors in frequency domain procedures.

A further key element of Phillips' paper is that spectral estimates of the cointegrating parameters are asymptotically equivalent to the corresponding maximum likelihood estimates. Moreover, the nuisance parameters introduced into the limiting distributions by the presence of nonstationary processes have only scale effects. It is therefore possible to carry out conventional asymptotic chi-squared hypothesis testing.

In light of the above, the principal aim of this paper is to present some initial estimates and inferences based on Phillips' theoretical results and suggested empirical procedures. The innovative aspects are: (1) it provides an early application of this methodology to macroeconomic time-series data,[2] thereby giving initial evidence on both the potential gains and difficulties relative to traditional methods; (2) it extends the Engle and Granger (1987) type scalar cointegration methods to vector cases, in a way which is not conditional on the precise modeling of short-run dynamics as is required, for example, in the maximum likelihood procedure developed by Johansen (1988, 1991); and (3) it illustrates the outcome of some simple hypothesis tests on

TABLE 7 (PART 2): - ANALYSIS OF CONSUMPTION OF ELECTRICITY PER SECTOR FOR THE YEAR ENDED MARCH 1990

		INDUSTRIAL					NON-DOMESTIC					TOTAL RETAIL SALES					
		Electricity Consumed	Income	Income per kWh sold	No. of Consumers	Average kWh per consumer	Electricity Consumed	Income	Income per kWh sold	No. of Consumers	verage kW er consume	Electricity Consumed	Income	Income per kWh sold	No. of Consumers	verage kWh er consumer	
		kWh	$	c	Number	kWh	kWh	$	c	Number	kWh	kWh	$	c	Number	kWh	
1	Electricorp	6658061022	238817982	3.59	5	1331612204	6704605311	246218295	3.67	6	434219	6,705,372,150	246287213	3.67	83	787616	1
13	Wairoa Electricity	566554	80078	14.13	4	141639	7135838	1066413	14.94	351	20330	19,620,735	2415008	12.31	2142	9160	13
4	Kaiapoi Electricity	4149994	362035	8.72	27	153703	8157298	819208	10.04	203	40184	23,688,400	1962600	8.29	1966	12049	4
32	Wairoa EPB	20175505	2010781	9.97	16	1260969	24586465	2815238	11.45	1174	20942	38,439,825	4249227	11.05	3465	11094	32
11	Tauranga DCED	8094676	791960	9.78	121	66898	45678840	5363616	11.74	1667	27402	61,436,502	6867012	11.18	4247	14466	11
8	Dannevirk EPB	14438557	1439082	9.97	36	401071	30286649	3646306	12.04	2365	12806	67,092,109	6918569	10.31	6971	9624	8
6	Napier City Council	7381559	932083	12.63	22	335525	45026804	5960330	13.24	1195	37679	75,665,280	8891822	11.75	5670	13345	6
7	Central Hawkes Bay EPB	19014873	1643948	8.65	43	442206	34285532	3702244	10.8	2018	16990	77,809,992	7656871	9.84	7286	10679	7
5	Buller Electricity	50536356	2740076	5.42	55	918843	59693857	3915015	6.56	800	74617	78,767,618	5588563	7.1	4231	18617	5
14	Whangarei DCED	6759676	828052	12.25	91	74282	50104221	6672334	13.32	1617	30986	92,360,818	10267500	11.12	8209	11251	14
9	Port Hills Energy	30195919	1907274	6.32	8	3774490	60397662	4235393	7.01	367	164571	100,115,501	7000364	6.99	4173	23991	9
28	Te Awamutu EPB	4850910	743287	15.32	36	134748	41532539	5118911	12.33	3144	13210	102,219,675	10468107	10.24	10269	9954	28
6	Cambridge EPB	35651541	2582328	7.24	32	1114111	56352103	5334493	9.47	1964	28693	102,697,172	9704710	9.45	7632	13456	6
1	Citipower Nelson	19470967	1639742	8.42	65	299553	59914493	6467236	10.79	1637	36600	109,114,807	10238244	9.38	8300	13146	1
15	King Country EPB	10707557	873261	8.16	53	202029	51627369	5159579	9.99	3134	16473	111,739,994	8962212	8.02	11805	9465	15
35	Waitomo EPB	30766367	3261873	10.6	81	379832	59798526	6883967	11.51	4259	14041	116,253,112	12680776	10.91	11969	9713	35
12	Timaru Electricity	16393457	1338977	8.17	50	327869	59547705	5421137	9.1	1482	40181	121,110,609	9985147	8.24	8757	13830	12
37	Westpower	35513804	3659838	10.31	171	207683	78403544	8610365	10.98	2592	30248	132,748,843	13771292	10.37	11394	11651	37
20	Otago EPB	27990336	2950725	10.54	26	1076551	64461481	7039719	10.92	3979	16200	146,467,453	14538718	9.93	14706	9960	20
33	Waitaki EPB	31955945	2564696	8.03	78	409692	72029730	6376851	8.85	2459	29292	147,706,631	11855668	8.03	11624	12707	33
10	Egmont EPB	82821735	6492431	7.84	52	1592726	121551284	11719422	9.64	3173	38308	185,403,334	17846665	9.63	12049	15387	10
8	Palmerston North MED	9849730	1332223	13.53	99	99492	89007067	12146479	13.65	2818	31585	187,660,961	19105084	10.18	18256	10279	8
10	Taupo Electricity	93784378	6511858	6.94	43	2181032	132697830	11575019	8.72	1796	73885	195,359,257	17065279	8.74	10637	18366	10
31	Wairarapa EPB	19300374	2557181	13.25	194	99486	76881573	9869261	12.84	4246	18107	196,988,469	22105659	11.22	19124	10301	31
1	Ashburton	39597858	2989340	7.55	27	1466587	113157567	9276244	8.2	3708	30517	198,237,084	16558063	8.35	12107	16374	1
17	Marlborough Electric	33324944	3105267	9.32	174	191523	92000739	9246738	10.05	3305	27837	201,098,052	17694897	8.8	17903	11233	17
9	Eastland Energy	44154285	5119659	11.59	85	519462	92802463	13492369	14.54	5126	18104	202,441,495	25139459	12.42	21229	9536	9
3	Bay of Islands EPB	37319189	3438919	9.21	54	691096	97699070	12106751	12.39	4505	21687	208,190,872	22554592	10.83	20964	9931	3
21	Otago Central EPB	16639277	1142533	6.87	30	554643	107652077	9334211	8.67	3109	34626	214,830,734	16847644	7.84	15746	13644	21
19	North Canterbury EPB	58739950	3797779	6.47	102	575882	113573219	9379860	8.26	4412	25742	225,715,588	18486131	8.19	18552	12167	19
3	Invercargill MED	20226132	1820509	9	129	156792	103125334	10439563	10.12	2656	38827	240,110,394	20949217	8.72	17628	13621	3
24	South Canterbury EPB	64479002	4563690	7.08	43	1499512	118792352	9110828	7.67	3750	31678	251,934,463	18412445	7.31	19157	13151	24
25	Taranaki EPB	137140607	10248831	7.47	125	1097125	174678668	15206673	8.71	3824	45680	254,996,887	23091463	9.06	14516	17567	25
11	Franklin EPB	56578534	5763035	10.19	260	217610	128086199	15211259	11.88	7715	16602	272,888,298	28508040	10.45	26634	10246	11
13	Horowhenua EPB	11938372	1661368	13.92	84	142123	96510628	14029959	14.54	5082	18991	276,736,472	30776381	11.12	34818	7948	13
7	New Plymouth Energy	66209095	3603753	5.44	286	231500	145650793	14857553	10.2	4135	35224	277,653,171	27597253	9.94	24044	11548	7
22	Rotorua Electricity	31945916	3703155	11.59	117	273042	138367999	17554347	12.69	4861	28465	307,885,316	32696999	10.62	27392	11240	22
26	Tasman Energy	99226898	8315683	8.38	503	197270	174089690	17291714	9.93	4793	36322	314,492,329	28608289	9.1	24228	12981	26
36	Wanganui-Rangitikei EPB	48881170	5460345	11.17	116	421389	150549382	17661682	11.73	7120	21145	334,419,262	33394684	9.99	33184	10078	36
16	Manawatu-Tararua EPB	108740666	10874788	10	293	371129	198444591	21739818	10.96	7154	27739	364,627,100	35010505	9.6	30047	12135	16
27	Tauranga EPB	56967717	5483378	9.63	199	286270	152288879	16461414	10.81	7693	19796	381,840,003	38685728	10.13	43158	8847	27
1	Southland EPS	122440100	11345087	9.27	137	893723	206616192	21779392	10.54	10375	19915	411,630,859	39166926	9.52	34983	11767	1
4	Bay of Plenty EPB	298640246	18761155	6.28	64	4666254	364755533	26622608	7.3	5006	72864	489,696,351	37705695	7.7	22029	22230	4
18	North Auckland EPB	305516267	19740329	6.46	112	2727824	377737613	28564128	7.56	6220	60730	534,318,804	42721422	8	30175	17707	18
12	Hawkes Bay EPB	139529002	13120486	9.4	213	655066	267461707	29379215	10.98	7139	37465	562,540,413	54808418	9.74	45498	12364	12
30	Waikato Electricity	106262366	9577315	9.01	437	243163	326311511	37330650	11.44	11307	28859	648,653,610	68070177	10.49	59317	10935	30
2	Dunedin Electricity	88936440	6828542	7.68	255	348770	301946212	24729121	8.19	6645	45440	737,642,010	51524332	6.99	49005	15052	2
5	MED Capitalpower	33439051	3587739	10.73	190	175995	525063689	59602944	11.35	8367	62754	918,119,155	83619031	9.11	56915	16131	5
14	Hutt Valley Energy Board	160621712	16371115	10.19	448	358531	427505426	51166388	11.97	8332	51309	990,847,693	96646283	9.75	82688	11983	14
29	Thames Valley EPB	716102807	46690244	6.52	283	2530399	862749270	66718886	7.73	11552	74684	1,131,005,589	91143396	8.06	54467	20765	29
34	Waitemata EPB	148457644	15115737	10.18	959	154805	499085793	60558589	12.13	17000	29358	1,433,860,147	138710988	9.67	143869	9966	34
23	Southpower	277797543	25424918	9.15	1019	272618	896940345	90821673	10.13	17227	52066	2,013,768,831	169158657	8.4	132041	15251	23
2	Auckland EPB	618799732	49778762	8.04	925	668973	2197818501	227806731	10.37	31584	69586	3,712,879,052	346225504	9.32	230314	16121	2

TABLE 7 (PART 2): - ANALYSIS OF CONSUMPTION OF ELECTRICITY PER SECTOR FOR THE YEAR ENDED MARCH 1990

		INDUSTRIAL					NON-DOMESTIC					TOTAL RETAIL SALES					
		Electricity Consumed	Income	Income per kWh sold	No. of Consumers	Average kWh per consumer	Electricity Consumed	Income	Income per kWh sold	No. of Consumers	verage kW er consume	Electricity Consumed	Income	Income per kWh sold	No. of Consumers	verage kWh er consumer	
		kWh	$	c	Number	kWh	kWh	$	c	Number	kWh	kWh	$	c	Number	kWh	
1	Electricorp	6658061022	238817982	3.59	5	1331612204	6704605311	246218295	3.67	6	434219	6,705,372,150	246287213	3.67	83	787616	1
1	Ashburton	39597858	2989340	7.55	27	1466587	113157567	9276244	8.2	3708	30517	198,237,084	16558063	8.35	12107	16374	1
2	Auckland_EPB	618799732	49778762	8.04	925	668973	2197818501	227806731	10.37	31584	69586	3,712,879,052	346225504	9.32	230314	16121	2
3	Bay_of_Islands_EPB	37319189	3438919	9.21	54	691096	97699070	12106751	12.39	4505	21687	208,190,872	22554592	10.83	20964	9931	3
4	Bay_of_Plenty_EPB	298640246	18761155	6.28	64	4666254	364755533	26622608	7.3	5006	72864	489,696,351	37705695	7.7	22029	22230	4
5	Buller_Electricity	50536356	2740076	5.42	55	918843	59693857	3915015	6.56	800	74617	78,767,618	5588563	7.1	4231	18617	5
6	Cambridge_EPB	35651541	2582328	7.24	32	1114111	56352103	5334493	9.47	1964	28693	102,697,172	9704710	9.45	7632	13456	6
7	Central_Hawkes_Bay_EPB	19014873	1643948	8.65	43	442206	34285532	3702244	10.8	2018	16990	77,809,992	7656871	9.84	7286	10679	7
1	Citipower_Nelson	19470967	1639742	8.42	65	299553	59914493	6467236	10.79	1637	36600	109,114,807	10238244	9.38	8300	13146	1
8	Dannevirk_EPB	14438557	1439082	9.97	36	401071	30286649	3646306	12.04	2365	12806	67,092,109	6918569	10.31	6971	9624	8
2	Dunedin_Electricity	88936440	6828542	7.68	255	348770	301946212	24729121	8.19	6645	45440	737,642,010	51524332	6.99	49005	15052	2
9	Eastland_Energy	44154285	5119659	11.59	85	519462	92802463	13492369	14.54	5126	18104	202,441,495	25139459	12.42	21229	9536	9
10	Egmont_EPB	82821735	6492431	7.84	52	1592726	121551284	11719422	9.64	3173	38308	185,403,334	17846665	9.63	12049	15387	10
11	Franklin_EPB	56578534	5763035	10.19	260	217610	128086199	15211259	11.88	7715	16602	272,888,298	28508040	10.45	26634	10246	11
12	Hawkes_Bay_EPB	139529002	13120486	9.4	213	655066	267461707	29379215	10.98	7139	37465	562,540,413	54808418	9.74	45498	12364	12
13	Horowhenua_EPB	11938372	1661368	13.92	84	142123	96510628	14029959	14.54	5082	18991	276,736,472	30776381	11.12	34818	7948	13
14	Hutt_Valley_Energy_Board	160621712	16371115	10.19	448	358531	427505426	51166388	11.97	8332	51309	990,847,693	96646283	9.75	82688	11983	14
3	Invercargill_MED	20226132	1820509	9	129	156792	103125334	10439563	10.12	2656	38827	240,110,394	20949217	8.72	17628	13621	3
4	Kaiapoi_Electricity	4149994	362035	8.72	27	153703	8157298	819208	10.04	203	40184	23,688,400	1962600	8.29	1966	12049	4
15	King_Country_EPB	10707557	873261	8.16	53	202029	51627369	5159579	9.99	3134	16473	111,739,994	8962212	8.02	11805	9465	15
16	Manawatu-Tararua_EPB	108740666	10874788	10	293	371129	198444591	21739818	10.96	7154	27739	364,627,100	35010505	9.6	30047	12135	16
17	Marlborough_Electric	33324944	3105267	9.32	174	191523	92000739	9246738	10.05	3305	27837	201,098,052	17694897	8.8	17903	11233	17
5	MED_Capitalpower	33439051	3587739	10.73	190	175995	525063689	59602944	11.35	8367	62754	918,119,155	83619031	9.11	56915	16131	5
6	Napier_City_Council	7381559	932083	12.63	22	335525	45026804	5960330	13.24	1195	37679	75,665,280	8891822	11.75	5670	13345	6
7	New_Plymouth_Energy	66209095	3603753	5.44	286	231500	145650793	14857553	10.2	4135	35224	277,653,171	27597253	9.94	24044	11548	7
18	North_Auckland_EPB	305516267	19740329	6.46	112	2727824	377737613	28564128	7.56	6220	60730	534,318,804	42721422	8	30175	17707	18
19	North_Canterbury_EPB	58739950	3797779	6.47	102	575882	113573219	9379860	8.26	4412	25742	225,715,588	18486131	8.19	18552	12167	19
21	Otago_Central_EPB	16639277	1142533	6.87	30	554643	107652077	9334211	8.67	3109	34626	214,830,734	16847644	7.84	15746	13644	21
20	Otago_EPB	27990336	2950725	10.54	26	1076551	64461481	7039719	10.92	3979	16200	146,467,453	14538718	9.93	14706	9960	20
8	Palmerston_North_MED	9849730	1332223	13.53	99	99492	89007067	12146479	13.65	2818	31585	187,660,961	19105084	10.18	18256	10279	8
9	Port_Hills_Energy	30195919	1907274	6.32	8	3774490	60397662	4235393	7.01	367	164571	100,115,501	7000364	6.99	4173	23991	9
22	Rotorua_Electricity	31945916	3703155	11.59	117	273042	138367999	17554347	12.69	4861	28465	307,885,316	32696999	10.62	27392	11240	22
24	South_Canterbury_EPB	64479002	4563690	7.08	43	1499512	118792352	9110828	7.67	3750	31678	251,934,463	18412445	7.31	19157	13151	24
1	Southland_EPS	122440100	11345087	9.27	137	893723	206616192	21779392	10.54	10375	19915	411,630,859	39166926	9.52	34983	11767	1
23	Southpower	277797543	25424918	9.15	1019	272618	896940345	90821673	10.13	17227	52066	2,013,768,831	169158657	8.4	132041	15251	23
25	Taranaki_EPB	137140607	10248831	7.47	125	1097125	174678668	15206673	8.71	3824	45680	254,996,887	23091463	9.06	14516	17567	25
26	Tasman_Energy	99226898	8315683	8.38	503	197270	174089690	17291714	9.93	4793	36322	314,492,329	28608289	9.1	24228	12981	26
10	Taupo_Electricity	93784378	6511858	6.94	43	2181032	132697830	11575019	8.72	1796	73885	195,359,257	17065279	8.74	10637	18366	10
11	Tauranga_DCED	8094676	791960	9.78	121	66898	45678840	5363616	11.74	1667	27402	61,436,502	6867012	11.18	4247	14466	11
27	Tauranga_EPB	56967717	5483378	9.63	199	286270	152288879	16461414	10.81	7693	19796	381,840,003	38685728	10.13	43158	8847	27
28	Te_Awamutu_EPB	4850910	743287	15.32	36	134748	41532539	5118911	12.33	3144	13210	102,219,675	10468107	10.24	10269	9954	28
29	Thames_Valley_EPB	716102807	46690244	6.52	283	2530399	862749270	66718886	7.73	11552	74684	1,131,005,589	91143396	8.06	54467	20765	29
12	Timaru_Electricity	16393457	1338977	8.17	50	327869	59547705	5421137	9.1	1482	40181	121,110,609	9985147	8.24	8757	13830	12
30	Waikato_Electricity	106262366	9577315	9.01	437	243163	326311511	37330650	11.44	11307	28859	648,653,610	68070177	10.49	59317	10935	30
31	Wairarapa_EPB	19300374	2557181	13.25	194	99486	76881573	9869261	12.84	4246	18107	196,988,469	22105659	11.22	19124	10301	31
13	Wairoa_Electricity	566554	80078	14.13	4	141639	7135838	1066413	14.94	351	20330	19,620,735	2415008	12.31	2142	9160	13
32	Wairoa_EPB	20175505	2010781	9.97	16	1260969	24586465	2815238	11.45	1174	20942	38,439,825	4249227	11.05	3465	11094	32
33	Waitaki_EPB	31955945	2564696	8.03	78	409692	72029730	6376851	8.85	2459	29292	147,706,631	11855668	8.03	11624	12707	33
34	Waitemata_EPB	148457644	15115737	10.18	959	154805	499085793	60558589	12.13	17000	29358	1,433,860,147	138710988	9.67	143869	9966	34
35	Waitomo_EPB	30766367	3261873	10.6	81	379832	59798526	6883967	11.51	4259	14041	116,253,112	12680776	10.91	11969	9713	35
36	Wanganui-Rangitikei_EPB	48881170	5460345	11.17	116	421389	150549382	17661682	11.73	7120	21145	334,419,262	33394684	9.99	33184	10078	36
37	Westpower	35513804	3659838	10.31	171	207683	78403544	8610365	10.98	2592	30248	132,748,843	13771292	10.37	11394	11651	37
14	Whangarei_DCED	6759676	828052	12.25	91	74282	50104221	6672334	13.32	1617	30986	92,360,818	10267500	11.12	8209	11251	14