Effect of Changes in Regulatory Quality on Electricity Lines Investment and Reliability in New Zealand

Richard MEADE[†]

New Zealand Institute for the Study of Competition and Regulation

Victoria University of Wellington

NEW ZEALAND

James TREMEWAN

Victoria University of Wellington

NEW ZEALAND

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Abstract: Various studies indicate a negative relationship between investment on the one hand, and regulation, reduced regulatory quality, and increased regulatory uncertainty on the other. Shifts to a proportional representation form of government, or to incentive regulation, are specifically argued to reduce investment. Boyle and Guthrie (2003), however, predict an ambiguous relationship between investment and uncertainty. Electricity lines (i.e. distribution) companies in New Zealand have experienced multiple regulatory innovations over 1990-2005, all of which could be predicted to reduce investment and thereby service reliability rates. We find, however, that investment and reliability rates have in fact increased over this period, contrary to this prediction. Part of this increase in investment rates is explicable in terms of rising demand and electricity prices, and declining capital goods prices. Yet we find a positive structural break for investment in 1995, and for reliability in 2000. We interpret these results as indicating that considerable investment uncertainty relating to wider electricity sector reforms, and particularly to distribution sector reforms over 1989-1995, resulted in lines companies deferring investment in this period. With the final removal of franchise areas on 1 April 1994 the nature and extent of lines company competition became apparent, resolving the preceding investment uncertainty. Any adverse impacts of subsequent regulatory innovations on otherwise increased investment and reliability rates were not identified by our analysis. We leave it to future research to demonstrate the deferral of lines company investment over the late 1980s and early 1990s.

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1. Overview

1.1 Institutions, Regulation, Uncertainty and Investment

Regulatory quality is a function not only of the fact and nature of regulatory institutions, but also of the wider institutional environment. Via their effect on regulatory quality such factors should influence investment rates, particularly in industries such as electricity distribution where assets are long-lived and investments are generally irreversible to some degree. In turn they should therefore also influence service reliability rates. Furthermore, uncertainty as to regulatory and wider institutional arrangements will itself affect the timing of such investments by possibly giving rise to a valuable option to defer (but possibly to accelerate) investment. PricewaterhouseCoopers (2004) offers evidence of New Zealand generation and transmission investments being deferred due to regulatory uncertainty. These investment linkages are examined in this study using regulatory information disclosures and other data compilations for electricity lines (i.e. distribution) companies in New Zealand.

Brennan and Schwartz (1982) argue that a regulated firm's investment risk is directly related to regulatory policy, which allocates uncertain costs and benefits between investors and consumers. Loayza et al. (2004) document a negative impact of regulation on the proximate determinants of economic growth, including investment. Alesina et al. (2002) find strong evidence in a sample of OECD countries for a negative association between tight product market regulation (particularly entry barriers) and investment. Other studies identify particular characteristics of regulation that are more or less favourable for investment. For example, Guthrie (2005), and Gilbert and Newbery (1994), predict that rate of return regulation will be more supportive of efficient investment than incentive regulation, especially where investment risks are high. Moreover, Evans and Guthrie (2005) show that incentive regulation is unsustainable when there is too tight a choice of regulatory asset base, and that when demand is uncertain and investments irreversible an appropriate rate of return exceeds that typically allowed by regulators, thus hampering investment. Hence any shift from rate of return to incentive regulation should be expected to be negative for investment.

In another vein, various studies demonstrate the importance of institutions such as contract enforcement and property rights for investment. Knack and Keefer (1995) use cross-country data to examine the role of institutions in explaining economic growth and investment. They find that institutions protective of property rights are crucial to each, rivalling the importance of education, and affecting both the magnitude and efficiency of investment. Similarly, Clague et al. (1999, p. 200) find a "strong, positive, and highly significant relationship between [their country-specific measure of contract enforceability and property right security] and investment" for OECD and non-OECD countries. Using case studies these authors show that this measure is negatively correlated with political events that should be expected to undermine property rights and contract enforceability. These studies provide peripheral evidence on the likely impact of regulation on investment. On the other hand, Davis

(2005) argues that economic growth is governed less by static measures of institutions, and more by flexibility in political and legal systems enabling adaptation to changes in the economic environment.

Political institutions can thus also affect both regulatory quality and investment. Proportional representation, in particular, is argued to adversely affect both. Pagano and Volpin (2005) find proportional electoral systems to be less protective of investors than majoritarian systems (such as the Westminster-style "first-past-the-post" or FPP system). Bertelli and Whitford (2005) argue that perceptions of regulatory quality are dependent on the vertical separation of powers among domestic political institutions. They find evidence for regulatory independence being associated with perceptions of higher regulatory quality in presidential systems of government. However, systems with proportional representation (and federal systems) are found to exhibit uniformly lower perceptions of regulatory quality. Such studies indicate that shifts in political systems from a majoritarian to proportional basis should be negative for regulatory quality and investment.

How regulation is implemented and enforced has also been found to affect investment. Falaschetti (2005) finds that local exchange service providers in the US maintain lower capital stocks in states where public utility commissions are elected, arguing that the election of regulators strengthens consumers' bargaining power or weakens regulatory commitments. Bittlingmayer (2001) argues that low US investment rates in the late 1950s and early 1960s were the product of aggressive antitrust and related "anti-business" initiatives of the day. Azam et al. (2005) develop a model showing such effects to be path dependent, with institutional changes revealing a government to be predatory (rather than restrained) able to reverse economic development. This suggests that the impact on investment of changing regulatory institutions depends on what those changes signal in terms of the government's type. Guthrie (2005) similarly suggests that regulatory opportunism tends to cause investment deferral.

Finally, a broad literature has emerged modelling and documenting the effect of uncertainty on investment (see, for example, Dixit and Pindyck (1994), Caruth et al. (1998), Schwartz and Trigeorgis (2001)). One general theme is that where investments are irreversible and made under uncertainty, the firm possesses a valuable option to defer investment, but that option is extinguished once investment is made. Chen and Funke (2003) develop a partial equilibrium real options model predicting that uncertainty in a country's political environment increases the value of the option to defer making a partially irreversible investment decision, thus lowering foreign direct investment. Similarly, Teisberg (1993) develops a real-options model demonstrating why electric utilities facing uncertain and asymmetric profit and loss regulation delay investment and opt for smaller, shorter-lead-time technologies (reducing the period in which the value of the completed project is uncertain). Boyle and Guthrie (2003), on the other hand, show that the effect of uncertainty on investment can be ambiguous. They develop a model in which uncertainty as to a firm's future financing capacity reduces the value of the option to defer investment, thus accelerating

investment relative to first-best timing. Hence policy and regulatory uncertainties may be negative for lines company investment, although the reverse might equally be true.

1.2   Key Institutional and Regulatory Changes for New Zealand Lines Companies

New Zealand electricity lines companies provide a useful sample with which to examine these linkages between institutions and investment. They have ranged in number from 52 in 1990 to 28 in 2005. Comprehensive data has been collated on these companies over this period, including regulated information disclosures since 1995. As documented in Evans and Meade (2005), during this period New Zealand's lines companies underwent waves of significant structural and regulatory changes in the context of wider industry reforms commencing in 1984. These reforms were accompanied by more general institutional changes, notably a shift in the electoral system from FPP to German-style mixed-member proportional representation (MMP) in 1996, consequent to a binding referendum in 1993.

Specific lines companies reforms began with their corporatisation in 1993,[1] following recommendations made in 1989.[2] So-called "light-handed" regulation of lines companies – comprising information disclosure regulations, general competition law rules, and the threat of specific regulation – arose under 1992 legislation.[3] Traditional franchise areas were progressively dismantled, for smaller customers from 1 April 1993, and all customers (including the more contestable larger ones) from 1 April 1994. Information disclosure regulations were implemented in 1994,[4] and tightened in 1999.[5] These were based on a hybrid form of regulation – combining features of rate of return and incentive regulation – using optimised deprival values (ODVs) as the relevant asset base.[6]

Further lines company reforms included the imposed ownership separation of lines and other activities (such as energy retailing and generation) in 1999 following controversial 1998 legislation.[7] Specific price controls were proposed but abandoned in 1999,[8] only to be resurrected in the form of CPI-X incentive regulation under recommendations made in 2000,[9] and implemented in 2003 following 2001 legislation.[10] More general industry reform affecting lines companies took the form of a shift towards centralised industry governance in 2003. This involved the creation of a government-controlled agency, the Electricity Commission, to regulate various electricity sector activities under empowering legislation passed in 2001.[11]

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[1]   Energy Companies Act 1992.
[2]   Electricity Task Force (1989).
[3]   Electricity Act 1992.
[4]   Electricity (Information Disclosure) Regulations 1994.
[5]   Electricity (Information Disclosure) Regulations 1999.
[6]   Ernst & Young (1994).
[7]   Electricity Industry Reform Act 1998.
[8]   Commerce (Controlled Goods or Services) Amendment Bill 1999.
[9]   Inquiry into the Electricity Industry (2000).
[10]   Commerce Amendment Act (No. 2) 2001.
[11]   Electricity Amendment Act 2001, which was subsequently expanded under the Electricity and Gas Industries Bill enacted in October 2003.

1.3 This Study

Table 1 summarises a sample of key regulatory and institutional changes that can be predicted (although not uniformly) to have had negative consequences for New Zealand lines company investment and service reliability rates. We examine the impact of these changes using data for 1990 through 2005. Where possible, we take the relevant date of each change as being the first date at which it became probable that the change would occur, which in many cases we assume to be when legislation implementing the change was introduced into Parliament. For significant changes occurring very early in our data set, we also include the later dates at which those changes were first implemented. Aside from lags in investment decisions, however, it is possible that any investment effects from those changes will already have been impounded by those later dates.

Table 1: Key Regulatory and Institutional Changes, 1990-2005

Year Ended March	Event
1992	Introduction of legislation creating information disclosure regime.
1994	Binding referendum opts for proportional representation over FPP.
1995	Electricity information disclosure regulations first implemented.
	Franchise areas finally dismantled (larger customers contestable).
1997	First MMP election.
1999	Forced unbundling of lines ownership from competitive activities.
	Tightening of information disclosure regulations.
2000	Introduction of abortive legislation imposing incentive regulation.
	CPI-X incentive regulation recommended by new government inquiry.

Notes: Data for reliability rates available from 1995 onwards only, so tests for changes in reliability rates relate only to this period.

These changes include the dismantling of franchise areas, the advent of "light-handed" regulation, a shift to proportional representation, controversial ownership unbundling legislation affecting the security of lines company property rights, a tightening of information disclosure regulations, a shift from a form of rate of return regulation to incentive regulation, and the centralisation of industry governance under a government agency. Individual changes, as well as the accumulation of changes, will also have affected investment uncertainties.

In some years more than one such change occurred, meaning that any measured impacts on investment and/or service reliability rates will reflect either some or all of these changes. It is possible that the occurrence of multiple changes in any year may have

offsetting effects on measured investment and reliability rates, particularly where the uncertainty effects on investment are ambiguous.

2. Methods

2.1 Models for Lines Company Investment

Modelling company-level investment rates remains a challenging econometric problem.[12] Despite their limited empirical success, models based around Tobin's "q-theory" (as surveyed in Bond et al. (2004)) remain popular, and have been trialled in this study. We also investigate an alternative investment model based on an *a priori* selection of explanatory variables. Once the most promising investment model was identified, we were then able to use that model to investigate whether the regulatory and institutional changes identified in Table 1 led to regime changes in lines company investment rates. All financial variables and rates were converted into real terms.

In particular, we examined standard q models such as that of Bond et al. (2004), and also forms of the standard model extended to account for debt financing and taxes, such as that of Blundell et al. (1992). The dependent variable in such models is investment over contemporaneous capital stock (I/K). Additional explanatory variables suggested by these authors, relating to liquidity constraints and market power, including various lag structures, were also examined. As shown by Hayashi (1982), q models can be estimated by replacing unobservable "marginal q" with observable "average q" under certain assumptions, notably perfectly competitive output markets. Since electricity lines companies are natural monopolies, this assumption should lead to a divergence between average and marginal q values. Accordingly, we also examined a q model incorporating Blundell et al.'s (1992, p. 251) suggestion that the present value of monopoly profits be deducted in the numerator of their q expression, to account for output market imperfection.[13] This present value is readily estimated for New Zealand lines companies using regulatory information disclosures and the measure of excess profits proposed by Lally (2002), although other authors argue for more general estimates (see Boyle et al. (2006)). Finally, Bo (1999) augments the q modelling approach to include uncertainty measures as well. We similarly include both general and firm-specific uncertainty measures in our q models to examine whether they increase those models' predictive power.

Our alternative model was developed on the basis that the likely determinants of lines company investment are electricity demand, the price of investment goods, and lines charges. Electricity demand and lines charges should be positively related to investment rates, while

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[12] See, for example, Oliner et al. (1995), and Erickson and Whited (2000).
[13] Hayashi (1982) also discusses q measurement in the presence of imperfect output markets. Similar models to that used here are proposed in Schiantarelli and Georgoutsos (1990), and Galeotti and Schiantarelli (1991). Cooper and Ejarque (2001) propose an alternative, simulation-based approach.

the reverse should be true for the cost of investment goods. Here the dependent variable is the log of the ratio of investment to contemporaneous capital stock (log(I/K)).

We have proxied demand using capacity utilisation – peak demand over installed capacity – since investment should arise once demand nears the distribution network's technical limits. We have proxied lines charges using the Consumers Price Index (Electricity Sub-series), noting that this series includes both lines and energy charges. The price of lines investment goods is measured using the Capital Goods Price Index (Electrical Distribution Equipment Sub-series) to 1999, and the Electric Motors, Generators and Transformers Sub-series thereafter.

A general uncertainty variable has been trialled to measure any impact on investment from uncertainty in the general economy. Volatility in the trade-weighted index (TWI) of the New Zealand dollar against a basket of its major trading partner currencies is one such measure considered. In the style of Bo (1999) we model this series as an AR(1) process, and estimate general uncertainty using the resulting estimate of year-on-year volatility. Another general uncertainty measure is volatility in the term premium, measured again following Bo's (1999) method but using the difference between the 10 and one year New Zealand Government Bond rates.

2.2   Reliability Model

Reliability has been measured using a regulatory disclosure variable available since 1995 known as SAIDI. This is the sum of interruption duration factors for all interruptions, divided by the total number of consumers. A higher SAIDI figure thus indicates lower reliability. Three factors likely to be important determinants of electricity distribution reliability are lines density, transformer capacity density, and capacity utilisation.

Lines density – the ratio of total line kilometres to gigawatt hours (GWh) transmitted – should be expected to be inversely related to reliability (i.e. positively related to SAIDI). Given a fixed probability of a fault occurring in any given length of line, the longer the line, the higher the probability of failure. In addition, companies with low lines density – i.e. high lines kilometres per GWh sold – have longer networks to maintain with lower revenue (determined largely by GWh). Similarly, one would expect transformer capacity density to be negatively related to reliability.

Capacity utilisation – the ratio of maximum load to transformer capacity – should also be negatively related to reliability. Greater capacity utilisation means that equipment is being operated at closer to its technical limits, thus increasing the chance of failure.

An additional factor that may affect reliability is the number and average size of customers (measured as the ratio of total customers to GWh). A large number of residential customers may wield sufficient political power to encourage a local distribution company to maintain reliability. On the other hand, larger consumers will have greater economic influence,

so the sign of this affect is *a priori* unknown. One would also expect an underlying trend increase in reliability, due to improvements in technology.

Following this discussion, the sign of kilometre length and maximum load should be unambiguously positive. An increase in transformer capacity will increase transformer capacity density, but decrease capacity utilisation, so the expected sign is *a priori* unknown. An increase in GWh will increase lines and transformer capacity density, but means that the system will be closer to capacity, so again the sign is indeterminate.

2.3   Data Sources

Prior to the implementation of the Electricity (Information Disclosure) Regulations 1994, data on each electricity lines company was compiled and published annually by the Ministry of Commerce. The Ministry then compiled and published regulatory information disclosures under the disclosures regime, from 1995, until responsibility for this was assumed by its successor body, the Ministry of Economic Development (MED). From 2004 responsibility for information disclosures passed from the MED to the Commerce Commission, where it continues to reside. The Electricity Networks Association (1995-98), accounting firms such as Ernst & Young (1996-99) and PricewaterhouseCoopers (1999 to present), and private publishers such as Carolyn Wiley (1993-98), each provide annual compilations of information disclosures as well. In some cases these additional sources were required to augment the official compilations, especially over 1995 through 1998, where there were significant omissions in the regulatory information disclosures databases.

In the early to mid 1990s significant ownership changes took place as part of distribution sector rationalisation. Since these changes involved both full and partial mergers and de-mergers, we have opted to use an unbalanced dataset comprising all companies for which the relevant variables were available (or readily estimable), as and when they existed in that form. For investment modelling we thus had access to data for 1990 through 2005. Since no data on distribution reliability was published prior to 1995, the reliability modelling uses data for 1995 through 2005 only. Details of these ownership changes are summarised in Ministry of Economic Development (2005).

An important limitation in the New Zealand lines company data is the lack of traded share prices with which to estimate share values. The vast majority of lines companies have never been listed on any share market, and those few that were either did so for only a short time, or were subject to protracted takeover contests. These contests made their shares relatively illiquid, and meant their share price was tied more to the probability of takeover success than to underlying value. Thus share values required for investment models using q ratios have had to be estimated using simple theoretical share valuation models based on estimates of sustainable long-term unlevered cash flows discounted at an appropriate weighted average cost of capital (WACC).[14] In turn a key parameter underlying the WACC

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[14]   See, for example, Brealey and Myers (2003).

calculations – the asset beta required for estimating the cost of equity using the capital asset pricing model (CAPM) – has been assumed to be 0.6, based on Boyle et al. (2006). Market risk premium estimates for use in the CAPM vary between 9% and 7.5% p.a. for the relevant years, as provided by PricewaterhouseCoopers. A margin of 1.5% over the 10 year New Zealand Government Bond rate is assumed to estimate the borrowing cost of all lines companies in the sample.

All price indices were sourced from Statistics New Zealand. Interest and exchange rates were sourced from the Reserve Bank of New Zealand. Statutory tax and depreciation rates were sourced from the New Zealand Department of Inland Revenue.

2.4   Estimation

All our models have been estimated using fixed effects, pooled OLS regressions.[15] To untangle the ratios involved in our reliability model, the estimation has been performed in log form. Although total customers appear in the SAIDI denominator, there should be no problem with endogeneity, as there is little likelihood of reverse causality existing. The small variation of reliability of electricity supply is unlikely to be a large factor in determining where a consumer will locate themselves when compared to other social or economic considerations.

3.   Results

3.1   Investment Models

Annual net cash flow figures for each company were often negative, which if used would have produced share value estimates (as required given the lack of traded share price data) in the q variable calculations that were also negative. We therefore instead used mean or median net cash flows for each company to estimate their long-term sustainable cash flow, and used these figures in our share value estimates in the q variables. Furthermore, excess profits, as used to calculate the present value of monopoly profits in our modification to Blundell et al.'s (1999) q formula, were similarly negative in many years for many companies. As for net cash flows this was largely resolved by using mean or median excess profits when calculating the present value of monopoly profits. With these estimates q ratios were positive for most companies and in most years. Where they were negative we set their value equal to zero, which may bias our investment model q variable coefficients, but removes the intuitive difficulty of negative q values.

Despite the use of estimated rather than traded share values, and mean or median rather than annual cash flows and excess profits, significant q coefficients were produced in

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[15]   Fixed effects were invariably found to be jointly significant. In each model, Hausman's test found company specific effects to be correlated with the regressors, eliminating the possibility of using random effects estimations.

all six of our q model variants, as shown in Table 2. The explanatory power of the q models was consistently modest, however, with a maximum R-squared of just over 27% for the standard q model per Bond et al. (2004), and the debt financing and taxes q model per Blundell et al. (1992), in each case using median net cash flows (variants BD2 and BL2).

**Table 2: q Models for Investment, Pooled OLS Regressions, 1990-1995.**

q Model Variant	BD1	BD2	BL1	BL2	MBL1	MBL2
q coefficient	62.070***	30.323***	46.430***	23.413***	14.306***	11.165***
Standard error	(16.556)	(5.371)	(12.374)	(4.165)	(5.142)	(2.678)
Observations	545	545	564	545	525	525
R-squared	0.248	0.274	0.246	0.274	0.235	0.250
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Period fixed effects	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Dependent variable is I/K. All q variables are in real terms. BD1 is standard q model per Bond et al. (2004) using mean net cash flows. BD2 is standard q model using median net cash flows. BL1 is debt financing and taxes q model per Blundell et al. (1992) using mean net cash flows. BL2 is debt financing and taxes q model using median net cash flows. MBL1 is Blundell et al. (1992) q model modified to allow for monopoly profits using mean net cash flows. MBL2 is modified Blundell et al. (1992) model using median net cash flows. * Significant at 10%. ** Significant at 5%. *** Significant at 1%.

Other variables were also tried in the regressions, following the approach of Bond et al. (2004) and Blundell et al. (1992). Specifically, we variously added our measure of the present value of monopoly profits, and also revenue divided by capital stock as an alternative measure of output market imperfection. General uncertainty variables were also tried, following Bo (1999). Additionally, various lag structures were also investigated. In all cases no significant variables were found. Hence, since the q model variant BD2 had the most observations, the most significant q coefficient, and explained more variation than the others, we adopted this variant for our analysis of regulatory changes on investment.

Figure 1 illustrates the fixed period effects for our selected q model of investment. From this figure it can be seen that the lines company investment rate was in fact rising, with a possible break evident from around 1995 or 1996. Regulatory dummy variables for each of the events listed in Table 1 were tested to determine if any of the specified dates coincided with a shift in investment rate. Clearly the hypothesis that the events in Table 1 reduced investment rates would be rejected even if any such dummy variables proved to be significant, as they would have had a positive rather than negative coefficient.

Figure 1: q Model BD2, Fixed Period Effects, 1990-2005
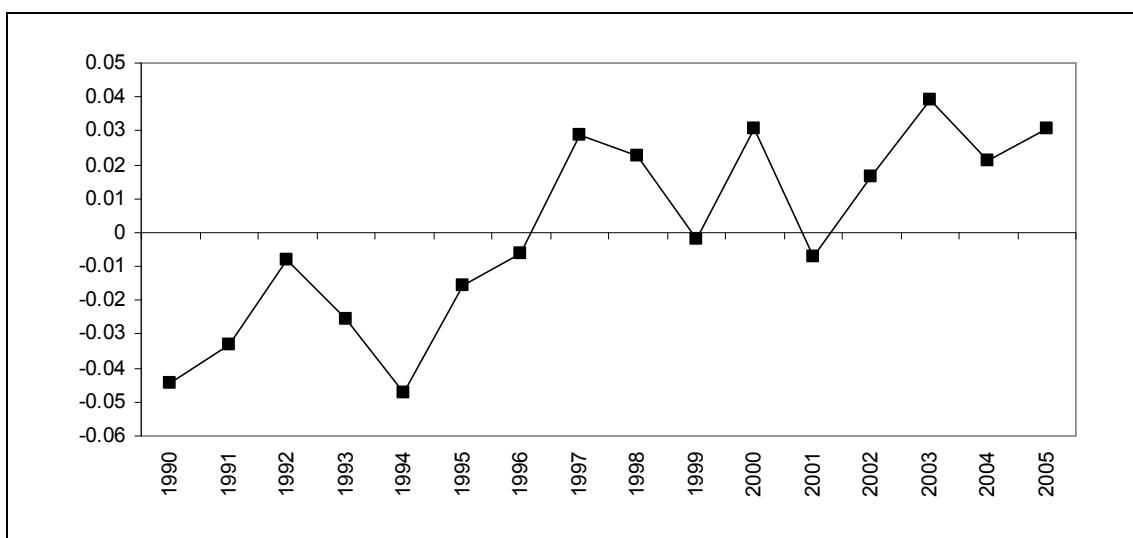
The strong rise in investment meant that all regulatory dummy variables, when included individually, had positive and significant coefficients. Inspection of Figure 1 suggests that a dummy variable for the 1995-2005 (i.e. 1995+) period is most appropriate. Indeed, it had the highest statistical significance of all the dummies. As this dummy has been included after inspection of the data, the standard critical value will not be appropriate. We are not aware of any critical values having been determined for this use in panel data models, however with a t-statistic of 4.9 we would expect that this coefficient is significant.

Controlling for time trend, however, the 1995+ dummy was no longer significant (column 3 of Table 3). For reasons to be discussed in Section 3.3, we have reason to believe that a regime change did in fact occur in 1995, although for reasons different to those underlying the hypothesis of negative investment impacts in Table 1. Thus we prefer the 1995+ dummy variable over time trend. To shed additional light on the matter, we turn now to our alternative investment model (columns 4-6 of Table 3).

The alternative investment model explains around 58% of observed variation, and all coefficients have the expected sign (column 4 of Table 3). Higher capital goods prices reduce investment, while higher capacity utilisation and electricity prices increase it. All are significant at the 10% level or less. Figure 2 sheds light on whether these variables can account for the observed increase in investment. As can be seen, capital costs have been falling throughout the sample period, while electricity prices have risen. The combination of these trends should be expected to result in increased investment, as observed. Indeed, adding a time trend to the alternative model (column 5 of Table 3) produces an insignificant coefficient, and at the same time causes the coefficient on electricity prices to become insignificant, suggesting collinearity. While this might also suggest that the significance of electricity prices in column 4 was spurious, panel unit root tests on the residuals reject this. We thus incline towards rejecting the time trend variable in favour of real electricity prices.

Table 3: BD2 and Alternative Investment Models, Pooled OLS Regressions, 1990-2005

	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
Dep't variable	*I/K*	*I/K*	*I/K*	*log(I/K)*	*log(I/K)*	*log(I/K)*
q (BD2)	29.707***	29.372***	29.705***	-	-	-
	(5.287)	(5.275)	(5.273)	-	-	-
Dummy 1995+	0.044†	-	0.022†	-	-	0.308†
	(0.009)	-	(0.014)	-	-	(0.111)
Time trend	-	0.005***	0.003*	-	0.015	-
	-	(0.001)	(0.002)	-	(0.037)	-
Log(PI)	-	-	-	-2.668**	-2.834**	-1.471
	-	-	-	(1.297)	(1.362)	(1.358)
Log(CapUtil)	-	-	-	0.254*	0.258*	0.200
	-	-	-	(0.137)	(0.138)	(0.138)
Log(CPIE)	-	-	-	0.876***	0.486	0.487
	-	-	-	(0.318)	(1.021)	(0.345)
Constant	0.037***	0.027***	0.027**	10.524	14.233	4.453
	(0.009)	(0.010)	(0.010)	(11.084)	(14.426)	(11.226)
Observations	545	545	545	562	562	562
R-squared	0.249	0.251	0.255	0.578	0.578	0.584

Notes: Standard errors are in parentheses. All financial variables are in real terms. Firm fixed effects included but not reported. q is per the BD2 model variant. PI is the lines investment cost sub-series of the Capital Goods Price Index. CapUtil is capacity utilisation, being peak demand over installed capacity. CPIE is the Electricity sub-series of the Consumers Price Index. * Significant at 10%. ** Significant at 5%. *** Significant at 1%. † Significance level unknown.

Figure 2: Real Investment Cost and Electricity Price Indexes, 1990-2005
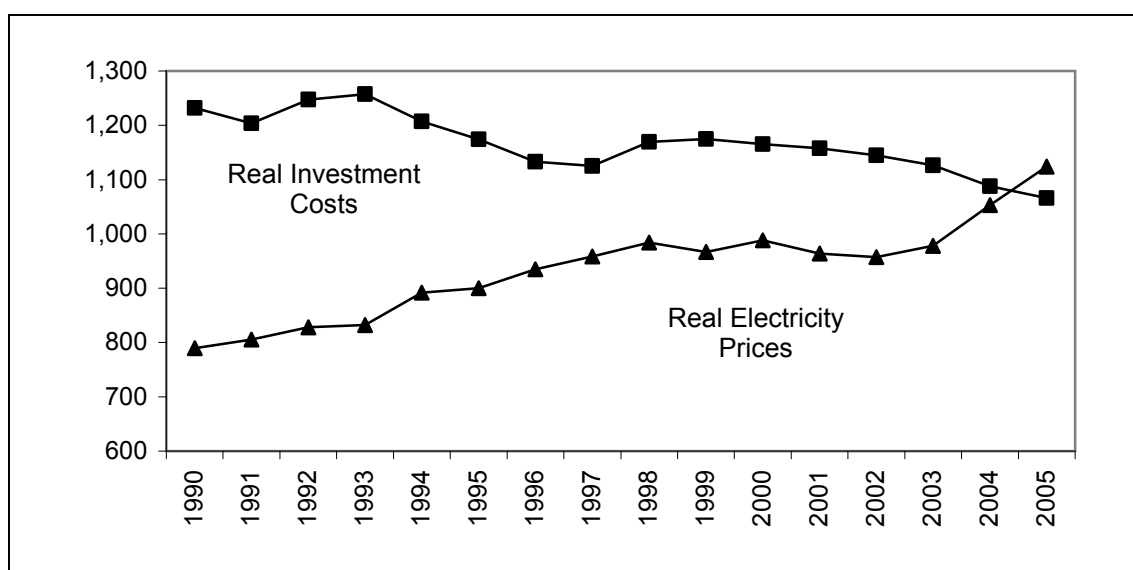
Replacing the time trend variable in column 5 of Table 3 with the 1995+ regulatory dummy variable (column 6) produces a coefficient that is positive and highly significant. This dummy gives the best fit of all dummies examined. After its inclusion no other regulatory dummy was significant (even using standard critical values), while the significance of the 1995+ dummy variable remained high. Although the coefficients on capital goods prices, capacity utilisation and electricity prices become insignificant in this case, we believe the retention of these variables remains reasonable on *a priori* grounds. It is possible that reverse causality is an issue in respect of electricity prices, as lines companies' monopoly status enables them to raise prices in anticipation of investment perhaps more so than competitive firms. However, reverse causality is unlikely to arise in respect of capacity utilisation, or capital goods prices (where lines firms are most likely price-takers).

Thus, after controlling for these *a priori* factors, there remains a discernible change in investment rates from 1995, although in the positive direction. On the face of it the hypothesis that the regulatory events in Table 1 should have led to decreased investment rates must therefore be rejected. As discussed in Section 3.3, however, the observed increase in investment rates from 1995 remains explicable in uncertainty terms. This is despite the fact that when general uncertainty variables were also tried in the alternative investment model, as they were in the q models, they produced insignificant coefficients.

3.2   Reliability Model

Performing an OLS regression with both company and period specific effects on all the variables gives the period fixed effects shown in Figure 3.

Figure 3: SAIDI, Period Fixed Effects, 1995-2005

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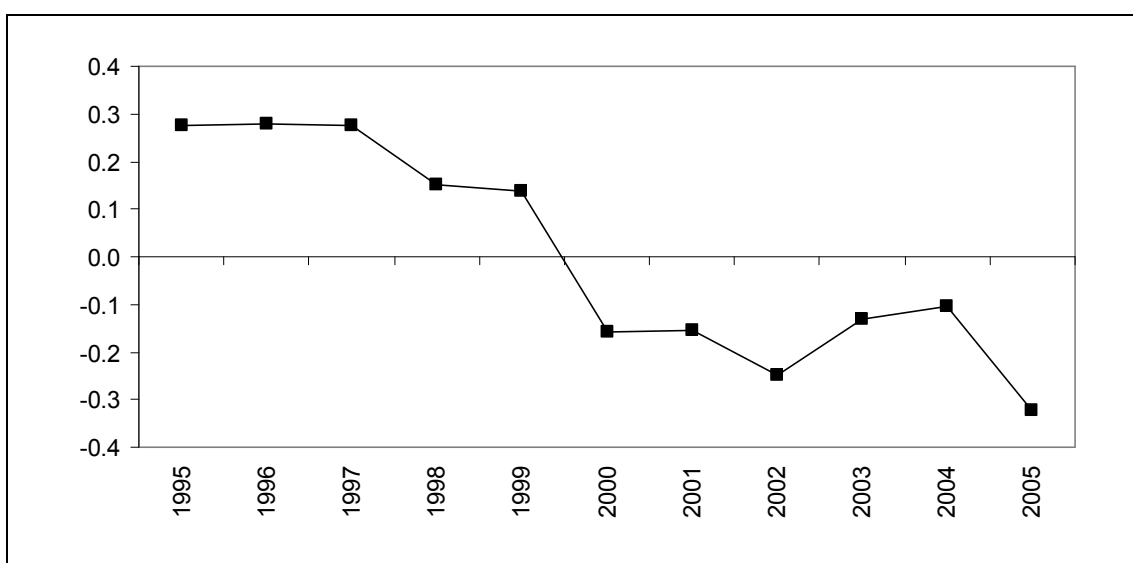
Controlling for relevant variables, there is clearly a negative trend in SAIDI, but also a large step between 1999 and 2000. This suggests the inclusion of a linear time trend and dummy variable for the 2000-2005 (i.e. 2000+) period. The results of this regression – this time with just company fixed effects – is given in Table 4.

Table 4: Reliability Model, Pooled OLS Regressions, 1995-2005

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Lines length	0.646***	0.245	2.642	0.0087
Total customers	-1.059***	0.388	-2.728	0.0067
Transformer capacity	0.318	0.257	1.237	0.2172
Peak demand	0.478**	0.234	2.041	0.0421
GWh	-0.049	0.063	-0.766	0.4442
Time trend	-0.025**	0.016	-1.669	0.0961
Regulatory dummy 2000+	-0.272†	0.092	-2.959	0.0033
Constant	5.368***	1.573	3.412	0.0007
Observations	359	Log likelihood		-172.3
R-squared	0.781	Durbin-Watson		1.667
Adjusted R-squared	0.746			

Notes: Dependent variable is log(SAIDI). All variables in logs (except dummies). Fixed effects included but not reported. * Significant at 10%. ** Significant at 5%. *** Significant at 1%. † Significance level unknown.

Both the time trend and dummy are highly significant, using conventional critical values. The dummy variable was included after observing the data, but again, the t-statistic is possibly large enough to compensate for this. The signs of all other included variables are in accordance with predictions. Line length, maximum load, and total customers are significant at the five percent level. Transformer capacity and GWh are insignificant, probably due to their contradictory effects.

Alternative models were estimated including dummies for different periods, both with and without a time trend. The dummies all indicated an increase in reliability in later periods, and time trends were consistently negative, but none of these models fitted the data as well as the one reported.

The data clearly shows an increase in reliability in an environment of tightening regulation. In the period following the forced unbundling of lines ownership and the threat of price control we observe a 27% reduction in SAIDI. However, what has caused the increase in reliability cannot be determined from this study. It is clear based on our modelling that changes in regulation have not had an observably deleterious effect on reliability.

One possible explanation for the trend increase in reliability is the observed increase in investment over the period. Investment was omitted from the regression because of its high collinearity with line length and transformer capacity, and the probability that it is endogenous. Ideally investment and reliability should be estimated simultaneously in a dynamic panel model.

Other factors that could be considered in future studies to account for the trend are expenditure on maintenance (excluded from this study because of insufficient data), and other factors affecting outage rates such as extreme weather events.

3.3   Discussion

The events listed in Table 1 are hypothesised to reduce regulatory quality and/or increase regulatory uncertainty. Based on the results of other studies they are in turn predicted to reduce lines company investment rates, although the uncertainty model of Boyle and Guthrie (2003) allows for some ambiguity on this point. Reduced investment rates should also result in reduced service reliability rates.

Our data in fact demonstrates positive trends in both investment and reliability rates over the 1990-2005 and 1995-2005 periods respectively. In the case of investment rates, we find evidence of a structural break occurring in 1995, with investment rising from then. We also find evidence of a structural break in respect of reliability rates, once again in the positive direction, but from 2000. On the face of it this requires plain rejection of the effects hypothesised for the events in Table 1. Over a period of tightening regulation investment and reliability rates have in fact risen. The positive structural break for reliability in 2000 would seem to naturally flow from that for investment in 1995.

It is possible, however, that regulatory uncertainty in fact did increase as a consequence of the events in Table 1. The rise in investment and then reliability rates might have followed in accordance with the model of Boyle and Guthrie (2003). Under this scenario, for example, a shift to CPI-X regulation of lines companies may have raised the risk that future price cap and asset base reviews would limit firm cash flows and hence reduce lines companies' ability to fund investments.

An alternative explanation is that tightening regulation reduced investment uncertainty rather than caused it to increase. For example, the advent of CPI-X regulation to replace "light-handed" regulation will have resolved uncertainty regarding the timing, form and incidence of specific regulation (while not eliminating regulatory uncertainty altogether). In this case the common hypothesis that uncertainty causes investment deferral remains sound, but a rise in investment should have been predicted due to reduced uncertainty rather than *vice versa*.

The explanation we prefer, however, is that significant investment uncertainty was in fact resolved from 1995, and thus an increase in investment and reliability rates should have

been predicted. New Zealand lines companies faced considerable investment uncertainty, regulatory and otherwise, from the late 1980s through to the mid 1990s. The recommendations of Electricity Task Force (1989) included radical structural changes for lines operators, including corporatisation, the removal of franchise areas, and "light-handed" regulation. All of these measures were to be implemented by 1 April 1994. As shown in Table 1, the year to March 1995 included the implementation of the inaugural information disclosure regulations, as well as the final dismantling of franchise areas, meaning that the largest and most contestable customers became exposed to inter-lines company competition. Until 1 April 1994 lines companies faced significant uncertainty as to how competition would evolve, but from that date the nature and extent of any competition became apparent. Of the two events listed for 1995, the advent of competition is likely to have been the more significant.

Based on this interpretation, the other events listed in Table 1 may well have reduced regulatory quality and/or increased regulatory uncertainty, and in turn reduced the increased investment and reliability rates relative to what they otherwise might have been. However, our analysis was not able to unearth any such effects. We leave it to future research to extend our data series back into the early 1980s and to verify whether the advent of electricity sector reform in 1984, and proposed lines company reforms from the late 1980s in particular, resulted in the deferral of investment from that time until 1995.

4.   Conclusions

Many studies have found or argued for a negative effect of regulation, declines in regulatory quality, and/or increases in regulatory uncertainty, on investment rates. Despite numerous regulatory innovations in the New Zealand electricity sector over 1990-2005, our data indicates rising – rather than falling – investment and reliability rates. Part of this investment (and hence reliability) increase is explicable in terms of growing demand and electricity prices, and falling investment costs. Yet a step jump in investment from 1995, and in reliability from 2000, remains. We interpret this as an indication of investment uncertainty arising in the late 1980s and early 1990s due to wider electricity sector reforms, leading to a deferral of investment over that period. Subsequent regulatory innovations may well have reduced the increased investment and reliability rates relative to what they otherwise might have been, but our analysis was unable to unearth this. We leave it to future research demonstrate a deferral of lines company investment in the late 1980s and early 1990s as a consequence of wider electricity reforms at that time.

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