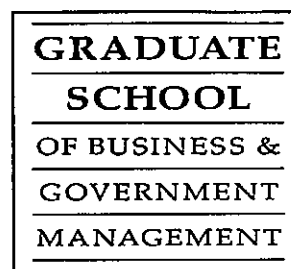# GSBGM Research Publications Series

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Government department to public
corporation in a deregulated
economy: The economic
efficiency of New Zealand
telecommunications

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Government Department to Public Corporation in a Deregulated Economy: the Economic Efficiency of New Zealand Telecommunications

by

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Abstract: This paper estimates the productivity and consumer and producer gains of the telecommunications network market as Telecom has developed as an SOE and public company. The growth in productivity is estimated to have resulted in an annual compound average of 5.6 per cent cost reduction. The consumer gains have been substantial. They have come from price reductions on 1987 consumption levels and, to a lesser extent, from output expansion. In addition there has been marked improvement in the quality of outputs. The consumer and producer and share price analysis indicate that a deeper examination, than simply looking at a company's risk-adjusted rate of return, is required to understand the impact on economic efficiency of different organisational structures and operating environments.

1 Introduction

The New Zealand deregulatory experience dates from 1984 when The Labour Government came to power and implemented a wide range of economic reforms. Over the ensuing eight years these included the deregulation of foreign exchange and financial markets, removal of agricultural subsidies, reduction of tariffs and removal of quantitative import restrictions, substitution of value-added for income taxes, labour market deregulation and re-vamping the public sector. The sweeping changes provide the opportunity to analyse the deregulation of an economy classified by the IMF as industrialised. Many of the countries that are implementing such comprehensive change started at a less developed stage and are following a different sequence of reforms. The New Zealand reforms were implemented in a plural democracy, and most of them drew heavily on developments in microeconomics of the 1970s and 1980s.[1]

Prior to the 1980s government-supplied goods and services covered a huge range, from printing services, and agricultural produce, to banking and telecommunications. The New Zealand solution to providing a large range of services, including what were argued to be natural monopolies, had been to set up government departments. Many commentators, such as McKinlay (1987), argue that the widespread reliance on state production of many goods and services, particularly public utilities, was generally the pragmatic solution to problems besetting a small developing economy. Undeveloped capital markets and the large size of projects drew government intervention, usually ownership. There is some isolated evidence of ideologically based state ownership. But there is no evidence of the debate about government ownership versus regulation of a public company which took place in the US about 1910.[2] Government ownership extended well beyond natural monopolies and utilities. Condliffe (1930) reports that the New Zealand Government established businesses with the avowed intent of promoting competition in thin markets. However, economists have provided few carefully documented analyses of the economic history of Government provision. Quigley (1989) is an exception, and its analysis of the 1894 Advances to Settlers Act provides substance to the view that Government provision was frequently an attempt to rectify market problems created by Government regulation.

The public sector component of reform embodied the notion that the core public service could be separated from activities that delivered goods and services for which good substitutes could be found, or produced, in the private sector. Essentially the differentiation was based upon the extent to which output could be measured. Those activities that were amenable to measurement, for example railway, postal and telecommunications services and forestry production, were bundled into stand-alone state enterprises, and those of a qualitative nature, for example policy

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[1] The use of economic theory is evident from the papers of The New Zealand Treasury (1984,1987).
[2] See Anderson (1980).

advice, were retained in the form of government departments. Lying between these extremes of measurability, the Government has retained a strong managerial and funding role in health and education, and one of the factors in this has been the extent of asymmetric information reflecting difficulties of quantification of outputs in these areas. Carroll (1991) makes a formal argument that establishes the importance of output measurability for the nature of the delivering organisation. It draws on the multi-task principal-agent model of Holmstrom and Milgrom (1991).

New Zealand's establishment of state-owned enterprises and, in some cases their subsequent privatisation, has differed from that of other countries in respect of the order in which the reforms were carried out. The financial sector was deregulated at the onset of the reforms, and the New Zealand dollar was floated in 1985. Although there had been some financial market deregulation during the 1970s, the financial market reforms of the early 1980s precipitated rapid, and sometimes costly, developments in these markets. By the time state-owned enterprises were privatised in the late 1980s and early 1990s the domestic capital market had evolved to the point where it was functioning much more efficiently than formerly, and it had adapted to the openness to foreign markets and investors. The sequence of the reforms was also important for state-owned enterprises and privatisation in that import protection and tariffs were reduced, and the legal framework for the conduct of business in a deregulated environment was well in place before the privatisation programme. The legal framework was moulded by competition policy that included much less regulation in general and less industry-specific regulation in particular.[3] The Commerce Act of 1986 was designed to place reliance on actual and potential competition for the regulation of prices and monopoly behaviour.

The creation of state-owned enterprises and privatisation activity of the past 8 years were signalled by the State Owned Enterprises (SOE) Act of 1986. The particular sequence of reforms means that SOE creation and sale have been carried out in sophisticated capital markets and in a largely deregulated open economy. Even utilities have been subjected to limited regulation and little protection from competition. This paper traces the development of the telecommunications industry from government department to incorporation as a state-owned enterprise and to sale as a public corporation, Telecom Corporation of New Zealand Ltd.. The study is unusual in that it estimates the consumer and producer benefits of the transition, and, as part of this evaluation, estimates the productivity growth of the industry.[4]

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[3] See the discussion of Vautier (1987).

[4] Until 1992 Telecom was the sole firm in the telecommunications market. We equate the industry with Telecom although since that date Clear Corporation has made inroads into the tolls market. Clear Corporation, started operating in the New Zealand Telecommunications market in 1991. It is majority owned by MCI Communications and Bell Canada from North America and minority partnered by New Zealand based companies Television New Zealand, Todd Corporation and New Zealand Railways. It has focussed on the toll market where it has gained significant market share. In 1993 the second major competitor, Bell South started to establish a cell-phone network.

While any counterfactual scenario with which the performance of Telecom can be compared must be problematical, our estimates suggest that there have been major consumer gains since the government department was bundled into a SOE and privatised: thus strongly pointing to economic efficiency gains of the organisational restructuring and de-regulation. In the next section we review what might be expected of the relative economic efficiencies of the different organisational structures. Section 3 sets out the development of Telecom and its operating environment. In Section 4 we describe the productivity study, and the changes in producer and consumer benefits are presented in Section 5. In the sixth and final section we comment on our findings and the position of telecommunications in New Zealand.

2 The Economic Efficiency of Different Organisational Structures

The central argument as to why government departments perform less economically efficiently than SOEs, which, in turn, perform less efficiently than private firms has to do with the political connection to management, multiple objectives and the absence of an immutable budget constraint.[5] We briefly review these principal-agent issues before linking them to the experience of Telecom.

As Holmstrom and Milgrom (1991) formally demonstrate, multiple and non-quantifiable objectives have direct implications for organisational structure and internal contractual arrangements. In the case of telecommunications the outputs are quantifiable, and hence the core telecommunications business is amenable to modern business management techniques. Multiple objectives have stemmed from the desire by successive governments to effect transfers of purchasing power between groups in society through the prices of telecommunications products, and to affect the level and quality of telecommunication services provided to interest groups and to regions. One worldwide example of this is government commitment to universal service wherein pricing schemes are adopted to promote the goal of each household having a telephone. Universal service has been advocated on the ground that there are externalities associated with any consumer's access to additional subscribers, and a view that all households should have a telephone.[6] Such externalities will be negligible for countries with a high proportion of subscribing households, and there are various ways in which households may choose access to telephones. Regulation has been pervasive in telecommunications. It has entailed price control and rigidly enforced market segmentation aimed at giving the regulators the power to implement their desired pricing regimes. These have generally entailed cross-subsidisation of local calls by long distance calls. Regulation is

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[5] Economic efficiency is taken to be the sum of producer and consumer surpluses. It is affected by the firm's pricing decisions and its productivity or, in Liebenstein's (1966) terms, x-efficiency.
[6] Noll (1986) and Evans and Garber (1989) analyse the implications of the pressures from competing groups for US regulators' pricing of telecommunications services.

changing as technological advances in telecommunications have rendered it increasingly difficult to enforce market segmentation.[7] Telecommunications firms operating as government departments have a wider array of objectives, in comparison with state-owned enterprise and public company structures. They are directly under the minister for that department and thus they are the most vulnerable to political pressure and objectives that can be implemented in an untransparent way. As one of many objectives, the goal of economic efficiency will be traded-off against other objectives, and not accorded central priority: thus adversely affecting efficiency.

In addition to their intimate political connection, government departments face different incentives to be economically efficient. They have had to meet terms and conditions of employment of the core public service, although in New Zealand this requirement has been substantially relaxed. They have had hierarchical decision procedures which have entailed oversight by other departments, in particular The Treasury. Again this has been considerably relaxed in New Zealand, but Treasury oversight of government departments remains, and borrowing is tightly controlled. In part, the operational rules of departments are designed for monitoring purposes. Organisational principal-agent theory tells us that there is a trade-off between the costs of providing contractual incentives to induce good performance, and the costs of monitoring: at the monitoring extreme lies the bureaucracy solution. The more prevalent multiple and qualitative objectives, the more weight is optimally shifted to the bureaucratic style of organisation, as compared to an organisational structure relying on contracts with sharp performance incentive provisions. Because of the presence of bureaucratic structures, bundling activities, such as telecommunications, into stand alone entities with clear measurable objectives will almost certainly lead to an improvement in economic efficiency over that of departmental structures.

In addition to these factors, government departments may not have immutable budget constraints, in that their losses may be met by government. While this can occur with SOEs, the purpose of any transfer of funds to SOEs is more transparent. The possibility of government funding losses reduces incentives to seek productive efficiency, and this is an important component of economic efficiency.

The formation of SOEs, required bundling certain activities into stand-alone entities. It entailed making implicit contracts explicit, and defining property rights. The allocation of functions, outputs, resources and contractual relationships to these entities was a necessary first step in converting Government trading organisations into separate entities. Each SOE is

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[7] Technological advance has affected the telecommunications industry in a number of important ways. In addition to providing new products it has fundamentally changed the nature of networks, reduced the need for specialist operational staff, such as engineers, and increased the competitive nature of the industry itself.

to function as a business, and one which is not required to provide un-paid social services. Any non-commercial activity required of them by Government is delivered under an explicit contract. Management is responsible for pricing and investment decisions, subject to the caveat that a Statement of Corporate Intent has to be accepted by the Government each year. It sets out the corporate policy for the ensuing two years and other matters to do with facilitating monitoring. The Act provides for a Board of Directors accountable to the Minister of Finance, and another minister who holds the shares.[8] Employees of an SOE are not covered by any Public Service terms and conditions of employment.

A crucial feature of the Act entailed subjecting the enterprises to the same antitrust and company law facing private enterprise. When this is combined with the fact that the bundling exercise typically entailed elimination of explicit contracts giving preferential access to Government procurement and finance, an SOE is on a similar footing to privately owned firms. Indeed, for the increased flexibility of decision making, the more distant relationship to politicians and the sharper incentive contracts of SOEs to generate efficient pricing, as well as improvements in x-efficiency, requires that they operate in markets with actual, and credible potential competition. In the case of telecommunications, the industry was deregulated, and Telecom was required to offer access to the network on "reasonable terms and conditions": there being no regulatory impediment to industry entry.

While SOEs were set up to mimic privately owned firms, they differ in a number of respects. The differences include the SOEs' untested limited liability status, their reduced monitoring resulting from non-transferable shares and their relationship to Government, albeit much weaker than that of a government department. These impediments to efficiency provide arguments for privatisation. If the limited liability status is not credible then capital might be raised at more advantageous interest rates than would be otherwise the case, and debt holders may not be so demanding of the company's performance. Also, it may weaken internal incentives to strive for efficiency. Monitoring of SOEs is a government function rather than a function of the voting populace that owns the enterprises. Such diffuse ownership provides negligible incentives for any particular owner to scrutinise the enterprise, and, although politicians might be judged on enterprise performance, they will be elected on a raft of issues, and thus are not directly accountable for such performance. Private ownership does provide strong incentives for direct interest in, and monitoring of the company by owners and debt holders. It means that there are three groups of customers which have solid concerns about the company's performance, product consumers, owners and debt holders, each of which can express their views in ways that affect the firm.

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[8] In addition, the government may influence SOE policies directly via the appointment of directors.

Although the creation of the SOEs markedly improves the transparency of links to Parliament and politicians SOEs are not as time consistent in their business objectives as privately owned firms.[9] In private markets the business objective of maximising the value of the firm will persist over time, because there is no reason to believe that the owners will change their objectives. This commitment to behaviour is time consistency.[10] The managers of SOEs have to assess whether their owners are committed to value maximisation, and it is likely that the commitment is weaker than for the case of privately owned companies. In the past politicians have used government departments to effect various policies, and they are likely to do so in the future. What is important for a lack of time consistency is the possibility that future incentives will be such that politicians depart from purely business objectives. Since getting re-elected is likely to be affected by special interest groups in the community, these incentives remain and, indeed, may be time consistent from a politician's viewpoint. To the extent that the managers of privately held firms have a more intensive commitment to business objectives, in a competitive environment, their firms will generally be more economically efficient than comparable SOEs.

This concludes a review of the rationale for expecting economic efficiency to increase as a government department is transformed into an SOE and then privatised. To measure this increase entails much more analysis than simply measuring the entity's rate of return and comparing it to the rates of return of other companies in that entity's risk class. First, such a comparison requires using the firm's shareholders' funds rather than market value, because SOEs are not traded in the market place. Second, even if the market value was available it is determined by expectations of future performance, and is affected by current performance only insofar as it affects expectations. Thirdly, a firm's rate of return is affected competition and by whether or not the firm is dominant in the market place. It may not indicate whether the firm is x-efficient or economically efficient. We study economic efficiency by assessing the x-efficiency change which has taken place in Telecom as an SOE and public company. Records of the Government department do not permit evaluation of departmental performance. We conclude by assessing the changes in consumer and producer surpluses which have taken place since the formation of the SOE.

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[9] The advantage of the political separation of the SOE model over a that of a Government department became evident when the Electricity Corporation submitted its Memorandum of Intent in 1991. In it, the Corporation argued for an steadily increasing price of electricity over time until the price reached what the corporation estimated to be long-run marginal cost of the next block of generation capacity. The ensuing public furore educated many, including ministers, to the economic principle involved, and focussed attention on the core issues. The debate never would have taken place under the former Electricity Department organisation where pricing decisions and planning were not automatically in the public arena.

[10] For a formal discussion of time consistency see Fudenberg and Tirole (1991, 74-77).
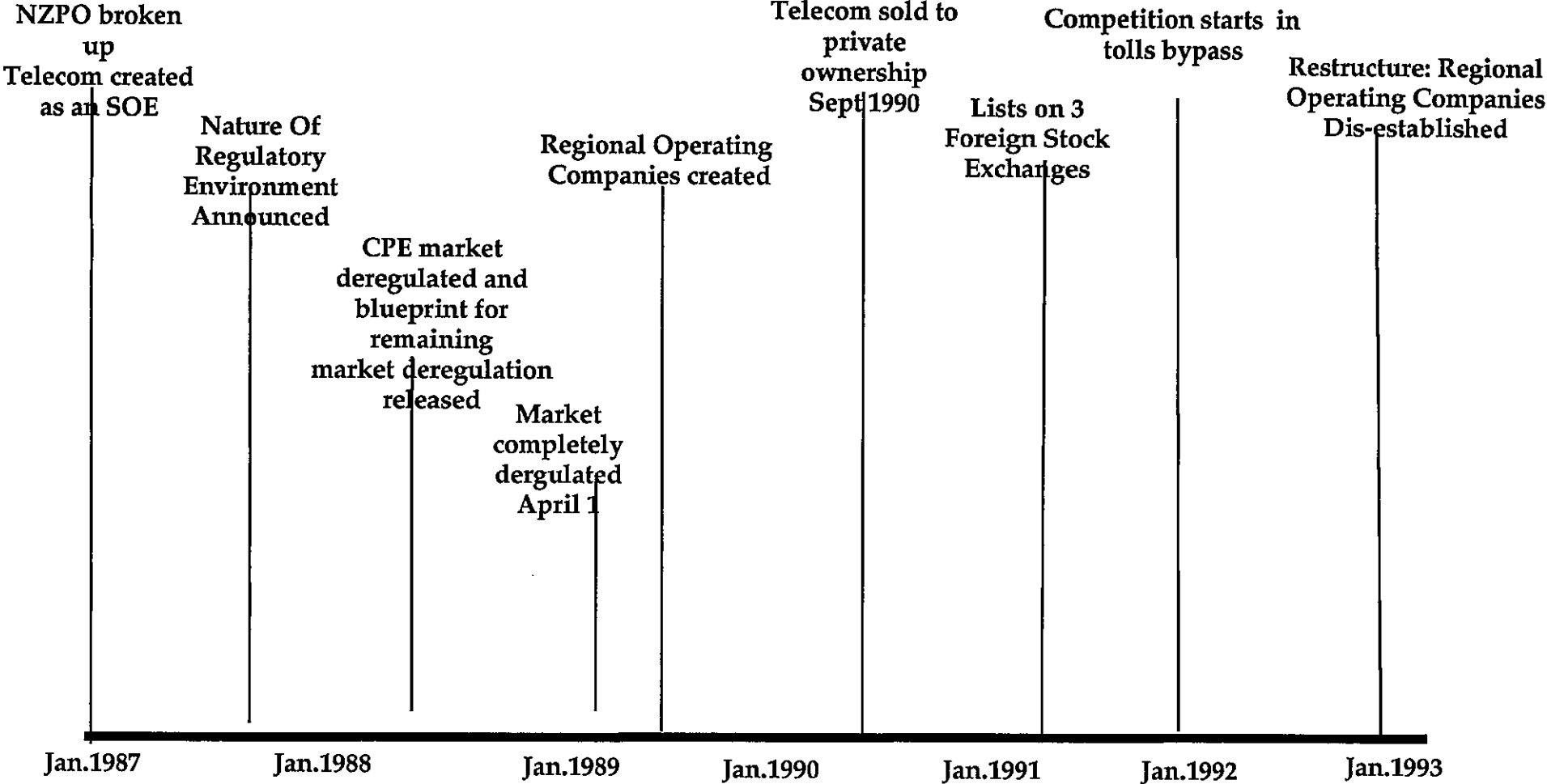
3. The Evolution of Telecom

Established in the 19th century as a postal organisation to which responsibilities for telegraph and telephony were later added, the New Zealand Post Office (NZPO) operated as a Department of State under the Post Office Act of 1959. In addition to delivering telecommunications, postal and banking services, it provided Government with policy advice, it regulated the telecommunications and radio networks and represented New Zealand in a number of international forums. The NZPO was an archetypical government trading department. It was constrained in its operation by the Public Service terms and conditions of employment and operating systems. Its pricing and provision were very much determined by the Cabinet of the elected political party via the Minister responsible for the NZPO. Investment decisions had to pass political and Government checks. Their financing required formal Government approval and was subject to the scrutiny of the Treasury. The fact that the NZPO regulated telecommunications at the same time as providing them led to confused objectives and restricted competition.

The structure of the NZPO is set out in Appendix 1. At the time of incorporation it was much like Williamson's (1970) "U" form of organisation. The structure was unwieldy in that the Director General's position had 4 Deputy or Assistant Directors reporting to it as well as 17 Regional engineers and 22 Chief Postmasters. Operation of the supply and maintenance of telecommunications services were separate from the provision of clerical telecommunications services. Lines of accountability were unclear: the Deputy Director General of Telecommunications, for example, was responsible for the business activities of the telecommunications services, but had no direct control of pricing or customer service operations. The lines of business Directors had no control over staff selection. Overall, the operations of the Post Office were totally controlled through rigid channels to a very large central head office.

Telecommunications operations and assets were bundled into an SOE on 1 April 1987. A schematic description of key dates, including those of regulatory change, is presented in Figure 1. The Telecommunications Act of 1987 provided a timetable for phasing in competition. By 1 April 1989 Telecom's statutory monopoly was eliminated, and the terms and conditions of competitive forms' connections to the network were subject only to the anti-competitive provision of the Commerce Act 1986.[11] As Boles de Boer (1993) points out, the statements of corporate intent for 1987, 1988, and 1989 stress commercial goals, and they place increasing emphasis on business objectives.

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[11] Under the Telecommunications Disclosure Regulations 1987, Telecom must make public certain interconnect pricing arrangements, and standard prices, and discounting policies must available for official and public scrutiny.

Figure 1

NZPO broken
up
Telecom created
as an SOE

Nature Of
Regulatory
Environment
Announced

CPE market
deregulated and
blueprint for
remaining
market deregulation
released

Market
completely
dergulated
April 1

Regional Operating
Companies created

Telecom sold to
private
ownership
Sept 1990

Lists on 3
Foreign Stock
Exchanges

Competition starts in
tolls bypass

Restructure: Regional
Operating Companies
Dis-established

Jan.1987   Jan.1988   Jan.1989   Jan.1990   Jan.1991   Jan.1992   Jan.1993

During its first year as an SOE Telecom had to quickly develop and implement the structures and management control systems necessary to allow it to perform as a private business. The structure it chose is reported in Appendix 1. It was designed to decentralise decision making, and improve accountability through incentive contract systems. The subsidiary companies were allocated their own assets. Operational and investment decisions were delegated to the executive of the subsidiary companies which were to operate at "arms length" from each other. Although much investment was decided in the subsidiaries, the Board of Directors was the ultimate decision making body for major investment and would assess investments proposed by the managers of the Regional Operating Companies (ROCs). An Executive Management Board was established to screen proposals for large investments.

Within the four regional operating companies there was the same managerial structure, and each of the other subsidiaries had a full complement of management staff. Clearly, the functions: finance, sales and service, and network and information systems were duplicated across the seven subsidiaries. If this duplication was not to reduce technical efficiency the decentralised system would have had to be significantly more productive than a centralised structure. Such productivity may result from decisionmaking closer to customers, and by stimulating competition between subsidiaries. The structure did provide tournaments for a range of existing NZPO staff to show their abilities and skills in a deregulated business environment.[12] Their performance in the ROCs would affect their promotion in the company and affect their prospects for employment if the decentralised ROCs were replaced by a centralised organisational structure. Thus the decentralised ROCs offered the potential for competition in performance between them.

Following the establishment of the SOE prices were set on a more commercial basis, but their rate of increase did not exceed that of the Consumer's Price Index. Capital investment increased dramatically as Telecom expanded capacity, and improved the quality of the network. From July 1988 to July 1991 the proportion of electronic exchanges grew from less than 40 per cent to more than 85 per cent. Some of this work had been proposed under the NZPO. The electronic exchanges reduce operational costs to Telecom, and they improve the quality of connections.

On 12 September 1990, Telecom Corporation of New Zealand was sold by the Government to a consortium led by Bell Atlantic and Ameritec.[13] Under the competitive tendering process the purchase price was NZ$4.25 billion and the purchasers were required to sell a majority of

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[12] See Rasmusen (1989,167) for an introduction to tournaments in organisations.

[13] The Government retained a "Kiwi" share which requires the company to offer a free residential local calling option and to not increase the price of residential access by more than the rate of increase in the Consumers' Price Index.

the shares to private investors. On 19 July 1991 the consortium complied with the requirement and sold 724.5 million shares. Telecom Corporation of New Zealand shares are now listed on New York, London, Sydney and New Zealand stock exchanges. The market value of the company is now more than twice the Government sale price.

As a corporation with publicly held shares investment remained at the SOE level for a year, when followed a considerable reduction in the rate of investment from its peak of 1990. All SOEs were constrained from diversification and hence more diversified activity has been sought by Telecom since privatisation: much of this activity being directed at expanding demand for existing networks. In 1992 a re-organisation of the structure was announced: it is still being implemented. The latest restructure was significant in that it entailed eliminating the regional operating companies and thus precipitating a much greater degree of centralisation. The current structure is described in Appendix 1. The five subsidiaries now have quite different functions. To the extent that the costs of duplication associated with decentralisation outweighed the benefits of decision making closer to the work place and the presence of internal company tournaments, the centralisation will improve x-efficiency. Also, in the increasingly competitive environment of telecommunications, co-ordinated strategic behaviour will be easier in a less decentralised company.

4. The Productivity of Telecom

In this section we estimate the productivity, or x-efficiency, change in Telecom over the period 1987-1993, that is, since its incorporation as a SOE.[14] This change is of interest in it own right because many of the arguments for the corporatisation and privatisation processes have to do with incentives and monitoring of the entity and with internal contractual and behavioural changes which will improve the level of output produced by any bundle of inputs; that is, improve x-efficiency. Furthermore, productivity change is an important ingredient of the change in consumer and producer welfare which has taken place over this period. These welfare changes are examined in the next section.

We focus on network productivity and do not consider ancilliary activities such as provision of a business directory and equipment sales. We adopt the standard approach of estimating productivity change from the production relationship

$$q(q_1,...,q_i) = f(t,m(m_1,...,m_k),l(l_1,...,l_h),k(k_1,...,k_n))$$

where $q(q_1,...,q_i)$ is an index of aggregate output formed from i outputs,

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[14] Each cited year refers to the year ending March of that year.

t is time,

$m(m_1,...,m_k)$ is an index of material inputs,

$l(l_1,...,l_h)$ is an index of labour inputs, and

$k(k_1,...,k_n)$ is an index of capital.

It yields the growth rate of total factor productivity in year t as

$$g[t] = g[q] - rsg[i]$$

where $g[.]$ denotes rate of growth, rs is returns to scale and $g[i] = \alpha_1 g[m] + \alpha_2 g[l] + \alpha_3 g[k]$ is aggregate input growth constructed using non-negative weights, the α_i, which sum to one.[15] The growth in total factor productivity is measured as the difference between the growth in the indices of outputs and inputs adjusted for returns to scale. Scale economies mean that rs will exceed one. Telecommunications networks are characterised by significant fixed costs and thus enjoy scale economies. For the analysis of welfare in the next section we use as marginal cost a weighted sum of average incremental costs calculated for network components in 1992 and fixed costs for that year to calculate network costs. This specification means that Telecom does have scale economies and that the returns to scale can be calculated from the measured Telecom network cost function. They will be greater than one because of the declining average cost of the network. In this case there is a further complication resulting from the fact that the percentage cost reduction yielded by any productivity growth will be less than the percentage productivity growth. This occurs because under scale economies efficient input use will adjust less to productivity improvements than would be the case under either decreasing or constant returns to scale.[16]

It is likely that $g[t]$ will also reflect more than simply organisational gains in x-efficiency. Quantitative output changes may not capture quality changes which are of benefit to consumers and thus may understate output growth which is relevant to consumers. We examine this issue by supplementing the calculation of $g[t]$ with information about changes in quality of service. In addition, inputs may embody technological advance. If this occurs and technological

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[15] For a review and application of this approach see Kendrick (1973), and for an application to utilities see Denny, Fuss and Waverman (1979). The impact of returns to scale on the measurement of productivity is illustrated in Appendix 2 by means of a Cobb-Douglas production relationship. This Appendix also illustrates how to calculate returns to scale and their effect on the extent of cost reduction brought about productivity growth. It should be noted that this procedure assumes that, to a good approximation, productivity growth has been neutral with repect to inputs. Setting aside the conceptual issues involved in sorting out neutral from non-neutral productivity growth - for example, labour saving technical change- the few data points for the study preclude examining non-neutrality.

[16] An analogy can be drawn with an expansion of output: costs will change less under increasing returns, rs>1, than rs≤1 because inut use will change less.

advance of the company is not measured then our index will reflect technological advance as well as organisational efficiencies.[17]

We now turn to measurement issues. One reason for carrying out a total factor productivity study is that profits and rates of return will reflect any strategy for pricing above Ramsey pricing which is possible because of the dominant position of the company.[18] Such pricing, and even Ramsey pricing itself, mean that output indices constructed using these prices may not accurately indicate output changes. To address this issue we have chosen to use the price-free measure of aggregate output; total minutes of use of the network.[19] The input markets are taken to be competitive. The index for material inputs was constructed by using Statistics New Zealand's Producer's Price Index, (PPI), to place expenditure on inputs, other than those associated with capital and labour on a 1987 constant-price basis. Material input has components such as; power, travel, property rental, stationery, legal advice, vehicles and consultants. Restructuring costs, insofar as they could be isolated from the accounts, have been excluded from the input indices, as these costs did not represent inputs which contributed to the delivery of telecommunications outputs.

A lack of suitable data, in part stemming from different classifications used by the NZPO and Telecom, mean that labour cannot be separated into its component types. The labour index is described in Figure 2. It does not include labour used putting capital in place as part of the investment programme, and the expenditure from which the index is constructed does not include severance payments for staff made redundant. Some investment-labour was supplied under contracting-out arrangements. Certain ROCs initiated limited contracting-out of particular operational services in 1990. This will appear as reductions in the labour index and increases in the materials index, but the magnitudes of the effects will be small. The data of Figure 2 illustrate that while there has been a large reduction in the numbers employed, it has not been matched by the same reduction in expenditure on labour in 1987 prices. There has been a change in the composition of the labour force resulting in higher average salaries. Since 1987, staff classified as operational and engineers have both fallen by approximately 55 per cent. During this time, management numbers have remained almost unchanged. The average salary

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[17] See Norsworthy and Jang (1992) for discussion of the implication of quality changes for the measurement of productivity and for the estimation of quality adjusted indices.

[18] Ramsey (1927) provided the pricing rules for a declining cost industry which restricted it to normal profits. Where demands are not importantly affected by demands for other outputs, the rules imply pricing above marginal cost in inverse proportion to the elasticity of demand for any output.

[19] The issues associated with this measure of output are canvassed in Boles de Boer (1993, 76-81) and Kiss (1983). The output index aggregates minutes of use of local, residential, and business, calls, and domestic and international calls. While minutes of use for toll calls are measured local call minutes of use have to be estimated using various factors, including the number of lines and surveys of the durations and number of calls. The data are much less reliable in the 1980s than those of the 1990s. For this reason the minutes of use in 1987 have also been estimated a second way by using surveys of residential use in the mid 1980s together with relationships between residential and business use in the 1990s, when more data are available.

Figure 2
Labour

■ Number of Employees (00s)

□ Expenditure ($m)*
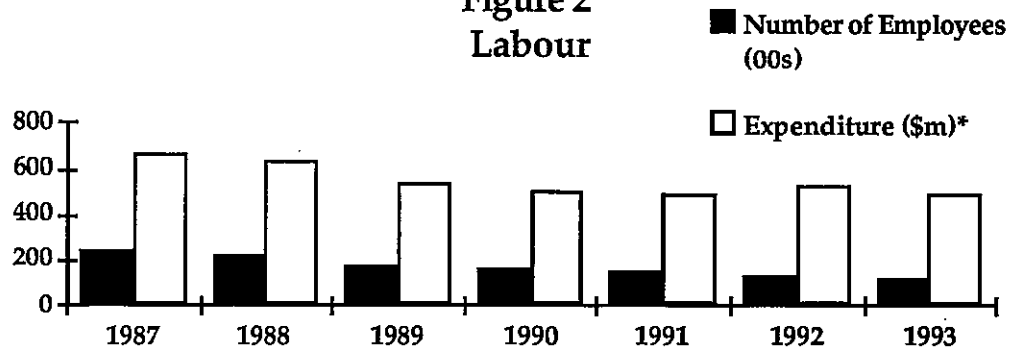
* Based on the cost of labour (in 1987 $s) involved in the production process.
  It excludes labour used on projects and redundancy payments.
  Labour expenses were deflated to 1987 $s using Statistics New Zealand's Wage Rate Index

Figure 3
Exchange Capacity Utilisation
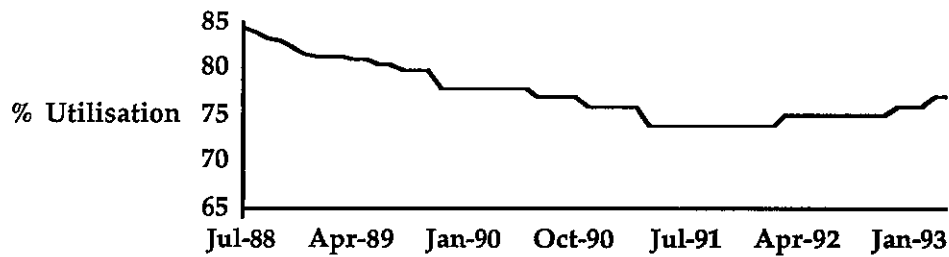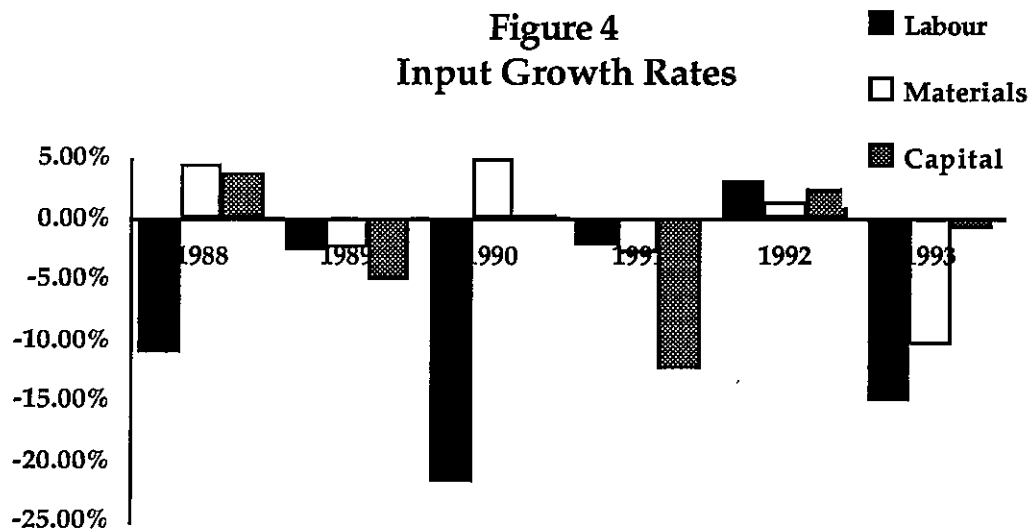

Figure 4
Input Growth Rates

■ Labour

□ Materials

▧ Capital

of all staff has increased because managerial staff were paid more than both engineers and operational staff.

The stock of capital in the network in any year is constructed by first valuing the components of the network at market prices and aggregating them to form the total replacement cost of the network. Second, the non-network component of total capital consisting of items such as specialist network technology platforms, computers for information processing, billing and local area networks is calculated from investment in these items and from depreciation which assumes an economic life of four years. This non-network component forms about 10 per cent of total capital. The network and non-network components are deflated by the PPI to measure expenditure on them in 1987 prices, and they are aggregated to form the total capital of Telecom. Thus the capital index is the replacement value of capital in each year in 1987 prices. It reflects technology actually used by Telecom. To the extent that technology has been changing more rapidly in telecommunications than in other industries and it is embodied in capital, deflation by the PPI price index, which applies to all industries, will lead the capital index to understate increases in the quantity of capital employed.[20]

During the period of the study, Telecom invested heavily in the network. The balance of this investment between upgrading and raising the capacity of the network to meet anticipated customer demands, and investment aimed at pre-empting competition is problematical.[21] In any event, the substantial investment may have affected the utilisation rate of capital, and thus the estimate of productivity change. Although, time series estimates of utilisation of the network are not available, there are data which describe the utilisation of SPC exchanges: these form 22 per cent of the total value of the network. These data are described in Figure 3, and they indicate declining utilisation rates. The optimal utilisation rate, which recognises that extra capacity is required for exigencies, may be less than the 85 per cent reported for mid 1988. Nevertheless, we explore the effect of the reduction in utilisation of the network by applying the utilisation rates for SPC exchanges across all capital equipment, under the assumption that provision for unanticipated demand shocks is covered at the 85 per cent rate.

The growth rates of inputs are depicted in Figure 4. They show that capital has declined steadily over the period: the decline in capital of 1991 reflecting efficiencies achieved under the

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[20] Norsworthy and Jang (1992, Ch.7) discuss, typically hedonic, quality-adjusted price series. In the absence of a quality adjusted price index for telecommunications capital they suggest using total factor productivity of an industry which employs similar equipment. Their application to the US semi-conductor industry suggests an annualised real price decline of 7.4 per cent for the period 1976-86. Applying this figure to the measurement of capital in this study would increase measured capital to the extent that the reported productivity growth would be lower by approximately 30 per cent. While this may be illustrative, uncertainty about the level of capital services remains.

[21] The strategic uses of excess capacity to deter entry of a potential entrant, or to discipline the pricing behaviour of a competitor are discussed in Tirole (1988, Ch.6).

Figure 5
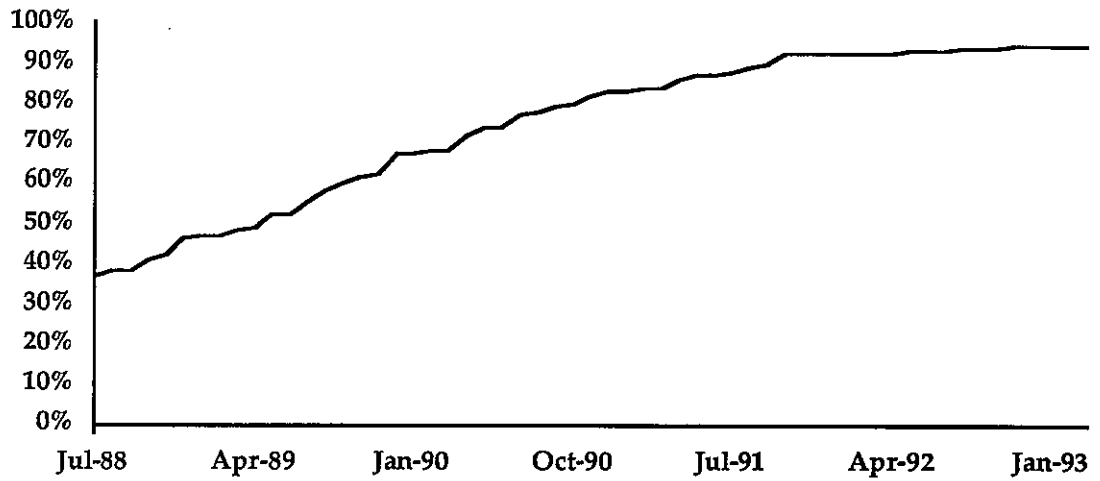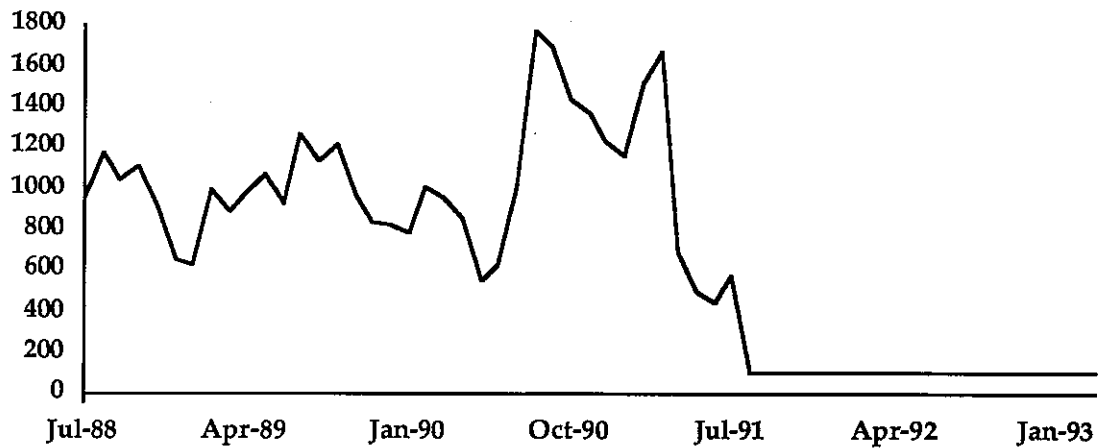## Proportion of Computerised Exchanges

Figure 6
Number of Persons Waiting for Service

new SPC exchanges. There have been three substantial declines in the labour input. The first occurred immediately after incorporatisation as a SOE, the second was in 1990 just prior to privatisation, and the third occurred in 1993 as part of a major restructuring; entailing elimination of the ROCs and the duplication of managerial and administrative services which they represented. Although capital and labour both declined, substitution of capital for labour has taken place. It is noteworthy that material input grew in three years.

The growth in total input was obtained by weighting together the growth rates of the three inputs. For this purpose the annual rental value of capital was calculated using the company's average cost of capital. The weights, α_i, were calculated as the ith input's share of total expenditure, including the rental value of capital, in each year.[22]

We estimate that output grew over the 6 years by 35% per cent. When we subtract the growth in total input adjusted for returns to scale we get we get an annual compound productivity growth of 9.5 per cent. This figure increases to approximately 10 per cent when capital is adjusted for utilisation. To the extent that the unutilised capital represents excess capacity which is designed to pre-empt competition, it is the higher figure which represents gains in productivity, but such is the productivity growth that the capital utilisation adjustment does not much affect conclusions. The economies of scale are quite significant and so the compound annual percentage cost reduction resulting from productivity growth of 5.6 per cent is quite a lot lower than th rate of productivity growth. The aggregate network cost reduction over the period is 38.3 per cent.

Both the rates of productivity growth and cost reduction are very high by the standards of other industries, and by the standard of the telecommunications industry, at least for the period 1963-1982.[23] Although the numerical estimates of productivity change must be viewed cautiously because of data measurement issues, their order of magnitude does suggest that there has been most significant productivity growth and cost reduction. They will reflect technical change as well as organisational changes.

As part of evaluating this conclusion we need to examine whether the gain in total factor productivity has been at the expense of output quality. Indeed, to the extent that output quality is of direct concern to customers it is a relevant, but unobservable, component of output, and

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[22] The Tornqvist (1936) index, where the weights are averaged between time periods, was used to construct the index of aggregate input growth.

[23] See the total factor productivity figures cited in the report *The Contribution of Telecommunications Infrastructure to Aggregate and Sectoral Efficiency*, DRI/McGraw-Hill, Lexington, MA, February 1991, and those of Norsworthy and Jang (1992) for the computer industry.

Figure 7
Faults

Figure 8
Total SPC Downtime

Figure 9

Price
Marginal
Cost

Demand

mc87

a

b

c

p87

p93

mc87
mc 93

mc 93

f

e

d

q87   q93

Output

Gain in consumer plus producer surplus, ie: gain in welfare

Consumer plus producers surplus in 1987 (note the role of rationing)
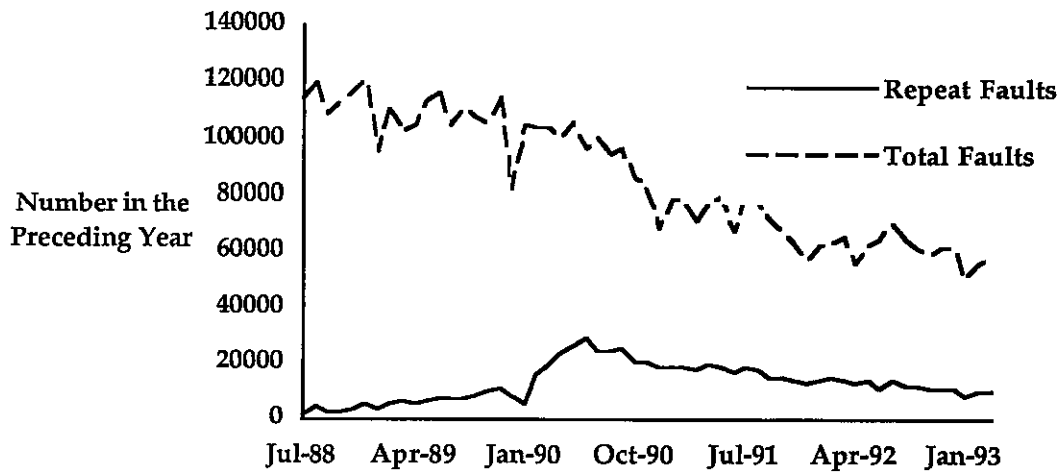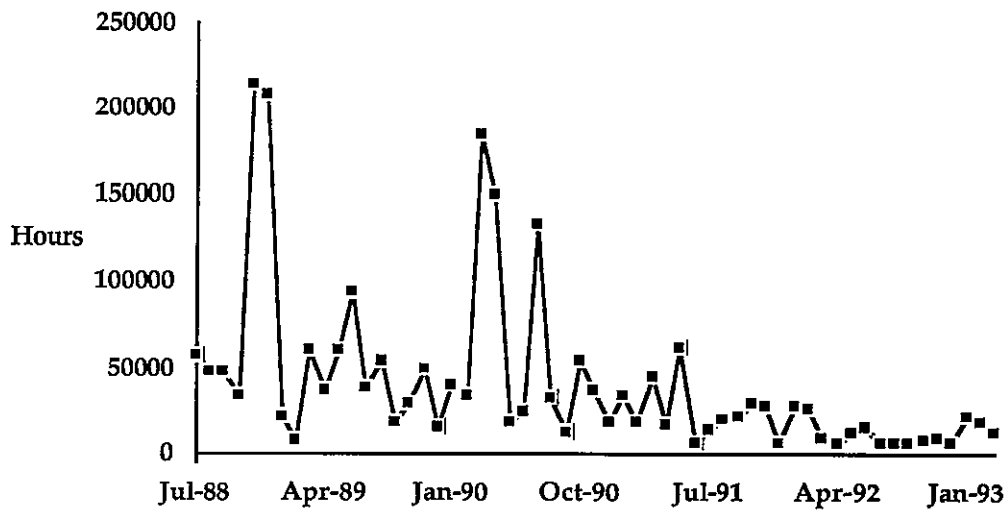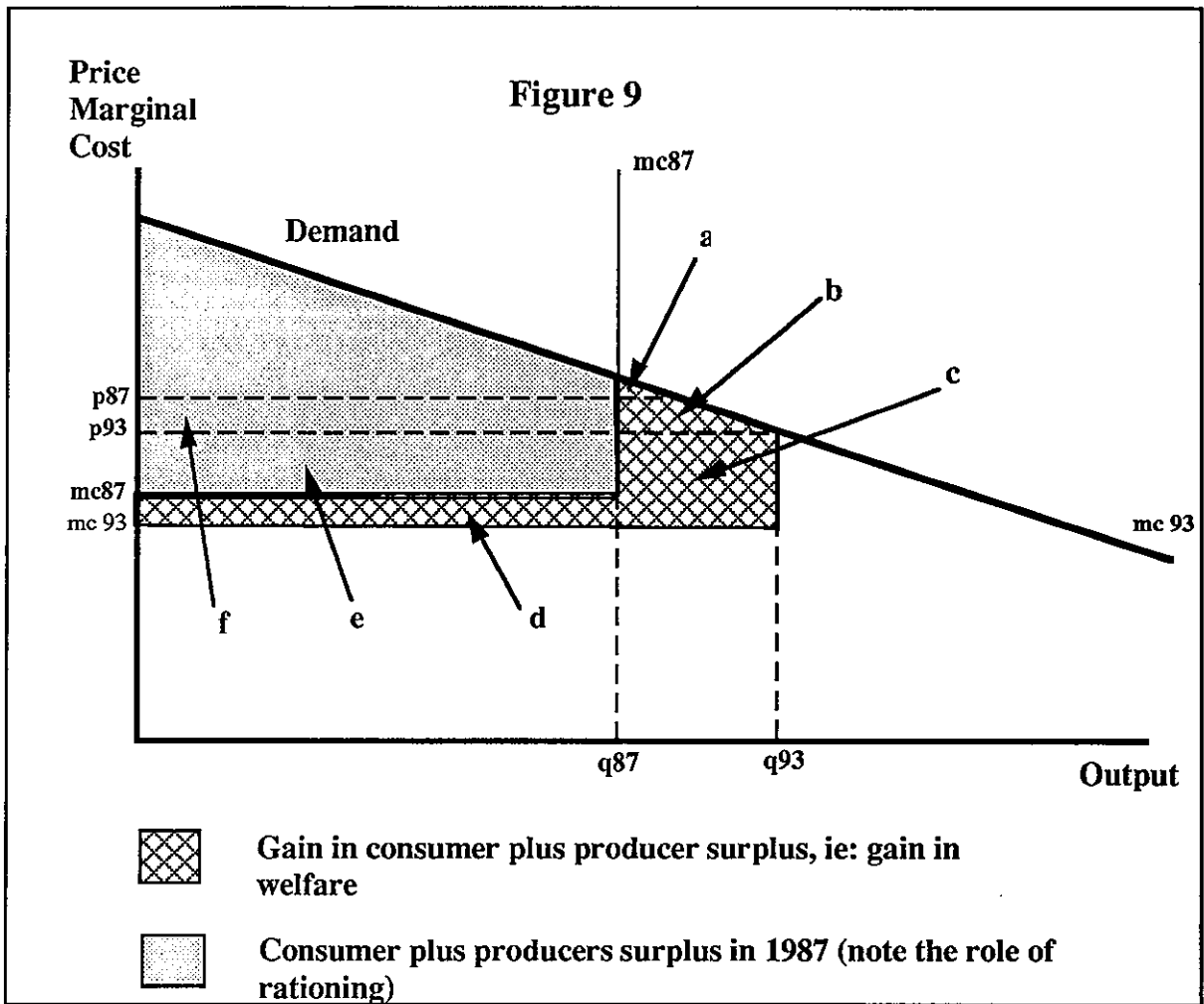
improvements in it can be regarded as output growth. We report, in Figures 5-8 quality indicators which are of direct relevance to customers. The span of certain data are limited by the fact that collections began in July 1988. Figure 5 describes the penetration rate of electronic exchanges and it illustrates the point made earlier that the use of these exchanges has increased to the point that virtually all exchanges are electronically operated using sophisticated software. In addition to reducing Telecom's operating costs these exchanges improve the quality of minutes of use through their clearer connections and their ability to offer digital transmissions.

The number of customers waiting at the last day of the month for services such as the installation of a phone are described in Figure 6. They illustrate that, although there was an increase at the time the regional operating companies were established numbers waiting have fallen to a negligible number. At the time the SOE was formed the numbers waiting for telephone installation was even higher than that reported in Figure 6. From Figures 7 and 8, total faults have halved since mid 1988 and exchange downtime has fallen dramatically. Exchange downtime and repeat faults increased substantially in 1990; again the period when the ROCs were established. While downtime returned rapidly to its downward path repeat faults have proved more resilient. There is some suggestion that the nature of contracts affected repeat faults in the two ROCs which contracted-out repair work, but one of the other two ROCs also experienced a sharp increase and slow decline in repeat faults. Total faults do not include repeat faults and they have declined significantly. While our analysis will capture cost reductions, our measure of output will not reflect enhanced quality. We conclude that quality of service has improved since 1987, making our quantitative estimate of productivity growth a lower limit to gains in x-efficiency.[24]

5 Consumer and Producer Benefits

We turn now to changes in aggregate welfare which have flowed from Telecom since 1987. These are indicated by changes in producer and consumer surpluses generated over the period and they incorporate the productivity change. The framework is described in Figure 9, which describes the telecommunications market as it applies to Telecom in 1987 and 1993. The diagram assumes a stable demand curve over the period and that demand can be separated into residential and business. At the time of incorporatisation as a state-owned enterprise, in 1987, there was excess demand for the network. This appeared as an inability to make calls, particularly at certain times of the day, and in the time it took to implement customer services. It is depicted as a vertical marginal cost curve. In the diagram, a indicates the gain in consumer surplus yielded by relaxing the capacity constraint, f+b is the consumer surplus gain from

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[24] To use the quality indicators to construct an estimate of output growth which incorporated quality would require weighting minutes of use and these indicators. There is no natural weighting scheme for this aggregation.

reduced real prices, and c+d indicates the increase in producer's surplus resulting from improved productivity, as it applies to variable costs, and the expansion in demand. The area f has no effect on total welfare, but is a transfer from producers to consumers. To producer's surplus must be added the improved productivity of the fixed assets. All prices, costs and consumer and producer surplus measures will be expressed in constant 1987 prices.

Although the demand function is depicted as linear, the calculations assume that it has a constant price elasticity of -0.5, a magnitude which is in broad accord with unpublished studies of the New Zealand telecommunications market over the period of this study. The expansion in output consumed is attributed entirely to the removal of rationing and the price changes which have taken place since 1987.[25] In particular, it is assumed that the demand curve has not shifted over the 6 years as a result of income growth. In fact, New Zealand was in a recession over this period and income, as measured by GDP, did not grow during this time.[26] The price of aggregate output is calculated as the weighted average of the prices of the components of aggregate output - these are local, toll and international toll calls - where the weights are the shares of the component outputs in total output. The complication stemming from the fact that residential local calls have no per-minute charge, was addressed by assuming that the telephone rental was entirely for making local calls, and by dividing local minutes of use into the rental charge to express local calls on a per-minute basis. Telecom's costs have been allocated between fixed and variable items in calculating the long run average incremental cost which is used as marginal cost in our welfare analysis. The division is somewhat arbitrary in that all costs are variable in a long time frame. The incremental cost of any service is defined to be that cost which can be avoided if the service is not offered. Average incremental cost combine the incremental costs of different services to form an average to represent the incremental cost of the network itself. Fixed costs include the joint and common costs which are required to produce the combined outputs of Telecom; in particular they include expenses such as executive personnel costs, executive support costs, for example office space costs, regional management costs and capital charges for non-operational expenses. In 1992 the weighted average marginal cost of all network minutes of use was estimated and then converted to 1987 prices by means of the PPI.

The results of the welfare analysis are summarised in Table 1.[27] They suggest that the bulk of the gains have accrued to consumers and that the most of these stemmed from price reductions on 1987 consumption levels. Telecom, as the producer, has fared less well. Price reductions transferred producer surplus to consumer surplus, and the productivity gains and output

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[25] Note that capacity had been expanded to the point that rationing had been eliminated by mid 1988.

[26] See the GDP data reported by the New Zealand Institute of Economic Research (1993). Although the demand function is now changing because of presence of competitors, this was not a significant factor until 1993.

[27] The results reported here extend Boles de Boer (1993) by one year. The data for the calculations which led to these results are not reported in full as certain of them are commercially sensitive.

Table 1

Consumer and Producer Benefits: 1987-1993
in 1987 Prices

Consumer Surplus Gain: Area a+b+f

Residential	$307.93m	($251.7m)*
Business	$348.02m	($287.3m)

Producer Surplus Gain: Area c+d-f

Residential	-$104.08m	(-$85.07m)
Business	-$131.89m	(-$110.72m)
Fixed Cost Reduction	$155.05m	
Total	$575.03m	($498.26m)

* The data contained in the brackets are based on alternative method of estimating 1987 output.

expansion have not been enough to offset the transfer. Implementing the capacity-adjusted productivity gain does not materially affect the conclusion. The size of the total gain to society is quite significant. Indeed, at a discount rate of 10 per cent total gains are of the same order of magnitude as the original sale price of Telecom in 1991; even at the lower level of benefits reported in Table 1. Furthermore they understate the gains accruing to the telecommunications market as a whole. Our calculations have estimated consumer and producer surpluses for Telecom alone, and yet competitors, particularly Clear Corporation, have gained a substantial 18 per cent share in the tolls markets. The growth of this share has been such that the issue becomes of significance in the 1993 year. If it is assumed that the competitors are at least breaking even, then there have been additional gains in consumer surplus stemming from consumers switching to Telecom competitors in the de-regulated environment. The total gains reported in Table 1 thus understate the welfare gains enjoyed by the total telecommunications market over the period.

Reconciling the reduced producer's surplus with the share price performance is complex because New Zealand real interest rates have fallen significantly since 1991, and the share price reflects expectations. Also, some of the growth in share price will have been affected by revenue growth from non-network activities. Nevertheless it is useful to attempt a reconciliation: relevant information is presented in Figure 10. We graph the share price against a modified New Zealand share price index. We use the index as a basis of comparison because it reflects changes in general economic conditions that will also affect Telecom's share price. The index is New Zealand's Capital index after removing Telecom. That company has a high weight in the index.[28] It is immediately apparent that Telecom's share price has performed better than the average of all listed shares in New Zealand, particularly since early in 1993. The difference may be understated in the graph because the share prices are ex-dividend and Telecom will almost certainly have paid more dividends per share than would be the average of other companies.

The data suggest that Telecom has performed better than the market average, despite the loss of producer's surplus. There are various explanations for this outcome. The share price will reflect the expected stream of dividends to shareholders, and thus expected future cash flows. Various factors will affect this expectation. Telecom has carried out an extensive, primarily internally funded, investment programme the magnitude of which is indicated in Figure 11.[29]

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[28] The index is the New Zealand Capital index after the removal of Telecom. It uses as weights each company's market value relative to the total market value of companies included in the index. The index reported in the graph was obtained by subtracting Telecom's share price times its weight (while this weight has varied over time, a good approximation is 20%), and dividing by 1 minus the weight. The division preserved an index with weights summing to 1. Telecom's share price was adjusted to ensure that the same number of shares were outstanding pre and post Telecom's mid 1993 share re-purchase.

[29] The data of Figures 10 and 11 are in nominal terms.

Figure 10
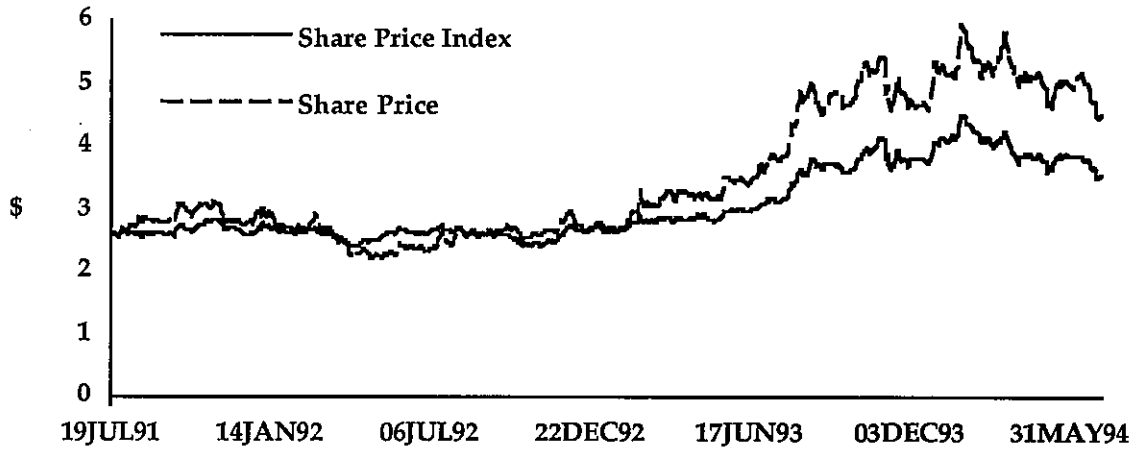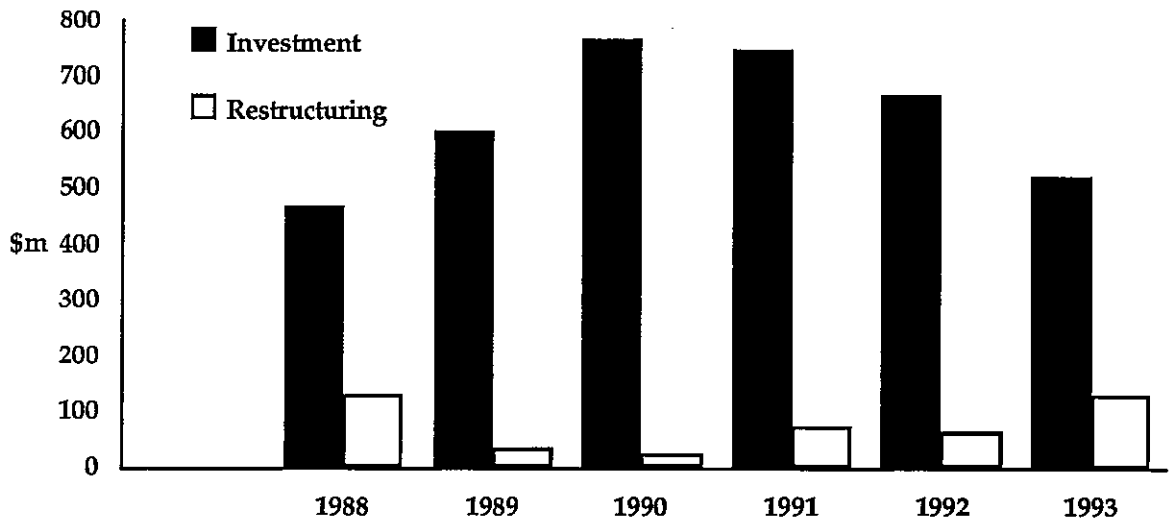## Telecom's Share Price Performance

Figure 11
Investment and Restructuring Expenditure

Investment expenditure increased until 1991 since when it has steadily declined. The share price increases coincidentally with the decline in cash devoted to investment; however, in an informed market, and at a company's optimal debt-equity balance, it should not make any difference whether investment is funded internally or by borrowing. While continuing to finance investment internally when Telecom had a low debt/equity ratio can be expected to restrict the share price, it is unlikely to account for the pattern of growth in Telecom's share price from January 1991.[30] The pattern may well have been affected by the amount and direction of the huge investment which has taken place since 1987. If investment projects were not percieved by investors as well directed, for example, investment which ineffectively pre-empted competition, then the massive investment may have been percived as having significant components which were not achieving the company's cost of capital. To the extent that the less productive investments have declined with the decline in aggregate investment the share price will rise. In addition, as restructuring has proceeded it may be that the non-production costs of restructuring have been lower than investors anticipated. When these factors are combined with growth in non-network services it is entirely possible that the share price may rise even when some producer's surplus has been transferred to consumers.

6 Concluding Discussion

This paper has described the static productivity and welfare gains which have occurred over time in network activity as Telecom has developed as an SOE and public company. While exact figures should be viewed with caution because of a variety of measurement issues, their order of magnitude does suggest that there have been significant consumer benefits from the transition, and the share price indicates that investors have also gained. The growth in productivity has been high and it has resulted in an annual compound average of 5.6 per cent cost reduction. It will reflect changes in organisational efficiency, changing technology and substitution of capital for labour. The three major restructurings of the company will have carried tangible and intangible adjustment costs. While every endeavour has been made to exclude the tangible costs from our productivity analysis, those which are intangible will have affected performance.

The consumer welfare gains reported in this study are confined to the the network telecommunications market: there has been no attempt to incorporate wider efficiency effects of improved telecommunications productivity, or of changes in input employment. These gains are most significant: they have come from price reductions on 1987 consumption levels, and to a lesser extent from output expansion. In addition there has been marked improvement in the

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[30] While Telecom's share repurchase of 1993 was carried out to raise the debt/equity ratio, it is likely to have had a small "cost-of-capital" effect on the share price because New Zealand has a dividend imputation regime. It may have had some effect through the valuation placed on the shares by foreign investors however.

quality of outputs. The welfare and share price analysis indicate that a deeper examination, than simply looking at a company's risk-adjusted rate of return, is required to understand the impact on economic efficiency of different organisational structures and operating environments.

Static performance is an extremely important component of economic efficiency, but the inter-related concept of dynamic efficiency is also significant to overall performance. Dynamic efficiency includes the implications of a variety of issues. It includes the timing of investment for example, and, in turn, this reflects the timing of establishing network capacity and the adoption of technical change. The level of investment in the network has expanded capacity and introduced new technology, particularly electronic exchanges. A de-regulated environment, and for much of our period of analysis Telecom was either facing competition or preparing for competition, encourages the early adoption of new technology.[31] When this is combined with the fact that technological change is rapid in the world of telecommunications the rapid adoption of new technology will be important in retaining the position of a major telecommunications company. If the capacity expansion data are indicative, there is some suggestion that capacity need not have been expanded so rapidly. Because of rapid technological change, and the nature, and hence cost, of network bypass opportunities it is not at all obvious that investment in extra capacity will pre-empt competition. If this is the rationale for some past investment it is unlikely to have been dynamically efficient.

It is of general interest that for Telecom decentralisation does not seem to have been efficient. Indeed, our data suggest that performance in a number of dimensions deteriorated at the time the ROCs were established, although performance improved over time once the ROCs were in place. While the exact motivation for the ROC structure is not clear, even if they were viewed at the outset as transitional their performance remains of interest. The costs of duplication of mangers and their support systems in the ROCs, and other units, seem to have offset the advantages of decision making closer to the work place, and the efficiencies yielded by tournaments between different ROCs. However, the tournaments may have played a screening role which was of longer term benefit to the company. The efficiency of decentralised decision making may have been reduced by the requirement that significant investment decisions should be centrally determined. Some degree of centralised decisions must be expected in a network industry, and in a competitive market strategic behaviour may require it.

A key question in government department and SOE reform is the extent to which organisational performance is affected by the monitoring of private markets and the clearer focus on business objectives of public companies, versus simply the effect of competition on performance. It is difficult to separate the effect of deregulation and competition from that of privatisation in our

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[31] See the discussion of Dixit and Pindyck (1994, ch. 8).

study. While potential competition was recognised by Telecom as an SOE in the 1980s, to the extent that it may have affected investment decisions, the full import of competition was graphically brought to light by the rapid acquisition of toll market share by Clear Corporation in the 1990s, and this occurred soon after Telecom was privatised. There have been productivity gains throughout the period, but the data, and the formation of the Regional Operating Companies and their dissolution, suggest that productivity gains since privatisation have been at least that of the SOE period.

Telecom operates in an increasingly competitive oligopolistic environment. Its structure and performance priorities are determined by the current and potential competition it faces and its commitment to shareholders. Study of the evolution of the telecommunications market will continue to yield data on strategic behaviour and its consequences for consumers and producers in a deregulated market under going a technological revolution.

Appendix 1: Organisational Structures

NEW ZEALAND POST OFFICE: GOVERNMENT DEPARTMENT
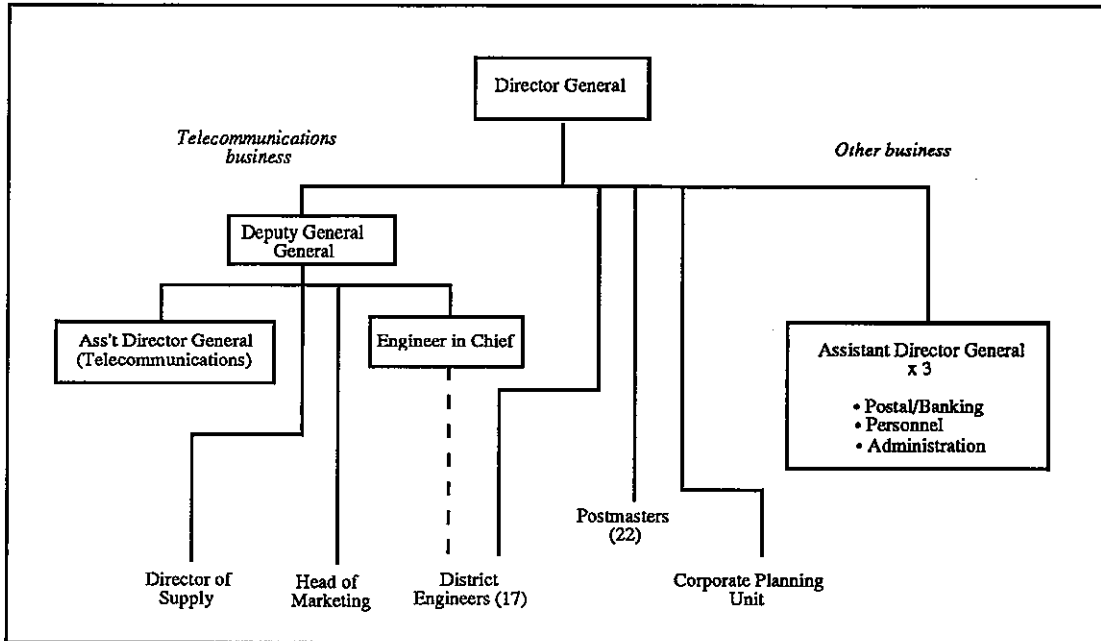
TELECOM: SOE
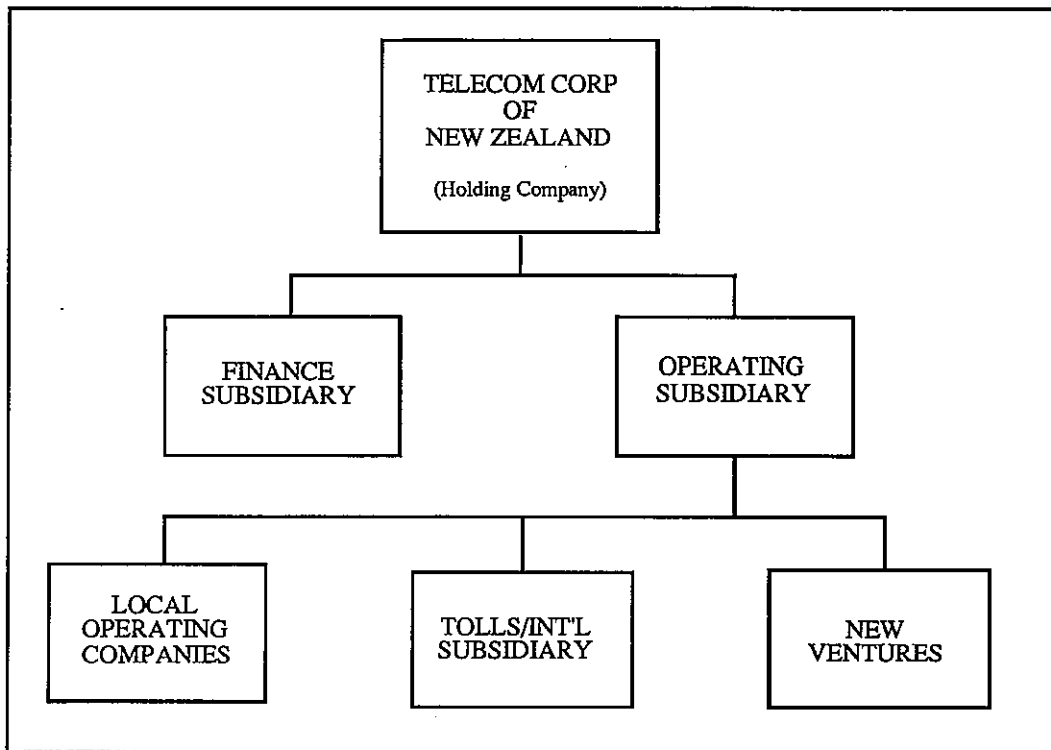
SOE: SUBSIDIARIES

TELECOM IN 1992

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                    ┌─────────────────────┐
                    │   TELECOM CORP      │
                    │   OF NEW ZEALAND    │
                    │                     │
                    │  (Holding Company)  │
                    └─────────────────────┘
                              │
              ┌───────────────┴───────────────┐
     ┌─────────────────┐            ┌─────────────────┐
     │  ENTERPRISES    │            │   TELEPHONE     │
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│ MOBILE   │ │  INT'L   │ │ DIRECTORIES  │
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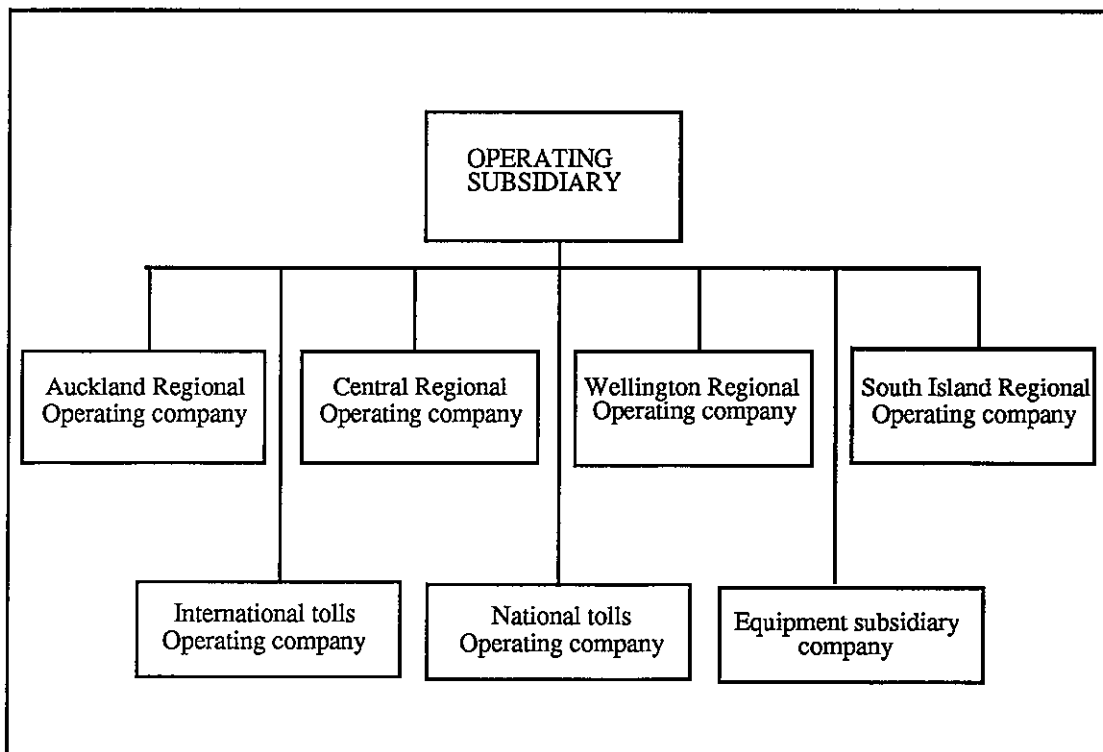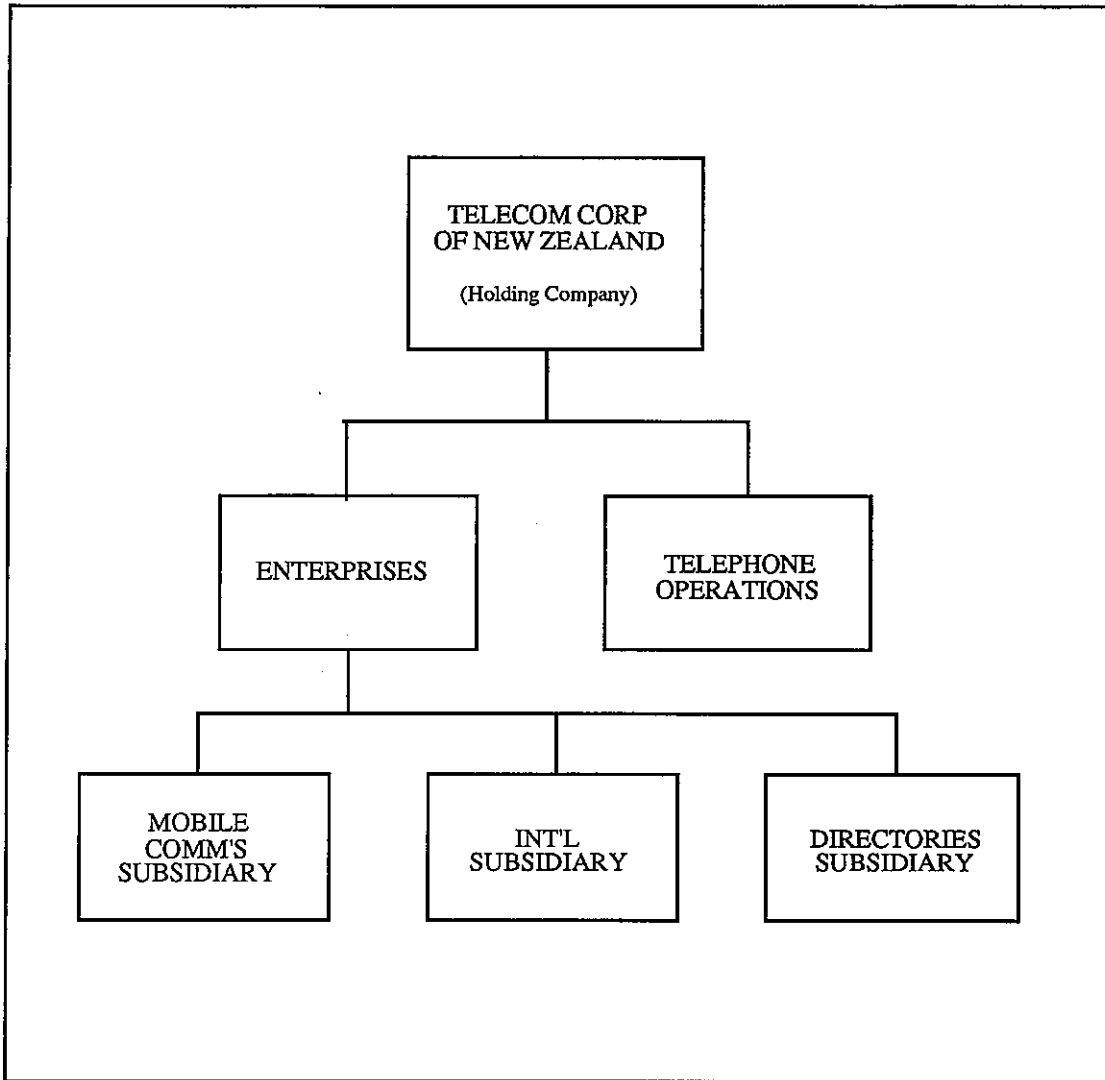
Appendix 2: Implications of increasing returns to scale

In order to link productivity change to changes in the cost function we assume a Cobb-Douglas production function and use its concomitant cost function to approximate the network cost function in the region of Telecom outputs. The Telecom cost function is assumed to consist of fixed and variable cost thus: c(q) = f + mcq. The production relationship is then

$$q = f(t,l,k) = a(t)m^{\alpha}l^{\beta}k^{\gamma}$$

and returns to scale are rs= $\alpha + \beta + \gamma$. Growth in output is

$$g[q] = g[a] + \alpha g[m] + \beta g[l] + \gamma g[k]$$
$$= g[a] + (\alpha + \beta + \gamma)\{\frac{\alpha}{(\alpha + \beta + \gamma)}g[m] + \frac{\beta}{(\alpha + \beta + \gamma)}g[l] + \frac{\gamma}{(\alpha + \beta + \gamma)}g[k]\}$$
$$= g[a] + rs\{\alpha * g[m] + \beta * g[l] + \gamma * g[k]\}$$
$$= g[a] + rs\{g[i]\}$$

where $\{\alpha^*, \beta^*, \gamma^*\}$ is the set of cost shares of each input (this is readily established from the associated cost function set out below), $\alpha^* + \beta^* + \gamma^* = 1$, and the growth rate of total input is $g[i] = \alpha * g[m] + \beta * g[l] + \gamma * g[k]$. It follows that

$$g[a] = g[q] - rsg[i].$$

Under constant returns to scale rs=1 and under economies of scale rs>1.

The cost function for the Cobb-Douglas production function is

$$c(q, w_1, w_2, w_3) = \varphi(q,t)c(w_1, w_2, w_3)$$
$$= a(t)^{-1/rs}q^{1/rs}\Phi w_1^{\alpha^*}w_2^{\beta^*}w_3^{\gamma^*}$$

where Φ is a function of α, β and γ only, and the w_i are prices of the input indices. It follows that the proportional change in total, marginal and average cost resulting from the growth in productivity, $g(a)$, is $[1 + g(a)]^{-1/rs}$.

Notice that the elasticity of average cost with respect to output is (1-rs)/rs which enables rs to be calculated from estimates of fixed costs, f, and marginal cost, mc, using the cost function c(q) = f + mcq.

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