Telecommunications Act 2001

Section 64 Review and Schedule 3 Investigation into Unbundling the Local Loop Network and the Fixed Public Data Network

APPENDICES TO DRAFT REPORT

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Table of Contents

APPENDIX 1: List of Submissions on the Issues Paper

1.	BayCity New Zealand Ltd	7 August 2003
2.	Broadcast Communications Limited	26 May 2003
	- Supplementary BCL Submission	20 June 2003
3.	Business New Zealand	14 May 2003
4.	CallPlus Limited	28 May 2003
	- Supplementary CallPlus Submission	22 July 2003
5.	Consumers' Institute	15 September 2003
6.	Counties Power	14 May 2003
7.	Mr Wally Muzyka	30 April 2003
8.	New Zealand Business Roundtable	14 May 2003
9.	Nortel Networks	27 May 2003
10.	Paul Budde Communications Pty Ltd	17 July 2003
11.	Siemens (NZ) Ltd	26 August 2003
12.	Telecom	30 May 2003
13.	TelstraClear	27 May 2003
14.	TUANZ	14 May 2003
15.	Walker Wireless	21 May 2003

APPENDIX 2: Modelling the Impact of Unbundling the Local Loop Network and the Fixed Public Data Network: Report by OXERA

Efficiency Analysis to Support Cost-benefit analysis: Report by OXERA

OXFORD ECONOMIC RESEARCH ASSOCIATES

NEW ZEALAND COMMERCE COMMISSION

MODELLING THE IMPACT OF UNBUNDLING THE LOCAL LOOP AND FIXED PUBLIC DATA NETWORK

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Contents

1. Introduction

The Telecommunications Act 2001 (the Act) regulates the supply of telecommunications services in New Zealand. It establishes the potential for the local telecommunications network to be unbundled in order to introduce competition in the provision of local services. Under Section 64 of the Act, the Commerce Commission (the Commission) is required to undertake a review of whether access to the unbundled elements of the local loop network of incumbent, Telecom New Zealand (TCNZ), and access to the unbundled elements of, and interconnection with, TCNZ's fixed Public Data Network (PDN) should be regulated.

Two regulatory scenarios are under review:

- *specification*, which allows non-price aspects to be regulated, with wholesale prices assumed to be set competitively through commercial negotiation;
- *designation*, which allows the Commission to regulate wholesale price if the parties are unable to reach commercial agreement themselves.

OXERA was asked by the Commission to carry out economic cost–benefit modelling in support of this review.[1] This paper outlines the structure of the model constructed to address whether local loop unbundling (LLU) should be regulated and presents the results of the analysis. The analysis focuses on the impact of a regulatory decision on the consumer, compared with a 'counterfactual' scenario—ie, what would have happened in the absence of regulation. The impact of regulation is therefore presented as an incremental change relative to the counterfactual.

Consumers might expect to benefit from regulatory intervention through lower prices and potentially more and better services. This impact on consumers is measured by reference to the consumer surplus that is generated. From an economic standpoint, this surplus is generated by lower prices for the existing installed base (the 'price effect'), plus an increase in take-up (a 'take-up effect') and a potential improvement in the level of service innovation. The methodology by which these effects can be identified is detailed in section 2.3 of this paper. LLU allows new entrants direct access to the consumer by permitting them to rent the copper loop or physical connection. Voice and data services that compete with the incumbent may then be provided. Hence, LLU can be used to proxy for full facilities-based competition, without the potential efficiency drawbacks of duplicating the local network.

Unbundling can be preferable to service-based competition (using wholesale input services provided by TCNZ), as it allows entrants to provide new and more innovative services over the local network. Wholesale access restricts the entrant to delivering

[1] OXERA was provided with technical advice throughout the project by InterConnect Communications Ltd.

services based on the capabilities of the TCNZ underlying network, likely to be similar to TCNZ's retail offerings.

In general, the competitive provision of data services is a strong *ex ante* rationale for unbundling. The only competition in access that TCNZ currently faces is in certain geographic areas where there is a cable network, as well as some satellite and wireless services. However, unbundling may not necessarily result in a net benefit—there are significant costs involved, including that of establishing the physical point of interconnection and commercial, technical and operational procedures.

The regulatory options analysed in the modelling are:[2]

- Option 1: full unbundling;
- Option 2: line sharing;
- Option 3: bitstream access;
- Option 4: unbundling of, and interconnection to, the fixed PDN.

Full unbundling would allow for an entrant to provide both data and voice services over the local loop. *Line sharing*, also known as 'shared access', refers to an entrant providing data services over the high-frequency portion of the copper loop, while TCNZ continues to supply voice services. In both instances of unbundling, the entrant invests in upgrading the local loop and installing the appropriate capital equipment on the exchange side, such as digital subscriber line access multiplexers (DSLAMs).[3]

Bitstream access refers to the situation where the incumbent installs a high-speed access link to the customer premises. This may be by installing appropriate ADSL equipment and configuration in the local access network. This access link is made available to other operators which are then able to provide high-speed services to end-consumers. In effect, bitstream access is the provision of transmission capacity.[4]

The PDN is used to provide a number of distinct data services. *Unbundling of, and interconnection to, the PDN* would allow entrants access to end-consumers (businesses) in order to provide a variety of data services.

This paper details the economic basis for the methodology adopted in the modelling in section 2 and presents the results in section 3. The methodology used is explained in section 4. Data relating to the construction of the model, including prices and costs, is set out in section 5.

[2] Using the scenarios as defined elsewhere by the Commission, options 1 and 2 together are equivalent to Scenario A; option 3 corresponds to Scenario B; and option 4 corresponds to Scenario C.
[3] These would be installed in an exchange (or equivalent) to allow for the provision of DSL services to the end-consumer over the copper loop. The consumer requires an appropriate DSL modem.
[4] See European Commission (2001), 'High Speed Bitstream Access', ONPCOM0-18 Rev 1, September.

This is a public version of the report, from which confidential commercially sensitive information has been removed. Where this has occurred, the relevant text or data has been replaced by square brackets [✂]

2. Approach to Cost–Benefit Analysis

Any regulatory decision should take into account the ultimate impact on consumers, and such intervention in the market should be motivated by an expectation of improving consumer welfare. In this regard, the relative impact on different *firms* within the market (incumbent or entrants) is of secondary importance, subject only to the requirement that any intervention does not impede their ability to deliver the requisite services to consumers.[5]

The primary concern of the cost–benefit modelling is therefore to determine whether there is a net consumer benefit from the various forms of unbundling that are being proposed. The main driver of this increased benefit is new market entry. For each unbundling option, the model forecasts when it is likely (ie, commercially viable) that firms will enter. Consumers benefit from entry in a number of ways, as a result of competitive pressure:

- price reductions for services they already receive;
- the expansion of existing services to those consumers that cannot currently receive them; and
- the introduction of innovative new services.

The cost–benefit analysis (CBA) is neutral as to whether these benefits are derived from TCNZ or particular entrants, or even whether entry has to occur for the benefits to be realised. For example, there may be a reduction in TCNZ's prices as a result of the threat of entry, even though no new entry actually occurs; the model would weight this benefit equally with the benefits arising where entry does occur.

An important issue is the extent to which this approach captures efficiency gains (allocative, productive or dynamic) that may result from regulatory intervention. Productive efficiency occurs when goods are produced at minimum cost; allocative efficiency is concerned with pricing competitively (in a standard theoretical economic approach, this is usually taken to mean at marginal cost); and dynamic efficiency results from enhanced levels of innovation and investment in the future.

A CBA approach focused on consumer benefit does not explicitly model efficiency gains. This is because it would be a complex exercise, requiring detailed cost modelling of the incumbent and potential entrants, for which all the necessary information is unlikely to be available. In addition, the cost structure of the industry (high fixed costs and low marginal costs) means that marginal cost pricing is not a helpful pricing rule. Furthermore, estimation of dynamic efficiency is likely to be largely speculative and hard to determine since it is entirely forward-looking.

[5] For example, regulators may take into account the impact of price controls on the incentive for firms (especially the incumbent) to continue to invest in the network and/or innovative service provision.

The alternative to modelling the efficiency gains directly is to estimate the consumer benefits arising from liberalisation. This approach has the advantage of implicitly capturing the allocative and productive efficiency gains arising from increased competition, which are passed on to consumers, while disregarding those that are reinvested by the firms or retained as profit.

Some dynamic efficiency gains may also be captured if service innovation is used to proxy for this benefit (see section 2.3). However, the gains from dynamic efficiency that are realised in the future are likely to outweigh those captured here. Given their uncertain nature, it is not possible to estimate these explicitly in any meaningful way. Rather, it can be posited that there are likely to be greater dynamic efficiency gains as a result of introducing competition.

Therefore, a number of questions must be addressed in the modelling:

- where does new entry occur?
- what happens in the absence of new entry?
- how are retail prices likely to change following entry?
- what is the likelihood of service innovation, and what form might it take?
- how should the benefits to consumers be valued?

Each of these questions is considered below, along with an outline of the approach that has been adopted.

Before addressing these issues, it is instructive to consider the services that will be subject to unbundling. There are two types of service that can be delivered to consumers through fixed copper telephone wires: voice and data. While voice services are reasonably static in their characteristics and any innovation mainly relates to tariff structure or related value-added services (eg, call minding),[6] data services are potentially very varied.

The standard services provided using data capacity (the high-frequency bandwidth on the copper access pair) are data transmission, including access to the Internet and email. However, there are many more uses that can be made of the data capability, including information services, voice over IP (Internet Protocol), and, ultimately, video over the fixed wireline. These last two services are currently at the fringes of being technologically feasible, and neither has been rolled out on a mass scale anywhere in the world, although many trials are being undertaken.[7]

[6] It is for this reason that voice services are often referred to as POTS—plain old telephony services.

[7] Although cable networks currently provide television over a fixed wireline, they do this by separating services between two cables. Television and data services are provided on one cable, while a separate dedicated cable carries the voice service. In contrast, provision of data services (potentially including television) over PSTN lines involves a single wire for both data and voice, complicating the spectrum management issues.

Given the scope for increasing the diversity of data services available to consumers and the standard nature of voice telephony (with the exception of voice over IP), the most attractive commercial proposition for new entrants usually relates to data services. These offer the greatest opportunity to deliver value-added products to consumers, and hence to extract higher revenues. For this reason entrants in most countries around the world have unbundled the local loop primarily in order to provide data services.

The situation in New Zealand is potentially slightly different, as the incumbent, TCNZ, has not been subject to sector-specific regulation until relatively recently.[8] It might be possible that, as a result, TCNZ continues to earn substantial returns on its voice services.

In principle, this outcome would suggest that voice services could also provide entrants with considerable opportunity to earn a reasonable profit. However, the standardised nature of voice services means that it is straightforward for TCNZ to respond aggressively to any new entrant with regard to price; furthermore, the lack of geographical averaging means that the response to entry may be selective. Given that TCNZ (as the incumbent) has already sunk its investment costs and hence faces a lower cost (even if all other costs were equal) than a new entrant, the risks for an entrant unbundling voice-only services would be high.

Therefore, notwithstanding the absence (until recently) of any sector-specific regulation of TCNZ's voice services, it is assumed that an entrant's principal reason for unbundling is to provide data services, and they would not unbundle an exchange solely to provide voice services. However, as noted above, the unbundling options under discussion allow the entrant to unbundle the whole copper loop to provide both data *and* voice services to consumers (full unbundling); or to unbundle only to deliver data services, with TCNZ continuing to provide voice telephony (line sharing). Line sharing is technically more complex in terms of spectrum management, and hence is more costly at the wholesale level.

Furthermore, where an entrant has unbundled an exchange to provide voice and data services, it is assumed that they will also provide voice-only services to any consumer wishing to take them. This is because, while the risks of unbundling solely for voice may be significant, the incremental costs of providing voice-only services once the exchange has already been fully unbundled (for data and voice combined) are negligible.

2.1 Where does new entry occur?

TCNZ is in the process of upgrading many of its local exchanges to digital data capability through the installation of DSLAMs, inter alia. This allows the bit rate transfer to be

[8] The 'Telecommunications Service Obligations (TSO) Deed for Local Residential Telephone Services' dates from 2001, and requires a local free-calling option for local residential customers. The standard residential rental is defined as the pre-government sales tax standard residential, as it was in November 1989. It cannot be increased in real terms, although TCNZ can selectively offer lower prices.

increased to provide high-speed data transmission. In the first instance, this is asymmetric (ADSL), with considerably greater speeds (up to 2 megabits per second, Mbps) downstream (ie, towards the customer) than upstream.

One of the characteristics of ADSL is that the bit rate degrades the further the customer is located from the local exchange. Therefore, in order to ensure that a reasonable number of customers can be provided with the same service, the highest bit rates are often not guaranteed, especially to rural customers. In general, only those customers sufficiently close to the exchanges may receive higher line speeds. It is possible to upgrade lines to provide a guaranteed symmetric line speed of 2 Mbps or higher through the use of other technology, such as SHDSL (symmetric high-speed digital subscriber line), but this has a much smaller radius around the exchange. To take advantage of these speeds, customers must usually be within 2km of their local exchange. The advantage of such high committed rates is that more advanced and bandwidth-intensive services, such as television, can be provided over the telephone lines.

For the CBA, it is assumed that TCNZ and the entrant(s) will upgrade to provide ADSL services only, although at least one of the potential entrants that replied to the Commission's Issues Paper considered that they would aim to provide SHDSL services.

There are three aspects that an entrant will take into account when deciding whether to enter at a particular exchange:

- whether the lines are technically upgradeable;
- the likely take-up of broadband services; and
- commercial viability.

2.1.1 Technical capacity

Not all lines in a local exchange can be provided with high-speed data services. The lines available to an operator upgrading the exchange are therefore likely to be a subset of the total number of lines in that exchange-serving area (ESA). Hence, the first calculation for an entrant (or TCNZ) is the number of lines that could be technically upgraded.

This estimation process involves establishing the number of lines within the required distance from the exchange. Also, as discussed above, this is a function of the committed line speed that the operator wants to offer, but, for ADSL, the cut-off in the model is taken to be 7km (although this assumption can be varied).

In addition, there are other technical characteristics of local lines that can make the upgrading of relevant lines impossible, or at least considerably more expensive. These include the existence of sub-loops, where lines are served from a cabinet that is remote from the exchange itself, and may be connected to the exchange by optical fibre, or some other form of distribution line. For spectrum management reasons, it is not possible to serve sub-loops from a DSLAM sited in an exchange, especially not if TCNZ has already upgraded the lines by placing a DSLAM in the cabinet itself. As cabinets are very small, it is likely that there is insufficient space to accommodate an entrant's DSLAM as well as that of TCNZ, and it may also be uneconomic for two firms to serve the small number of end-user lines connected to a sub-loop.

As a result, the number of technically upgradeable lines in the model excludes any lines sited on sub-loops. Although this may not reflect actual practice in all cases, it is a conservative assumption in terms of the CBA, because it reduces the number of subscribers that might receive upgraded services and the benefits of competition.

Further technical issues to be taken into account concern those lines connected with non-copper distribution lines, such as those employing pulse code modulation (PCM). PCM inhibits the deployment of ADSL services, and these lines have therefore been excluded. There may also be spectrum management issues relating to interference between lines within a cable sheath. Evidence from Australia suggests that, in practice, the likelihood of this causing a material deterioration in service is very low (around 1%), so the central case in the model assumes that the reduction in serviceable lines due to interference is zero, although this interference factor can be modified.

These adjustments yield the number of technically upgradeable lines in each ESA, and these form the baseline volume for the subsequent analysis.

2.1.2 Take-up of broadband services

Having established the number of technically feasible lines for upgrading, it is necessary to identify the likely purchase of broadband by consumers. Not all consumers are interested in high-speed data services and, of those who are interested, not all can afford them (assuming a greater-than-negligible price). However, as the decision of whether to upgrade an exchange is a commercial one, the potential demand for the services must be established.

At present, New Zealand has a high level of total Internet penetration by household, relative to other countries, and this is mainly narrowband dial-up rather than broadband. Indeed, there are only around 40,000 residential ADSL subscribers in the country. The level of Internet access also varies between the different geographic areas in New Zealand.

It would be reasonable to assume that a proportion of those households currently purchasing Internet services would, over time, adopt high-speed services. Therefore, the penetration rate is likely to be a percentage of the present Internet usage rate. In consultation with Commission staff, OXERA determined that the penetration rate would be based on Internet take-up in New Zealand. In the counterfactual, it is assumed that up to 20% of *Internet* households will take broadband. This is adjusted upwards in the options to reflect any price reductions that result.

This is illustrated in Table 2.1 below. The percentage of Internet households is multiplied by the base percentage to produce the penetration rate for the counterfactual. For example, this would be 9.6% (20% × 48%) for metro areas. In the scenarios there is a price fall. This is combined with the elasticity effect and the base percentage to produce a moderated base percentage. As above, this is multiplied by the percentage of Internet households to determine the penetration in the scenarios.

Table 2.1: Illustration of calculation of penetration rate

Area	Internet penetration 2003 (households) (A)	Base percentage (B)	Price fall (C)	Elasticity (D)	Moderated base percentage (E=B+(CxD))	Penetration rate (ExA)
Metro	48%	20%	15%	–1.5	42.5%	20%
Urban	33%	20%	15%	–1.5	42.5%	14%
Suburban	36%	20%	15%	–1.5	42.5%	15%
Rural	42%	20%	15%	–1.5	42.5%	18%

The penetration predicted by the modelled counterfactual would be equivalent to a take-up of broadband by around 2.5% of the population by 2010, which is towards the lower end of the range of experience in other jurisdictions, as presented in Table 2.2.

Table 2.2: Broadband take-up (per 100 population)

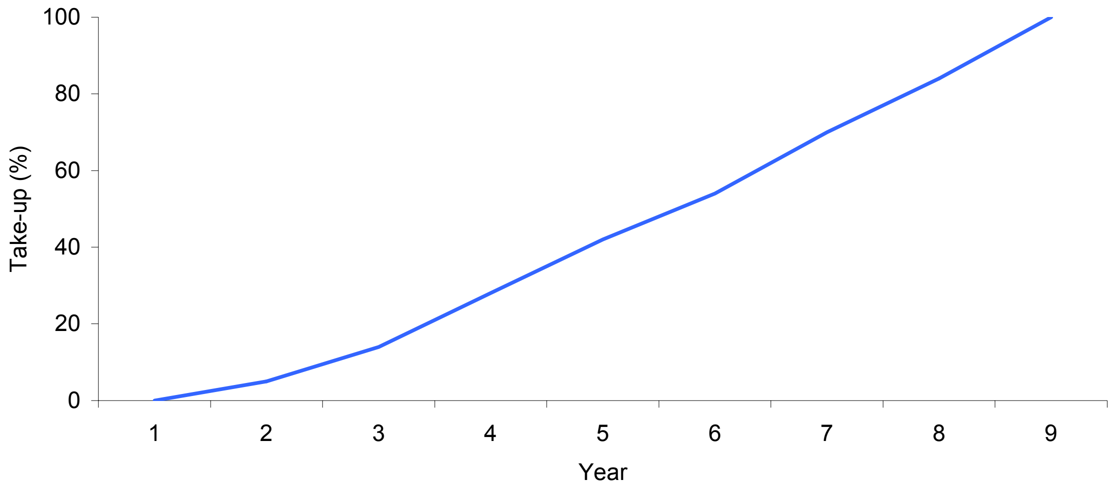
Country	Dec 1999	Dec 2000	Dec 2001	Jun 2002	Dec 2002
Australia	0.1	0.4	0.9	1.3	1.8
France	0.1	0.3	1.0	1.6	2.9
Germany	0.0	0.2	2.4	3.1	4.1
New Zealand	0.0	0.3	0.7	1.1	n/a
Sweden	0.1	1.2	5.4	7.0	8.1
UK	n/a	0.1	0.6	1.3	2.3
USA	0.6	2.2	4.5	5.6	7.3

Source: OECD 'Communications Outlook 2003', except figures for Dec 2002, which are based on Oftel and ACCC.

This relationship was used to generate the total likely penetration of broadband services, which, in the absence of any rationale to make adjustments by geographic region, was applied uniformly to all ESAs.

This is the likely penetration for any given price level. However, consumers will not switch to broadband immediately; as with any technological product, there will be a gradual adoption as consumers become more aware of the service and its characteristics. An adoption profile has therefore been generated that moderates the speed with which the penetration increases towards its determined maximum. The adoption rate used is shown in Figure 2.1, and has been derived from the historic take-up of personal computers (PCs) in New Zealand. The rationale behind this is considered further in section 5.2. The use of a gradual adoption rate also reflects the fact that prices are modelled on a downward glide path towards the ultimate competitive level in each scenario.

Figure 2.1: Modelled take-up rate for broadband services



In addition, it is recognised that not all consumers interested in broadband will take ADSL. Some will take high-speed services from other providers using alternative infrastructures, such as cable, satellite or wireless. Similarly, existing subscribers to these alternative technologies may churn back to ADSL wireline services as prices fall. As non-ADSL networks are not explicitly modelled, this effect is accounted for by a percentage net churn of potential ADSL subscribers each year to non-ADSL services. This has the effect of further reducing the potential subscribers available to TCNZ and the entrant(s).

Having combined all of these adjustments, the model produces an estimated proportion of the total technically feasible number of lines that are likely to take ADSL services in each ESA every year. This is split between business and residential subscribers and, in each case, is allocated between TCNZ and the entrant(s) in each year. The apportionment mechanism takes into account two assumptions:

- when LLU is introduced, there is a net churn to the entrant(s) from TCNZ's installed base of subscribers in those exchanges it has upgraded; and
- new subscribers (ie, those that do not take DSL at the beginning of the year, but are projected to take it up during the year) are apportioned between TCNZ and the entrant(s) on the basis of a competitive market-share rate.

2.1.3 Commercial viability

As noted above, an entrant's decision to enter the market is determined on the basis of whether it is a commercial proposition—ie, whether it is likely to be profitable. Therefore, in modelling the impact of LLU, it is necessary to replicate this decision process. The model does this through a net present value (NPV) calculation of the costs and benefits to the entrant, at the level of each ESA. If the NPV of entry is positive, it is assumed that entry will occur; if negative, there will be no entry. The entrant's profit is allowed for by a return-on-sales percentage incorporated within the NPV calculation. The entrant must achieve a target return on sales in order to produce a positive (or zero) NPV, and thus enter.

The inputs to the NPV are the relevant costs and revenues that the entrant will incur/receive. The costs are broken down into a number of categories: one-off costs of setting up the LLU regime; one-off costs of unbundling a particular line, which arise when a customer is first connected; and the fixed and variable charges of supplying a customer each year.

Revenues are based on the prevailing price level in any particular year, and comprise a fixed connection charge for each new subscriber and a monthly fee for the service.[9]

The NPV function in the model takes these costs and revenues, multiplied by the relevant number of subscribers, and calculates the resulting NPV, were entry to occur. This is carried out twice for each scenario to allow for differing levels of entry that reflect different prices. It is assumed that the maximum number of entrants in any ESA will be two, and that, if two firms enter, the competitive price will be achieved.

The first entry cycle calculates the NPV with only one entrant, and therefore assumes that the market price will be above the fully competitive level. If this is positive, at least one entrant would offer services. The second cycle does the same for two entrants at the competitive price level. If the second cycle is positive, two-firm entry is predicted.

Therefore, the result of the NPV calculation is that the model predicts the ESAs in which one firm, two firms or no firms will enter.

2.2 Retail price effects following entry

The relevant retail price is the price that consumers must pay if they are to use broadband services. Given that broadband is of little use to residential customers without an Internet service provider (ISP) for Internet access and e-mail, the price should include ISP costs. Furthermore, most, if not all, businesses also access the Internet, and so would also need an ISP. The broadband connection may be used for other forms of data transfer, but these firms would still incur an ISP cost. This price comprises a monthly access charge payable to the local telecommunications access provider (currently only TCNZ), plus a monthly charge payable to the ISP.

The primary benefit to consumers from LLU is likely to be an increase in competition in the provision of services over the local loop. This should reduce the price of current services and increase the diversity of new services that become available. The latter is considered in the next sub-section.

The effects of the price changes in the model are twofold: they produce a benefit for those consumers that already take broadband, but they also result in increased take-up of services by consumers through the penetration rate. This latter effect is produced by the application of a price-elasticity factor combined with the price reduction.

[9] As the model operates on an annual basis, the monthly fee is aggregated up to the annual level through a simple sum; there are no within-year discount factors.

Price benefits result from greater competitive pressure on TCNZ and on all firms providing retail services to consumers. If the current (pre-LLU) price is not at the most efficient level, because of either allocative inefficiency (excess profitability) or productive inefficiency (producing at a cost greater than that indicated by the efficiency frontier), competition should help to reduce price. This will result from either an erosion of margin, and hence increased allocative efficiency, or a reduction in excess costs of production.

As noted above, the assumption is that the optimum competitive price level is only obtained when there are two entrants, resulting in three competing companies in the market. It is also assumed that the price fall due to efficiency gains will not materialise in the first year, but will be spread over five years. This produces a glide path for prices as they gradually fall, reaching the final competitive price (100% of the price reduction) in year five.

When there is only one entrant, it is unlikely that the market will be fully competitive; the price is therefore assumed to be between the current price and the fully competitive level. Again, the price falls over time, reaching its final level after five years. Section 5 details the prices used and how they were derived.

2.3 Service innovation

As noted in the introduction to this section, dynamic efficiency is hard to estimate going forward. The nature of innovation means that it is difficult to know with any certainty how future changes will affect the consumer. The CBA therefore does not explicitly measure the benefits to consumers from gains in dynamic efficiency. However, the gains from increased dynamic efficiency are included implicitly, if assumptions are made about the future behaviour of consumers. This section explains how these estimates of dynamic efficiency may be derived.

For tractability within the model, it is necessary to use only a single product in the modelling (ie, a single representative product for each of the business and residential segments). However, there are many different products currently available on the market, and it is likely that even more will be provided in the future as a result of investment and innovation.

In order to generate a price for a representative product, a weighted average price of the current prices is calculated for the different TCNZ products that are available. This effectively produces a standardised product consumed in 2003, and the model predicts the impacts of any changes in its price. In practice, for LLU and bitstream, this is a weighted composite of the various Jetstream products currently available.

It has been suggested, both in responses to the Issues Paper and directly to OXERA in the course of discussions with TCNZ and potential entrants, that the services delivered over the coming years are likely to change considerably. In particular, the bundle of products available to consumers is likely to expand, while the average amount they spend each month is likely to remain reasonably constant. This service innovation could be one of the significant benefits of LLU, as entrants cannot deliver new services through the existing wholesale access provisions. Therefore, in estimating the benefits of LLU, it is important to take into account the impact of service innovation (as a proxy for dynamic efficiency).

For those customers that decide to take the increased bundle of services, the average price they would pay is expected to remain stable over the next few years, while the bundle of services they receive increases.[10] This suggests that the value to consumers of the new services must be at least the difference between the price they are paying, and the effective price they would pay for a product bundle without the new services—that is, the standardised product in the model. Otherwise, it would be profitable for an entrant to offer the current (standardised pre-innovation) bundle at the prices used in the model, and consumers would not purchase the innovative new bundle.

Following this logic, for those consumers taking the expanded bundle of services, the difference between the predicted standardised product price in the scenarios of the model and the counterfactual (without LLU) price is therefore a reasonable proxy for consumers' valuation of the new service innovation that may arise following LLU.

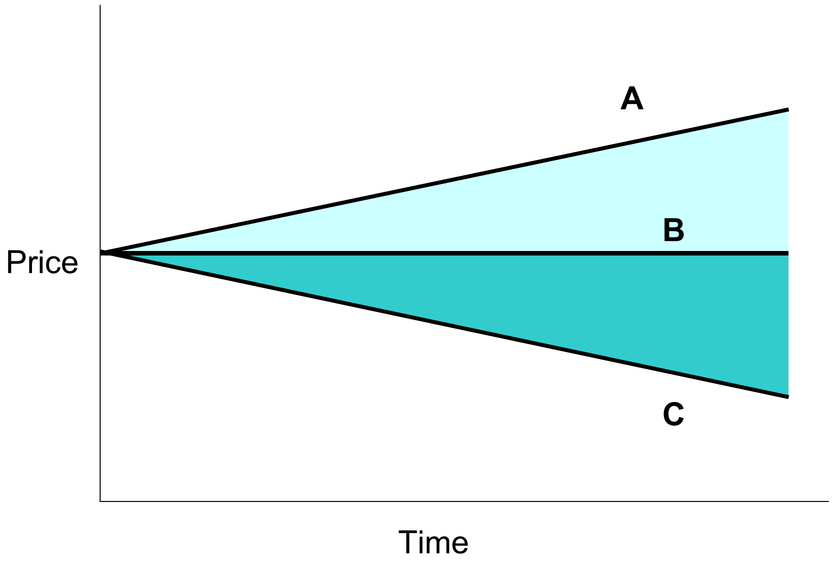
In practice, however, not all consumers will take the expanded bundle of services, but unless demand for this product is explicitly modelled, it is not possible to determine the proportion of consumers that would take it. While some consumers will take the larger bundle (at potentially the same price as currently), others would prefer to have the current standardised product at a cheaper price. This latter group receives the allocative and productive efficiency gains in the form of the reduced price for the standardised product.

Thus, the 'price effects' resulting from the modelling described below represent a mix of allocative and productive efficiency benefits for consumers who do not opt for the expanded bundle, and the dynamic efficiency gains for who that do. Those taking the new bundle would gain allocative and productive efficiency gains because the price for the new bundle would be higher in the absence of regulatory intervention (or may not actually be available). These benefits are not estimated, and so, overall, the approach adopted here is likely to be a conservative estimate of the benefits to consumers.

This approach is illustrated in the Figure 2.2 below. Line B represents the current price that remains static in real terms, while the price of the standardised bundle following liberalisation falls over time, as shown by line C. Therefore consumers that do not take an expanded service bundle have a welfare gain equivalent to the difference between B and C; this is the result of improved allocative and productive efficiency.

[10] This is the expectation of [✂], as expressed to OXERA in meetings and written responses to questions. OXERA has not explicitly investigated the likely composition or pricing of new products in the future, and the assumptions in this regard in this section are based on the views of industry participants.

Figure 2.2: Illustration of the efficiency gains for existing broadband subscribers



Those customers opting for the increased bundle would (under the assumptions presented above) continue to pay equivalent to the line B. However it is assumed that the bundle would originally have cost equivalent to line A in the absence of liberalisation. Therefore for these consumers the valuation of the new bundle must be at least the difference between B and C (otherwise they would not pay this price for it), and if the new services are introduced as a result of liberalisation, this valuation is a proxy for dynamic efficiency as described. The allocative and productive efficiency gains to subscribers taking the expanded bundle is represented by the difference between A and B.

2.4 Market outcome in the absence of entry

At present, TCNZ has no obligation to set an average, or standard, price across New Zealand; it is able to price in response to entry in a very localised manner. It is therefore assumed in the model that any price benefits arising from the introduction of LLU are limited to those exchanges where entry occurs; all others remain with the current TCNZ price forecast for the period.

This is a conservative assumption because there may be an effect of general competitive pressure in the market that forces TCNZ to lower its prices across all, or a substantial number of, its exchanges. If this were the case, many more subscribers would be affected, and the benefits resulting from LLU would be correspondingly greater.

2.5 Valuing consumer benefits

Having identified all the relevant components of the likely market development over the relevant period, the consumer benefits arising from LLU can be calculated. As noted, these benefits take two main forms:

- any ‘price effects’ that arise for existing subscribers as a result of the regulatory scenarios are straightforward to calculate as they represent the difference between the scenario and counterfactual prices; and

- consumers benefit from the expansion of the market through lower prices and increased availability of services to consumers in areas where the exchange was not previously upgraded. All subscribers benefiting from an increased availability of services do not gain a price benefit (as they did not previously pay the higher price), but they do gain an increase in their consumer surplus by receiving services that they did not previously have. This 'take-up effect' is the difference between their willingness to pay and the amount they actually paid for their broadband services.

Figure 2.3 illustrates these two benefits. P_0 is the price in the counterfactual (ie, with no regulatory intervention); P* is a representative (lower) price, following regulation.[11] Q_0 is the number of subscribers in the counterfactual (ie, with no regulatory intervention); Q* represents the (increased) number of subscribers following intervention.

The price effects enjoyed by the existing installed base are represented by the rectangle. Mathematically, this area is equal to:

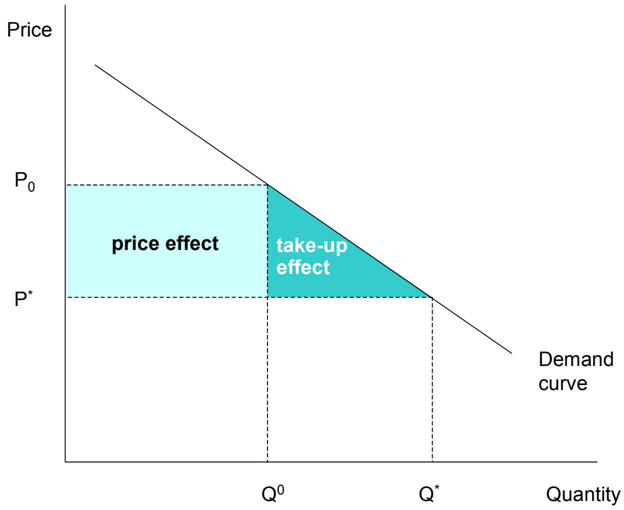
$$(P_0 - P^*) * Q_0$$

The take-up effect is represented by the triangle. Mathematically, this area is equal to:[12]

$$(P_0 - P^*) * (Q^* - Q_0) * 0.5$$

[11] This figure is purely illustrative. It is not drawn to scale, and should not be taken to represent the actual results.
[12] This calculation is an approximation, since the actual size of the triangle would depend on the shape of the demand curve, which has not been explicitly estimated.

Figure 2.3: Representation of the benefits to consumers



As noted in section 2.3, a further form of benefit arises from the increased bundle of services. Such benefits are more difficult to estimate without consumer surveys and econometric estimations of consumers' valuation of the different services that become available. Even if the consumer valuations could be determined, it remains uncertain as to whether any particular service would ultimately be delivered, despite the best intentions of service providers in advance of LLU.

Nonetheless, as detailed in section 2.3, given the expectations of TCNZ and potential entrants, it could be contended that part of the difference between the counterfactual and scenario prices represents an approximation of the value of new services. Any additional benefit is not estimated by the model, but the 'price effect' referred to above could be considered to cover both the allocative and productive gains for some consumers and the dynamic efficiency benefits for others.

3. Results

As noted in section 1, the focus of this CBA is the potential gains to consumers from regulatory action—either specification or designation. Therefore, the only gains that are relevant are those that are incremental, as a result of regulatory intervention. As described in section 2, the benefit (or loss) that is due to regulatory action is calculated by comparing welfare gains with the outcomes in the counterfactual.

Potential gains to consumers are reflected in better and more services at lower prices. As has been discussed, in economic terms, these are proxied by measuring the welfare gains to consumers that result from two effects:

- the *price effect*, where existing consumers benefit from a reduction in the retail price;[13]
- the *take-up effect*, where the price falls lead to an expansion in take-up.

Together, these constitute consumer surplus.

Table 3.1 reports the consumer surplus gains over the base case that result in each scenario using the central case assumptions detailed in section 5, many of which can be varied. A sensitivity analysis for certain variables is set out in section 3.1.

Table 3.1: Present value of consumer surplus, 2005–10 (NZ$m)—central case

Option	Specification			Designation		
	Price effect	Take-up effect	Total	Price effect	Take-up effect	Total
1: Full	6.1	0.3	6.4	133.7	46.9	180.6
2: Line sharing	11.2	1.0	12.2	27.9	10.2	38.1
3: Bitstream	49.9	5.3	55.2	111.8	40.1	151.9
4: PDN	92.6	0.0	92.6	287.2	0.0	287.2

To understand these effects in more detail, Tables 3.2 and 3.3 report the price and volume effects that underpin each scenario, split between business and residential.

[13] As noted in section 2.5, this is also likely to include benefits from dynamic efficiency improvements.

Table 3.2: Retail price falls over a five-year period, as a result of unbundling (%)

Option	Specification		Designation	
	Business	Residential	Business	Residential
1: Full	21.4	20.4	57.0	31.7
2: Line sharing	20.7	18.9	54.1	21.7
3: Bitstream	20.7	18.9	52.9	19.6
4: PDN	23.0	n/a	42.2	n/a

Table 3.3: Number of customers gained at 2010, as a result of unbundling (% in brackets)

Option	Specification		Designation	
	Business	Residential	Business	Residential
1: Full	2,383 (2)	6 (0)	27,720 (21)	1,311 (1)
2: Line sharing	3,255 (2)	205 (0)	8,703 (7)	26 (0)
3: Bitstream	13,809 (10)	2055 (2)	34,243 (26)	1,232 (1)

The results show that there is a positive gain to consumers from regulation in all options and scenarios, although these are more heavily skewed towards business than residential. The gains are derived from the price reductions over the counterfactual that result in gains to the existing subscriber base and the consequent increased take-up of DSL broadband services. The results are therefore sensitive to both the assumptions underlying the relevant costs and revenues, and those used to predict take-up. Overall, the assumed retail price falls, even under designation, do not look out of line with observed outcomes in other jurisdictions.[14]

The take-up effect for the PDN is zero because it is assumed that new demand cannot be stimulated by the entrant, and that all existing data tails are being used when unbundling occurs. Therefore, the entrant only gains through churning customers from TCNZ, and no new subscribers join as a result of unbundling.

The difference in benefits between the specification and designation scenarios (resulting from the different retail price reductions) is driven by the assumptions on the way in which wholesale access prices are set and the ensuing entry decisions. In specification, they are set using a retail-minus approach, against the retail price of TCNZ (adjusted for the threat of entry). In designation, they are set using a cost-plus approach. The latter approach may result in lower retail prices, driving the higher welfare benefits. The difference in wholesale prices between specification and designation depends on the

[14] However, as noted below in sensitivity 7, the prices for designation are approximately equal to those for specification. This outcome would depend on the relative negotiating strengths of the incumbent and the entrant(s).

relative strength of the bargaining position of entrants under specification. It may be argued that marked differences could not persist between the negotiated outcome for wholesale prices under specification and cost-based wholesale access prices under designation—any initial differences would be eroded by entrants threatening to ask the Commission to designate the service.

In general, it is business customers that would benefit from the unbundling, as demonstrated by the larger increases in take-up, in both levels and proportions (see Table 3.3). The modelling work undertaken here estimated much slower residential take-up than that forecast by TCNZ in its business plan. To the extent that this underestimates penetration, the approach modelled will be conservative, particularly with regard to the assumed price-related consumer benefits.

The differences between Option 1 and Option 2 in designation reflect the additional benefits of cheaper voice services, as, in Option 2, entrants provide data services only. In Option 1, the opportunity to offer the bundled product attracts more entry and reduced prices, leading to higher consumer surplus.

The higher benefits from bitstream access (Option 3) compared to Option 2 reflect the fact that there is a lower total cost of providing the unbundled service, because collocation costs are avoided. In addition, entrants face a lower risk of investing in network components (eg, DSLAMs) that might not be fully utilised. This option is consequently more attractive, entry occurs at more exchanges and hence the market expands more.

Overall, the model predicts the highest benefits for full unbundling where cost-based access price regulation is introduced (excluding the specialised services offered by the PDN). The other forms of access, particularly bitstream, also show significant benefits. There are substantial gains to existing PDN customers following the liberalisation of this service.

As the costs and benefits modelled are either financial, or have been converted to a financial measure, there are certain aspects of LLU that have not been taken into account. For example, experience around the world suggests that collocation is extremely difficult to organise, even with regulatory intervention, notwithstanding the access price charged by the incumbent. In particular, there is broad scope for gaming by the incumbent in order to increase the difficulty of entry, and so attempt to limit the number of successful entrants. Such costs have not been modelled.

3.1 Sensitivity analysis

As the model has been constructed to allow the key variables to be adjusted in each case, there are many potential sensitivity analyses that could be run. For this analysis, six sensitivities to the central case have been selected for Options 1 to 3:

Sensitivity 1 the elasticity has been set to –1 (down from –1.5);

Sensitivity 2 the price fall for retail prices under specification has been set to 10% (ie, the price is higher than in the central case) and 30% (ie, the price is lower than in the central case);

Sensitivity 3 the price fall for retail prices under designation have been set to 40% (ie, the price is higher and the price *fall* is lower than in the central case);

Sensitivity 4 the cut-off limit for feasible ADSL connections is reduced from 7km to 4km;
Sensitivity 5 the return on sales is increased to 18%; and
Sensitivity 6 the weighted average cost of capital (WACC) is set at 18%.

For Option 4, PDN Sensitivities 1 and 4 are not applicable.

**Table 3.4: Present value of consumer surplus, 2005–10 (NZ$m)—
Sensitivity 1: elasticity set to –1 (–1.5 in central case)**

Option	Specification			Designation		
	Price effect	Take-up effect	Total	Price effect	Take-up effect	Total
1: Full	6.1	0.2	6.3	100.0	23.3	123.3
2: Line sharing	7.4	0.5	7.9	27.9	6.8	34.7
3: Bitstream	41.8	2.9	44.7	85.2	20.0	105.2

Lowering the elasticity has a varying effect on the results, but is most marked in the designation scenario. This is because the price effects are more significant here, which give rise to more of an effect on the size of the potential market. The overall shape of the results, and the conclusions to be drawn from them, do not change.

**Table 3.5: Present value of consumer surplus, 2005–10 (NZ$m)—
Sensitivity 2*a*: retail price reduction under specification set to 10%**

Option	Specification			Designation		
	Price effect	Take-up effect	Total	Price effect	Take-up effect	Total
1: Full	3.7	0.0	3.7	n/a	n/a	n/a
2: Line sharing	0.6	0.0	0.6	n/a	n/a	n/a
3: Bitstream	10.1	0.6	10.7	n/a	n/a	n/a
4: PDN	78.1	n/a	78.1	n/a	n/a	n/a

Reducing the expected retail fall under specification to 10% has a marked effect on the welfare benefits. There is little expansion of the market and this limits entry in all cases. When the retail price fall is increased to 30%, the welfare effects are positive, as the market expansion effects feed through in three Options. The exception is Option 4, where a greater price reduction than in the central case produces less entry. This is because the price fall reduces the available revenue (and hence the level of entry), but does not have a countervailing demand expansion as in the other Options.

Table 3.6: Present value of consumer surplus, 2005–10 (NZ$m)—
Sensitivity 2*b*: retail price reduction under specification set to 30%

Option	Specification			Designation		
	Price effect	Take-up effect	Total	Price effect	Take-up effect	Total
1: Full	23.0	3.4	26.4	n/a	n/a	n/a
2: Line sharing	13.5	2.2	15.8	n/a	n/a	n/a
3: Bitstream	71.7	12.6	84.2	n/a	n/a	n/a
4: PDN	64.4	n/a	64.4	n/a	n/a	n/a

Table 3.7: Present value of consumer surplus, 2005–10 (NZ$m)—
Sensitivity 3: retail price reduction under designation set to 40%

Option	Specification			Designation		
	Price effect	Take-up effect	Total	Price effect	Take-up effect	Total
1: Full	n/a	n/a	n/a	120.5	27.1	147.6
2: Line sharing	n/a	n/a	n/a	58.7	14.2	72.9
3: Bitstream	n/a	n/a	n/a	103.9	25.9	129.9
4: PDN	n/a	n/a	n/a	281.4	n/a	281.4

Given that the underlying price fall is different in the four options, restricting it to 40% has a differential impact in each case. As expected, there is less gain from the take-up effect where the price reductions are the greatest.

Table 3.8: Present value of consumer surplus, 2005–10 (NZ$m)—
Sensitivity 4: feasible ADSL connection distance set to 4km (7km in central case)

Option	Specification			Designation		
	Price effect	Take-up effect	Total	Price effect	Take-up effect	Total
1: Full	6.1	0.3	6.4	123.9	43.6	167.5
2: Line sharing	7.3	0.7	8.0	27.6	10.1	37.8
3: Bitstream	39.7	4.2	43.9	97.1	34.9	132.1

Changing this assumption reduces the addressable market and hence affects all the estimates. It has the greatest impact under designation, where there is the greatest penetration growth.

Table 3.9: Present value of consumer surplus, 2005–10 (NZ$m)— Sensitivity 5: return on sale set to 18% (15% in central case)

Option	Specification			Designation		
	Price effect	Take-up effect	Total	Price effect	Take-up effect	Total
1: Full	6.1	0.3	6.4	123.6	43.7	167.4
2: Line sharing	7.4	0.7	8.1	27.9	10.2	38.2
3: Bitstream	41.8	4.4	46.2	100.6	36.2	136.8
4: PDN	42.6	n/a	42.6	258.1	n/a	258.1

Increasing the required return on sales to 18% does not have any impact under specification on full unbundling implying that the returns for this Option are greater than 18% in all the unbundled ESAs. For the remaining Options (2, 3 and 4) the consumer surplus falls, suggesting that returns are lower than 18% in a number of ESAs. Under designation, increasing the return on sales requirement has the effect of reducing entry in all the Options except line sharing. Hence, there is a reduction in consumer surplus for full unbundling and bitstream access, and a reduction in the price effects for PDN.

Similar effects drive the results when the sensitivity to a higher WACC is tested. The WACC is used to determine the discount rate for the NPV calculation, so it is this that has been altered to run the sensitivity test in Table 3.10; hence increasing the WACC (discount rate) reduces the net benefits.

Table 3.10: Present value of consumer surplus, 2005–10 (NZ$m)— Sensitivity 6: WACC set to 18% (13% in central case)

Option	Specification			Designation		
	Price effect	Take-up effect	Total	Price effect	Take-up effect	Total
1: Full	6.1	0.3	6.4	127.0	44.9	171.9
2: Line sharing	7.4	0.7	8.1	27.9	10.2	38.2
3: Bitstream	44.1	4.6	48.7	111.8	40.1	151.9
4: PDN	85.3	n/a	85.3	287.2	n/a	287.2

In summary, as expected, the model is most sensitive to the assumed price variations and the elasticity factor, as these drive the size of the market, entrants' decisions to participate in the market, and the size of the welfare gain. The results suggest that, if unbundling is to deliver social benefits, the way in which the wholesale price is set will be important. For entry to occur, cost-based access is preferable, given that there are significant costs in addition to the unbundled elements in providing full retail services.[15] Under this form of access pricing (the designation scenario above), there are consumer gains (from reduced prices and market expansion) in all the options, but full unbundling provides the most marked changes.

[15] The access could be determined using a retail-minus approach, as long as there were a good understanding of the extent of the avoided costs.

4. Model Structure

This section presents the structure of the model, and details how it determines the various outputs required to model the impact of regulation in the four options. Data used to populate the model is presented in section 5.

The difference between the specification and designation cases is that, for designation, the wholesale access prices for unbundling may be set by the Commission (ie, they are regulated) should a determination be requested; however, there is no difference in the *structure* of the model between these two scenarios. All that changes is the input costs and price data.

Furthermore, the components of full unbundling are data and voice services, while line sharing involves the provision of data only. Therefore, there is a high degree of commonality between these options on the data side. The primary difference is in the entry decision; for full unbundling, the entrant takes into account the costs and revenues of both data and voice (exploiting any economies of scope that exist), while for line sharing there are costs and revenue from data services only.

In the following sub-sections, the model approach that is outlined with regard to the data applies equally to full unbundling and line sharing. The NPV assessment of the entry decision and the consumer welfare calculations are addressed separately.

4.1 Counterfactual

The counterfactual sets out what can be expected to happen in the future if LLU were not introduced. By definition this is a forecast, or best estimate, of the likely outcome.

The importance of the counterfactual is that it provides the base case against which to measure the incremental benefits of LLU. All benefits accruing to subscribers are measured relative to the counterfactual, and, from an economic perspective, only those benefits over and above what would have occurred in the base case are important. Since the benefits forecast to accrue to consumers are measured by price reductions, the only difference between the counterfactual and each scenario is the effect of any price changes that result from regulatory intervention. These price reductions drive the take-up of services. In other words, the number of subscribers in the counterfactual is forecast using the same methodology as take-up in Options 1–3, minus the price effect (as described in section 2.1.2).

There are two services in the counterfactual—data and voice—each provided to business and residential customers. The method by which the counterfactual numbers in the model are derived is outlined below.

4.1.1 Business and residential

TCNZ provided data on the number of lines on an ESA basis, split between business and residential. TCNZ also provided data on the number of working ADSL ports, which were allocated to business and residential customers using the same proportion as the split for the lines.

4.1.2 Data subscribers

The number of data subscribers in the counterfactual was forecast using the same methodology as described in section 2.1.2, albeit with a level retail price (the model is defined in real terms).

Data prices include the cost of the ISP for both business and residential customers since this is a real cost that the consumer must face, as discussed in section 2.2.[16]

4.1.3 Voice subscribers

New Zealand already has a very high level of voice telephony penetration, so it was assumed that 100% of the lines detailed by TCNZ were used to provide voice services (excluding those used for non-PSTN services). Furthermore, given the high current penetration, it was assumed that there would be no further growth in the number of voice lines. This is a conservative assumption, as it is likely that new house building and the growth of multiple lines for residential customers will increase the number of voice lines over the period.

4.1.4 Prices

It was assumed that prices would remain static in real terms for both voice and data services over the period of analysis. This applies to both the connection charges for data and voice, and the monthly line-rental and service charges.

4.2 DSL data unbundling

4.2.1 Business and residential customers

Business and residential customers on DSL data or bitstream services are served from the same ESA using the same equipment (eg, DSLAMs). There is no dedicated business or residential capacity other than the specific line running to the customer premises. Therefore, equipment resulting from an investment in upgrading an exchange can be used for either business or residential services, and the likely demand from both would be taken into account in making the unbundling decision.

As a result, the number of likely customers for each market segment must be calculated separately, but both should be included when assessing the entry decision. As the process for determining the likely take-up is the same for both groups, it is not explained separately below. However, the distinct business and residential data inputs are detailed in section 5.

4.2.2 Technically upgradeable lines

The number of technically upgradeable lines is the starting point for the model, as an indication of the potential size of the market. As noted, the number of lines in each ESA

[16] The new entrant may or may not provide ISP services itself (on an arm's-length basis). However, the cost will always form part of the consumption decision from the consumer's perspective (regardless of whether they are business or residential).

that can be upgraded to DSL services will be reduced owing to certain technical constraints, including:

- distance from the exchange;
- transport technology (eg, PCM);
- existence of sub-loops;
- interference.

In practice, it was difficult to ascertain independently the coincidence of these factors without detailed and exhaustive engineering analysis of TCNZ's network. For instance, some lines that are outside the requisite distance from the exchange may also be on a sub-loop or served by a PCM transport cable. Therefore, to apply these factors successively would understate the number of DSL-upgradeable lines.

As an alternative, OXERA obtained TCNZ's estimates of the number of upgradeable lines per ESA that it has used for its own engineering purposes. This information forms the basis for the number of lines available to entrants.

4.2.3 Price-determination mechanism

Section 2 discussed the likely impact of LLU on the price of voice and data services in New Zealand. In the ESAs in which entry occurs, it is assumed that there will be a reduction in price, the extent of which depends on whether one or two firms enter.

For data services, under the specification scenario, there will be a negotiation between TCNZ and the entrant in order to determine the appropriate wholesale prices for unbundling; while, for designation, this will be established by the Commission, if a party applies for a determination. The prices used in the model have therefore been developed on different bases for these two scenarios.

Specification

The prices under the specification scenario are the result of a top-down retail-minus approach. The current TCNZ weighted average price for data services, including the ISP charge, is calculated (the existing prices of the services are weighted by the proportion of subscribers taking each service) as the starting point (the base price). It is then assumed that, as a result of entry, TCNZ will be forced to become more productively efficient, and to lower its profit level. This results in a profit and efficiency reduction to the base price. In addition, certain costs of LLU are incurred by both TCNZ and the entrant(s), namely the set-up of TCNZ's information systems. As these are common to both TCNZ and the entrant(s), it is assumed that they will be recovered from consumers and will be added back into the price.

The result of these adjustments is a retail price that is likely to decrease over time under full competition (two entrants). It is assumed that the full price adjustment does not occur in the first year, so a glide path is used with the end price reached in the final year of modelling—year five.

Where there is only one entrant, the full benefits of competition are not obtained, and the retail price in this case is assumed to be above the retail price for full competition. In the central case, the one-entrant price is 10% above that for full competition.

Designation

For the scenario of designation of prices by the Commission, a bottom-up approach is used to derive retail prices.

The regulated wholesale prices were based on recommendations by the Commission's consultants, COVEC, which estimated wholesale access and line-rental charges for LLU data services. The overall retail price was derived by summing the wholesale cost with the costs of regulatory submissions, ISP charges, backhaul, collocation and general operating expenditure (OPEX).

It is assumed that TCNZ is not allowed to recover its portion of the operating support system (OSS) costs from the entrants. Rather, this will be covered out of profits or the additional price above the entrant level when there is only one entrant. In some circumstances, Oftel has adopted this approach with BT in the UK.

4.2.4 Penetration of high-speed data services

To determine the number of customers that subscribe to high-speed data services, the model requires a measure of penetration that identifies the percentage of customers with upgradeable lines that actually subscribe to DSL. The measure used is related to Internet penetration, as described in section 2.1.2. In practice, the Internet penetration rate varies by geographic region, so estimates of penetration were obtained for metro, urban, suburban and rural areas.

This penetration is moderated by a price effect; the percentage expected overall price fall for the relevant scenario (derived from the price-determination formula above) is multiplied by an elasticity factor to obtain the adjusted penetration rate.

However, as described in section 2.1.2, it is assumed that neither the price reduction nor the increase in penetration occurs immediately. Instead, consumers' take-up of high-speed data services grows gradually over time as an increasing number of subscribers become used to broadband; this is represented by a take-up profile derived from the take-up of PCs in New Zealand. The take-up rate determines the percentage of the ultimate penetration that is achieved in each year, reaching 100% in the eighth year following upgrade, producing a level of penetration that applies to each year. The percentage penetration rate is applied to the number of upgradeable subscribers for each year to determine the number of subscribers interested in taking broadband services.

A significant number of ESAs have been upgraded already, and more will be upgraded before unbundling is introduced. For these ESAs the model ascertains the year in which upgrading took place (or is due to take place), and adjusts the forecast take-up rate to match the rate used with the correct year following upgrade in the take-up profile. This ensures that the forecast number of subscribers is appropriate to the circumstances of individual exchanges.

An additional adjustment is made to account for the number of potential subscribers that choose to use alternative technologies. The number of upgradeable lines multiplied by the penetration rate gives the number of subscribers interested in broadband *per se*, but not necessarily in DSL. There are alternative technologies such as cable or wireless that can also deliver high-speed data products, so the number of potential subscribers is reduced by a percentage to represent the net churn to different infrastructures.[17]

Resulting from these calculations is a number of forecast DSL subscribers for each year. These are split between business and residential users on the basis of the proportion of business and residential customers in 2003.

4.2.5 Apportionment of subscribers between TCNZ and entrant(s)

In order to determine the number of subscribers that a new entrant would gain, it is necessary to apportion the forecast business or residential subscribers between the entrant(s) and TCNZ. This is achieved through the use of churn rates and competition for new subscribers.

The entrant acquires subscribers from TCNZ on the basis of a net churn factor that also takes into account any TCNZ win-back from the entrant.[18] The churn rate is applied to TCNZ's installed base at the end of the previous year to determine the number of subscribers switching to the entrant during that year.

New subscribers are apportioned between TCNZ and the entrant(s) on the basis of a competitive acquisition factor that is weighted towards TCNZ, reflecting its favourable position as the incumbent. In each year the residual of the total forecast subscribers less TCNZ's existing installed base is allocated on the basis of the competitive acquisition factor.

Therefore, at the end of each year, TCNZ's number of subscribers for the start of the next year is determined as its subscribers at the start of the year minus subscribers lost through churn to the entrant(s), plus the new subscribers won in competition in the market. Similarly, the entrant's subscribers are the start number plus gains from churn and competition.

4.2.6 Economic feasibility test for entry

The entry decision is addressed at the ESA level, and firms decide to enter on the basis of the NPV of the relevant costs and revenues for that ESA. The revenues are a product of the prices detailed above, multiplied by the number of subscribers, where relevant. The costs are a combination of one-off set-up costs per ESA, one-off per-subscriber

[17] The use of a net churn figure accounts for the fact that TCNZ and/or the entrant(s) may also gain existing customers back from other technologies in each year.
[18] Implicit in this is an assumption that there will be net churn towards the entrant. This reflects what has happened in the course of competition between TCNZ and Telstra Clear.

connection costs (incurred as subscribers join) and monthly per-subscriber fees. The costs used in the model, and their derivation, are considered in more detail in section 5.

The model runs the entry decision twice in order to determine how many entrants provide unbundled services. The sequential logic is as follows.

- *Will one firm enter?* The model calculates the NPV given the number of subscribers at a price denoted P_1, using the churn and competitive acquisition rates, and the relevant costs. P_1 is above the fully competitive price.
- *Will two firms enter?* This model run halves the number of subscribers available to each entrant, assuming that they will be shared equally between them, and determines the NPV as before, using a price denoted P_2, where this is the fully competitive price.

Entry only occurs when the NPV calculated is positive. If only one firm enters, prices are assumed to fall, but not to fully competitive levels. If two firms enter, then full competition would ensue.

The churn rate towards the entrants does not increase as a result of two (or more firms) entering, as compared with the situation with one entrant. This is likely to understate the actual market reaction, and thus reduce the likelihood of entry.

For line sharing, the entrant supplies only data services, and the above analysis applies exactly. However, it is slightly different for full unbundling. In the full unbundling option, the NPV is determined on the basis of the sum of the revenues from data and voice services, and the costs are those relating to voice and data services provision. These include costs common to data and voice, as well as costs related to the separate provision of the services. It is assumed that the entrant is able to take advantage of any economies of scope between voice and data in providing the unbundled exchange.

4.2.7 Consumer welfare calculation

The estimation of consumer welfare is the principal output from the model, and is derived from the modelling process outlined above. As discussed in section 2.5, two main forms of benefit apply to consumers:

- price effect; and
- take-up effect.

The process by which each of these is calculated in the model is considered below. However, in the welfare context, the definition of 'consumers' is broad, and includes all subscribers to voice and data services affected by changes resulting from unbundling. This implies that the benefits to both business and residential users are taken into account and weighted equally in the consumer welfare calculation.

As noted above, where there is no entry, there is assumed to be no welfare benefit, as prices do not change in the central case.

The consumer welfare benefit is calculated for each year in each ESA. If the ESA has not been unbundled, the consumer benefit is zero.

Price effect

For each ESA the model predicts the number of subscribers taking data services in each scenario (ie, specification and designation) for the years that are modelled. The counterfactual provides the annual number of subscribers that would have been receiving data services without unbundling. It is this latter group that receives the price benefits.

The extent of the price benefit per subscriber is calculated as the difference between the counterfactual price and the scenario price, given the number of entrants, for the ESA in the relevant year. However, as detailed above, it is assumed that, where there is only one entrant, TCNZ does not fully meet the entrant's price. During the period of analysis, it is not possible to identify whether consumers that would be subscribing to TCNZ in the counterfactual would alternatively take services from TCNZ or the entrant. Thus, it is not possible to determine the price they would be facing.

As an alternative, for the purposes of the welfare calculation, a weighted average of the TCNZ and entrant prices is used as a comparator to the counterfactual price, deriving the per-subscriber price benefit. This price–benefit value is multiplied by the number of subscribers in the counterfactual. That is, each consumer who would otherwise have been subscribing to data services in the counterfactual will benefit from lower prices as a result of unbundling. The quantum of this effect is the extent to which prices are lower, summed across the number of affected subscribers in the counterfactual.

Take-up effect

Those subscribers that would not have taken data services were it not for the price falls gain a welfare benefit equivalent to the difference between their willingness to pay and the price they actually paid.

The model calculates this effect by taking the difference between counterfactual and scenario prices multiplied by the number of affected subscribers, divided by two. While this is a necessarily simplistic estimate, it would underestimate the size of the take-up effect, and is thus a conservative approach.

The total consumer surplus from data unbundling (Options 1 and 2) is the sum of the price and take-up effect estimates.

4.3 Voice unbundling

For the reasons discussed in the introduction to section 2, it is assumed that voice services are only unbundled when an entrant is offering full unbundling; they do not unbundle in order to provide local calls and access services alone. This sub-section outlines how the model calculates the benefits to consumers from the unbundling of voice in the full unbundling scenario.

4.3.1 Number of subscribers

The number of voice subscribers is determined by the existing number of TCNZ subscribers in 2003. This assumes that there is close to 100% voice penetration, and the number of households or lines does not grow significantly over the period.

It is reasonable to assume that all subscribers with lines take voice services. The assumption of no market growth over the period of analysis is conservative and may understate the benefits to consumers.

4.3.2 Price of voice services

The derivation of voice services in the specification scenario is the same as for data services. That is, the existing TCNZ retail price is used as a starting point and adjusted for an improvement in allocative efficiency (reduced profitability), productive efficiency, and an increase in costs due to the common costs of LLU. Also, as with data services, the one-entrant price is assumed to be 10% above the fully competitive price.

In this case, however, there is both a stand-alone voice product and a bundled voice and data product. Both of these products are currently offered by TCNZ; there are, therefore, no existing retail prices from which to derive the unbundled prices.

Due to the low level of wholesale elements (that need to be purchased from TCNZ) in the unbundling of voice services, and the economies of scope in the unbundled line-rental charge, it is assumed that there is no difference between the retail prices for unbundled voice services under specification and designation.

4.3.3 Levels of switching

Given the absence of market or subscriber growth, the only way in which the entrant gains subscribers is by churn from TCNZ. Therefore, a net churn factor is applied to the number of TCNZ subscribers each year to determine the number of subscribers switching to the entrants.

As outlined at the beginning of this section, some subscribers receive voice-only services from an entrant offering full unbundling. This is addressed in the model by estimating the number of subscribers that will switch to voice services, regardless of whether they also take data services. The number of voice-only subscribers can then be calculated as the difference between the total number of voice switchers, and those taking data services. Within the model, however, voice services subscribers are treated as a single block, separate from data subscribers (except for the entry decision, as discussed below).

4.3.4 Entry decision

The process by which the entry decision is modelled is the same as for DSL data unbundling. However, as noted in section 4.2.6, the decision to enter for voice services is a joint one with that for data services, and the costs and revenues are pooled in order to determine whether full, unbundled entry is commercially viable.

4.3.5 Welfare calculation

As there are no new subscribers, there is only a price benefit for existing subscribers. This is calculated as in section 4.2.7, taking the weighted average price reduction multiplied by the number of consumers that benefit from it.

This benefit is added to the benefit from unbundled data services subscribers to determine the total welfare benefit of full unbundling.

4.4 Bitstream access

Bitstream access provides a *service*-level entry to DSL data provision. The entrant buys the complete service for a high-speed (eg, 2 Mbps) link to the consumer, and the service includes delivery to a data switch in TCNZ’s network. The entrant would need to arrange backhaul to its own network from this point.

The entrant is therefore bound by TCNZ and its investment plans because the high-speed link will only be available at exchanges that TCNZ has already upgraded. The entrant cannot upgrade an exchange itself through bitstream access.

Bitstream access enables the entrant to provide high-speed data services to residential or business customers, which is the same outcome as DSL data services unbundling, albeit via a different technical solution. Therefore, it is assumed in the model that the retail products and corresponding prices are the same as for DSL data services.

4.4.1 Availability of bitstream access

Bitstream services can only be obtained where TCNZ has already upgraded the exchange, so the potential subscribers available to the entrant are limited to those within these exchanges. Once an exchange has been upgraded, TCNZ has indicated that some marginal investment may be required in order to expand the number of DSL lines that can be provided, but this can be achieved in a reasonably straightforward manner. Hence, the actual number of lines per exchange is not a restricting factor, as the capacity can be expanded to meet demand.

TCNZ also supplied to the Commission its plans for upgrading ESAs over the next few years, but the scheduling of this investment by year was not detailed. For the purposes of modelling, it has been assumed that an equal number of exchanges was upgraded in each of the three years of the upgrade plans (ie, the total number of planned upgraded ESAs over the next three years was divided by three to obtain the annual number of upgrades), and that the exchanges were upgraded in order of size, with the largest upgraded first.

This provided the number of exchanges, and hence subscribers, that could be accessed by bitstream services. It was assumed that no exchanges were upgraded beyond those in TCNZ's plans, which may reduce the total number of lines available for bitstream access, and hence underestimate the potential consumer benefits.

4.4.2 Price

The retail services being delivered through bitstream access are the same as those for DSL data LLU; the DSL data retail prices are therefore applied to the bitstream services under specification.

Under designation, the prices are built up in the same way as for DSL data LLU, but some costs are not incurred, such as collocation.

4.4.3 Entrant subscribers

Although the entrant does not upgrade new exchanges, it can expand the market by competing on price (or on the bundle of services it offers, as discussed in section 2.4). Thus, the entrant gains retail subscribers from TCNZ, or competes with TCNZ for new subscribers.

The number of new subscribers in each year is determined in the same way as for DSL data LLU above, as is the apportionment between TCNZ and the entrant for churn and competitive acquisition.

These calculations give the number of subscribers that take bitstream access services from the entrant.

4.4.4 Entry decision

The entry decision is also modelled in the same way as for DSL data LLU, using the revenues from subscribers and the costs specific to bitstream access.

4.4.5 Welfare calculation

In line with the DSL data welfare calculation, there is a price and take-up effect for existing and new subscribers, respectively. Although the subscribers that are predicted in the counterfactual to take broadband would not be receiving their services through bitstream access, the *product(s)* they receive would be identical. Therefore, the consumer is ambivalent regarding the technology used to deliver its services, and all that matters is the relative price. To the consumer, the delivery of services by TCNZ or a bitstream access operator would appear the same.

4.5 PDN

The PDN consists of a set of dedicated data access lines running to customers' premises. Each access line comprises two twisted copper pairs, one of which provides an upstream connection, the other a downstream connection. As the copper is dedicated to data, consumers need a separate voice line, and the PDN connections are installed as required, rather than being readily available should a customer decide to subscribe. For these reasons, the PDN is assumed to be a business, rather than a residential, service.

4.5.1 Potential subscribers

The number of potential subscribers to PDN services is limited to the number of existing data tails in TCNZ's network because the entrant unbundles the existing infrastructure and does not install new connections.

4.5.2 Pricing

The services delivered by the PDN are numerous, and varied. For instance, it is possible to provide high-speed Internet access, as with ordinary DSL connections. However, the PDN could also be used by customers to transmit low-level automated data, such as stock-replenishment systems in supermarkets. It is therefore difficult to identify a single, or even representative, service that is delivered over the PDN. In consultation with the Commission staff, OXERA considered two products: Frame Relay and Digital Data Service. Prices for the representative product used in the modelling were based on an average of prices for sample customers. This is further explained in section 5.

4.5.3 Entrant subscriber acquisition

As the entrant does not expand the number of PDN connections, the subscriber growth is limited to churning existing PDN subscribers away from TCNZ's services.

4.5.4 Entry decision

In the same way as for the other forms of unbundling, the entrant will decide whether to unbundle a particular exchange on the basis of the relative discounted costs they would incur and revenues that they would acquire. However, because of the lack of definition regarding the representative product, it is difficult to match underlying costs with services. Similarly, the model cycles through the prices for one and then two entrants in order to determine the appropriate level of entry. The outputs from this are the identity of the exchanges where unbundling of the PDN occurs, the number of entrants, and thus the number of lines that are affected.

4.5.5 Consumer welfare analysis

The entrant is only taking demand away from TCNZ, so the welfare calculation consists solely of a price effect. Those subscribers that take data services from the entrant following unbundling benefit from a lower price. Therefore, the welfare benefit equates to the number of subscribers affected, multiplied by the price fall compared with the counterfactual.

4.6 Impacts of other regulatory decisions

4.6.1 Number portability

As of September 2003, New Zealand does not have a direct number portability scheme that would allow customers to retain their existing telephone number when they move house.[19] It is anticipated that such a scheme will be introduced in the foreseeable future, and probably before unbundling comes into effect.

The impact of a number portability system would be to increase the likelihood of consumers switching suppliers as the switching costs are reduced. It has been identified in both mobile and fixed-line markets that the need to change telephone number can significantly inhibit switching behaviour.[20]

In terms of the modelling, the introduction of number portability could be accommodated through an adjustment of the churn rate in the full unbundling scenario to take into account the anticipated higher switching rate. As the other forms of unbundling relate to data rather than voice services, number portability is not relevant.

4.6.2 Wholesale decision

A decision on the wholesale determination could result in lower prices for wholesale services. Indeed, the Commission has made a decision that the discount will be 16%. This in turn could alter entrants' decisions over which regulatory route to use to supply consumers through: purchase of wholesale services from TCNZ; or LLU.

The impact of the wholesale determination is likely to be that it will encourage more entry, and thus have a downward effect on retail prices. This in turn could expand both the market and the proportion of subscribers obtaining services from entrants. A reasonable price fall, given wholesale prices based on the retail price minus 16%, would be 3%.

As the wholesale determination has only recently been made, there has been little new entry using the new wholesale terms. Therefore, the potential 3% reduction in the counterfactual price has not been modelled in the central case. A sensitivity test has been

[19] There is an indirect process where the number remains with the initial provider and calls are then forwarded to the appropriate service provider, but this is an unwieldy and inefficient method of achieving number portability.
[20] Monopolies and Mergers Commission (1995), 'Telephone Number Portability: A Report on a Reference under Section 13 of the Telecommunications Act 1984', December.

carried out (but is not reported in section 3), and this demonstrated that the impact of the wholesale decision did not have a significant effect on the consumer surplus results reported in Table 3.1.

5. Data Employed

This section sets out the data used in the model, and how prices and costs have been derived for the counterfactual and the different options. In particular, this section considers the following options:

- counterfactual;
- option 1: full unbundling;
- option 2: line sharing;
- option 3: bitstream;
- option 4: PDN.

5.1 Counterfactual

5.1.1 Business and residential

The starting point (end 2003) for the forecast of business and residential subscribers in the counterfactual is derived from information supplied by TCNZ. Each segment is then forecast separately using the same methodology as described for the options given TCNZ's roll-out plans, but there is no price reduction.

5.1.2 Data subscribers

The starting point (end 2003) for the forecast of subscribers in the counterfactual is derived from information supplied by TCNZ, giving mid-2002 and mid-2003 figures. The figure for end 2003 is interpolated.

5.1.3 Voice subscribers

The number of voice subscribers is assumed to remain flat. The numbers used correspond to the PSTN circuit ends supplied by TCNZ.[21]

5.1.4 Prices in the counterfactual

Retail prices in the counterfactual are assumed to be the same as those currently charged by TCNZ. These prices ('P_0') form the basis against which consumer surplus changes resulting from regulatory intervention are measured.

The model makes a distinction between residential and business customers. For each of these two customer categories, the following prices are used:

- voice services only; and
- data services only.

For Option 1, full unbundling, the retail price used is the sum of these two services. In the case of residential products, this is because TCNZ no longer offers a bundled voice and

[21] Data received from TCNZ, July 9th 2003.

data product.[22] For the business sector, no information was available on the pricing of bundled voice and data business products, as these are determined by commercial agreements with TCNZ on an individual basis. In both cases, it is therefore assumed that the price of the bundled product for business is equal to the sum of the prices for voice services only and data services only.

Tables 5.1 and 5.2 describe the packages offered to residential and business customers, respectively, by TCNZ, including the monthly charge currently payable to TCNZ, the monthly charge payable to the ISP, and the up-front connection charge.

Table 5.1: TCNZ's residential packages

Product	**Description** (speed/traffic limit)	**Monthly charge** (NZ$, incl. GST)	**ISP charge** (NZ$, incl. GST)	**Connection charge** (NZ$, incl. GST)
Voice				
Home Line	Unlimited local calls	39.3	n/a	38
Data				
Jetstream Home 1000 Access	2Mbps/1Gbps	69.0	16–20	99
Jetstream Home 500 Access	2Mbps/500Mbps	49	16–20	99
Jetstream Starter Access	128kbps/unlimited	29.5	34.95–7.95	99

Source: TCNZ's website (accessed August 11th 2003), and data received from TCNZ, July 16th 2003.

Table 5.2: TCNZ's business packages

Product	**Description** (traffic limit)	**Monthly charge** (NZ$, excl. GST)	**ISP charge** (NZ$, excl. GST)	**Connection charge** (NZ$, excl. GST)
Voice				
Business Line	Unlimited local calls	58.42	17.78	55.00
Data				
Jetstream 600	600MB	61.33	17.78	220.44
Jetstream 1200	1.2GB	120	17.78	220.44
Jetstream 1800	1.8GB	176	17.78	220.44
Jetstream 3000	3GB	292	17.78	220.44
Jetstream 5000	5GB	458	17.78	220.44
Jetstream 10000	10GB	888	17.78	220.44
Jetstream 20000	20GB	1600	17.78	220.44

Source: TCNZ's website (accessed August 11th 2003), and data received from TCNZ, July 16th 2003.

[22] As of October 2003, TCNZ only offers a triple-play bundle, which incorporates Sky TV as well.

TCNZ offers many and varied service packages. For the purposes of modelling both the residential and business sectors, it has been necessary to use a 'representative product'. Appropriate representative prices have been calculated using an average of the prices of the different packages (including the cost of the ISP) weighted by the proportion of customers currently subscribing to each package. The weights used are presented in Table 5.3.

Table 5.3: TCNZ's residential and business packages—proportion of customers (%)

Product	Weights
Residential packages	
Data	
Jetstream Home 1000 Access	[✂]
Jetstream Home 500 Access	[✂]
Jetstream Starter Access	[✂]
Business packages	
Data	
Jetstream 600	[✂]
Jetstream 1200	[✂]
Jetstream 1800	[✂]
Jetstream 3000	[✂]
Jetstream 5000	[✂]
Jetstream 10000	[✂]
Jetstream 20000	[✂]

Source: Data received from TCNZ, August 12th 2003.

The resulting representative prices for voice, data, and voice and data packages,[23] shown in Table 5.4 below, correspond to the retail price (P_0) that would prevail if no LLU were mandated (either under specification or designation). These prices are annualised to make them consistent with calculations undertaken under the specification and designation scenarios.

[23] Where the bundled price is the sum of the prices of the two products separately.

Table 5.4: Counterfactual retail prices (NZ$)

Service	Residential customers[1]		Business customers[2]	
	Annual charge[3]	Connection charge[4]	Annual charge[3]	Connection charge[4]
Voice	472	38	701	55
Data	813	99	1,428	220
Voice and data	1,284	99	2,129	220

Note: [1] Inclusive of GST [2] Exclusive of GST. [3] Inclusive of ISP charges [4] Prices exclude other charges such as modems and filters.
Source: OXERA calculations; TCNZ website.

5.2 Full unbundling

5.2.1 Business and residential

The split between business and residential customers used throughout the cases is derived from information on business and residential circuit ends provided by TCNZ.[24]

5.2.2 Technically upgradeable lines

The basis for the number of technically upgradeable lines in each ESA is information supplied by TCNZ. [25] TCNZ has defined lines in range as those that meet TCNZ deployment criteria for DSL.[26] This includes lines up to 7km, but only at a rate of 500Kbps. The model allows this distance to be reduced, and so lowers the number of 'lines in range'. This calculation uses teledensity information supplied by TCNZ.[27]

5.2.3 Prices

Specification

As noted in the introduction, specification implies that prices are subject to competitive pressures. The effects of competition are modelled by calculating the specified prices using a top-down retail-minus approach. Two prices are calculated: P_1 and P_2.

P_2 is the retail price that would emerge as a result of full competition. Full competition is defined as the case where there are at least two entrants in addition to TCNZ in a specific ESA. P_1^E is the price an entrant would be able to charge if there were only one entrant. It is assumed that the full benefits of competition will not be obtained in this instance; therefore P_1 is slightly above P_2. P_2 is calculated according to the following formula:

$$P_2 = P_0 - \%\ \Pi - \text{efficiency} + \text{LLU costs}$$

[24] Data received from TCNZ, July 9th 2003.
[25] Data received from TCNZ, July 9th 2003.
[26] Data received from TCNZ, July 9th 2003.
[27] Data received from TCNZ, July 16th 2003.

where:

P_2 = the competitive retail price. Under full competition, it is assumed that the retail prices of TCNZ and those of the entrants will converge at this price over a five-year period. Prices follow a glide path to reach P_2 over the five-year period used. At this point, P_2 is the same for TCNZ as for the other two entrants;

P_0 = TCNZ's pre-entry retail price, as discussed above and presented in Table 5.4;

% Π = the reduction in TCNZ's profitability that would be expected given full competition. A reduction of 10% of the pre-entry price P_0 is assumed in the central case. This occurs in the first year of specification;[28]

efficiency = the underlying assumption is that TCNZ will become more productively efficient when competition is introduced. An annual efficiency gain of 3% is assumed in the central case. Over the five-year period, this would imply a 16% reduction in P_0 after the introduction of specification. This is based on both evidence from academic studies on the impact of market liberalisation and privatisation in efficiency (as measured by a total factor productivity index) in the telecommunications sector across different countries,[29] and OXERA's analysis of TCNZ's efficiency as detailed in the appended supporting paper, 'Efficiency Analysis to Support Cost–Benefit Analysis'.

OXERA was presented with analysis carried out by PwC Consulting which showed that TCNZ was as efficient as the best US local telecoms operators. However, flaws were identified in the procedures adopted in the estimation of TCNZ's efficiency. Once these were corrected, a range of estimates was produced for the efficiency improvements that TCNZ would have to make in order to become efficient. The lowest estimate was 2.3, while the highest was 5.2; the 3% used in the modelling was well within this range.

Furthermore, the efficiency improvements deducted from the price allow only for catch-up to the efficiency frontier, and do not adjust for the shifting of the frontier over time. In high-technology industries, the frontier is considered to move relatively quickly due to technological

[28] This is within range of estimates of falls in profit margin following telecommunications market liberalisation in other jurisdictions. See, for example, Daßler, T., Parker, D. and Saal, D. (2001), 'Economic Performance in European Telecommunications, 1978–98: A Comparative Study', Aston Business School Research Paper RP0108, March, Aston University.
[29] In particular, see Daßler et al. (2001), op cit; and Martin, S. and Parker, D. (1997), *The Impact of Privatisation: Ownership and Corporate Performance in the UK*, London: Routledge.

improvements. For example, Oftel determined a frontier shift of around 3% per annum for BT, and this would be added to any catch-up requirements to generate the overall annual required efficiency improvements. Therefore, even if TCNZ were on the frontier, efficiency gains of 3% a year could still be expected. In sum, the efficiency allowance in the model is a conservative estimate.

LLU costs = certain costs of LLU are incurred by both TCNZ and the entrants, namely the set-up of TCNZ's OSS system. Costs of NZ$ [✂] are allowed per connection.

The set-up costs of TCNZ's OSS system are calculated using information submitted by TCNZ.[30] TCNZ's response presents the fixed set-up costs associated with implementing unbundling, which include process additions and re-engineering, OSS investment and transaction costs. The lower bound of the table corresponds to the case of LLU. TCNZ estimates that these costs amount to approximately NZ$[✂]. The Commission's view is that 'on-set costs'[31] under the scenario of commercial agreement would be shared equally by the access provider and the access seeker. Therefore, it is assumed that NZ$[✂] (ie, 50% of NZ$[✂]) will be recovered from consumers over the five-year period.

Table 5.5 shows the P_2 of the representative bundled voice and data product, and voice, which results after a five-year period, both for residential and business customers. The counterfactual P_0, or prices given no regulation, is also shown. The table refers only to the annual charge. As in the other cases, one-off connection charges are assumed to remain constant under partial and full competition, and under specification and designation scenarios.

Table 5.5: Full-competition retail prices under specification (NZ$ per year)

Price	Residential customers		Business customers	
	Voice and data	Voice	Voice and data	Voice
P_0	1,284	472	2,129	701
P_2	1,022	396	1,673	573

Source: OXERA calculations.

As noted, P_1^E is the price charged by the entrant when it is the only new operator. It is assumed to be 10% above P_2. Given entry by one operator, TCNZ is likely to respond by

[30] Data received from TCNZ, August 8th 2003.

[31] 'On-set costs' have been defined by the Commission as 'those one-off costs to set up the framework for LLU. Examples of such costs include the development of EDI and the establishment of codes and practices'. Commerce Commission's response, August 4th 2003.

lowering its prices from the pre-entry price P_0, although its prices are likely to differ from those of the entrant. TCNZ's response price, P_1^T, is calculated as follows:

$$P_1^T = P_1^E * (1 + \text{competitive-response factor})$$

where the competitive-response factor is the margin above P_1^E that TCNZ can justify. For voice services, it is estimated using instances where TCNZ has responded to competition—notably in Wellington, where TelstraClear competes with TCNZ to provide local calls and access over its cable network.

In the case of bundled residential voice and data packages, the competitive-response factor results from the comparison of TCNZ's Jetline Home 1000 package and TelstraClear's High Speed Express, which are comparable products in terms of the speed and traffic limit. The comparison results in an uplift factor of 15%.

Table 5.6 presents the central case results for the residential and business retail prices (P_1) for the representative bundle of voice and data services, and voice services, given one entrant (partial competition).

Table 5.6: Partial-competition retail prices under specification (NZ$ per year)

Price	Residential customers		Business customers	
	Voice and data	Voice	Voice and data	Voice
Entrant (P_1^E)	1,124	436	1,840	630
TCNZ (P_1^T)	1,293	471	2,116	681

Source: OXERA calculations.

Designation

As noted in the introduction, designation implies that the Commission may be called upon to regulate prices. In this case, it would be regulating the wholesale access prices. This is just one part of the final retail price charged.

Retail prices under designation are determined using a bottom-up approach, comprising:

- wholesale access prices;
- other costs incurred as a result of unbundling;
- a contribution for non-LLU network and non-network costs; and
- a return on sales.

To determine the retail prices, all the cost elements are annualised and expressed on a per-connection basis. In the case of set-up costs that depend upon the number of connections per exchange, an average number of connections per exchange in metro, urban, suburban and rural locations is assumed in the central case. This is based on information supplied by TCNZ. Costs on unbundling that are incurred only once have been annualised by assuming an amortisation over the expected economic life of the asset.

The costs were estimated assuming that the entrant will require LLU to provide data services. The costs to provide voice services have been calculated as the *additional* costs that would be incurred by an entrant providing data services. Each of the cost elements is explained below.

Table 5.7 presents the resulting prices for the bundled voice and data, and voice under designation. As in the specification scenario, P_1^E under designation is assumed to be 10% higher than P_2. The table also presents the value of P_0, which would prevail if no entry occurs under designation.

Table 5.7: Retail prices under designation (NZ$ per year)

Price	Residential customers		Business customers	
	Voice and data	Voice	Voice and data	Voice
P_0	1,284	472	2,129	701
Entrant (P_1^E)	965	436	1,007	630
TCNZ (P_1^T)	1,110	471	1,159	681
P_2	877	396	916	573

Source: OXERA calculations.

Wholesale access prices for LLU

The regulated wholesale prices are based on recommendations by the Commission's consultants, COVEC, which estimated wholesale full access rental and full access connection for data services.[32] These estimations result from a benchmarking regression analysis of access rental and access connection charges across 15 European countries that have mandated unbundling and line sharing. The resulting benchmark full access rental charge is NZ$286.20 per year, and the benchmark full access connection charge is NZ$172.46.

It is assumed that these costs are the same for business and residential connections. In the central case, the access connection charge has been amortised over an expected life of a connection of five years.

Other costs incurred as a result of unbundling

Other costs arising from unbundling include one-off costs as well as annual costs. The following cost items have been considered.

- *DSLAMs*—the fixed costs of installing DSLAMs for data services depend on the number of connections per exchange. TCNZ's provided DSLAM node capital costs, depending on the number of connections.[33]

  In the central case, an average of 1,000 connections have been assumed, amortised over an expected economic life of 10 years. This is based on experience from other jurisdictions. It is assumed that these costs are the same for residential and business connections. Furthermore, it is assumed that the capital costs of the

[32] COVEC (2003), 'Pricing of Unbundled Access', September 8th.
[33] Data received from TCNZ, August 8th 2003.

DSLAMs remain the same in the provision of data services only, and combined data and voice services.

- *Backhaul*—one-off backhaul costs have been calculated using information supplied by TelstraClear (see Table 5.8).[34] This information refers to the maximum one-off cost per exchange to lay fibre from TelstraClear's network into TCNZ's exchange. It is assumed that these cost figures would apply in the provision of data and voice services.

Table 5.8: Backhaul set-up costs, voice and data (NZ$)

Type of ESA	NZ$
Metro	25,000
Urban	80,000
Suburban	175,000
Rural	300,000

Source: OXERA calculations, based on information supplied by TelstraClear.

In the central case, the annualised cost per connection results from calculating an average cost per ESA amortised over an expected economic life of 20 years, and divided by the central-case average of 1,000 connections per exchange. The expected economic life is based on experience from other jurisdictions, as considered by consultants, ICC. The average cost per ESA results from weighting the above costs by the proportion of TCNZ's lines in range by type of ESA. The weights are as follows: metro ([✂]%), urban ([✂]%), suburban ([✂]%), and rural ([✂] %).

In the central case, the model assumes that the backhaul costs of providing voice in addition to data services would be around 5% higher. Therefore, the backhaul cost of providing data services is given by Table 5.9.

Table 5.9: Backhaul set-up costs, data (NZ$)

	NZ$
Metro	23,810
Urban	76,190
Suburban	166,667
Rural	285,714

Source: OXERA calculations.

Furthermore, for business connections, a 30% uplift factor over the costs of backhaul for residential connections has been assumed. This is based on the

[34] TelstraClear (2003), 'Our Service Vision', presentation, August 1st.

assumption that business connections would use the network more heavily (eg, in terms of the data traffic and speed required).

- *Collocation set-up*—the estimated costs to establish LLU telehousing space in an existing exchange have been supplied by TCNZ (see Table 5.10).[35] These costs include provision of seismic frames and cable trays, fire protection, air conditioning, power, project management and contingency allowance, and have been calculated for three alternatives: eight-bay LLU hostel room, four-bay LLU hostel room, and two-bay co-mingling area.

Table 5.10: Estimated cost of LLU telehousing space in an existing exchange (NZ$)

	Eight-bay hostel	Four-bay hostel	Co-mingling
Number of bays	8	4	2
Number of cabinets	[✂]	[✂]	[✂]
Total set-up costs (NZ$)	[✂]	[✂]	[✂]

Source: Data received from TCNZ, August 8th, 2003

These costs include [✂] handover distribution frame (HDF) connections per bay for the hostel room options, and [✂] connections per cabinet for the co-mingling options. Combining this information with the number of bays and cabinets under the various options, collocation set-up costs have been estimated for different number of connections per exchange. For exchanges up to [✂], it has been assumed that the set-up collocation cost is an average of the per-connection cost for the co-mingling and four-bay hostel options. For exchanges over [✂] lines, the per-connection cost for the eight-bay hostel option has been applied. This method implicitly assumes a linear relationship between collocation set-up costs and the number of connections. It is acknowledged that there may be a non-linear relationship capturing economies of scale. As the approach may overestimate the collocation costs, a conservative approach is adopted regarding the costs that would need to be incurred to unbundle the local loop.

Furthermore, it has been assumed that the estimation supplied by TCNZ would apply in the specification scenario. Under designation, it is assumed that the Commission may not necessarily allow TCNZ to recover all the cost categories included in the estimation. In particular, under the central case, it is assumed that the Commission would allow 75% of these costs. The calculated collocation set-up costs under designation are as follows.

[35] Data received from TCNZ, August 8th 2003.

Table 5.11: Collocation set-up costs under designation (NZ$)

Average connections per exchange	Cost (NZ$)
500	[✂]
1,000	[✂]
1,500	[✂]
2,000	[✂]
3,000	[✂]

The annualised per-connection cost in the central case has been determined assuming an average of 1,000 lines per exchange, amortised over an expected economic life of 15 years.[36]

- *Tie cables*—tie cables may represent around 3% of the operator's fixed costs. Under the central case, the total tie cable costs per connection have been estimated as 3% of the sum of the access connection charge, backhaul, and set-up collocation.[37] This one-off charge per connection has been amortised over an estimated economic life of 15 years (based on Oftel's assumption of economic life[38]).

  It is assumed that the tie cable cost to provide voice and data services is 5% higher than the cost to provide data services only.

- *switch and infrastructure connectivity*—the provision of voice services, in addition to data, would require the entrant to install switches and infrastructure connectivity. Based on experience in other jurisdictions as considered by ICC, this cost has been estimated at NZ$2m per 2,000 connections. The figure has been converted into a per-connection cost on the basis of an amortisation over an expected economic life of 20 years. It is acknowledged that there may be economies of scale and therefore the relationship between costs of the switch and number of lines may not be linear. In addition, it is assumed that the cost for business connections is 30% higher than residential connection in the central case.

ISP services

It has been assumed that the provision of ISP services is already competitive. Thus, the retail price of these services includes only a return on investment. Accordingly, the costs of providing the services are set at the same level as the retail price has been set at the cost of consumption. That is, for residential services, the entrant incurs NZ$240 of annual

[36] Based on the experience from other jurisdictions, as considered by ICC.
[37] Based on the experience from other jurisdictions, as considered by ICC.
[38] Oftel (2000), 'Determination under Condition 83.16 of the Licence of British Telecommunications plc Relating to the Charges for the Provision of Metallic Path Facilities and Associated Internal Tie Circuits', December.

cost; and, for business, NZ$214. This is a conservative assumption as it does not allow any contribution from ISP services to support the entry decision.

Non-LLU costs

Two categories of cost have been considered:

- core network operating costs; and
- marketing and customer services operating costs;

The estimation of the core network operating costs has been based on BT's regulatory accounts for the year 2002, because no disaggregated information between network and non-network elements for TCNZ and TelstraClear was available.

The approach adopted is as follows: the proportion of network OPEX over total OPEX of BT's wireline business (ie, Network, Retail Narrowband Access business, and Retail Systems business) is estimated.[39] The total OPEX for the wireline business excludes notional payments from BT Network. This results in a proportion of 11.6%, which is applied to TCNZ's total OPEX (NZ$1,214m) for the wireline business, as contained in TCNZ's Annual Report for the year ended June 30th 2002. This gives an estimated NZ$141.1m for an entrant's core network OPEX.

The headline per-connection cost used is NZ$83, derived by dividing the total figure by the number of TCNZ access lines at end of June 2002, estimated at 1.7m. This figure is used for Option 1, or full unbundling. A lower figure of NZ$70 is used for Option 2 and 3, as there neither Option includes voice services, so the allocated operating costs have been reduced. It is assumed that regulatory costs are recovered as part of the operating costs.

The non-LLU network cost per business connection is set at 30% over the cost of a residential connection, since more network capacity may be required for business connections.

Marketing and customer services costs have been estimated to total NZ$100 per residential connection, based on experience from ICC. These costs are recovered partly through a direct charge and partly through the costs of providing ISP services, since there is an economy of scope in marketing activities as a result of providing both the broadband connection and ISP services. Again, business connections are assumed to cost 30% more than residential connections.

It is assumed that these costs would remain the same if the entrant provided voice services, versus providing bundled data and voice services.

[39] The categories included in the network OPEX are main and digital junction switch; local to remote transmission (link and length); local to tandem transmission; tandem to tandem transmission; product management; interconnect connections; and data services.

Return on sales

A return of 15% on the sum of the different costs components previously mentioned is included to allow for an appropriate return, in the central case.

5.2.4 Number of subscribers

The total number of telephony subscribers in New Zealand is assumed to stay flat going forward. The numbers used correspond to the PSTN circuit ends supplied by TCNZ.[40]

5.2.5 Penetration of high-speed data services

As detailed above, the number of subscribers per ESA per year for data services is determined as follows

Number of subscribers = price × price elasticity × penetration rate ×
take-up rate × (1 – competing technology churn) × number of lines

The price has already been considered above. The remaining elements are considered below.

Price elasticity

Specific price elasticities for New Zealand were not available, so information was sought on evidence of elasticity calculations in other countries for take-up of high-speed data services. Table 5.12 summarises the papers identified.

Table 5.12: Summary of academic research on high-speed data price elasticities

Demand price elasticity for high-speed residential cable–modem Internet access between –1.08 and –1.79	Kridel, Rappoport and Taylor (2000)
Point demand price elasticity for residential broadband in the USA between –2.15 and –3.76.	Goolsbee (2001)
Own-price demand elasticity (DSL): –1.18	Crandall, Sidak and Singer (2002)
Own-price demand elasticity (cable modem): –1.22	
Own-price elasticity for broadband Internet access: at least –2	BT (2003)
Own-price demand elasticity (DSL): –1.46	Telecommunications Research Group, Colorado University (2002)
Own-price demand elasticity (cable): –0.59	
Own-price demand elasticity (broadband) between –1.3 and –3.1 (based on experiment)	Varian (2002)

Sources: Kridel, D., Rappoport, P. and Taylor, L. (2000), 'The Demand for High-Speed Access to the Internet: The Case of Cable Modems', 13th Biennial Conference of the International Telecommunications Society. Goolsbee, A. (2001), 'Subsidies, The Value of Broadband, and The Importance of Fixed Costs', GSB University of Chicago. Crandall, R., Sidak, J.G. and Singer, H. (2001), 'The Empirical Case Against Asymmetric Regulation of Broadband Internet Access', *Berkeley Technology Law Journal*, **17**:3. BT (2003), 'BT's Response to Oftel's Consultation Document "Review of the Wholesale Broadband Access Market"', July 7th. Telecommunications Research Group (2002), 'Broadband Demand Study: Final Report', University

[40] Data received from TCNZ, July 9th 2003.

of Colorado at Boulder, November 15th. Varian, H. (2002), 'The Demand for Bandwidth: Evidence from the INDEX Project', University of California at Berkeley.

The estimate used in the model was an elasticity of –1.5 in the central case. As can be seen from the table, this is a reasonably conservative approach, as the range of industry elasticities is from –1.08 to –3.1, and there are a number of studies reporting figures of around –1.5.

Penetration rate

The overall level to which demand will ultimately rise, given a particular price and sufficient time for consumers to adopt the new services, is referred to as the penetration rate. Ideally, this level should be identified through the use of detailed consumer survey information. TCNZ was unable to provide OXERA with this evidence, although it is understood that some market research of this form has been undertaken in the past.

In consultation with Commission staff, OXERA determined that the penetration rate would be determined in relation to Internet take-up in New Zealand. It was considered that, if prices were to fall by 20% from current levels, it is likely that penetration would reach 50% of current Internet penetration. In order to determine an estimate of the current level of penetration on this basis, this 50% estimate was rebased to account for the fact that prices have yet to fall 20%. Thus, 30 percentage points were deducted, resulting in an initial multiplier for penetration of 20% of current Internet penetration.[41]

As no individual statistics were available for business customers, it was assumed that current Internet penetration would be much higher than for business than for residential customers. A figure of 85% total penetration was used, without any difference between geographical areas. The multiplier applied to this to determine the base broadband penetration was 35%. This is higher than for residential customers, reflecting the fact that businesses are more likely to take broadband.

Take-up rate

It is a common feature of technology markets that consumers take time to adopt the new technology, even if it is at a price that they find attractive. There will therefore be a rate at which adoption occurs, referred to as the 'take-up rate'.

High-speed data services are relatively new throughout the world, so no areas, including New Zealand, are likely to have reached the peak of their demand profile. Accordingly, the full take-up profile is unknown, so a proxy measure must be used.

[41] This is calculated by multiplying the 20% price fall by the elasticity factor of –1.5 to determine the penetration effect resulting from the 20% price change. As this price change has yet to arise, penetration was reduced by 30 percentage points, to 20%.

The take-up of PCs in New Zealand has been used as the model to determine the profile of broadband adoption. Computers are a high-technology product, and the market is highly competitive, so it has similar economic characteristics to high-speed data services.

Detailed data on computer take-up was available from 1995 to date, and this provided a partial profile of take-up. In order to complete and derive take-up from introduction, the profile was backwards inducted to zero over three years. The resulting profile, expressed as a percentage of the total penetration that is achieved in each year following the introduction of high-speed data services, is shown in Table 5.13.

Table 5.13: Take-up profile

Year	1	2	3	4	5	6	7	8
Take-up	5%	14%	28%	42%	54%	70%	84%	100%

Competing technology churn

The above calculation results in an estimation of the number of subscribers that are likely to take high-speed data services, but not necessarily ADSL. Therefore, the model allows for a proportion of subscribers to choose to take their services from alternative infrastructures—mainly cable, satellite or wireless.

There are drawbacks with satellite and wireless that suggest that these infrastructures may not be direct substitutes for the fixed wireline. Nonetheless, consumers do currently switch from TCNZ to these different networks. Therefore, the competing technology churn factor has been set at a low level, at 5%.

5.2.6 Apportionment of subscribers between TCNZ and entrants

The new entrants gain subscribers in two ways: through churn from TCNZ; and through competition with TCNZ for new subscribers.

The churn rate used in the model is a blended rate between business and residential, and is set at 5%. This is a net churn rate, which means that it takes account of both churn from TCNZ, and win-back by TCNZ from the entrant. The 5% figure is derived from the experience of competition between TCNZ and TelstraClear in Wellington and Christchurch.

The competitive acquisition rate is 25%, implying that entrants gain 25% of all new subscribers, with the remainder going to TCNZ. This is less than 50% market sharing, as might be expected in a fully competitive situation, recognising that TCNZ is likely to retain an element of consumer loyalty, despite the market liberalisation.

5.2.7 Economic feasibility test for entry

The test for whether firms enter the market is based on an NPV analysis of the expected costs and revenues. The relevant costs are discussed below and the revenues are generated from the number of subscribers that the entrant acquires (discussed above) multiplied by the relevant price.

The only additional data item required for this part of the analysis is the discount rate, and this should reflect the entrant’s cost of capital. The value for this is assumed to be 13% on the basis of TCNZ’s submissions to the Commission in relation to the TSO. This is also similar to the costs of capital in the recent UK Competition Commission investigation of the UK mobile operators.[42]

Costs for entry decision

The model uses an NPV calculation to model the entry decision that an operator might make. The costs used for the NPV calculations are grouped as follows:

- one-off set-up costs;
- investment in DSLAMs;
- ongoing (per year, per exchange);
- fixed one-off costs per line; and
- variable costs per line.

The sources of information are the same as those described in the previous sub-section regarding prices under designation.

One-off data set-up cost

For the provision of data services, the following costs have been identified:

- *collocation*—these costs are adjusted depending on the type of exchange (ie, metro, urban, suburban, and rural). The average number of lines per type of exchange has been derived from the number of lines in range, as determined by TCNZ, adjusted by the penetration of broadband. Then, the average number of lines per type of ESA is multiplied by the average set-up collocation cost per connection, as considered in the previous sub-section. It is assumed that, under designation, these costs would represent 75% of the costs under specification;
- *backhaul*—one-off installation costs are calculated per exchange according to location, as for collocation. Figures are those presented in the previous section;
- *tie cables*—the cost of tie cables is calculated as 3% of the total for collocation, and backhaul, for each type of exchange location.

One-off voice set-up cost

- *backhaul*—one-off installation costs are calculated per exchange according to location, as for collocation. The incremental backhaul set-up costs to provide voice services, in addition to data services, are calculated as the difference between the backhaul costs to provide the bundle of voice and data, and data only;
- *tie cables*—as explained previously, it is assumed that the tie cable costs to provide voice and data services are 5% higher than the costs to provide data only;
- *switch and infrastructure connectivity*—these are estimated at NZ$1,000 per connection. An average cost is derived for each type of exchange location, using the average number of connections per location, adjusted by the churn rate

[42] OXERA has not carried out its own assessment of TCNZ's cost of capital, and the use of the 13% value in the modelling work does not imply that OXERA considers this to be TCNZ's cost of capital.

accumulated over a five-year period. This reflects the notion that the entrant would not provide voice services to all the lines in range in an exchange. As mentioned before, it is acknowledged that there may be economies of scale and therefore the relationship between costs of the switch and number of lines may not be linear.

Table 5.14 presents the total data and voice set-up costs per type of ESA.

Table 5.14: Total set-up costs per type of ESA (NZ$)

	Specification		Designation	
Type ESA	**Data**	**Voice**	**Data**	**Voice**
Metro	[✂]	[✂]	[✂]	[✂]
Suburban	[✂]	[✂]	[✂]	[✂]
Urban	[✂]	[✂]	[✂]	[✂]
Rural	[✂]	[✂]	[✂]	[✂]

Source: OXERA calculations.

Fixed one-off costs per line
The wholesale access connection charge is determined by COVEC at NZ$172.46 per connection. It is assumed that this value represents 75% of the charge that would prevail under specification. Furthermore, it is assumed that the incremental charge to provide voice in addition to data services is zero.

DSLAMs
The cost of installing a DSLAM depends on the average number of connections per entrant, as supplied by TCNZ. The model chooses the size of DSLAM that is required to serve the expected number of subscribers over a two-year investment cycle. That is, the model checks every two years after the initial upgrade of the ESA whether a new DSLAM is necessary to cope with the expected demand for the coming two years.

Variable cost per line
Three cost elements have been identified for the bundle of voice and data services:

- the wholesale access rental charge used is determined by COVEC at NZ$286.20 per year, per connection;
- the costs of marketing and customer services are estimated at NZ$50 per residential connection; these costs are increased by 30% for business connections; and
- the cost of providing ISP services, set at NZ$240 for residential and NZ$214 for business (annualised). In the case of residential, the ISP cost represents the forward-looking charge that consumers are likely to pay as they migrate towards faster broadband packages.

Ongoing costs
Ongoing costs are incurred every year following unbundling, but cannot necessarily be attributed on a per-connection basis. This category includes core network operating costs and the costs of regulatory submissions. As explained in the previous section, the per-connection cost has been estimated at NZ$83, which has then been multiplied by the average number of lines per type of ESA to derive ongoing costs under designation.

Under specification, the cost is reduced to NZ$[✂] to reflect the fact that no costs for a pricing determination are incurred under specification.[43]

5.2.8 Consumer welfare calculation

The price and new subscriber aspects of the welfare effects are calculated based on the subscriber numbers derived using the data outlined above. In addition, the prices used are the initial pre-unbundling price, and a weighted average of the prices of the entrant(s) and TCNZ's response price. This weighted average is calculated in the standard manner, weighting TCNZ's response price by its number of subscribers, and the entrant's price by the number of its subscribers.

In addition, a discount rate is used to discount the welfare benefits. This is approximated at 6%, being the yield on New Zealand government bonds.

5.3 Line sharing

5.3.1 Levels of switching

The level of switching between TCNZ and the entrant is determined by the churn rate of 5%, an estimate based on information from TCNZ, as discussed above.

5.3.2 Prices

Specification

The derivation of retail price under specification follows the same methodology described in section 5.2.3 for the option of full LLU (Option 1). The same assumptions are made in the central case: profit reduction of 10%; efficiency improvements of 3% per annum; and LLU costs of NZ$[✂] per annum, per connection.

Table 5.15 presents the derived retail price (ie, annual charge) faced by residential and business customers under full competition (P_2). Again, the price reduction is assumed to be achieved over five years. The pre-entry prices (P_0) for residential and business data have been estimated in Table 5.4.

Table 5.15: Retail prices under full competition—line sharing (NZ$ per year)

Price end of year	Residential customers	Business customers
P_0	813	1,428
P_2	659	1,133

Source: OXERA calculations.

[43] The cost of NZ$[✂] is determined by taking the regulatory costs to be incurred by entrants which amounts to NZ$[✂] (figure provided by the Commerce Commission), amortising this over 5 years and 50,000 subscribers.

P_0 has been calculated as a 'representative' retail good, using the profile of consumers across the retail data products available from TCNZ (as shown in Table 5.3) to arrive at a weighted retail price. It includes ISP charges.

The estimation of retail prices under partial competition, P_1^E and P_1^T, follows the same methodology described previously for the option of full LLU.

As the packages offered by TCNZ and TelstraClear were not strictly comparable, it was not possible to derive a competitive response price. Therefore, TCNZ's response for residential data is assumed to equal the entrant's price—ie, a competitive-response factor of 0%. The same competitive-response factor was applied to business data.

Table 5.16 presents the central-case results of the residential and business retail annual charge for data services under line sharing and partial competition—ie, P_1^E and $P_1^{T.}$

Table 5.16: Retail prices under partial competition—line sharing (NZ$ per year)

Price	Residential customers	Business customers
Entrant (P_1^E)	725	1,246
TCNZ (P_1^T)	725	1,246

Source: OXERA calculations.

Designation

The approach used to determined retail prices for data services under designation follows the same bottom-up approach described in section 5.2.3. The following costs items are assumed to be the same as for full LLU:

- DSLAMs; and
- collocation set-up.

Regarding the remaining cost components, the main differences are:

- *non-LLU network and non-network costs*—under line sharing, these costs are set at NZ$70 per connection (NZ$83 under full LLU), to reflect the fact that less cost is incurred as there are no voice services;

- *wholesale prices for shared access*—the wholesale charges for line sharing are based on estimates provided by COVEC. They estimated an annual rental charge for share access of NZ$134.5 per connection, and a shared access connection charge of NZ$203.68,[44] which has been amortised assuming an expected life of a connection of five years;

[44] COVEC (2003), op. cit.

- *tie cables and backhaul*—the costs of tie cables and backhaul are assumed to be 5% higher when the entrant provides voice and data services, than when data-only services are provided;

- *switch and infrastructure connectivity*—the provision of data-only services does not involve switch and infrastructure connectivity, and hence no costs are incurred.

Table 5.17 presents the resulting prices for line sharing under designation. As in the case of full LLU, P_1^E is assumed to be 10% higher than P_2, with P_1^T equal to P_1^E. The table also presents the value of P_0 that would prevail if no entry occurs under designation.

Table 5.17: Retail prices under designation—line sharing (NZ$ per year)

Price end of year	Residential customers	Business customers
P_0	813	1,428
Entrant (P_1^E)	701	720
TCNZ (P_1^T)	701	720
P_2	637	655

Again, the ISP charges are included in the retail prices calculated, using the weights identified in section 5.1.4.

5.3.3 Entry decision

The data used to derive the prices and number of subscribers has already been discussed, as has the discount rate. Regarding the costs, the following categories remain the same as those considered in section 5.2.7:

- one-off data set-up costs;
- investment in DSLAMs; and
- ongoing (per year, per exchange);

However, the following costs categories differ from the full LLU option. These mainly refer to the different wholesale charges for shared access. In particular:

- *fixed one-off costs per line*—these correspond to the wholesale shared access connection charge, as determined by COVEC for the case of designation. It is assumed that this charge is 75% of that which would prevail under specification;
- *variable costs per line*—these correspond to the wholesale shared access rental charge plus marketing and consumer services OPEX, plus the ISP charge. It is also assumed that the level of rental charge under designation is 75% of the charge that would prevail under specification, as the costs used in specification are those provided to OXERA for modelling purposes by TCNZ without validation by the Commission. It is likely that there would be some reduction in these costs following regulatory intervention.

5.3.4 Welfare calculation

The prices and subscriber numbers have been detailed above. The weighted average price is determined in the same manner as in section 5.2.8, and the discount rate used is also the same.

5.4 Bitstream access

5.4.1 Availability of bitstream access

It is assumed that bitstream services will only be available where TCNZ has upgraded an exchange (ie, installed a DSLAM) or has indicated that it intends to do so.

5.4.2 Entrant subscribers

As with LLU data services, the entrant gains subscribers from TCNZ and through competition in the market. The forecast of potential subscribers is derived using the same data as in section 5.2.4.

Given that the services offered by the entrant over bitstream are assumed to be the same as those available using LLU data services, the churn competitive acquisition rates are also assumed to be the same.

5.4.3 Prices

Specification

It is assumed that the retail prices in the provision of bitstream services for residential and business customers are the same as those estimated under the line-sharing scenario, where the entrant provides data-only services. This is because, although the modes of delivery differ, end products provided to the consumer will be reasonably substitutable, at least initially. Therefore, the retail prices shown in Tables 5.15 and 5.16 are also used for this case.

Designation

The approach used to determined retail prices for bitstream data services under designation follows the same bottom-up approach described previously. There are some cost differences with respect to the line-sharing option. Under bitstream, the entrant does not have to incur the costs associated with collocation, DSLAMs, and tie cables, as these are incurred by TCNZ. These costs have therefore been excluded from the bottom-up calculation. In addition the non-LLU network costs were reduced to NZ$70, as noted in Section 5.2.3.

Furthermore, the wholesale rental charge per connection is assumed to be higher than the rental charge for line sharing, as it should account for the cost of DSLAMs, operating expenditure related to the DSLAMs, and other related costs, such as a contribution to the network costs up to the point of interconnection.

Table 5.18 presents the resulting prices for data services under designation.

Table 5.18: Retail prices under designation—Bitstream (NZ$ per year)

	Residential customers	Business customers
P_0	813	1,428
Entrant (P_1^E)	720	739
TCNZ (P_1^T)	720	739
P_2	654	672

Source: OXERA calculations.

Again, ISP charges are included, using the data presented in section 5.1.

5.4.4 Entry decision

The entry decision takes the prices, costs and subscribers derived above and determines the NPV of entry on an ESA basis. The discount rate is the same as in section 5.2.6. The costs used for the NPV calculations are similar to Option 2 (line sharing), with the following two main differences:

- the only set-up cost per type of ESA considered is that of backhaul, as presented in section 5.2.3. As explained before, the collocation set-up and tie cables are not incurred by the entrant; and
- the wholesale access rental charge is estimated at NZ$194.5 in the central case. This estimate comprises NZ$134.5 for the line sharing wholesale rental charge, plus NZ$60 to cover additional fixed costs (eg, DSLAMs) incurred by the incumbent.

5.4.5 Welfare calculation

The estimate of the impact on welfare is also generated in the same manner as for section 5.2.8, using the weighted average entrant and TCNZ prices determined in section 5.4.2.

5.5 PDN

5.5.1 Possible subscribers

It is assumed that the number of potential PDN subscribers stays flat. The total number of PDN subscribers is taken to be 'Non-PSTN' lines, as supplied by TCNZ.[45]

5.5.2 Entrant subscriber acquisition

By definition from section 5.5.1, the entrant will only be able to acquire customers that are already subscribing to TCNZ services, as these are the only customers with PDN lines. There are no networks that currently offer the same services, as TCNZ is able to provide on its PDN. Therefore, there is no experience in New Zealand on which to draw to determine the churn rate. In consultation with the Commissioners, the rate was set at 10%.

5.5.3 Prices

As mentioned previously, it is difficult to identify a single, or even representative, service that is delivered over the PDN. This is because the types of service that can be provided are significantly different, with important price variations between products. The pricing structure generally includes an installation charge and monthly charges for access and transmission. However, the price paid will depend on a number of factors, including location of head office, and number and type of branches (ie, whether they are connected to CBD, metro, or regional exchanges). In consultation with the Commission staff, two services were used to determine the price of the representative product: Frame Relay and Digital Data Services. The prices of these services, which were provided to the

[45] Data received from TCNZ, July 9th 2003.

Commission by TCNZ, are based on a sample customer. A summary of these sample prices is presented in Table 5.19.

Table 5.19: TCNZ's data services (sample customer) (NZ$)

Data product	Installation charge	Access charge (monthly)	Transmission charge (monthly)
Frame Relay[1]	[✂]	[✂]	[✂]
Digital Data Service[2]	[✂]	[✂]	[✂]

Note: [1] This refers to a sample customer with [✂][2] This refers to a sample customer with [✂].
Source: Data received from TCNZ, July 16th 2003.

The variable price of the representative products is an average of the annualised access and transmission charges, weighted by the proportion of customers in these services.[46] The resulting price corresponds to an average price for a sample customer that has a head office and eight branches. This average price has been expressed in terms of average price per tail/exchange. The resulting annual price per tail corresponds to P_0, and is presented in Table 5.20.

Costs relating to the recovery of TCNZ's OSS costs from the entrant(s) of NZ$[✂] per year have been added to the prices.

Specification

The estimation of prices under specification follows the same top-down methodology used in the other options, assuming a one-off profit reduction of 10%, and efficiency improvements of 3% per annum. Table 5.20 presents the derived retail prices for PDN services under full competition. It also shows the retail prices under partial competition, P_1^E and P_1^T. The derivation of these prices follows the same methodology described previously for the other options. It has been assumed that the competitive-response factor is equal to zero, as in the options of line sharing and bitstream. Therefore, TCNZ's response price is assumed to equal the entrant's price.

Table 5.20: Retail prices under partial and full competition—PDN for specification and designation (NZ$ per year, per tail)

Price	Specification	Designation
P_0	[✂]	[✂]
Entrant (P_1^E)	[✂]	[✂]
TCNZ (P_1^T)	[✂]	[✂]
P_2	[✂]	[✂]

Source: OXERA calculations.

[46] Data received from TCNZ, July 16th 2003.

Designation

As mentioned before, the price of the representative product is based on a sample customer with one headquarter and eight branches in CBD, metro, and regional areas. Building the price under designation using a bottom-up approach would require the identification of all the relevant cost categories for the provision of services over the unbundled PDN. However, most of the costs are likely to depend on the type of ESA. Given the difficulty in matching these costs to a representative product (a problem not encountered in the other options), and the absence of detailed cost information, a top-down approach is used to determine retail prices for the representative service provided over the PDN under designation. In particular, it is assumed that prices under designation would represent 75% of those that would prevail under specification.

In addition, the costs of regulatory submissions, estimated at NZ$[✂] per annum, have been added to the designated prices.

5.5.4 Entry decision

The entry decision is based on the same NPV calculation as described in the other scenarios, using the same discount rate. Regarding the costs, it is assumed that the data services to be provided over the PDN are services with a speed of up to 2Mbps, as these could be supplied over copper circuits. For services over 2Mbps, different technology, such as radio or fibre, would be required.

As with demand, the available information on the costs underlying the provision of PDN services is very limited. Assumptions have been made, based on experience from other jurisdictions. As noted above, it is assumed that an entrant would provide PDN services only over existing data tails, and therefore would incur the costs of unbundling, rather than those of installing the data tails. The different cost components were calculated for the sample customer specification (ie, one head office and eight branches, each at a different exchange). These costs were then converted into cost per exchange/tail. The following cost categories have been considered.

Set-up costs

- *collocation costs*—assumed to be the same as those incurred in the case of line sharing;
- *backhaul costs*—it is assumed that these are 40% higher than those incurred under the line sharing and bitstream options; and
- *connectivity from the DSLAM to the digital distribution frame (DDF)*—this cost is assumed to be equivalent to 3% of the sum of collocation set-up and backhaul costs.

Ongoing costs

Ongoing costs per exchange are assumed to be the same as those incurred under line sharing.

Fixed costs per tail

The wholesale connection costs are assumed to be equal to the one-off retail installation charge (NZ$[✂])[47] minus 20%, and re-expressed in terms of cost per tail per exchange. It is assumed that, under designation, these costs will be equal to 75% of the level that would prevail under specification.

DSLAMs

For data services with a speed of up to 2Mbps, it is assumed that an entrant would install DSLAMs that can support symmetric and asymmetric DSL. The costs of installing a DSLAM have been assumed to be the same as those considered in the other options.

Variable costs per tail

The wholesale variable charge also follows a retail-minus methodology. It is based on a simple average of P_1^E, P_1^T and P_2, minus 20%.

5.5.5 Consumer welfare calculation

The estimate of the impact on welfare is generated in the same manner as for the other options. Unlike the other options, since it has been assumed that no further tails will be added, the take-up effect (ie, where the price falls lead to an expansion of take-up) is zero. Therefore, the welfare calculations accounts only for the price effect, where existing consumers benefit from a price reduction.

[47] Data received from TCNZ, July 16th 2003.

OXFORD ECONOMIC RESEARCH ASSOCIATES

NEW ZEALAND COMMERCE COMMISSION

EFFICIENCY ANALYSIS TO SUPPORT COST–BENEFIT ANALYSIS

SEPTEMBER 2003

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Executive Summary

This paper provides a review of the comparative-efficiency analysis of Telecom New Zealand (TCNZ) undertaken by PwC Consulting (PwCC), the results of which are detailed in its September 2002 report, 'TCNZ Efficiency Study Based on Stochastic Frontier Analysis (SFA)'.

In view of the lack of domestic telecommunication network operators against which to compare TCNZ, PwCC chose to use US local exchange carriers (LECs), which are responsible for local networks in the USA. A stochastic frontier model was then applied to this dataset in order to produce the relative efficiency estimates.

The robustness of the results from any comparative-efficiency analysis will depend on whether due process has been followed in the following critical areas.

- The definition of the efficiency measure to be used and the choice of comparators:
  - alternative definitions and comparative estimation techniques are discussed in order to provide a theoretical foundation to the review;
  - ideally, comparators should be chosen on the basis that their activities are comparable; however, in practice, the choice is often driven by the availability of data.

- The choice of relevant inputs, outputs and environmental factors, and adjustments to them to improve comparability—ensuring a balance between inputs and outputs and consistency across observations is crucial to the results of the analysis. Adjustments to the data, although sometimes necessary to ensure that like-for-like comparisons are made, can introduce bias into the analysis.

- The comparative-efficiency technique(s)—as each technique has idiosyncrasies, it is usually best to apply a number of alternative approaches.

A review of the PwCC report identified that, in the last two of these areas, there are several instances where PwCC's analysis might have introduced bias into the results, as discussed below.

OXERA's comparative-efficiency assessment found that in order for TCNZ to reach an efficient position, annual cost reductions within the range of 2.3–5.2% are required. This range represents the required savings that TCNZ needs to achieve to reach the efficient performance relating to the year 2000 (the year to which the data used in the analysis corresponds). However, the rapid technical and technological progress observed in the telecommunications industry results in large productivity gains that can be achieved over time, which can be confused with changes in efficiency. To control for these potential productivity gains, a 'frontier shift'—a measure of general industry (or minimum) improvements in productivity over time—needs to be estimated. However, this was beyond the remit of this study.

Inputs—choice, definition and adjustments

To provide a more complete picture of cost efficiency, PwCC chose to assess each company based on total expenditure. However, it used the accounting definition of capital costs, which includes depreciation and the cost of capital. It can be argued that this

definition might be inappropriate in this case, since comparative efficiency requires *economic* data—ie, data that reflects as accurately as possible the actual consumption and replacement of resources.

This definition of capital costs raises a number of issues. First, it includes depreciation, which, due to the fairly flexible treatment of accounting information allowed by US and New Zealand accounting practices, requires some form of standardisation. Even when a robust standardisation mechanism is applied, this does not necessarily mean that the comparisons are like-for-like if the capabilities of the underlying assets in LECs and TCNZ differ markedly.

A second issue relates to the inclusion of the cost of capital. Financing costs are not usually covered by a cost-efficiency analysis and there is a significant risk of double-counting when depreciation is also included in the analysis. Asset values and depreciation are highly correlated, especially in this case, where depreciation itself is a function of the asset base and a common (to all assessed companies) asset depreciation profile. Thus, the inclusion of a cost of capital element in the analysis artificially increases the relative impact of the value of the asset base on the efficiency estimates. This leads to the efficiency of companies with large networks (and thus asset base) being understated, while that of smaller companies is overstated.

Lastly, the use of cost of capital in comparative efficiency assessment provides incentives for underinvestment. Two companies with identical outputs and cost structure may display different asset base values due to deferred investment by one of them. When these companies are assessed in a comparative-efficiency setting that includes cost of capital, the company with the smaller asset base value will appear more efficient, although the differences are in fact the results of deferred investment. The practice of using depreciation as a substitute for capital expenditure (CAPEX) also suffers from this lack of discrimination between inefficiency and deferred investment; the inclusion of a cost of capital measure will only serve to amplify the incentives for underinvestment. The inclusion of the cost of capital in the definition of total cost is therefore likely to result in an understatement of TCNZ's relative efficiency.

The third issue relates to the aggregation of the components that make up the total cost. Aggregating the various cost categories into a single cost measure by summing them is not necessarily optimal owing to the bias that could be introduced into the analysis as a result of assuming that the marginal rate of substitution (MRS) between operating expenditure (OPEX) and CAPEX is equal to one.

Undertaking a comparative-efficiency analysis can be difficult, especially when differences in reporting requirements and/or data availability necessitate data standardisation, which is usually the case when international comparisons are made. The process of data standardisation needs to consider—and, where possible, correct for—inconsistencies in both financial and operational data. Such inconsistencies are usually caused by:

- differences in the outputs produced (services offered);
- differences in accounting methods;
- different definitions and availability of control variables;
- price differences between countries; and
- lack of available data for the same period.

To allow for the fact that the LECs and TCNZ offer different services, PwCC removed all costs relating to international calls. However, deducting costs that relate to services not offered by the LECs or TCNZ, respectively, does not necessarily ensure comparability, since any potential economies of scale and scope that may exist are not taken into account. It is also possible that there are internal cross-subsidies between functions within each operator, which cannot be accounted for by the approach adopted. This could have the effect of inflating TCNZ's relative efficiency estimate.

The differences in accounting practices were dealt with by converting asset expenses from a historic-cost accounting (HCA) to a current-cost accounting (CCA) reporting format. With regard to the formula used for this conversion, a problem may arise with the simultaneous use of a general inflation rate, which is country-specific, and the telecoms-specific inflation rate. The formula to derive CCA values from HCA values compounds general and telecoms-specific inflation rates. This would only be appropriate if the telecoms-specific rate is an **adjustment** to the general inflation rate. If, on the other hand, it is in itself a telecoms-specific inflator, which already includes the effects of the general inflation, the inclusion of the general inflation rate in the formula could not be considered justifiable.

Outputs—choice, definition and adjustments

The adjustments made by PwCC to output and environmental factors (or variables) were mostly due to some LEC data not being available. Adjustments to the access lines variable (ie, the use of leased-line ends instead of pure leased-line numbers) do not appear equitable, since disproportionate weight is placed on the leased-lines category (given that the other line categories are not subject to any weighting factor), which requires assumptions to be made. A more equitable treatment might have been to use pure leased-line numbers rather than leased-lines ends, to avoid bias being introduced into the analysis. The likely effect of such bias would be to overstate TCNZ's efficiency estimate.

The call minutes variable for the LECs was not directly available as they only report the number of calls. PwCC therefore estimated call minutes according to average call duration. This average figure is based on calls with the most expensive tariff, which could introduce significant bias into the analysis by artificially reducing one of the outputs produced by the LECs and thus inflating TCNZ's efficiency estimate.

Application of comparative-efficiency technique(s)

Apart from the issues relating to data collation and standardisation, the robustness of efficiency analysis depends to a large extent on the appropriate application of the estimation technique. The first step in this process is to identify all the factors that could influence costs (as discussed above) and to specify a functional form to describe the general form of the relationships between them (if parametric techniques are used).

The choice of functional form will have a significant impact on the accuracy of the efficiency estimates. PwCC used a Cobb–Douglas functional form, which has the drawback of not permitting alternative types of returns to scale at different scale sizes (due to the function being homogeneous to the first degree). A more flexible functional form (eg, translog) might be more appropriate in this case. Another alternative could be to bypass completely the issue of functional form specification by using data envelopment analysis (DEA), which does not require a function form to be specified. DEA also treats returns to scale equitably by allowing increasing, constant and decreasing returns to scale to be displayed by the same model, based on relationships between inputs and outputs that are informed by the data.

The second step is then to narrow these factors down to the most important by applying a variable selection methodology. In PwCC's analysis, it first removed variables that displayed high correlation due to the fear of possible multicollinearity. However, given that multicollinearity does not affect the efficiency estimates when panel data is not available, the exclusion of possibly significant variables for this reason does not appear justifiable. PwCC then used a 'backwards' orientation approach to select the variables to be used in its model. While valid, this approach is usually used only as a cross-check on results from the general-to-specific approach (considered by econometrics practitioners to be best practice), since it could ignore mutually supporting relationships between variables, and thus conclude that such variables are insignificant.

The third step in the process is the application of the chosen estimation technique(s) to the data. PwCC chose to consider only stochastic frontier analysis (SFA), but applied this in such a way that it cannot be considered to be a traditional SFA approach. For example, PwCC's set its model parameters (ie, the regression constant and the variable coefficients) based on average cost levels for given output levels; whereas, in a traditional application of SFA, the prerequisite model parameters are based on minimum costs. This naturally affects the residuals ultimately obtained, and hence the efficiency estimates that are based on those residuals will be inaccurate.

One of the recognised weaknesses of the SFA approach is its reliance on the distributional assumption for the inefficiency component of the residual. It is therefore common practice in comparative-efficiency assessments based on SFA to use a number of alternative distributional assumptions (such as exponential, half-normal or gamma) to obtain the efficiency estimates. In addition, best practice recommends that the efficiency estimates produced by a parametric approach be cross-checked using a non-parametric method, such as DEA, which does not rely on distributional assumptions or indeed function specifications. Any differences in efficiencies obtained from the alternative methods can then be investigated with a view to obtaining a more reliable set of results. PwCC assumed a truncated normal distribution, without considering alternative distributional assumptions.

A point not touched on by PwCC is the common ownership structure of some LECs, which could cause problems in the analysis. Although data for 50 individual LECs is available, a closer examination reveals that they are owned by only 12 independent companies. This could have a significant impact on the efficiency estimates produced, especially if some of the functions common to all LECs are carried out at a group level.

In conclusion, PwCC's comparative-efficiency analysis departs from standard practice and, in a number of areas, its approach appears to introduce bias into the results. Although PwCC was in part successful in collating and adjusting required financial and operational data, its analysis is hampered by the decision to rely exclusively on the results from a single efficiency measurement technique, which then appears to be implemented erroneously. It should be noted, however, that OXERA's assessment presented here is based on a reconstruction of PwCC's methodology described in its report; some differences between OXERA's interpretation and PwCC's actual approach might exist.

Contents

1. Introduction

The analysis in this paper has been carried out in support of OXERA's cost–benefit modelling of unbundling the local loop and public data network, undertaken for the New Zealand Commerce Commission. This paper should therefore be considered in conjunction with the OXERA paper 'Modelling the Impact of Unbundling the Local Loop and Fixed Public Data Network', and the outputs from the analysis have been used to inform the modelling presented therein.

Comparative efficiency has seen widespread application in the regulation of utility companies that were formerly publicly owned, from water and sewerage to gas transportation and storage. In the telecommunications industry, comparative-efficiency analysis based on international comparators has been used, for example, to inform price reductions for BT, the UK telecommunications network operator.

Given the significance of the results of comparative-efficiency analysis, it is crucial for the exercise to be as robust as possible, subject to the nature of the industry examined and the availability of data on possible comparators. The robustness of the results will depend to a large degree on whether the assessment exercise has followed due process, according to current academic standards, and whether the analytical choices taken at critical points in the process can be justified according to the unique nature of such assessment. In a comparative-efficiency assessment, the critical points are as follows.

- *Definition of the measure of efficiency to be used*—the analysis can measure productive or cost efficiency, the latter being more suitable for regulatory purposes. The definition of the measure also has a major influence on the choice of efficiency measurement technique.

- *The choice of comparators*—this is usually determined by the availability of data on companies whose activities could be considered sufficiently comparable.

- *Adjustments to data to improve comparability*—these are sometimes necessary to ensure that like-for-like comparisons are made, especially when international comparators are used.

- *Choice of relevant outputs and environmental factors*—the choice of the outputs and other factors used in the comparisons is crucial to the results of the analysis.

- *Application of the comparative-efficiency technique(s)*—each technique has its own requirements and idiosyncrasies. The efficiency estimates produced need to be 'translated' into terms relevant to the cost or production levels of the company being assessed.

- *Validation of the results*—this is one of the most important steps, since it will determine the robustness of the final estimates and whether they can be used for regulatory purposes.

An overview of the PwCC report identified several instances where the analysis applied might have introduced bias into the results.

- *Definition of the efficiency measure and the choice of comparators*—there are various definitions of efficiency, depending on the underlying measure to be compared, and a number of techniques that could be applied to arrive at the desired measure. However, PwCC considers only a single approach to be relevant, rather than using a number of approaches to arrive at overall efficiency estimates, as best practice recommends. Comparators should ideally be chosen because their activities are similar; in practice, however, they are often chosen because data is available. Section 2 discusses alternative definitions of efficiency and the more widely used approaches to measuring it, together with their relative advantages and disadvantages. It concludes with a discussion on the appropriate use of international comparisons.

- *The choice of relevant inputs, outputs and environmental factors, and adjustments to them to improve comparability*—PwCC's comparative-efficiency analysis is based on a definition of total costs, which might be considered unsuitable for the purposes of this study. Also, in order to improve the comparability of the assessed companies, PwCC made a number of adjustments to the financial and operational data, which, in some areas, appear to rely on simplistic or subjective assumptions. Section 3 examines the definition of total costs and the adjustments to the financial and operational data.

- *Application of the comparative-efficiency estimation technique*—PwCC's approach to variable selection does not appear to be compatible with the general-to-specific approach used for this purpose by most econometric studies and considered to be best practice. Also, its application of SFA does not appear to be robust, given that the analysis is applied to a 'unit cost' measure. Section 4 examines the methodology used and discusses its robustness, offering comparisons with the general-to-specific methodology. Also, given that it is difficult to follow PwCC's methodology for obtaining the 'unit cost' measure, and that the term 'unit cost' could be considered misleading, this topic is discussed in this section.

The final section of this paper presents OXERA's comparative-efficiency estimation procedure and results. The analysis in this section takes into account the points made in previous sections of the paper, and presents an alternative efficiency estimate for TCNZ, which is more firmly grounded in theory and is informed by a range of estimation techniques.

2. Definition and Approaches to Measuring Efficiency

Comparative-efficiency analysis is one of the most widespread techniques for measuring performance. One of its greatest advantages, and the reason behind its widespread application, is the fact that it bases the performance estimate of an assessed company on the relative, *realised* performance of other companies, judged to be comparable. As such, the performance estimate (usually referred to as an 'efficiency estimate') of each assessed company is not derived through the application of arbitrary assumptions, but is obtained by examining the performance of other companies that use similar resources to achieve similar outcomes.

There are various definitions of performance, including measures that relate to revenue efficiency (the ability of the assessed entity to produce revenues), profit efficiency and, more commonly, production and cost efficiency. In any case, efficiency is defined as the ratio of realised outcomes (revenues, costs, outputs, etc) to efficient outcomes. The latter are estimated through the comparative-efficiency process and are based on the realised outcomes of comparator entities, namely organisations, companies, production departments (referred to as 'decision-making units, or DMUs), or, in general, any self-contained unit that uses a set of resources (inputs), to produce a set of outcomes (outputs).

Production and cost efficiency measures are most relevant for regulatory purposes. The latter are commonly used because they are less prescriptive, and thus not only satisfy the criterion of 'arm's length' regulation, as practiced in the UK and the USA, but also sidestep the issue of aggregating inputs into a meaningful, single measure. This is important since, in most real-life applications, the assessed DMUs use various inputs to produce various outputs. Thus, in order to obtain a measure of efficiency, some form of weighting factor is required. Since DMUs usually produce a range of outputs, a methodology for aggregating these into a single output measure is also required; this is usually achieved by applying the chosen comparative-efficiency technique.

The most appropriate efficiency measure to use is linked to the choice of the estimation technique to be employed. There are basically two forms:

- non-parametric techniques, based on mathematical approaches;
- parametric techniques, based on statistical-regression approaches.

These are explored in turn below.

2.1 Non-parametric techniques

Non-parametric techniques make *a priori* assumptions about the form of the relationship between the factors in the analysis. The simplest non-parametric measure for assessing performance, which also happens to be one of the most widely used, is single factor productivity indicators. Data envelopment analysis (DEA) is an extension of these indicators that allows for multiple factors to be considered.

Efficiency is often measured by examining partial productivity indicators. A partial productivity indicator (P_t) is a ratio of one of the outputs produced (Y_t) to one of the inputs used (I_t). The growth in this ratio over time can be interpreted as an indicator of efficiency gains. Therefore, efficiency improvement can be monitored through a change in the productivity measure, as given by Equation 2.1.

$$P_t = \frac{Y_t}{I_t}$$ Equation 2.1

If the productivity measure increases, it can be inferred that there has been technical progress and/or the use of current inputs has become more efficient. In other words, higher levels of output can be provided without using extra inputs, or the same levels of output can be achieved using lower input levels. One of the most widely used partial productivity measures is output per head.

Single factor productivity is the simplest, and most intuitive, measure of productivity. In Equation 2.1, I_t would be replaced with the particular input of interest (eg, labour, capital or raw materials). However, increases in this index cannot be identified solely as technical improvements, since changes in the choice of input mix will influence these measures. For example, if a firm replaces much of its billing workforce with an improved information technology system, per-capita output will increase significantly, although productive efficiency could fall when both inputs are considered. A similar problem arises from an increase in outsourcing, in that the labour productivity measure could increase substantially, concealing an increase in input costs. Also, the use of such ratios does not allow for certain factors not under the company's control ('exogenous factors') to be taken into account. Such factors could, for example, be the geography and demography of an area served by a network industry (such as electricity distribution or telecommunications), or the regulatory environment under which a regulated company operates.

A simple measure of efficiency (ie, output divided by input) is inadequate when multiple inputs or outputs exist. In such cases, weights need to be assigned to each input and output in order to arrive at aggregate measures of total input and total output that will, in turn, be used in the relative efficiency measure. Thus, a common measure for relative efficiency is:

$$\text{weighted sum of outputs} \div \text{weighted sum of inputs}$$

This creates the complication of identifying appropriate weights for each input and output used in the analysis. This complication exists because companies may choose to organise their operations differently and, therefore, value inputs and outputs differently. DEA recognises this and allows each assessed company to adopt an individual set of weights that will maximise its relative efficiency score. The only restriction is that, when these weights are applied to the other companies in the comparator set, none should present relative efficiency scores above 100%.[48] In other words, each company will choose a set of weights that will present its performance in the best possible light, provided that the adoption of this set of weights by another company will not result in its being assessed as

[48] Additional restrictions could be placed on the model according to predefined notions of the intrinsic value of the inputs and outputs.

'super-efficient'. The effects of exogenous factors can also be accounted for using DEA by including these factors in the analysis as an input (if it is deemed that such a factor has adverse effects in the realisation of a company's outcomes), or as an output (if it is established that the factor in question has a positive effect on the company's outcomes).

There are several advantages of DEA analysis. First, it is non-parametric, and thus it is not required to assume *a priori* a functional form for a cost or production function on which the efficiency estimates will be based.[49] Second, it allows comparisons to be made between companies based on non-economic variables, such as performance and quality indicators. For a more thorough discussion, please refer to appendix 1.

2.2 Parametric techniques

Parametric techniques use regression analysis to estimate a mathematical function, usually regarding costs or a single output, which describes the relationship between the dependent variable and various factors that may influence the transformation process (from inputs to outputs). To formulate this function, first the analysis needs to assume a functional form. This will determine the form of the relationships between the dependent variable and the factors to be included in the analysis. The researcher then tests different hypotheses regarding which factors are significant in the input-to-output transformation process and to what degree. The researcher's hypothesis is evaluated through the use of statistical hypothesis testing, which is an integral part in any statistical analysis. After the significant factors have been identified, their relative impact on the dependent variable is estimated by applying the chosen regression technique—the most widely used being ordinary least squares (OLS). This production or cost function will then form the basis for estimating the efficient production or cost level for each company in the assessment.

The analysis does not use the production or cost function *per se* because it relates to average performance, rather than 'frontier', or efficient, performance. Thus, some adjustments are necessary to shift the average function to a frontier position. These adjustments depend on the parametric comparative-efficiency technique employed in the analysis.

Deterministic techniques assume that any deviation from the average production or cost function can be attributed to greater or smaller efficiency relative to the industry average.[50] This is a strong assumption, given that some stochastic (random) element is always present in the analysis, owing to measurement errors, difficulties in quantifying some qualitative factors, or even rounding errors. This stochastic element will introduce some bias into the deterministic analysis, the extent of which will depend on the size of this element relative to the inefficiency component. If it is assumed that the stochastic element is relatively small, the use of deterministic approaches could be justified.

[49] As is the case for the parametric approaches described below.
[50] DEA, discussed in section 2.1, is also a deterministic technique.

Rather than assuming that the analysis is free from any significant stochastic element, it is more equitable is to use a technique that allows the analysis to quantify this element, and thus correct for it. Usually referred to as stochastic techniques, the most widely used and well-developed example is stochastic frontier analysis (SFA).

Given that stochastic approaches are superior in terms of the robustness of the efficiency estimates produced, a pertinent question could be why SFA has not rendered the other deterministic techniques obsolete. This is because the estimation of the stochastic component requires restrictive assumptions regarding the distribution of the inefficiency component (ie, how widespread the inefficiency is in the industry and the extent to which it is shared between companies).[51] These assumptions are subjective, since the shape of the distribution of the inefficiency component cannot be estimated *ex ante*, which adds a large element of researcher judgement into the process. Also, due to the complex statistical process, SFA requires a well-populated dataset (ie, containing a large number of comparators) in order to produce reliable estimates.

2.3 Summary assessment of the available approaches

Table 2.1 details the relative merits of the various approaches.

[51] This definition is simplified here; for a more technical and precise discussion, see appendix 3.

Table 2.1: A comparison of comparative-efficiency techniques

Problem	DEA	Regression	SFA
Ability to handle multiple inputs and outputs	Yes, simple	Yes, complex and not always accurate	Yes, complex and not always accurate
Specification of the functional form	Not required	Required, mis-specification can have large impact on accuracy	Required, specification of the distribution of the residuals is also required, mis-specification can have a large impact on accuracy
Sample size	Small sample size can be adequate	Moderate sample size required—statistics become unreliable if too small	Large sample size required (more than 50 observations)
Explanatory factors highly collinear	Better discrimination	Possible misleading interpretation	Possible misleading interpretation
Explanatory factors have a low correlation	All efficiency scores tend to be close to unity, although refinements are possible[52]	No problem	No problem
Noise, such as measurement error	Highly sensitive, but refinements can be made	Affected, but not as severely as in DEA	Specifically modelled
Testing, including variable selection	Sensitivity analysis is possible. However, it is complex and therefore more subjective	Straightforward statistical testing	Straightforward statistical testing

Note: Little discrimination is observed, as units appear efficient owing to lack of suitable comparator units. However, refinements are possible, see, for example, Dyson, R. and E. Thanassoulis (1988), 'Reducing Weight Flexibility in Data Envelopment Analysis', *Journal of Operational Research Society*, **39**, 563–76.
Source: OXERA.

As the table illustrates, each technique has advantages and disadvantages, and it is therefore difficult to recommend one technique over any other. The definitive answer will depend on the situation and the main question of interest. With a large dataset, and with careful testing of model assumptions, SFA has few drawbacks—the main one being its sensitivity to the distributional assumption of the residuals. Both OLS and SFA do provide straightforward procedures for testing the significance of individual variables. The parametric methods also give a clear estimate of the size of the relationship between a cost driver and the relevant cost.

[52] Little discrimination is observed, as units appear efficient owing to lack of suitable comparator units. However, refinements are possible. See, for example, Dyson, R. and Thanassoulis, E. (1988), 'Reducing Weight Flexibility in Data Envelopment Analysis', *Journal of Operational Research Society*, **39**, 563–76.

DEA, on the other hand, does not provide a clear-cut framework for hypothesis testing.[53] However, it can provide a wealth of useful information in addition to the simple efficiency ranking of companies. For example, the technique can provide answers to the following questions.

- Which company (or combination of companies) is inefficient company A most like?
- How much does company A need to reduce an input in order to be placed on the frontier?
- What is the nature of returns to scale at each part of the efficient boundary?
- How much of the overall inefficiency is caused by technical inefficiency, allocative inefficiency, congestion of inputs or scale inefficiency?

Over the past ten years, there has been increasing interest in the relevant academic literature regarding the precision of each approach under different assumptions. Banker, Gahd and Gorr, for example, report findings from a Monte Carlo experiment to the effect that the relative precision of DEA and SFA is context-specific.[54] DEA is favoured where measurement error is unlikely to pose much of a threat and where the assumptions of neo-classical production theory are in question. Conversely, SFA should have the advantage of being able to cope with severe measurement error and where simple functional forms provide a close match to the properties of the underlying production technology. Gong and Sickles report findings along similar lines, so that 'as mis-specification of functional form becomes more serious, DEA's appeal (vis-à-vis SFA) becomes more compelling.'[55]

In assuming an environment characterised by measurement errors and stochastic variation, SFA appears (at least at the conceptual level) to produce more accurate results than deterministic approaches. Even so, results drawn from Banker, Gahd and Gorr's (1993) DEA versus SFA comparison 'show DEA to produce more accurate efficiency estimates … even with remarkably high measurement errors present'. SFA only gains the upper hand when measurement errors reach a threshold of between ±17% and ±45% of observed output values (depending on sample size, technology, and the distribution of inefficiency). Results also suggest that SFA is more accurate whenever the sample size reaches a threshold of 50 units and distributional *assumptions* mirror 'actual' distributions of noise and inefficiency. In other words, the expected trade-off applies with relatively few caveats: SFA has the advantage of being able to cope with *severe* measurement error or when the distributional assumptions required in separating measurement error from inefficiency accurately reflect the properties of the underlying production environment.

[53] However, the model formulation stage of a DEA analysis is usually supplemented by some statistical and regression analysis that provides some statistical evidence of the significance of variables likely to be included in the model.

[54] Banker, R.D., Gadh, V.M. and Gorr, W.L. (1993), 'A Monte Carlo Comparison of Two Production Frontier Estimation Methods: Corrected Ordinary Least Squares and Data Envelopment Analysis', *European Journal of Operational Research*, **67**, 332–43.

[55] Gong, B.H. and Sickles, R.C. (1992), 'Finite Sample Evidence on the Performance of Stochastic Frontiers and Data Envelopment Analysis Using Panel Data', *Journal of Econometrics*, **51**, 259–84.

In one examination of performance in the electricity industry, Pollitt favoured DEA over the other techniques in practical applications.[56] In addition, Thanassoulis concludes that DEA offers better estimates of efficiency but at greater variability (ie, certain 'unusual' companies tend to have inaccurate efficiency assessments), as the DEA frontier tends to be defined by only a few companies.[57]

PwCC based its efficiency estimate solely on SFA, whereas the use of two, or all three, of the techniques is considered best practice, with the results from one technique used as a check for robustness on the results of the other. The analysis presented in section 5 attempts to produce efficiency estimates from a DEA model to be used as such a cross-check. However, issues regarding the data prevented the formulation of a robust model and thus the use of non-parametric estimation techniques was abandoned. (For more details, see section 5.2.)

2.4 The choice of comparators

To undertake a comparative-efficiency analysis, a decision needs to be made regarding the appropriate set of comparator DMUs (in this case, telecommunications network operators). The key factor that determines the comparability between the units of assessment is that they perform the same function(s) in terms of the types of resource they use and the outputs they produce.

International comparisons are usually employed in an efficiency assessment due to the lack of suitable comparators from the same country. PwCC gives some valid reasons for using US LECs as the sole comparators for the analysis, the major one being the availability and robustness of the dataset. The fact that the LECs could be considered to operate in an environment that provides strong efficiency incentives, especially after the shift from rate-of-return regulation to price-cap regulation, is also a good reason for their inclusion in the analysis, since it is likely that the estimated cost benchmarks will be close to international best practice.

When considering whether to use international comparisons in a comparative-efficiency analysis, an important element is the assumption about production technologies (or cost structures, depending on the model employed).[58] There are two options:

- a common frontier technology or industry cost structure may be assumed, allowing comparisons between international companies; or

[56] Pollitt, M. (1995), *Ownership and Performance in Electric Utilities*, Oxford University Press, p. 85.

[57] Thanassoulis, E. (1993), 'A Comparison of Regression Analysis and Data Envelopment Analysis as Alternative Methods for Performance Assessments', *Journal of Operational Research Society*, **44**:11, and (1994), 'Viewpoints—Performance Assessments using DEA: Discussion of "A Cautionary Note"', *Journal of Operational Research Society*, **45**:4.

[58] Production technologies determine the way in which inputs interact with each other in order to produce outputs. Similarly, cost structure determines which factors have an impact, or otherwise drive costs, and what form this relationship takes.

- different frontier technologies or cost structures exist in different countries (ie only firms from the same country may provide suitable performance benchmarks).

International comparisons are only feasible if it is assumed that the first assumption holds. There are several instances that could theoretically invalidate the common frontier assumption, or, more likely, create problems regarding the accuracy of the efficiency estimates produced.

Whether a company is public or privatised may have a significant effect on its cost structure, because the objectives vary considerably between public and private companies. Whether a company is regulated, in a competitive market or unregulated can also have a significant effect on its production technology and cost structure. This is because regulated companies or those in a competitive industry are likely to having stronger incentives to become more efficient, and will have therefore already made some cost reductions by changing their operating practices. A problem may also arise if companies with significantly different input quality are compared (eg, companies from the first and third worlds). However, only in the most extreme cases will the common frontier assumption be invalidated; in general, the differences will show up as inefficiency.

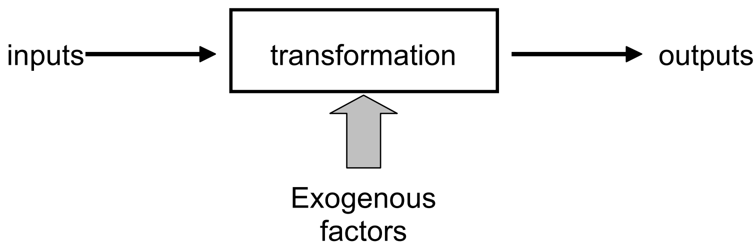
With respect to the comparisons between TCNZ and the LECs, an assumption about a common, or at least very similar, technological structure does not seem implausible, and it is not anticipated to cause any difficulties in the analysis. The ownership structure and, more importantly, the length of time under regulation might have some impact; however, this should not be significant enough to invalidate the results of the analysis. It also needs bearing in mind that, one of the underlying purposes of a comparative-efficiency analysis is to identify best practice and incentivise companies to reach the efficiency frontier. Therefore, factors such as how long the company has been subject to incentive regulation should not enter the analysis as they diminish the strength of the efficiency-improvement incentives. These factors should be taken into account at a later stage, in the analysis of the glide path of the cost reductions, where the regulator needs to make a decision regarding the rate of catch-up to the frontier and the time allowed for this catch-up to be achieved.

3. Balance of Inputs and Outputs

Before outlining the issues relating to the inputs and outputs used, the overall context of the analysis should be considered. Figure 3.1 illustrates a schematic representation of what an efficiency assessment is attempting to achieve.

Each unit uses a set of *inputs*, which it transforms into a set of *outputs*. The performance measurement to be undertaken addresses the issue of the effectiveness with which the unit converts its inputs into outputs.

Figure 3.1: Transforming inputs into outputs



An efficiency assessment is based upon the available trade-offs between inputs and outputs. The identification of what are the appropriate inputs and outputs in an assessment of efficiency is crucial. The former should capture all resource and environmental factors that have an impact on the outputs. The latter should reflect all outcomes based on which one wishes to assess the unit's efficiency. Furthermore, in principle, there should be *exclusivity and exhaustiveness,* in the sense that the inputs influence the output levels, and their influence is restricted to the output factors considered in the analysis. Therefore, all the inputs and outputs that could be relevant to the analysis need to be identified in the first place, as they encompass all the activities and outcomes of the assessed units.

The second issue to be addressed is data consistency, particularly when international comparisons are used. Data inconsistencies are usually caused by:

- differences in adopted accounting methods; and
- different definitions of control variables.

There are many cases in which there are substantial differences between which costs should be included in OPEX, and which in CAPEX, especially when some of the comparators undertake additional functions, as is the case with international calls in this analysis. In particular, the definition of CAPEX poses several problems, mainly due to the 'lumpiness' of capital investment in network industries. Failing to account for these investment cycles will introduce a serious distortion into the final efficiency scores. Therefore, CAPEX should be averaged over a period of years, using a consistent methodology. This requires:

- CAPEX data that span a number of years; and
- an asset valuation that was undertaken when the regulatory reform took place (in order to create an asset base), and any asset replacements undertaken since.

This kind of detailed data is necessary if CAPEX is to be correctly measured, and asset condition in the pre-regulatory reform period is to be controlled for. As a measure of real capital, the *replacement value* is the theoretically correct measure. An alternative approach, given that the above data is not available in this case, is to substitute CAPEX with a standardised depreciation measure, similar to the practice followed by PwCC.

As noted earlier, depreciation can be used as a proxy for actual capital consumption. Depreciation methods, along with the length of the asset's useful life, are important in the valuation of the capital base, which must be controlled for to ensure like-for-like comparisons. Depreciation charges, and an asset's useful lifetime, are often reported based on accounting convention, and not economic reality. Since it is difficult to calculate *ex post* the economic depreciation value for each asset of each company, the best solution is probably to categorise the assets and apply a standard depreciation method and asset life to each category. This practice was adopted by PwCC in the report for TCNZ.

To compare data across companies (and countries), a certain number of factors must be controlled for, in order for comparisons to be like-for-like. It is crucial for the accuracy of the analysis to confirm that each company provides data according to standardised definitions of the likely factors to be included in the assessment. A more detailed discussion regarding the standardisation procedures implemented by PwCC for such factors follows in the next section.

Where international comparisons are used, some additional standardisation processes are required. Relative differences in input prices, such as wage rates, may create problems in distinguishing between substitution effects and inefficiency. This problem could be resolved by using a producer purchasing parity (PPP) index for standardising costs to a base currency. However, the accuracy and overall robustness of PPP measures is sometimes doubtful. Thus, where there are significant differences in input prices, best practice recommends their inclusion as environmental factors in the modelling.

3.1 Inputs

3.1.1 Use and definition of total costs

PwCC bases its analysis on total costs, where total costs are equal to:

OPEX + depreciation + cost of capital   Equation 3.1

While this definition of total costs is consistent with *accounting* theory, that defines capital costs as the sum of depreciation and cost of capital, it can be argued that for the purposes of comparative efficiency, this definition might be inappropriate.

The first issue relating to PwCC's approach is the use of depreciation. When measuring comparative efficiency, it is important that the assessment exercise is based on *economic* data—ie, data that reflects as accurately as possible the actual consumption and replacement of resources. However, as these are usually hard to obtain, economic data must be reconstructed using accounting data, which is more widely available and measures how money is spent. This reconstruction process is almost always achieved by the standardisation of each company's asset base and the application of a standardised depreciation profile based on each asset category. The fact that accounting principles in both the USA and New Zealand allow for a fairly flexible treatment of accounting information makes such reconstruction a laborious process that requires a number of assumptions. Applying a standardisation mechanism does not necessarily mean that the comparisons made are like-for-like if the capabilities of the underlying assets in LECs and TCNZ differ markedly. However, it is hard to assess the capabilities of each asset type involved in the analysis. Section 3.1 discusses the standardisation process employed by PwCC in order to arrive at a consistent asset base, which is then used to calculate depreciation and the cost of capital.

A second issue relates to the inclusion of cost of capital in the definition of total costs. PwCC uses the following formula to calculate the cost of capital:

$$\text{cost of capital} = \text{WACC} \times \text{period-end asset base} \qquad \text{Equation 3.2}$$

PwCC uses a weighted average cost of capital (WACC) figure common to every company in the industry (the WACC of TCNZ according to an analysis conducted by PwC New Zealand). In reality, the cost of capital measure depends only on the asset base of each company. There are a number of arguments against the inclusion of the cost of capital in the analysis.

- The objective of this efficiency assessment exercise is to identify the level of efficient **costs** that each company should operate with, and not to inform about the level of financing actually required to secure the funds to cover these costs. The estimation of an appropriate level of financing for a regulated company requires a very detailed analysis, involving a separate benchmarking exercise to assess whether the rate of return of a regulated company actually reflects its cost of capital.
- When depreciation is included in the analysis, there is a risk of double-counting. Asset values and depreciation are highly correlated, especially in this case, where depreciation itself is a function of the asset base and a common factor in the asset depreciation profiles of all the companies being assessed. Thus, the inclusion of a cost of capital element in the analysis has the effect of artificially increasing the relative impact of the value of the asset base on the efficiency estimates. This results in the efficiency of companies with large networks (and, hence, asset base) being understated, and that of smaller companies being overstated.
- The use of cost of capital provides incentives for underinvestment. Two companies that are identical in their outputs and their cost structure may display different asset base values due to deferred investment by one of them. When these companies are assessed in a comparative-efficiency setting that includes cost of capital, the company with the smaller asset base value will appear more efficient, although the differences are in fact the results of deferred investment. The practice of using depreciation as a substitute for CAPEX also suffers from this lack of discrimination between inefficiency and deferred investment; the inclusion of a cost of capital measure will only serve to amplify the incentives for underinvestment.

Finally, the aggregation of the various cost categories into a single cost measure that is achieved by a simple sum is not necessarily optimal when undertaking a total cost comparative-efficiency analysis. This is due to the bias that could be introduced by assuming that the MRS between OPEX and CAPEX (which is substituted in this case by depreciation) is equal to one.

The MRS between OPEX–CAPEX could be defined as the ratio at which OPEX (CAPEX) can be substituted for a unit of CAPEX (OPEX) if the company is to continue producing the same amount of output. For example, an OPEX–CAPEX MRS of 1.5 means that a £1 reduction in OPEX would require a £1.50 increase in CAPEX in order to maintain the original level of output under conditions of efficient production. The marginal rate of substitution is likely to vary between companies depending on both the ratio of OPEX to CAPEX that the company uses, and environmental factors that usually affect companies asymmetrically. Therefore, the OPEX–CAPEX MRS under which each company operates would be expected to be unique for that company. By adding OPEX and CAPEX to obtain a total cost figure, an MRS equal to unity is imposed for every point of the frontier, since this definition of total cost implies that, at the observed level of activity, each assessed company considers that a unit of OPEX provides the same benefit as a unit of CAPEX.

However, although OPEX can, in large part, be linked with expenditure that relates to the year of the assessment, CAPEX, in the form of a standardised depreciation measure, is used as a *proxy* for capital consumption and thus has only an indirect relationship with the capital resources that are consumed. As a consequence, the analysis cannot assume that one-to-one substitution between OPEX and CAPEX is feasible, even if both are measures that are expressed in monetary units.

Two techniques allow for flexible MRS: using simultaneous equations with a regression-based approach; and DEA. Simultaneous equations generally require complicated procedures and do not lend themselves well for the purposes of comparative efficiency. DEA, by contrast, is simpler to use, its use in comparative efficiency is well documented, and it has been used before in the context of regulation.

In order to provide an alternative efficiency estimate for TCNZ, OXERA employed standardised depreciation as a proxy for capital consumption, similar to the approach adopted by PwCC, but excluded cost of capital from the definition of total cost.

3.1.2 Cost adjustments

The various cost adjustments, even though most of them are justified, may introduce some bias into the analysis. The adjustments made in para 3.3.4 of PwCC's report are intended in essence to allow for the fact that the LECs and TCNZ offer different services. However:

- given the relative size of the cost adjustments (almost 50% of TCNZ's OPEX is considered uncontrollable or removed from the analysis) and the fact that the largest cost adjustments were carried out for TCNZ, since only TCNZ provides international call services, this bias would be likely to inflate TCNZ's relative efficiency estimate.
- simply deducting costs relating to services not offered by TCNZ or LECs, respectively, does not ensure comparability, since any potential economies of scale and scope that may exist are not taken into account. It is also possible that there are cross-subsidies between functions within each operator, which are not accounted for by the approach adopted.

The adjustments made to convert HCA into CCA data were based on a formula used by Oftel, the UK telecommunications regulator, in a comparative-efficiency exercise to assess BT's costs. The formula is presented below:

$$\frac{CCA}{HCA} = ((1 + I_a) * (1 + I_g))^{[(1-NBV/GBV)/D]}$$ Equation 3.3

where:

- CCA = value at current cost accounting;
- HCA = value at historic cost accounting;
- NBV = net book value;
- GBV = gross book value;
- I_a = telecoms-specific inflation (%);
- I_g = general inflation rate of New Zealand or the USA;
- D = weighted average of depreciation percentage over the asset categories.

This formula makes intuitive sense, although there might be some errors in the way it is applied. To make it more intuitive, *[(1–NBV/GBV)/D]* could be substituted by *a*, where *a* is the average age of the asset category.

The formula contains a 'telecoms-specific' inflation rate, derived by 'the weighted average of the inflation rate by asset class' (PwCC, 2002, para. 4.2.3). Further information provided to OXERA by PwCC helps to clarify this definition. The weighting variable for the inflation rate is the GBV of each asset category for each operator, and thus the weighted average inflation rate is unique to each operator. Consequently, the use of the weighted average of the inflation rate by asset category measure takes into account the different mix of asset categories within the companies and is considered a reasonable adjustment.

A problem may arise with the simultaneous use of a general inflation rate, which is country-specific, and the telecoms-specific inflation rate. The formula to translate HCA values into CCA values compounds general and telecoms-specific inflation rates.[59] This would only be appropriate if the telecoms-specific rate is an **adjustment** to the general inflation rate. If, on the other hand, it is in itself a telecoms-specific inflator, which already includes the effects of the general inflation, the inclusion of the general inflation rate in the formula is not considered justifiable.

The data analysis in section 5 assumes that the inflation rates provided by PwCC are telecoms-specific rates, and not an adjustment to the general inflation index, and thus exclude the general inflation rate from the formula for converting HCA to CCA costs.

As already noted, for a comparative-efficiency exercise to be deemed robust, the comparisons must be undertaken on a like-for-like basis, in that cost items that are included for the LECs must be included for TCNZ as well. In addition, there must be a

[59] In other words, the effects of the general inflation rate are added to the effects of the telecoms-specific inflation rate. This is achieved by the $(1+I_a)*(1+I_g)$ part of Equation 3.3.

balance between inputs and outputs, so that, if an output is included, costs relating to the production of this output must also be included. It appears that PwCC's treatment of some cost items runs contrary to the above.

For the purposes of improving the comparability between TCNZ and the LECs, PwCC removed all costs items relating to the provision of international calling services from TCNZ's cost base, as these services are not provided by the LECs. This treatment is consistent with the underlying fundamentals of like-for-like comparisons and balance between inputs and outputs.

However, the OPEX measure used for the LECs includes expenditure categories relating to marketing and sales, customer services and billing. On the other hand, PwCC removed from TCNZ's operating expenses cost items that appear to be directly comparable with those above, namely items classified as:

- other services, mobile, directories etc;
- billing for national calls;
- sales and marketing costs for national calls.

PwCC's justification for removing these items was that the relevant activities for marketing and sales, billing and customer services are not undertaken by the LECs *for long-distance calls*. However, this is not entirely the case, given that the LECs provide call services that could be considered long-distance (ie, they cross the borders of a local calling area). They do not provide call services that cross the borders of their Local Access and Transmission Area (LATA), which represents the area to which they supply telecommunication services (which can include multiple states). The removal of marketing and sales, billing and customer services expenses also damages the balance between inputs and outputs for TCNZ. This is because, while national calls are considered in the modelling process (they are included in both the number of calls and call minutes variable), a cost that relates to their provision is missing from the analysis.

Given that there is a certain amount of uncertainty about the definition of national calls for TCNZ at this time, the analysis undertaken in section 5 looks at different definitions of operating costs in order to provide a broader picture of TCNZ's efficiency position.

3.1.3 Adjustments due to differences in reporting periods

Different countries may adopt different regulatory periods (ie, the between the price-control reviews) or different definitions of the accounting year. Thus, data from different countries may correspond to different time periods. For cost data, this can be corrected by using changes in the price index over time. However, if the time lag is considerable, there may be a problem as companies from different countries and time periods use a different technology function. The time lag in the data used by PwCC corresponds to the difference regarding the starting month of the financial year between the USA and New Zealand. PwCC implemented a correction to the data of TCNZ to match the definition of financial year in the two countries. However, it could be argued that this was unnecessary, given that a difference of a few months is unlikely to have any noticeable impact on the results of the analysis. Moreover, the correction itself might introduce some bias into the analysis, although its effects are likely to be insignificant.

3.2 Output

The PwCC comparative-efficiency analysis makes a number of adjustments to the output measures used, both to increase the comparability between TCNZ and the LECs, and to arrive at indicators that are more cost-reflective. Given that these adjustments are heavily influenced by a number of assumptions, this section examines closely PwCC's approach.

3.2.1 Access lines

Data on the number of access lines for the LECs was incomplete, as they do not report the number of leased lines, a major category of access lines. This figure therefore needed to be estimated. PwCC's decision to do this by weighting leased-line numbers by leased-line ends could result in bias being introduced into the analysis, and thus overestimate TCNZ's relative efficiency.

Access lines are potentially important in the analysis because they provide a measure of the company's customer base and thus the scale of its network. One category of access lines (64k-equivalent leased lines) is not reported by the LECs and thus had to be estimated. The methodology used by PwCC to estimate this access line category appears reasonable, given that it uses one of the most widely recognised relative industry price indexes available (Teligen's T-basket is fully supported by the OECD).

However, PwCC makes an additional adjustment regarding the quantification of leased lines that could be considered detrimental to the accuracy of the analysis. The report states that:

- The quantification of leased lines is based on the number of leased line **ends** rather than pure leased line numbers. [emphasis added]

It then explains that national leased lines have two ends, while international leased lines have only one. For the LECs, which do not report information regarding the number of leased lines, PwCC makes two assumptions: a national to international leased-line ratio equal to that of TCNZ; and that 'domestic' (national) lines are evenly split between intra-state and inter-state leased lines.

Given that no evidence is produced to support either of these assumptions, this treatment cannot be considered justifiable. Also, the original notion of using leased-line ends rather than pure leased line numbers is irregular, since it puts disproportionate weight on the leased lines category (special access lines and switched lines are not weighted by any factor). According to the above, it appears that the most equitable treatment would be to use pure leased- line numbers rather than leased-lines ends, to avoid introducing bias into the analysis, which might serve to inflate artificially TCNZ's efficiency estimate. This is also consistent with previous comparative-efficiency studies in the telecoms industry.

A possible issue that is not mentioned in PwCC's report is the method of aggregation regarding the different access-line categories. It is not clear what aggregation treatment was adopted by PwCC, but summing them into a single measure is not necessarily appropriate. This is because it is possible that only a single category has a significant influence on costs or that different categories have different impacts.

To examine this issue, the data analysis in section 5 considers each category of access lines separately, but also tests whether the aggregation into a single measure is appropriate. In more detail, the analysis tests for whether the impact on costs is significant when the following categories are included:

- switched access lines;
- special access lines;
- leased lines;
- the total number of access lines;
- the sum of switched and special access lines.

The quantification of leased lines is based on the methodology described above and is implemented using both leased-line ends (as per PwCC's approach) and the original figure of the number of leased lines.

3.2.2 Call minutes

The call minutes factor for the LECs was also not directly available, since they only report number of calls. The call minutes factor was therefore estimated based on average call duration. The average figure used by PwCC is based on inter-LATA minutes after adjusting for holding and set-up time. However, inter-LATA calls are the most expensive (comparable to long-distance national or international calls), and thus it could be argued that their average duration will be shorter than those of local or intra-LATA calls. Their choice as the measure for average call duration could therefore lead to an underestimation of the LECs' traffic volume, which would result in an overestimation of TCNZ's efficiency. Call minutes are divided into local, national and international for TCNZ and local, intra-LATA and inter-LATA for the LECs, with the sum of inter- and intra-LATA calls being defined as long-distance (LECs do not provide international calling services and inter-LATA calls are handled by interexchange carriers). Local calling areas differ in size across both companies and countries, and long-distance calls require different numbers of switching and transmission stages; as such, the use of unadjusted calling minutes is not entirely suitable for a comparative-efficiency analysis, especially one based on international comparisons. One way of getting around this problem is to convert call minutes into switch minutes. Switch minutes take into account the number of switches a call passes through and so companies with larger local areas will show a higher number of local switch minutes. The conversion involves multiplying call minutes by a routing factor, which is estimated based on the type of the call (local, national and international).

Depending on its type, a call can be routed through a number of switches, which in turn are divided into different categories. For the purposes of this analysis, two types of switches are of interest: local and main (also referred to as tandem). Thus, in order to arrive at a suitable measure of call minutes, two routing factors need to be taken into account. The routing factors used by PwCC for the LECs are based on previous work commissioned by Oftel regarding BT's comparative efficiency,[60] and, for the purposes of

[60] These are based on calculations carried out for the Hatfield cost model, one of the most widely used universal telecoms service costing models, although a number of assumptions were also made.

the analysis in this paper, are assumed to be reasonable. The routing factors for TCNZ were supplied directly by TCNZ and are also assumed to be robust.

To remove the possible bias resulting from PwCC's use of the average call duration for inter-LATA calls, the call minutes variable for the LECs in the analysis in section 5 is quantified by breaking down the number of calls into local, inter-LATA and intra-LATA and multiplying by an average call duration figure for each type of call. This average call duration figure was in turn informed by the aggregate call minutes by type of call measure, which is available for the whole of the USA and is published by the US Federal Communication Commission (FCC). A second adjustment was also deemed necessary, given that the figure reported by the LECs on the number of calls does not distinguish between successful and unsuccessful calls. Thus, using this figure as it stands artificially increases one of the outputs of the LECs, and therefore reduces the accuracy of the efficiency estimates produced. To overcome this potential problem, the number of calls output needs to be adjusted by the percentage of successful calls. Given that the FCC does not provide this statistic, the percentage of successful calls for TCNZ was used instead.

The analysis considers each category of call minutes separately, but also tests whether the aggregation into a single measure can be regarded as best practice, similar to the treatment applied for the access lines variable. In more detail, the analysis looks at:

- local call minutes;
- other call minutes;
- total call minutes;
- total switched minutes.

3.2.3 Number of calls

If robust data were available for the call minutes factor, the number of calls would not need to be included as a variable in the analysis. However, given the assumptions used to construct the call minute variable for the LECs, the inclusion of the number of calls in the general-to-specific approach is justified. PwCC refers to the adjustments needed to the TCNZ figure for the number of calls, scaling it up according to the percentage of successful calls. As TCNZ reports successful calls only, this adjustment is necessary to make the figure comparable with that for the LECs.

4. Application of the Estimation Technique

4.1 Independence of comparators

As noted above, the comparative-efficiency assessment may be complicated by the common ownership structure of some of the LECs. The finding that the 50s LECs are owned by only 12 independent companies could have a significant impact on the efficiency estimates produced, especially if some of the functions common to all LECs are carried out at a group level. For example, if corporate and human resource functions for all Verizon-owned companies[61] are outsourced to a Verizon-owned specialist company, it might not be equitable for TCNZ to include these costs in the analysis. Theory suggests that economies of scale present for these functions will result in much lower unit costs for all the Verizon-owned LECs. Only if TCNZ has the option to outsource these costs in the same market as that used by the LECs (or a similar one in terms of competitive prices) could the direct use of such data be considered equitable.

Econometric theory also suggests that the lack of independence between observations could introduce bias into the analysis. If ownership structure has a significant impact on costs—as is likely to be the case in the example used above—and a factor that describes the ownership structure of the assessed companies is not included in the model, then it will suffer from omitted variable bias. This kind of bias has the effect of overestimating or underestimating the impact of the other significant factors that are included in the model.[62] These problems have an adverse effect on the accuracy of parametric techniques only; from a modelling perspective, DEA only requires self-containment of the units of assessment in the sense that the inputs influence the output levels, and their influence is restricted to the output factors considered in the analysis.

4.2 Variable selection methodology

To construct an appropriate model to assess efficiency, a factor (or variable) selection methodology needs to be applied to the list of key variables identified in the preliminary analysis. A range of variable selection methodologies can be applied to parametric (regression-based) models, such as SFA, and recently these have been increasingly used in non-parametric modelling as well.

Ideally, the process of variable selection should be as systematic as possible. The general-to-specific approach imposes as few restrictions as possible upon the data at the outset and is generally considered best practice for both variable selection and model building. The process is initiated by the researcher identifying several explanatory variables (ie, output and environmental factors) that could, according to a combination of economic

[61] This company is chosen at random for the purposes of providing an example.

[62] In essence, omitting a significant variable from the model invalidates the assumption of zero conditional mean (ie, given the value of an explanatory factor, the expected, or mean, value of the error term is equal to zero). This in turn makes the model less accurate.

theory and prior research in the area, possibly influence the dependent variable (in this case, costs). The functional form of the model is then chosen, which will determine the general form of the relationships between the explanatory and the dependent variables. First, the general model is estimated and then progressively simplified by deleting insignificant variables, starting with the least significant one. After each variable is deleted, the general model is re-estimated until all the variables are significant. The final model should be a parsimonious model that cannot be improved upon.

The variable selection methodology used by PwCC could be considered as a variation on the general-to-specific methodology described above. However, instead of beginning with a general model, which includes all the explanatory variables of interest, one of the initial steps of the process is to identify the most significant variable, including it in the final model, which is then 'built' upon by testing for the significance of additional variables. While valid, such a 'backwards' approach would generally only be used as a cross-check on the general-to-specific approach, since it could ignore mutually supporting relationships between variables, and thus conclude that such variables are insignificant.

Furthermore, as the first step in the variable selection methodology, PwCC removed variables that displayed high correlation. As such, the number of calls and call minutes were summarily removed from the general model, on the grounds that possible multicollinearity could have an adverse effect on the accuracy of the model. However, given that multicollinearity becomes a significant factor in model accuracy in very few cases, and mostly when the model is used for forecasts, the exclusion of possibly significant variables for this reason does not appear justifiable.

The choice of a functional form for the model will also have a significant impact on the accuracy of the efficiency estimates. PwCC used a Cobb–Douglas functional form, which is widely used in efficiency and productivity studies. However, this specification has the drawback of not permitting alternative types of returns to scale at different levels of scale size (due to the function being homogeneous to the first degree). Therefore, a more flexible functional form (eg, translog) might be more appropriate.

Another alternative could be to bypass completely the issue of functional form specification by using DEA, which does not require a functional form to be specified. DEA also treats returns to scale equitably, by allowing increasing, constant and decreasing returns to scale to be displayed by the same model.

The models used to estimate TCNZ's relative efficiency in the analysis in section 5 are all constructed according to the general-to-specific methodology, with the translog being the functional form specification of choice in every case. A DEA model is also constructed to provide an efficiency estimate that is free of any possible bias due to functional form mis-specification.

The formula used by PwCC to convert the costs of the assessed LECs into comparable 'unit costs' could be considered quite difficult to follow. First, the characterisation of the output of the formula (see PwCC, 2002, para 4.3.4) as a 'unit cost' is misleading. In effect, the formula does arrive at a unit cost per line (weighted by the relative importance of the line variable to costs). However, as TCNZ's line values are included, the unit costs are converted back to estimated costs that would have been incurred by the LEC in question, had its values in the access line variable been equal to those of TCNZ. When both of the conversion formulae are taken into account, the resulting equation is:

$$\text{'adjusted unit cost'}_i = \frac{\text{Total cost}_i \times \text{TCNZ\_weighted output}}{\text{weighted output}_i}$$ Equation 4.1

or

$$\text{'adjusted unit cost'}_i = \frac{\text{Total cost}_i \times \left(\text{TCNZ lines}^a \times \text{TCNZ weighted scaled sheath length per line}^c\right)}{\left(\text{TCNZ lines}^a \times \text{weighted scaled sheath length per line}^c\right)}$$

Equation 4.2

According to the above, the ‘adjusted unit cost’ of LEC operator *i* is actually the total costs that it would incur if it faced the scale and environmental factors of TCNZ. These adjusted costs can be used as a first indicator of each company’s relative efficiency against an *average* benchmark. The company with the smallest adjusted score would be the assessed as the most efficient operator, while the company with the largest cost would be the most inefficient. The efficiency estimates produced would be equal to those produced by applying OLS to the dataset, without making any adjustments to shift the average cost function to a frontier position. However, the formulation of a SFA model based on these costs could lead to final efficiency estimates that are misleading, as the following section will demonstrate.

4.3 Application of SFA

The approach adopted by PwCC could be seen as having three stages.

- The first stage deals with the estimation of the regression coefficients. These are estimated using an OLS model to predict the mean level of total cost for the lines and sheath per access line of each company.
- During the second stage, the coefficient estimates from the OLS regression are used to calculate the unit cost of each LEC. This is then scaled up or down to reflect the scale size and the operating characteristics of TCNZ. As noted earlier, this ‘adjusted unit cost’ figure is a first indication of the company’s relative efficiency.
- During the third stage, the ‘adjusted unit cost’ is averaged. Residuals are then computed for each company reflecting the difference between their ‘adjusted unit

cost' and this average value. The SFA methodology of separating error from inefficiency is applied to the residuals obtained at this stage.[63]

This is not the traditional SFA approach. A key difference is that the model used to estimate the required model parameters (ie, the regression constant and the variable coefficients) relates to average cost levels for given output levels, whereas, in a traditional application of SFA, the prerequisite model parameters relate to minimum costs. This affects the residuals ultimately obtained and so, by definition, the efficiency estimates, which are based on those residuals, will be inaccurate.

One of the recognised weaknesses of the SFA approach is its reliance on the distributional assumption for the inefficiency component of the residual (a truncated normal distribution was assumed by PwCC). It is therefore common practice in comparative-efficiency assessment based on SFA to use a number of alternative distributional assumptions (such as exponential, half-normal or gamma) to arrive at efficiency estimates. Also, PwCC does not report the results of statistical checks that test for the validity of applying stochastic frontier processes in the dataset, such as determining the skew of the OLS residuals or applying a one-sided likelihood ratio test to the ratio of the variation of the error component to the inefficiency component.

[63] There is some confusion at this point in the PwCC report. C10 in Appendix C suggests that OLS regression was used to estimate a model, but the model quoted is a simple average process with no clear statement of the specification of the regression.

5. Efficiency Estimation and Results

The above review of PwCC's analysis has been at a theoretical level. This section presents the results of the data analysis undertaken by OXERA, which will help to quantify the effects of PwCC's estimation methodology and data adjustments. The results of four models used for estimating TCNZ's comparative efficiency are presented below, each based on a different dataset.

- The first model uses data supplied to OXERA by PwCC, without taking into account any of the data adjustments proposed in this paper. The difference lies in that the model is now constructed following the general-to-specific approach, and the decision of whether SFA is the appropriate estimation technique is informed by using the relevant statistical tests. The results of this model should give an indication of the effects of PwCC's variable selection methodology and application of SFA to the efficiency estimates of TCNZ.

- The second model takes into account all the data adjustments proposed by OXERA, with the exception of the definition of OPEX. In this instance, the model is constructed using the OPEX measure as provided by PwCC, which appears to include marketing, customer services and billing expenses for the LECs but to exclude such costs for TCNZ. The results of this model should give an indication of the effects of PwCC's adjustments to output data on the efficiency estimates of TCNZ.

- The third and fourth models are constructed using the same dataset as the second model (ie, taking into account all adjustments mentioned in this paper), but in these models OPEX either includes marketing, customer services and billing expenses for all companies, or excludes these items from the cost base of each company. The results of these models will present an upper and lower limit on TCNZ's efficiency estimate, based on conservative data adjustments and the robust application of comparative-efficiency methodology.

The estimation procedure followed by OXERA can be decomposed into the following steps.

- Collating and adjusting the necessary financial data—due to the aforementioned uncertainties regarding the appropriate definition of OPEX, three measures of OPEX were used:

  – the OPEX measure provided by PwCC, which appears to include marketing, customer services and billing expenses for the LECs but to exclude such costs for TCNZ. (This definition is used for the first two models);
  – OPEX including marketing, customer services and billing expenses for both TCNZ and the LECs. (This definition is used for the third model);
  – OPEX excluding these items from the cost base of each company. (This definition is used for the third model.)

  Asset expenses were then collated and used to construct the standardised depreciation measure. OPEX and the standardised depreciation measures were then summed to arrive at the three different measures of total cost that are used in the modelling.

- Collating and adjusting the necessary output data—the output data were disaggregated into more detailed categories than those used by PwCC. Also, the analysis uses pure leased-line numbers instead of leased-line ends, and constructs the call minute variable on a more disaggregated basis than PwCC.

- Adopting a translog functional form and applying a general-to-specific approach to the dataset. Initially, the analysis estimates the general, deterministic parametric models. After a suitable, robust model has been identified, the application of SFA is then tested. In the event of the SFA estimation technique not being appropriate (a decision that dependent on the results of the relevant statistical tests), the efficiency estimates are based on the corrected OLS approach.

- Developing and estimating the DEA model; the specification of the DEA model (ie, the decision on which factors to include) will be largely informed by the general-to-specific approach.

The above steps are not necessarily sequential. Usually, the first two steps of data collation and adjustment are executed keeping in mind how the data will perform during the estimation steps (ie, the last two). It is therefore best to view this process as an interaction between the above steps until an adequate model can be achieved.

5.1 Results from the parametric approaches

During the course of the analysis, it became apparent that the definition of operating costs has a substantial impact on TCNZ's efficiency estimates. The modelling was therefore undertaken for various cost definitions, using the three cost measures mentioned above. The results of the analysis, together with a brief description of the preferred models, follow.

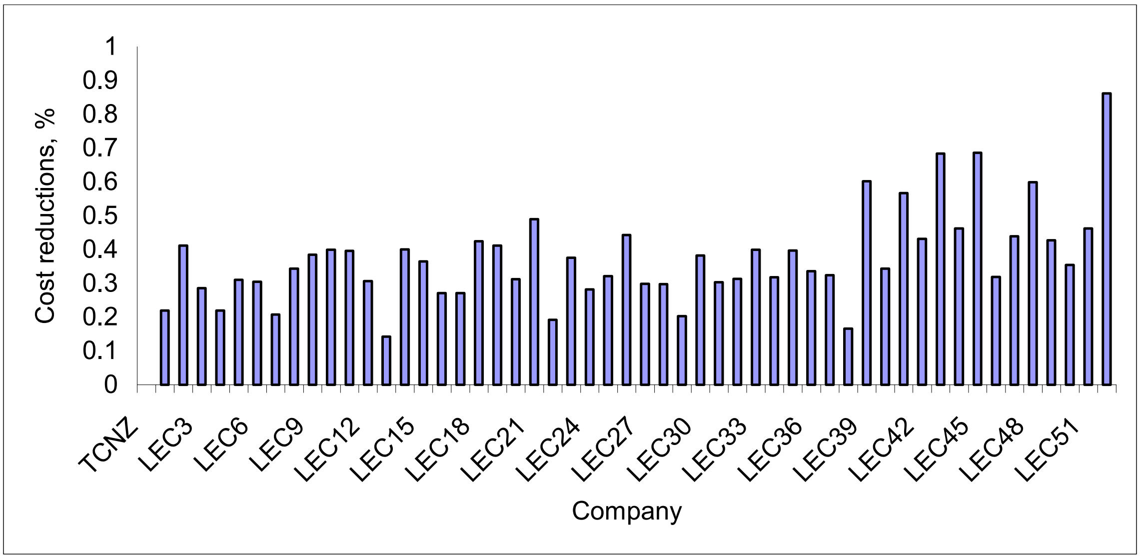
Model 1: Using the dataset as provided by PwCC

For this model, none of the adjustments noted in this paper were taken into account. Instead, the model is constructed using the dataset supplied by PwCC. The application of the general-to-specific approach leads to a model that adopts a Cobb–Douglas functional form[64] and takes into account the number of access lines, the length of sheath and the ratio of local to total calls. According to the relevant statistical tests, the application of SFA could not be supported, and thus the estimation procedure used was COLS. For a more detailed on the preferred model, see appendix 4.1.

[64] The application of translog resulted in all the cross-products being identified as statistically insignificant.

Figure 5.1 presents the efficiency estimates produced from this first model. TCNZ is identified as the most efficient company under this model and thus no cost reductions are required.

Figure 5.1: Efficiency estimates produced from the first model



Source: OXERA analysis.

Model 2: Using the operating cost figure for TCNZ as provided by PwCC, adjusting all other data

Under this definition, TCNZ operating costs do not include the following items:

- POLO (Vodafone);
- POLO (Telecom Mob);
- emergency calls;
- data services;
- other services, mobile, directories etc;
- CPE (customer premises equipment);
- network rates;
- international outgoing calls;
- bad debts;
- sales and marketing costs for national calls;
- billing for national calls.

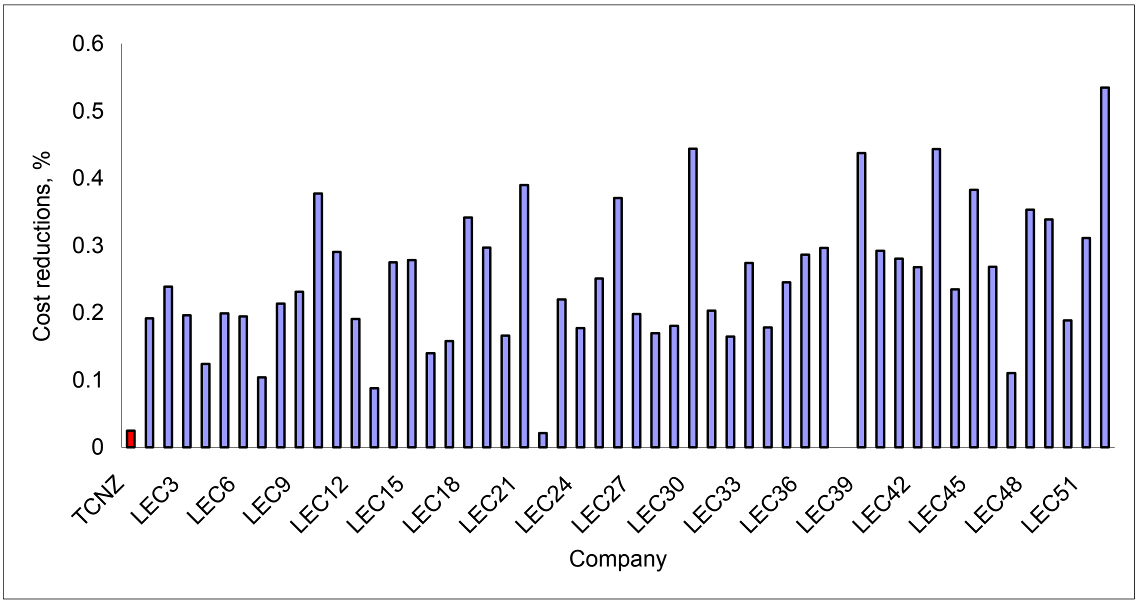
The application of the general-to-specific approach leads to a model that adopts a Cobb–Douglas functional form[65] and takes into account the number of switched access lines (all

[65] The application of translog resulted in all the cross-products being identified as statistically insignificant.

other access lines categories were statistically insignificant), the length of sheath and the number of other (non-local) calls. The relevant statistical test rejected the application of SFA at the 5% significance level and thus the estimation procedure reverted to COLS.[66] For more detailed on the model, see appendix 4.2.

Figure 5.2 presents the efficiency estimates produced by the second model.

Figure 5.2: Efficiency estimates produced from the second model



Source: OXERA analysis.

Under this model, TCNZ is ranked 3rd out of 53 companies, with required annual cost reductions to reach an efficient position within a five-year period equal to 0.5%. The ranking of TCNZ, as well as the company's required cost reductions to reach efficient performance, remain the same when SFA is used as the estimation technique.

Model 3: Including marketing, customer services and billing expenses in the OPEX of every company

The LEC definition of operating costs includes marketing and customer services expenses, while similar costs for TCNZ are excluded. To test the effects of excluding these items from the modelled costs in the event that this exclusion is deemed unjustified, the following cost items are added back into TCNZ's operating costs:

- other services, mobile, directories, etc;
- billing for national calls;

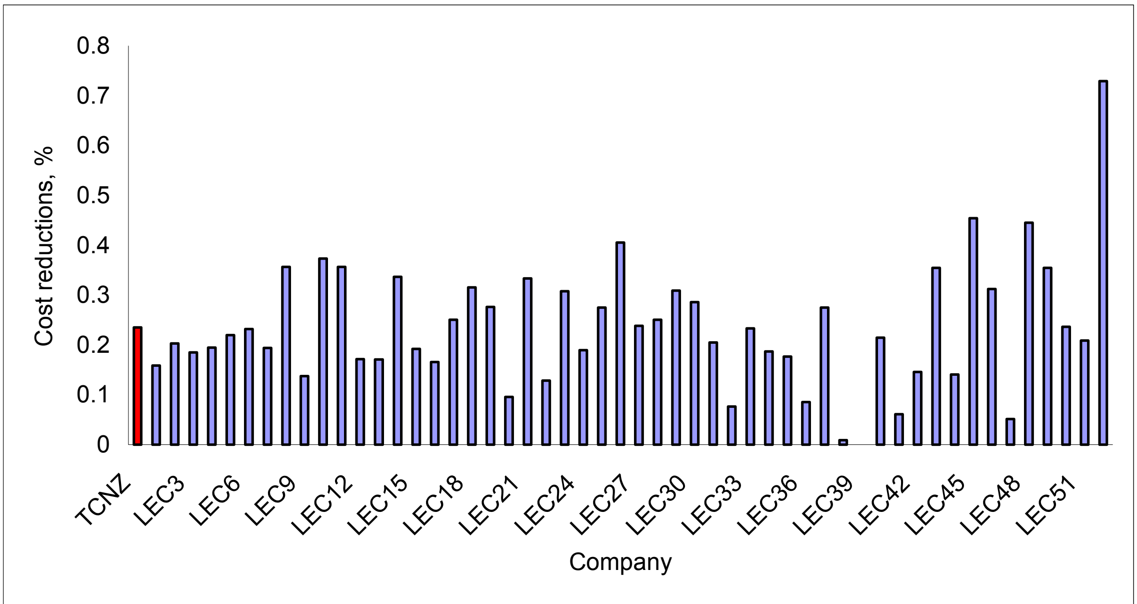
[66] However, the application of SFA could not be rejected at a 10% significance level and thus the results of the SFA model are also presented.

- sales and marketing costs for national calls.

The application of the general-to-specific approach leads to a model that adopts a translog functional form and takes into account the number of switched access lines and switched minutes. The relevant statistical test rejected the application of SFA and thus the estimation procedure reverted to COLS. For more detail on the model, see appendix 4.3.

Figure 5.3 presents the efficiency estimates arrived at by using the third model.

Figure 5.3: Efficiency estimates produced from the third model



Source: OXERA analysis.

Under this model, TCNZ is ranked 30th out of 53 companies, with required annual cost reductions to reach an efficient position within a five-year period equal to 5.2%.

Model 4: Excluding marketing, customer services and billing expenses from the OPEX of every company

Under this cost definition, the following cost items are excluded from the LEC's operating costs:

- total marketing expenses (which include product management, sales and product advertising costs);
- total services expenses (which include call completion, directory enquiry services, and customer services, such as billing and collection).

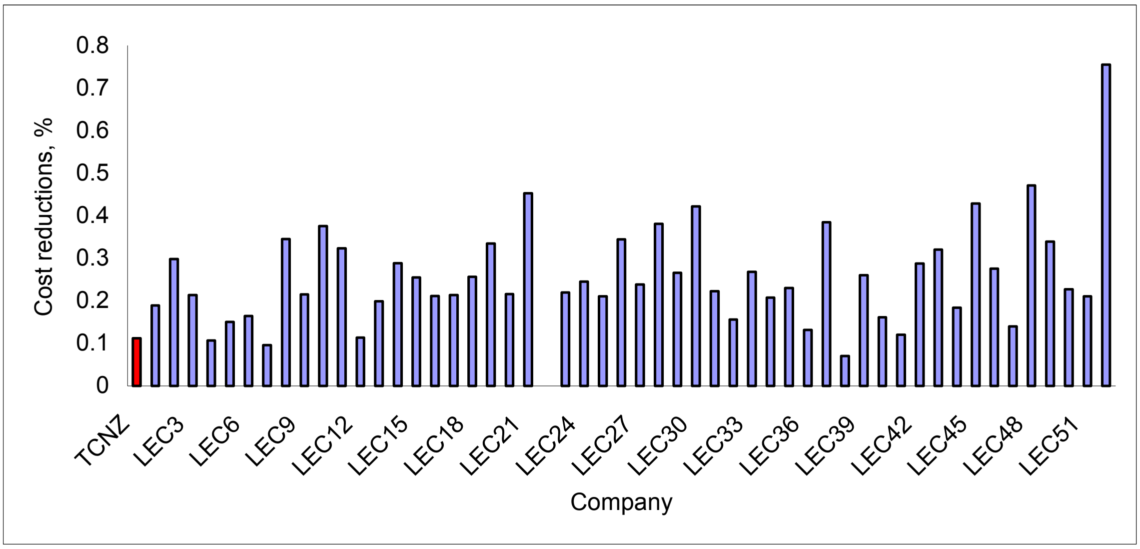
Similarly, TCNZ's operating costs exclude:

- other services, mobile, directories, etc;
- billing for national calls;
- sales and marketing costs for national calls.

The application of the general-to-specific approach leads to a model that adopts a Cobb–Douglas functional form[67] and takes into account the number of switched access lines, the length of sheath and the number of switched minutes. The relevant statistical test rejected the application of SFA and thus the estimation procedure reverted to COLS. For more detail on the model, see appendix 4.4.

Figure 5.4 presents the efficiency estimates produced by the third model.

Figure 5.4: Efficiency estimates produced from the fourth model



Source: OXERA analysis.

Under this model, TCNZ is ranked 5th out of 53 companies, with required annual cost reductions to reach an efficient position within a five-year period equal to 2.3%.

The results of the first two models suggest that the data adjustments carried out, other than those relating to OPEX, do not have an overly significant effect on TCNZ's efficiency position. However, this is not the case when the adjustments to the definition of OPEX are applied. The widely divergent efficiency estimates produced under the different cost definitions reveal that the analysis cannot reach a conclusive estimate of TCNZ's efficiency position until the issue of what are the appropriate cost categories to be included in the OPEX measure is clarified. However, the two models provide what can

[67] The application of translog resulted in all the cross-products being identified as statistically insignificant.

be considered as upper and lower limits for TCNZ's efficiency position. Section 5.3 elaborates on this.

5.2 Results from the non-parametric techniques

The results of the parametric techniques reveal the very large impact that the definition of OPEX has on the efficiency estimates. It is more than likely that this will be the case when non-parametric techniques are used in the estimation process. In fact, in the case of DEA, it is expected that different cost definitions will have a greater impact because measurement error has a large adverse effect on the accuracy of DEA. This fact prevented the formulation of a detailed DEA model that could be used to assess efficiency, as any efficiency estimate produced is likely to be heavily influenced by the inclusion or exclusion of the services in question. As such, no efficiency estimate produced by non-parametric approaches is provided in this analysis.

5.3 Summary of the results

The large impact of the inclusion or exclusion of marketing, customer services and billing expenses in the OPEX measure does not permit the analysis to provide a conclusive result on TCNZ's efficiency position. However, the results of the two final parametric models can be considered to be robust estimates for TCNZ's upper and lower efficiency score. This is due in large part to the properties that each model displays.

The third parametric model coefficients (which include marketing, customer services and billing expenses) are in line with what theory suggests about returns to scale and density and the relevant importance of such factors. In more detail, the model reveals that, for a medium-sized company:

- a small increase in access lines without a proportionate increase in switched minutes translates into a slightly larger proportional cost increase. This is consistent with industry knowledge which suggests that the expansion of a telecommunications network does not provide any economies of scale and, in most cases, provides scale diseconomies;

- a small increase in switched minutes without a proportionate increase in access lines translates into a very small cost increase. This is again consistent with industry knowledge which suggests that the increased usage of a fixed network incurs very small additional costs (usually referred as 'economies of density');

- a small, equal increase in both access lines and switched minutes results in an equiproportional increase in costs. Again this is consistent with both intuition and industry knowledge, as large increases in costs for expanding the network are somewhat offset by cost savings that can be made through increases in network traffic.

The fourth parametric model also displays desired and intuitive properties:

- The inclusion of the sheath length variable, which was deemed statistically insignificant by the previous model, reveals the increased importance of network length when only costs relating to the provision of the core network activities are considered.

- The size of the access lines coefficient relative to the coefficient of the switched lines variable reveals the large impact that the customer base has on costs, relative to the network traffic.

- When the two coefficients are considered together, they display constant economies of scale, in that an increase in access lines and switched minutes results in an almost equiproportional increase in costs.

Given that both models display properties that are both intuitive and in line with industry knowledge, the produced efficiency estimates can be viewed as an accurate range of TCNZ's efficiency score. Two additional points are of importance:

- the exclusion of international calling services from TCNZ's cost base is likely to result in an overestimate of its relative efficiency. This is because there are likely to be economies of scope between national and international calls. The fact that international calling services are not provided by the LECs does not permit the size of such economies to be estimated.

- The marketing, customer services and billing expenses data available for TCNZ is not provided in a disaggregated form. Thus, it is likely that costs that should be excluded are not. This is especially the case for TCNZ's customer services expenditure, which appears to include costs associated with mobile services, an expenditure not present for any of the LECs. This is likely to result in an underestimation of TCNZ's relative efficiency.

When the above points are considered, it could be concluded that TCNZ's relative efficiency lies within the range of 2.3–5.2%, with a point estimate lying somewhere in the middle of this range.

The efficiency range provided relates only to TCNZ's efficiency position at the time assessed by the analysis (ie, for the year 2000). However, relative efficiency needs to take into account future changes that are likely to affect performance. This is particularly relevant for the telecommunications industry, where rapid technical and technological change is observed.

In the event that the analysis is used to inform future cost reductions, a 'frontier shift' component will need to be estimated for the cost elements removed due to comparability reasons, but which are valid to be included for regulatory reasons (ie, they are not considered uncontrollable). This will not have an impact on the 'snapshot in time' efficiency estimate produced PwCC's or OXERA's analysis. However, if this estimate is used to inform the regulated revenues going forward, this frontier-shift adjustment will need to be taken into account. Oftel has repeatedly emphasised this point and has recently set a frontier shift for BT equivalent to annual cost reductions of 3%, over and above the cost reductions the company needs to achieve to reach the estimated frontier.

6. Conclusions

This paper has examined PwCC's report on the relative cost efficiency of TCNZ. There are a number of areas where it appears as though PwCC's approach has introduced some bias into the results. These are summarised below.

Choice, definition and adjustments to inputs

- The effect of the various cost adjustments was that almost 50% of TCNZ's OPEX is removed from PwCC's analysis. The cumulative size of these adjustments raises questions regarding the robustness of the result for TCNZ. For example, marketing expenses are removed for TCNZ but not for the LECs. The study provides some sensitivity analysis by including these cost items in the definition of OPEX for both TCNZ and the LECs, and by excluding these cost items from OPEX for both TCNZ and the LECs. The resulting efficiency estimates reveal that these adjustments have a significant effect on the accuracy of the analysis, and therefore the overall robustness of PwCC's efficiency estimates may be questionable.

- One of the various cost adjustments was the conversion of the asset expenses from a HCA reporting format to a CCA one. However, this conversion appears to compound general and telecoms-specific inflation rates. OXERA's analysis assumes that the telecoms-specific inflation rates take into account movements in the general inflation index, and thus the general inflation rate is removed from the relevant formula.

- PwCC uses a total cost measure as the only input. However, the aggregation of the various cost categories into a single cost measure by simply summing them can introduce bias into the analysis by assuming that the MRS between OPEX and CAPEX is equal to one.

- The definition of total cost that PwCC chose to adopt makes use of the accounting definition of capital costs, which comprises depreciation and a cost of capital.

  - In order to improve comparability, PwCC uses a standardisation process for the depreciation measure. However, this does not necessarily mean that the comparisons made are like-for-like if the capabilities of the underlying assets in LECs and TCNZ differ markedly.

  - The inclusion of the cost of capital is questionable. Financing costs are not in the usual remit of an efficiency analysis on costs. Moreover, there is risk of double-counting when depreciation is included in the analysis, increasing the relative impact of the value of the asset base on the efficiency estimates and understating the efficiency of companies with large networks, such as TCNZ. As such, OXERA's analysis does not include cost of capital in the definition of total cost.

- PwCC's cost adjustments are intended to allow for the fact that the LECs and TCNZ offer different services. However, simply deducting costs relating to services not offered by TCNZ or LECs, respectively, does not ensure comparability, since this does not take into account any economies of scale and scope that may exist. This could have the effect of inflating TCNZ's relative efficiency estimate.

Choice, definition and adjustments to outputs

- For access lines, PwCC used leased-line ends, instead of pure leased-line numbers. This puts disproportionate weight on the leased-lines category (since no weighting factor is applied to special access lines and switched lines) and requires assumptions to be made. It appears that the most equitable treatment would be to use pure leased-line numbers rather than leased-lines ends, to avoid introducing bias into the analysis. This treatment was adopted in OXERA's analysis.

- PwCC estimated call minutes for the LECs based on the average call duration of calls that carry one of the most expensive tariffs, and are thus likely to have the shortest call duration. This could result in artificially reducing one of the outputs produced by the LECs and thus overstate TCNZ's estimated relative efficiency. For the purposes of OXERA's analysis, a more equitable treatment that distinguishes between types of call is adopted.

Application of the comparative-efficiency estimation technique

- To identify the variables to include in the modelling, PwCC did not follow the standard general-to-specific methodology, but adopted a 'backwards' orientation, which could introduce bias into the results.

- The choice of a functional form for the model also has a significant impact on the accuracy of the efficiency estimates produced. However, PwCC used a Cobb–Douglas functional form only, which has the drawback of not permitting alternative types of returns to scale at different scale sizes. Alternative and more flexible functional forms should have been considered, as OXERA's analysis demonstrates.

- The common ownership structure of some LECs could cause some problems to the analysis. Although data for 50 individual LECs is available, a closer examination reveals that they are owned by only 12 independent companies. This fact could have a significant impact on the efficiency estimates produced, especially if some of the functions common to all LECs are carried out at a group level.

- PwCC's preferred estimation technique is SFA. However, it is implement in such a way that it fails to take into account the interaction between the parameters of the constant and error terms, which could invalidate the efficiency estimates ultimately obtained.

- One of the recognised weaknesses of the SFA approach is its reliance on the distributional assumption for the inefficiency component of the residual. However, PwCC considered only a single distribution—a truncated normal distribution. A number of alternative distributional assumptions should have been examined.

OXERA's comparative-efficiency assessment found that, for TCNZ to reach an efficient position, annual cost reductions within the range of 2.3–5.2% are required. This range represents the required savings TCNZ needs to achieve in order to reach the efficient performance relating to the year 2000 (the year to which the data used in the analysis corresponds). However, the rapid technical and technological progress observed in the telecommunications industry results in large productivity gains that can be achieved over time, which can be confused with changes in efficiency. To control for these potential productivity gains, a frontier shift needs to be estimated; however, this was beyond the remit of this study.

In conclusion, the comparative-efficiency analysis undertaken by PwCC departs from standard practice in comparative-efficiency assessments and, in a number of areas, the approach taken appears to introduce bias in the results. Although PwCC was in part successful in collating and adjusting required financial and operational data, its analysis was hampered by the decision to rely exclusively on the results from a single efficiency measurement technique, which then appears to be implemented erroneously. OXERA's assessment is based on reconstructing PwCC's methodology as presented in its report; some differences between OXERA's interpretation and PwCC's actual approach might exist.

Appendix 1: Data Envelopment Analysis

A simple measure of efficiency—ie, output divided by input—is inadequate when multiple inputs or outputs exist. In the case of multiple inputs and/or outputs, weights need to be assigned to each input and output in order to arrive at aggregate measures of total input and total output that will, in turn, be used to compose the relative efficiency measure. Thus, a common measure for relative efficiency is:

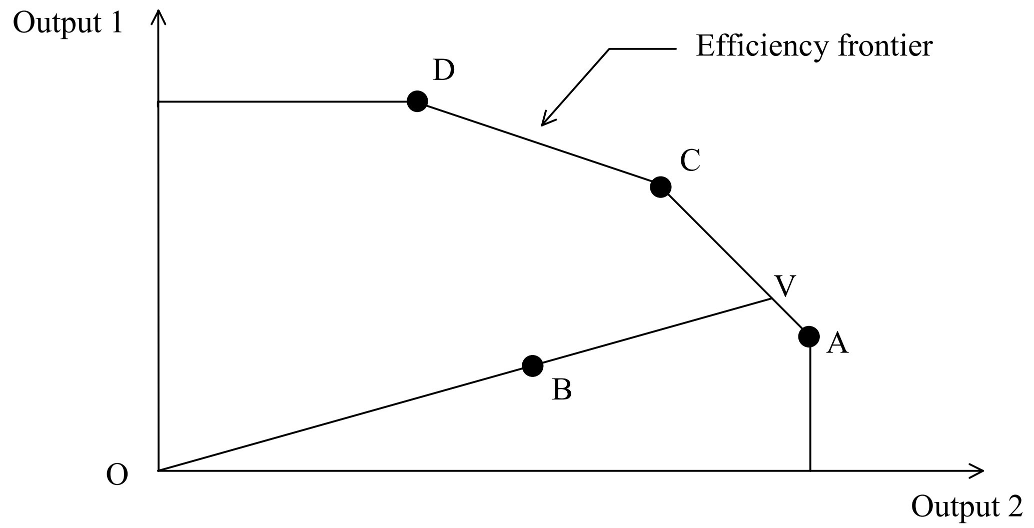
$$\text{weighted sum of outputs } \div \text{ weighted sum of inputs}$$

This adds the complication of need to identify appropriate weights for each input and output used in the analysis. This complication exists because companies may choose to organise their operations differently and, therefore, value inputs and outputs differently. DEA recognises this and allows each assessed company to adopt an individual set of weights that will maximise its relative efficiency score. The only restriction is that when these weights are applied to the other companies in the comparator set, none should present relative efficiency scores above 100%.[68] In other words, each company will choose a set of weights that will present its performance in the best possible light, provided that the adoption of this set of weights by another company will not result in its being assessed as 'super-efficient'.

The technique is based on the core premise that, if a given producer, A, is capable of producing Y(A) units of output with X(A) inputs, then other producers should also be able to produce **at least** the same level of output using the same level of inputs and controlling for differences in the characteristics of the operating environment that are outside the companies' control. To provide additional comparisons, DEA also assumes that combinations of two or more companies can be pooled to form a composite company with inputs and outputs that are the result of interpolation between the input and output sets of the 'pooled' companies; this is usually referred to as a 'virtual company'. DEA uses linear programming techniques to find the 'best' virtual company for each real one. If the virtual company is better than the original, either because it achieves more output with the same input, or the same output with less input, then the original company is judged to be inefficient. DEA selects the efficient observations and constructs a frontier from them, ignoring those observations that turn out to be inefficient. This can be illustrated figuratively for the single-input, two-output case (see Figure A1.1).

[68] Additional restrictions could be placed on the model according to predefined notions of the intrinsic value of the inputs and outputs.

Figure A1.1: Graphical example of DEA—output maximisation



The line connecting companies A and C shows the possibilities of virtual outputs that can be formed from these two companies. Since the line AC lies beyond AB and BC, a combination of A and C will create the most outputs for a given set of inputs. This line is called the 'efficiency frontier', and defines the maximum combinations of output that can be produced for a given set of inputs.

Since company B lies below the frontier, it is judged to be inefficient. Its efficiency is given by a measure of how far it is from this frontier—ie, from virtual company, V, formed from company A and company C. The efficiency of company B is then calculated by finding the fraction of inputs that company V would need to be able to produce as many outputs as company B. This is calculated by looking at the line from the origin, O, to V. The efficiency of company B is OB/OV. The figure also shows that companies A, C and D are efficient, since they lie on the efficiency frontier.

The figurative method is useful in this simple two-dimensional example, but cannot be applied in higher dimensions. The normal method for evaluating the efficiency of company B is by using the linear programming formulation of DEA. Analysing the efficiency of *n* producers then leads to a set of *n* linear programming problems. The following formulation is one of the standard forms for DEA.

$$\begin{aligned}&\min \Theta, \text{ s.t.}\\&Y\lambda \geq Y_0,\\&\Theta X_0 - X\lambda \geq 0,\\&\lambda \geq 0.\end{aligned}$$

where, λ is a vector describing the percentages of other producers used to construct the virtual producer, and Θ is the estimated value of the producer's efficiency. The first constraint forces the virtual unit to produce at least as many outputs as the studied unit. The second constraint finds out how much less input the virtual unit would need. The factor used to scale back the inputs, Θ, is the efficiency score of the unit.

There are several advantages of DEA analysis. First, it is non-parametric, in the sense that companies are compared without assuming a functional form for a cost or production function. Second, it is a technique that permits comparisons to be made between companies for non-economic variables, such as performance and quality indicators.

Appendix 2: Regression Analysis

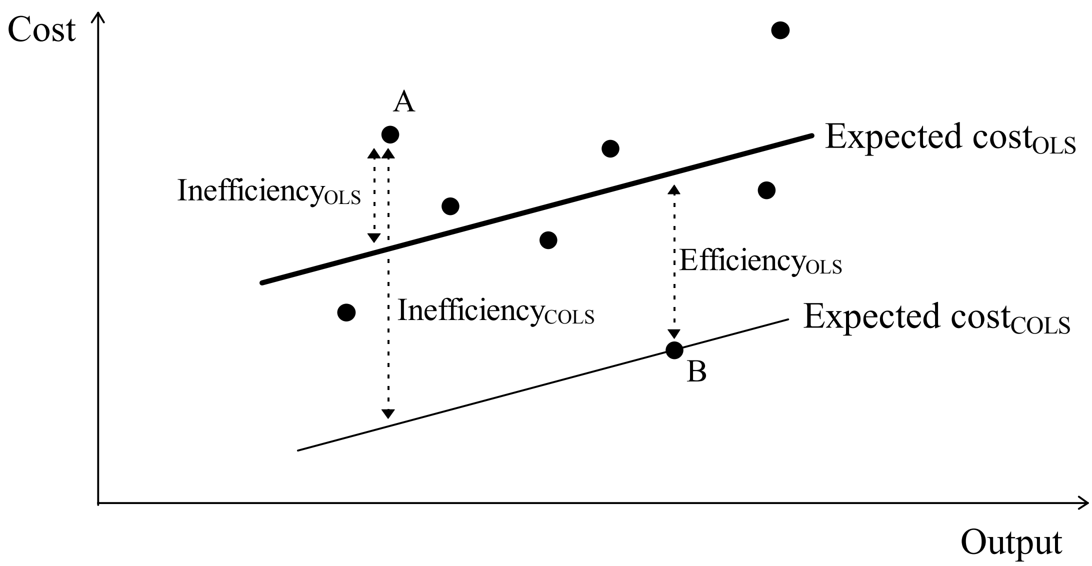
Comparisons of unit costs across companies take no account of the inherent differences between the companies. Regression analysis explicitly takes into account the influence of various factors in a company's operating environment that may explain differences in operating costs. First, a choice has to be made about the exact theoretical relationship—for example:

$$\text{cost}_i = \beta + \gamma\,\text{cost driver}_i + \varepsilon_i \qquad \text{Equation A1.1}$$

where the subscript i indexes the firms in the sample (1,2 . . . N).

The fact that the parameters β and γ do not change across companies implies that an industry average cost function is being estimated. This equation is estimated using OLS regression, which minimises the sum of the squared residuals, where the residuals represent the difference between the observed cost and the estimated, or expected, cost for each firm. The residual between the actual cost and the predicted cost is then treated as a measure of (in)efficiency—a positive residual implies inefficiency, as costs are greater than expected. This is illustrated below, ignoring the impact of additional cost drivers.

Figure A2.1: Graphical example of regression



In the above example, OLS regression results in the line *Expected cost$_{OLS}$* being fitted to the observations. Company A is then considered to be inefficient, as its observed costs are above its expected costs by the amount denoted *Inefficiency$_{OLS}$*. Company B is then considered to be efficient, as its observed costs are below its expected costs by the amount denoted *Efficiency$_{OLS}$*. Rankings may then be based on the percentage residuals.

The corrected ordinary least squares (COLS) method attempts to estimate a minimum cost frontier for the industry, rather than an average cost function. It does this by shifting the OLS estimated cost curve down to the most efficient company—ie, that company with the smallest, or largest negative, residual (in this case, company B). Inefficiencies are now denoted by the residuals from this new line, *Expected cost$_{COLS}$*. As a result, all companies are deemed to be inefficient, with the exception of the company on the frontier (company B), although the relative ranking of the companies will not alter.

Appendix 3: Stochastic Frontier Analysis

SFA is now a well-established method for comparing companies' relative efficiency levels. It is a relatively sophisticated regression technique that may be considered as a refinement of the more standard OLS regression method. This refinement is based on the attempt to separate the effects of measurement error and omitted explanatory variables from that of genuine inefficiency on the assessed level of efficiency of a set of companies.

Within the standard regression framework, it is acknowledged that the residual in an OLS-estimating equation reflects the combined effects of measurement error (in the dependent variable being modelled), omitted explanatory variables, and non-deterministic (ie, random) behaviour. However, in the application to the assessed levels of efficiency, all the estimated error term is ascribed to inefficiency. This approach may penalise companies with large regression residuals and which therefore appear inefficient in the models, since the impact of measurement error is not taken into account.

SFA attempts to divide these two components into their constituent parts: inefficiency; and measurement error, omitted variables, etc. This is done depending on how these two factors vary between companies—ie, their distribution. The measurement of relative inefficiency is then based solely on the former component—ie, the measurement error component is effectively ignored.

It is both inefficient and inequitable to base comparisons of efficiency levels, which are then used as a basis for setting efficiency targets that do not allow for the influence of measurement error and omitted explanatory variables, upon cost levels.

The division of the error term into these two components can be represented in the following way:

$$\varepsilon_i = u_i + v_i$$

where ε represents the standard OLS residual, which, under a set of assumptions, is able to generate desirable properties for the OLS estimator, including efficiency and no bias. Under SFA, this is decomposed into the two components, u, a noise term, and v, an efficiency term. The noise term, u, is intended to capture random statistical elements, such as measurement error, and is assumed to be symmetric (ie, it is equally likely to have a positive value as a negative value one). It is the inclusion of this effect that renders the industry cost frontier stochastic or varying between companies owing to such measurement error. Therefore, two companies with the same values for the underlying cost drivers may have different cost levels as a result of random fluctuations, *rather than differing efficiencies*. Any comparison that does not allow for such random fluctuations will exaggerate the extent to which some companies lag behind others, and will therefore unfairly disadvantage the company with a positive value for u.

The second term, v, is intended to capture the effects of inefficiency relative to the (stochastic) frontier, and is assumed to be asymmetric and one-sided. In other words, the stochastic frontier represents best practice, and companies cannot surpass it. This is in contrast to the OLS approach, where the regression yields an industry average with companies above and below the frontier. However, the OLS frontier may then be shifted to the company with the largest negative residual, such that, nominally at least, it reflects the idea of best practice and all companies have positive residuals. This latter approach is the COLS described earlier.

More generally, OLS will give a false impression of the extent of cost variation between companies that can be accounted for by differences in their efficiency levels rather than differences in factors that can be more readily described as 'chance'. This discussion serves to highlight that the importance of the extent to which variation in ε across companies can be accounted for by variation in u versus that in v.

Estimation of the stochastic frontier may proceed using either OLS combined with moment estimation, or maximum likelihood estimation (MLE). OLS-moment estimation begins with the OLS estimates for the parameters on each of the cost drivers. The second and third moments of the residuals are then calculated.[69] These are then used to estimate the variances of u and v. From these estimates, it is possible to correct the estimated constant term and the company-specific residuals, used as the measures of inefficiency.

An alternative estimation strategy is to use MLE, defined as the value that would be most likely to generate the observations. All unknown parameters are estimated jointly using iterative techniques, rather than sequentially, as in the OLS-moment estimation approach. Although the MLE is more efficient (more accurate) than the OLS-moment estimator, it is more difficult to compute. Nevertheless, most econometric packages contain MLE techniques.

In both cases, because only ε can be observed, distributional assumptions for u and v are required to separate the two error terms from the aggregate term.

[69] The mean of a distribution is its first moment, the variance its second and the skewness its third.

Appendix 4: OXERA Model Parameters

A4.1 Parameters for the first model

Ln(total costs_PwCC definition)	Coefficient	Standard error	t-value	Probability value
Ln(access lines_PwCC definition)	[✂]	[✂]	28.77	0.000
Ln(length of sheath)	[✂]	[✂]	3.65	0.001
Proportion of local calls to total calls	[✂]	[✂]	3.20	0.002
Constant	[✂]	[✂]	–3.43	0.001
Number of observations	52			
F(3,48) =	1,970.63			
Probability > F	0.000			
R-squared =	0.992			
Adjusted R-squared	0.991			
Root MSE =	0.130			
		Value	**Probability**	
RESET	F(3,45) =	2.110	0.112	
Heteroscedasticity	chi2(1) =	0.47	0.4933	
Skewness/kurtosis	adj. chi2(2)	3.45	0.1778	

Source: OXERA calculations.

The adj. R^2 value suggests that this model provides a good fit. However, the RESET tests suggest possible problems regarding functional form specification and omitted variables, given that the model fails to pass the test at a 12% significance level. Outlier analysis carried out suggested no problems with extreme observations.

When SFA was attempted, the following diagnostic test results were produced.

Distribution of the inefficiency component	Diagnostic test	Value	Probability
Half normal	chibar2(01)	0	1
Exponential	chibar2(01)	0	1
Truncated normal	z	–1.215	0.888

Source: OXERA calculations.

Since no test can reject the null hypothesis of the variation of the inefficiency component being greater than 0, the application of SFA cannot be statistically supported.

A4.2 Parameters for the second model

lncost	Coefficient	Standard error	t-value	Probability value
lncall_oth	[✂]	[✂]	–3.11	0.003
lnline_sw	[✂]	[✂]	16.04	0.000
lnsheath	[✂]	[✂]	2.19	0.034
Constant	[✂]	[✂]	–3.44	0.001
Number of observations	52			
F(4,48) =	1,970.63			
Probability > F	0.000			
R-squared =	0.994			
Adjusted R-squared	0.994			
Root MSE =	0.113			
		Value	**Probability**	
RESET	F(3,44) =	0.210	0.89	
Heteroscedasticity	chi2(1) =	0	0.9505	
Skewness/kurtosis	adj. chi2(2)	2.35	0.3081	

Source: OXERA calculations.

The adj. R^2 value suggests that this model provides a good fit and the model diagnostics suggest that no structural problems are present. Outlier analysis carried out suggested no problems with extreme observations.

When SFA was attempted, the following diagnostic test results were produced.

Distribution of the inefficiency component	Diagnostic test	Value	Probability
Half normal	chibar2(01)	1.62	0.102
Exponential	chibar2(01)	1.62	0.102
Truncated normal	z	0.915	0.18

Source: OXERA calculations.

The null hypothesis of the variation of the inefficiency component being greater than 0 is rejected at the 5% confidence level; however, for the half normal and exponential distributions, the hypothesis that SFA is applicable is significant at an 11% confidence interval. Due to this, the efficiency estimates of the SFA models are also reported.

A4.3 Parameters for the third model

lncost	Coefficient	Standard error	t-value	Probability value
lnline_sw	[✂]	[✂]	54.27	0.000
lnline2	[✂]	[✂]	2.66	0.010
lnswmin2	[✂]	[✂]	2.70	0.010
lnline_swmin	[✂]	[✂]	–2.66	0.010
Number of observations	53			
F(4,48) =	1,688.05			
Probability > F	0.000			
R-squared =	0.993			
Adjusted R-squared	0.992			
Root MSE =	0.129			
		Value	**Probability**	
RESET	F(3,45) =	1.380	0.263	
Heteroscedasticity	chi2(1) =	1.02	0.3128	
Skewness/kurtosis	adj. chi2(2) =	0.45	0.799	

Source: OXERA calculations.

The adj. R^2 value suggests that this model provides a good fit. The model diagnostics suggest that there might be a problem with the functional form specification, but this is mainly due to the fact that the constant term of the regression is statistically insignificant. Outlier analysis carried out suggested no problems with extreme observations.

When SFA was attempted, the following diagnostic test results were produced.

Distribution of the inefficiency component	Diagnostic test	Value	Probability
Half normal	chibar2(01)	0.48	0.244
Exponential	chibar2(01)	0.16	0.344
Truncated normal	z	0.597	0.275

Source: OXERA calculations.

Since no test can reject the null hypothesis of the variation of the inefficiency component being greater than 0, the application of SFA cannot be statistically supported.

A4.4 Parameters for the fourth model

lncost	Coefficient	Standard error	t-value	Probability value
lnswmin	[✂]	[✂]	2.06	0.045
lnline_sw	[✂]	[✂]	9.52	0.000
lnsheath	[✂]	[✂]	3.03	0.004
Constant	[✂]	[✂]	–6.35	0.000
Number of observations	48			
F(3,44) =	2,919.68			
Probability > F	0.000			
R-squared =	0.995			
Adjusted R-squared	0.995			
Root MSE =	0.104			
		Value	**Probability**	
RESET	F(3,41) =	0.760	0.526	
Heteroscedasticity	chi2(1) =	1.05	0.3058	
Skewness/kurtosis	adj. chi2(2) =	4.02	0.1341	

Source: OXERA calculations.

The adj. R^2 value suggests that this model provides a good fit. The model diagnostics suggest that no structural problems are present. The above model was formulated following the exclusion of a number of observations that were considered to be outliers. This assessment was reached when it was found that their inclusion in the model had an unduly large effect on its parameters and a detrimental effect on its overall accuracy. The companies removed from the analysis were: Verizon New York, Inc.; Verizon Washington, DC, Inc.; Puerto Rico Telephone Company Citizens of New York; and United Telephone Company of Texas, Inc.

When SFA was attempted, the following diagnostic test results were produced.

Distribution of the inefficiency component	Diagnostic test	Value	Probability
Half normal	chibar2(01)	0.13	0.362
Exponential	chibar2(01)	0.02	0.439
Truncated normal	z	0.305	0.38

Source: OXERA calculations.

Since no test can reject the null hypothesis of the variation of the inefficiency component being greater than 0, the application of SFA cannot be statistically supported.

APPENDIX 3: Pricing of Unbundled Access: Report by COVEC

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Pricing of Unbundled Access

for

New Zealand Commerce Commission

8 September 2003

This report sets out pricing principles for unbundled access and provides benchmark prices for a cost-benefit analysis of the Commission's scenarios for unbundling.

Contents

List of Tables

Executive Summary

Covec was asked by the Commerce Commission to report on several price-related issues for input into its assessment under section 64 of the Telecommunications Act (2001) (‘the Act’) of the merits of specifying or designating access to unbundled network elements. There were two specific components to the request.

First, a set of prices was required to feed into the formal cost-benefit analysis model being assembled and interpreted by OXERA. Secondly, we were asked to consider the options for defining initial and final pricing principles (which need to be stated for designated services) and to recommend a preferred approach in each case.

In addressing this mandate, we have been guided by the purpose statement contained in section 18 of the Act. This report begins with an analysis of the implications of the purpose statement for our work. We identify the price of access to unbundled elements as an important determinant of the costs and benefits of designation and discuss the channels through which the access price affects the long term benefit of end users.

We then discuss a set of relevant conceptual issues. These include the structure of pricing and the extent of geographical de-averaging. Regarding structure, there is a distinction required between the initial prices presented here for the cost benefit analysis and the prices that might ultimately be set by the Commissioner in the context of a determination. Discussions with OXERA and the Commerce Commission indicated that the cost benefit model being used to assess the merits of designation incorporates a two-part tariff for access to unbundled elements. This contrasts with the practice of telecommunications regulators, who have typically found the need for multiple tariff components. This is not to suggest that OXERA’s two-part tariff approach is inappropriate for the purpose to which it is being put, namely a cost-benefit analysis of a proposed regulation. On the contrary, considerable simplification is necessarily part of such an analysis, and a simplification of the tariff structure is no less objectionable than many other assumptions that are required.

The main implications of our conceptual analysis are for the pricing principles. We recommend that in the event that unbundling is designated, and determinations are required, separate tariffs should be struck for connection, monthly fees, co-location of different types, backhaul, and operational support systems. We also find that a limited form of geographical de-averaging is efficient.

We then discuss some practical matters for the setting of prices and the design of pricing principles. In combination with the evidence and the conceptual analysis, these lead us to the view that initial pricing principles should vary with the type of unbundled access. We favour benchmarking for unbundled access to full and shared local loops and access to the unbundled elements of the public data network. For bitstream access to the PSTN we recommend retail minus. We consider that bottom-up costing is an appropriate final pricing principle for all services except bitstream access. For the latter we recommend retail minus as the final pricing principle.

The final section of the report draws on publicly available data to derive service prices for use in the cost-benefit analysis. In the case of access to unbundled local loops and the unbundled elements of the public data network, our benchmarking directly results in an estimate for each price. For bitstream access we have used retail minus and have been obliged to develop weighted averages across the tariff options available. The weights used are reported here, and we will also pass the relevant spreadsheets to OXERA so that they can experiment with alternative weights should they choose to do so.

1. The Legal and Economic Context

This report contains key inputs into a study that, one way or another, will have a material impact on the development of the telecommunications industry in New Zealand. It is therefore necessary to ensure that the analysis is conducted in full view of the relevant legal and economic context. In this section we discuss the purpose statement contained in the Act, and the implications of this for the designation of unbundled access.[1]

Part 2 of the Act concerns designated services. Its purpose is described in section 18(1) as being

> "…to promote competition in telecommunications markets for the long-term benefit of end-users of telecommunications services within New Zealand by regulating, and providing for the regulation of, the supply of certain telecommunications services between service providers."

Further, in section 18(2), the "efficiencies" associated with particular outcomes are identified as a necessary criterion against which this purpose should be assessed.

At the time the Act was drafted and passed, there was consideration given to the addition of access to unbundled network elements into Schedule 1. This was decided against for largely pragmatic reasons. One of these concerned the workload of the Telecommunications Commissioner during the early stages of the regime. Instead, the Commissioner was required to conduct an investigation into the net benefits of providing access to unbundled elements and to report on this by December 2003.

Since the Act was passed, considerable additional experience with unbundling has been obtained in many countries. While the views of advocates on both sides of the current New Zealand debate may not have changed significantly, the Commissioner is now in a much better position to evaluate the relative merits of unbundling than was the case two years ago.

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[1] Specification does not concern us here because this status does not allow the Commission to rule on the pricing matters with which we are concerned.

2. How Unbundling May Promote LTBE

This report is part of a larger project designed to determine whether specification or designation of unbundled access will promote the long term benefits of end-users of telecommunications services in New Zealand. It is therefore relevant at the outset to consider, at least briefly, how this might occur.

Fundamentally, the source of a net benefit must be either sustainably lower prices for existing services, or the more rapid deployment of new services, or both. We consider each of these possibilities in turn.

Sustainably lower prices for existing services will be delivered by unbundling if and to the extent that: (a) the existing services are priced in excess of their cost; and (b) unbundling allows access to inputs at a lower cost than would otherwise be available, (c) and the administrative costs associated with unbundling are not too high. If any of these three conditions fails, unbundling will not promote the objectives of the Act in respect of existing services.

While there would seem to be several channels through which unbundling might deliver benefits to end users, the final welfare effect of such a step will clearly depend on the prices at which access is provided. The motivation for this project is therefore to estimate those prices. Our estimates will then be used in the broader cost benefit analysis.

3. Scenarios for Unbundling

Following are definitions of the four scenarios for which we were requested to determine initial and final pricing principles and also initial prices for the cost-benefit analysis.

3.1. Local Loop Unbundling Scenarios

Scenario A: Physical access to copper loops at the MDF and access at the cabinet where there is fibre in the feeder network (layer 1 in the OSI 7 layer model).

Scenario B: Access to a bitstream ADSL service at (a) Telecom's ATM switch (parent switch), and (b) the access seeker's Point of Interconnection with Telecom's ATM network (layers 2/3 in the OSI 7 layer model).

3.2. Fixed Public Data Network Unbundling Scenarios

Scenario C: Access to 2Mbit/s data tails at the Digital Distribution Frame (layer 2 access in the OSI 7 layer model).

Scenario D: Access to a bitstream services at speeds in excess of standard ADSL speeds at (a) Telecom's ATM switch (parent switch), and (b) the access seeker's Point of Interconnect with Telecom's ATM network and (layers 2/3 in the OSI 7 layer model).

Throughout the remainder of this paper we shall refer to these as scenarios A, B, C and D.

4. Conceptual Issues

In this section we discuss various general conceptual issues with regard to setting prices for unbundled local loop and public data network (PDN) services. The conceptual issues discussed here are general issues related to unbundling and for the most part we do not distinguish between the Commission's four unbundling scenarios. Where issues only apply to a subset of these scenarios, this will be specifically noted.

4.1. The Importance of Setting Appropriate Prices

The biggest challenge in implementing unbundling of the local loop and PDN is setting prices that provide appropriate signals to both the incumbent and entrants. Setting prices either too high or too low will send incorrect signals and will result in inefficiency by affecting the nature of competition in the market and technology choices of the firms.

First consider the case where charges for unbundled services are set too high. This will have the effect of reducing competition between the incumbent and any entrant. The reason is that these charges are a cost for the entrant(s) and revenue for the incumbent. Thus, high charges make it costly for the entrant(s) to sign up new subscribers, making entrants soft competitors. In addition, high charges also make the incumbent a relatively soft competitor, because it does not lose much revenue from losing a subscriber to an entrant.

Furthermore, setting relatively high charges for unbundled services will promote facilities-based entry through either duplication of the existing network or through alternative technologies such as wireless local loops. This is because the decision by an entrant of whether to engage in facilities-based entry depends on the opportunity cost of this entry. This in turn is determined by the prices that the entrant faces for access to unbundled services. Higher prices for these services reduces the opportunity cost of facilities-based entry as the profitability under service-based entry is lower.

There are similar, but opposite, effects from imposing local loop prices that are too low. Following similar logic as above, too low local loop prices will promote competition between the incumbent and entrant(s), but will make facilities-based entry relatively unattractive.

On the other hand, promotion of facilities-based entry through the adoption of new and superior technologies may be desirable from a welfare point of view. Section 4.2 covers this issue in more detail, but the key point to note is that the prices for unbundled services will have a strong influence on the adoption of alternative technologies.

4.2. When is Facilities-Based Entry Efficient?

Facilities-based entry in the context of unbundling involves creation of an alternative local-access network. In theory this could involve constructing a duplicate network, but if unbundling is implemented with correct prices, facilities-based entry is more likely to involve the use of an alternative technology such as some form of wireless access provision.

Such technology will presumably confer additional benefits to consumers through enhanced services and may also have lower operating costs. Overall, the alternative technology could be expected to generate a flow of net welfare gains over time.

However, this flow of welfare gains needs to be balanced against the one-off welfare cost of constructing the alternative network. In particular, a regulator who is deciding whether to promote facilities-based entry at any point in time must consider whether the present discounted value of the additional welfare that it generates is greater than the current-period cost of constructing the network.

Therefore, for facilities-based entry to be economically efficient, it must be the case that the present discounted value of the net welfare gains that it provides (due to lower costs or greater benefits, or both) exceeds the cost of constructing the alternative network. If not, it is not desirable to promote facilities-based entry even though such entry may be superior in some respects to the current technology.

4.3. Structure of Prices for Unbundled Services

Unlike setting the correct *levels* for the local loop prices and determining the likelihood of facilities-based entry, the appropriate *structure* of access prices for unbundled services is relatively easy to determine. In particular, the access prices charged to entrants should take the form of a multi-part tariff, so that prices reflect as closely as possible the actual costs incurred in providing such services.

In general, basic unbundled services should be priced using a two-part tariff such as a connection fee and a periodic (probably monthly) rental charge. This reflects the fact that there are one-off costs associated with switching existing lines from the incumbent's network to the entrant's network or with connecting new lines, and that there are ongoing direct and indirect costs associated with operating these lines.

Depending on the nature of the service-based entry undertaken by an entrant, costs additional to those discussed above will be incurred by the incumbent. These costs will be passed on to the entrants in the form of cost-based prices. To the extent that these costs are distinct and separable from those already mentioned, economic efficiency requires that these be priced separately. The three main types of cost that fall into this category are those that arise from backhaul, co-location, and operational support systems. We now briefly discuss the issues arising from these types of cost.

4.3.1. Backhaul

The need for backhaul will arise under the Commission's proposed scenarios B and D, if the access seeker chooses to interconnect at their point of interconnection with Telecom's ATM network, rather than at the closest feasible point to the customer (i.e. at the concentrator or switch end of the local loop or data tail). In this case, Telecom will incur costs of carrying the traffic over its network from the end of the local loop or data tail to the point of interconnection with the access seeker's network.

Since the costs associated with backhaul are not always incurred (depending on the entrant's choice of mode of entry), and are clearly separate from the costs of operating the local loop or data tail, they should be priced separately. Appropriate cost-based prices for backhaul will ensure efficient use of this option by entrants.

4.3.2. Co-location

The second type of cost that should be priced separately are those costs associated with co-location. Co-location costs are incurred by the incumbent when the entrant installs equipment at the incumbent's facilities and premises and these costs should be passed on to the entrant in the form of cost-based prices. Co-location costs will be incurred by Telecom if the entrant chooses scenarios A or C, and to a lesser extent under scenarios B and D.

Pricing for co-location is further complicated by the fact that in practice there are different ways that it can be implemented. In general there are three different ways that co-location can be achieved:

1. *Hosted* or *hostel* co-location: The equipment of access seekers is housed in separate rooms or areas at the incumbent's facilities.
2. *Co-mingling*: The equipment of access seekers is housed at the incumbent's facilities but is mixed in with the incumbent's equipment, not in a separate room or area.
3. *Distant* co-location: The equipment of access seekers is housed at a distant location and an external tie-cable is used to connect the incumbent's exchange with this remote site.

To promote the efficient use of each of these three types of co-location, each should be priced separately.

4.3.3. Operational Support Systems

Costs in this category are those associated with systems such as handling provisioning, pre-ordering, and fault testing. For example, Telecom may have to modify its operational support systems to incorporate handling of orders and faults related to unbundled local loops. Again, to the extent that these costs can be identified separately from other costs associated with the appropriate scenario, they should be priced separately.

4.4. De-averaging

De-averaging refers to the practice of setting different prices for unbundled services in different geographical locations. This allows the prices to better reflect the costs of serving different types of customer, and sends more appropriate signals than a uniform price. We are in favour of de-averaging as it is more likely to promote economic efficiency. The basic arguments have been laid out by the ACCC,[2] and Belfin *et al* (1999), and are as follows.

First, de-averaged prices are less likely to impose distortions on the investment decisions of Telecom or potential entrants. A uniform price will necessarily be above the cost of serving customers in low-cost areas such as CBDs and below the cost of serving customers in high-cost areas such as rural locations. A uniform price will therefore encourage facilities-based entry by entrants who are less efficient than Telecom in low-cost areas, possibly resulting in greater duplication of the local loop in these areas. Entrants will also use Telecom's infrastructure to a greater extent than is efficient in high-cost areas.

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[2] *Pricing of Unconditioned Local Loop Services (ULLS)*, Final Report, March 2002.

Second, uniform prices are likely to result in a greater degree of 'cream-skimming' by entrants than are de-averaged prices. Cream-skimming occurs when entrants confine their entry to high-value areas such as central business districts. Note, however, that cream-skimming is only undesirable to the extent that it is undertaken by inefficient entrants. For example, if high-cost entrants are induced to duplicate existing networks in high-value areas where the uniform price is too high, cream-skimming is inefficient. If entrants have lower costs, then cream-skimming is efficient.

In particular, as discussed above, a uniform price is more likely to promote inefficient facilities-based entry in high-value areas causing Telecom to lose more line revenue in these areas. Furthermore, in low-value areas where the uniform price is below the cost of providing access, Telecom will be unable to recover the cost of serving these customers.[3] Short of setting an individual access price for each local loop or data tail, cream-skimming cannot be prevented entirely. Nevertheless, some de-averaging will go some way towards reducing this problem.

Finally, it is likely that some technologies for providing access may be more appropriate in some areas. For example, wireless or satellite services may be the most appropriate technology for remote rural areas, while the copper network may be most appropriate in CBDs. Prices for unbundled services that at least to some extent reflect the cost of operating the existing network in these different areas will send better signals to guide investment in alternative technologies in different areas.

The main disadvantage of using de-averaging is that it requires setting more prices and thus is more time-consuming and expensive to implement. This cost must be compared to the benefits that flow from sending clearer investment signals, as described above. In New Zealand, as in Australia, the costs of providing service in urban and rural areas are likely to be very different. However, the costs and difficulties involved with setting a large

[3] A further complicating factor when implementing de-averaging is its implications for the Telecommunications Service Obligation (TSO). Of the four options presented by the Commission, the TSO is only applicable to scenarios A and B, since these are the only scenarios that involve voice services. Nevertheless, some research beyond the scope of the present study will have to be undertaken to determine the implications that unbundling has for the TSO.

number of geographically determined prices means that a relatively small number of price categories should be used.

The ACCC's approach of using four separate bands is a pragmatic way of addressing the problem of de-averaging without creating excessive regulatory overhead. These four bands are defined as:[4]

1. CBD areas (Sydney, Melbourne, Brisbane, Adelaide, Perth).
2. Urban areas of capital cities, metropolitan regions, and large provincial centres.
3. Semi-urban areas including outer metropolitan and smaller provincial towns.
4. Rural and remote areas.

A similar mapping could be applied to New Zealand. Some analysis beyond the scope of the present study would have to be undertaken to determine the appropriate number of bands and the exact band definitions.

In summary, we recommend that some form of de-averaging be implemented for the reasons outlined above. However, for pragmatic reasons de-averaging has not been applied to the initial prices developed in this report. In particular, the analysis required to identify appropriate bands has not been undertaken at this time.

4.5. Recommendations

The conceptual issues discussed in this section lead us to make the following recommendations with regards to prices for unbundled services:

- Care must be taken when setting access prices so as to achieve correct signals for service-based and facilities-based entry.

- The prices for unbundled services should reflect, as closely as possible, the costs associated with these services. To the extent that costs can be separated into components that affect decisions of access seekers (e.g. whether to use backhaul or the form of co-location), separate prices should be charged for these components.

- Some form of geographic de-averaging should be implemented.

[4] See *Pricing of Unconditioned Local Loop Services (ULLS)*, Final Report, March 2002.

5. Practical Issues

This section outlines practical issues surrounding pricing principles for designated services.

5.1. Initial versus Final Price Determinations

If private commercial negotiations between the incumbent and unbundled services access seeker fail, the parties may apply to the commission for a determination. In such instance, the Commission intervenes and sets prices for designated services on their behalf. In most jurisdictions, these prices are determined by a cost-based pricing model, of a similar form to those used for interconnection pricing. However, considerable time is required to fully calibrate and populate such models. Recognising this general point, the Act envisages that the Commissioner may wish to stimulate competition more expeditiously, setting short-term prices in an initial pricing determination. These initial prices bind market participants until final prices become available or until the parties reach mutual agreement through renegotiation.[5]

The remainder of this section outlines practical issues associated with determining initial and final prices for unbundled services. Due to the higher complexity and number of issues associated with final prices, the majority of our discussion will be confined to this area.

5.2. Setting Initial Prices

The short timeframe associated with initial price determinations significantly narrows the range of pricing principles on which they can be based. An attractive approach to selecting a reasonable price in a short timeframe is to use international benchmarks. This involves setting the initial price on the basis of average prices in other jurisdictions.

The benchmarking approach has many obvious advantages. First, relative to a bottom-up cost-based approach, it is quick and simple to implement. Second, it is highly transparent. Third, it ensures that regulatory decisions are not at

[5] To the extent that initial and final pricing principles differ, so too could the prices set by the Commission in their initial and final determinations. To this end, the Commission may wish to consider how the two sets of prices should be reconciled.

odds with those made by international counterparts. However, this approach also has its shortcomings.

First, benchmarking generally fails to account for differences in the operating environments faced by international and domestic market participants. This point was discussed in detail by Sidak and Singer (2002), who considered an extension to standard benchmarking analysis. The authors show how econometric modelling can be used to reflect the influence of variables that may influence unbundled services costs. These variables could include factors such as population density, wage rates, the degree of urbanisation, line density and so on.

Second, naïve averages, as used in standard benchmarking, can provide inaccurate in- and out-of sample predictions when they are small in relation to their sample variances. In other words, setting domestic initial prices on highly-variable international prices is dubious when confidence intervals on the sample mean are relatively large. This is particularly problematic if the international prices are highly skewed, with one or two outlying observations having a marked influence on the benchmark average. In this instance, sample medians provide more robust estimates.

Of course, there are also cases where benchmarking is not appropriate or not feasible. This may be due to lack of suitable data or some other compelling reason that precludes its use. An alternative that could be attractive in some circumstances is the 'retail minus' approach. This involves taking the retail price of a service and subtracting some percentage to derive the wholesale price. This does not completely avoid the issues associated with benchmarking, though it does considerably reduce their complexity. For example, exchange rates are largely irrelevant to the size of the appropriate discount.

The discount should be large enough to support an efficient supplier of the resale service. There is no need to provide a larger discount, and in any event, the final access price (retail minus discount) should not be less than the efficient cost of wholesale supply. Within these bounds however, there are divergent views among regulators about the appropriate amount to be subtracted. Some adopt a discount that reflects an estimate of the average mark-up across several of the incumbent's services. A well known alternative (the efficient component pricing rule) sets the discount with reference to the costs saved by the incumbent in not providing the retail component of the service. In our view, these conceptual differences combined with data limitations mean that there is little to be gained in benchmarking the discounts to be used in retail minus pricing. We therefore refer to retail-minus as a substitute for benchmarking and other pricing methods.

On the basis of available data and suitability of the various approaches, we recommend initial pricing principles in Table 1 be applied to the scenarios under consideration by the Commission.

Table 1 Recommended Initial Pricing Principles for Unbundled Services.

Unbundled Service	Initial Pricing Principle
Full and Shared (A)	Benchmarking
Bitstream Access (B)	Retail Minus
PDN Services (C & D)	Benchmarking

These recommendations are based on the following rationale. First, we consider that benchmarking is the best way to get a reasonable price in a short timeframe. While it is true that this approach is not without its problems, the Commission is experienced in dealing with those problems and can be expected to further develop and refine its benchmarking capability in the future. Furthermore, there is a good range of available data on many of the prices required for this study, so we recommend these be used in benchmarking analyses where that is feasible.

Benchmarking is not feasible for bitstream access pricing however, because of a lack of suitable data. There are several possible reasons for the lack of data, including the fact that this service is not available in all jurisdictions that have unbundled, that in some locations where it is available it has been a recent addition to the list of access types, and the diversity in definition of the bitstream service.

In seeking an alternative to benchmarking for the initial pricing of bitstream access we adopted retail-minus on the grounds that it is feasible (there is a retail bitstream service that can be used as the starting point), quick, and reasonable. On the last point, we note that of the alternative scenarios for providing unbundled access, bitstream access is the closest to pure resale and involves the lowest capital commitment from the access seeker. When compared with the regulation of voice services within this regime, bitstream access therefore looks more like “wholesaling” than “interconnection”.

5.3. Setting Final Prices

The general consensus amongst international regulatory bodies is that final unbundled services prices should reflect the cost of efficient service provision. In practice, however, we lack a method of identifying the cost of producing a specific service or services. All we know is the current cost of producing the bundle of services we presently sell.

The challenge for regulators is then to construct a model that accurately identifies the costs of the service to be regulated. This, in turn, requires regulators to consider three dimensions of an incumbent's costs: the method of cost capture; the cost base; and the cost standard. While these dimensions are not mutually exclusive, considering them in isolation helps identify the advantages and disadvantages of the possible approaches.

The remainder of this section considers each of these dimensions in the New Zealand context to recommend final pricing principles for unbundled services.

5.3.1. Cost capture

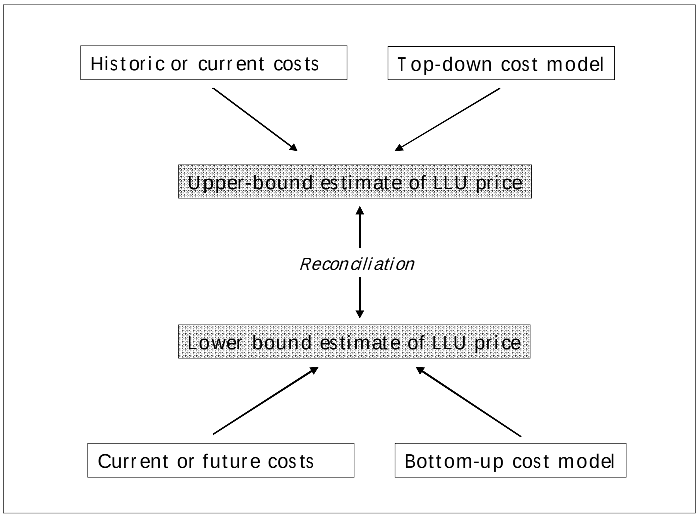
The first step in deriving unbundled services prices is to capture all costs borne by the incumbent in relation to the service being subjected to regulation. This can be done using either a top-down or bottom-up costing model. Top-down models use the existing network and information stored in company accounts to derive costs. Starting from a summation of all network costs, including overheads, an attempt is made to identify the costs associated with progressively more narrowly-defined services. Bottom-up models are frequently based on efficient rather than actual network design. In this case, construction involves designing a hypothetical optimized network of a pre-specified capacity using current technology. The inputs required to deliver the services over this hypothetical model are then costed, and unit costs computed.

In principle, under similar assumptions the two approaches should produce identical results. In practice, however, this is seldom the case. For instance, the Austrian regulator's bottom-up model gave only 56% of the costs produced by the incumbent's top-down model (Belfin *et al*, 1999). A similar discrepancy was reported in the United Kingdom, leading OFTEL to commission a full external reconciliation of the bottom-up and top-down results (Cave, 2002).

Discrepancies between top-down and bottom-up costs usually stem from three sources: different input assumptions; different cost bases (which we discuss later); and different network technology and topology. It therefore follows that if input assumptions and cost bases are roughly equal, any discrepancy can reasonably be attributed to inefficiencies of the existing network structure. In other words, the hypothetical optimised network underlying the bottom-up approach differs from the actual network, implying that the latter is suboptimal.

Broadly speaking, because bottom-up costs are generally based on an optimised network using the latest technology, they are usually lower than top-down costs, all other things being equal. This has led many researchers to describe top-down costs as defining an upper bound and bottom-up costs as defining a lower bound. This characterisation is illustrated in Figure 1.

Figure 1 Reconciliation of Top-down and Bottom-up Costs.



Just as each approach is based on its own set of inputs and assumptions, each also has its own advantages and disadvantages. These are summarised in Table 2.

Based on the relative advantages and disadvantages conveyed in Table 2 and in keeping with previous decisions of the Commission, we recommend using a bottom-up model for determining the final prices of unbundled services.

Table 2 Advantages and Disadvantages of Top-down and Bottom-up Models.

Method	Advantages	Disadvantages
Top-Down	Not as dependent on assumptions and external information	Prices may embody and pass on incumbent inefficiencies
	Prices are based on actual costs, rather than estimates	Incumbent may manipulate cost data to increase prices
	Information usually readily accessible from incumbent accounting data	Complexity of accounting information can hamper transparency of prices
		No incentives for efficiency
Bottom-up	Less dependent on incumbent information	Highly dependent on plausibility of assumptions
	Exclude possible inefficiencies from prices	Scope depends on availability of external data
	Greater transparency than top-down models	Requires detailed engineering model
	Provide correct signals for efficient entry & investment	

5.3.2. Cost Base

The next cost dimension to be considered is the cost base to which the bottom-up model will be applied. There are two bases to choose from: historic costs and forward-looking costs.

As their name implies, historic costs are costs incurred in the past for existing network equipment. As such, the information will be stored in the firm's accounting data and therefore readily accessible. Forward-looking costs, or more precisely "forward-looking costs of modern equivalent assets", are quite different. These are costs that would be incurred if network equipment were bought today or in the near future. Its definition can be complicated by technological innovation, which potentially renders older equipment obsolete. In general, if modern equivalent assets are more technologically advanced than actual installed equipment and / or if asset prices have fallen over time, forward-looking costs will be lower than historic costs.

As with the various forms of cost capture, the two forms of cost base also have their own advantages and disadvantages. These are summarized in Table 3.

Table 3 Advantages and Disadvantages of Historic and Forward-looking Costs.

Base	Advantages	Disadvantages
Historic	Information readily available	Does not reflect cost of modern efficient technology
	No assumptions required about equivalency of modern assets	Passes on legacy of all inefficient decisions and investments to new entrants
		Does not reflect evolution of asset prices
		Sends wrong signals to market
Forward-Looking	Most accurately reflects costs incurred by an efficient new entrant	Based on forecasts and therefore highly dependent on assumptions
	Eliminates inefficiency inherent in historic costs	
	Provides most accurate investment signals	

As noted earlier, the choice of cost base and method of cost capture are not mutually exclusive and should thus be considered jointly. In particular, top-down models can use only historic costs, while bottom-up models can only forward-looking costs. Since we earlier recommended a bottom-up model, our choice of cost base is restricted to forward-looking costs. This is consistent with the cost base used by the Commission in previous telecommunications determinations.

5.3.3. Cost Standard

The final cost dimension that needs to be considered to establish final pricing principles is cost standard. This refers to the scope and type of costs that feed into the costing models. As you would expect, the choice of cost standard has a significant effect on the total estimated cost of service provision and thus the regulated price of unbundled services.

Although the choice of cost standard is restricted by the choice of cost capture (as was the case with cost base), we first outline the most common forms of cost standard used internationally to regulate unbundled services prices.[6]

Fully Distributed Costs (FDC) allocates all of an organisation's costs to its services and products. Therefore, the costs of a given service are composed of direct volume-sensitive costs, direct fixed costs and a share of the joint and

[6] Cost standard definitions in this section were abridged from Andersen (2002).

residual common costs. Often the proportion of joint and residual common costs is causally related, although it is sometimes allocated in an arbitrary manner. Difficulty in allocating unattributable costs is the major weakness of this cost standard – there is too much flexibility and lack of accountability in the costs derived.

Stand-alone Costs is a cost standard that measures the cost of providing a service in isolation from the other services of the company. It includes all costs directly attributable and all shared cost categories related to production of the service, which includes volume-sensitive, fixed, common and sunk costs. Under this allocation method, the shared costs are totally supported by the service that is to be provided in isolation.

This standard does not lead to economic efficiency if used for pricing and resource allocation decisions. Purchasers of this service bear the burden of the total costs of resource that are also used in the provision of all other services, thereby distorting price signals.

Embedded Direct Costs (EDC) considers only the directly attributable and indirectly attributable volume-sensitive and fixed costs. This is considered by many regulators to be too narrow a description of costs for the purpose of LLU prices.

Marginal Costs (MC) measure the costs of increasing the production output by one additional unit or the costs saved by reducing the production output by one unit, holding the production levels of all other services constant. This definition implies that MC include only the direct volume-sensitive costs of the given service, excluding all cost categories that do not either demonstrate a causal relationship with the unitary change in output, or do not vary with the output.

Marginal Costs are hard to implement because costing of unitary changes in production output is rarely possible (capital and labour are difficult to divide). Furthermore, joint and common costs will not be covered if all services are priced at marginal cost.

Long-Run Average Incremental Costs (LRAIC) associates a long-term horizon to incremental costs. Incremental Costs measure the cost variance when increasing or decreasing the production output by a substantial and discrete increment. In the particular case where the increment considered is a single unit, incremental costs equal marginal costs. Because the increment is substantial, not only the volume sensitive and directly attributable costs are taken into account. Some capital and fixed costs are also incorporated in the cost of the service. In the long-term all costs are treated as variable as the production capacity is not a constraint any more. Therefore, long-run incremental costs include capital and the volume-sensitive costs related to substantial change in production.

Among the cost standards listed above, the two most commonly used by international regulators for unbundled services are FDC and LRAIC. Before recommending a cost standard upon which to establish final pricing principles we first briefly outline the advantages and disadvantages of these two main approaches. These are summarised in Table 4.

Given that we have already selected a bottom-up cost model based on forward-looking costs, only one of these cost standards is applicable – LRAIC. Fortunately, this is also the standard most likely to produce efficient prices. Further, since the Commission is developing a total service long run incremental cost (TSLRIC) model, which is an embodiment of the LRAIC approach, many of the difficulties in constructing and populating the model articulated above are circumvented.

Table 4 Advantages and Disadvantages of FDC and LRAIC.

Standard	Advantages	Disadvantages
FDC	Relatively easy to develop	Disincentive for incumbent to be efficient
	Based on readily available information	Cost allocations largely arbitrary when indirect costs are high
	Easy to audit/transparent	Do not provide correct signals
LRAIC	Generate efficient, subsidy-free prices	Very difficult to construct & require numerous inputs
	Provide correct price signals	Hard to understand/audit
	Do not propagate legacies of an inefficient incumbent	Data not extracted from accounts, so expensive to populate

In implementing the TSLRIC cost concept, the relevant increment is taken to be the entire service at issue. Restricting attention to capital costs for a moment, the cost base for TSLRIC is defined as the difference between the capital costs of building two modern networks: one of which provides the service at issue, while the other does not. To the extent that some components of the network need to be larger when the service is provided, the cost of providing that additional capacity is relevant. The cost base is then annualized (using assumptions about asset lives, depreciation rates and the rental cost of capital), and unitized (to share the annual cost over the relevant number of units of the service provided). It should be clear that this results in an averaging across all units of the service of the long-run incremental cost of providing the service.[7]

In general, we consider that a bottom-up, forward-looking LRAIC concept be should used for determining final unbundled services prices unless the form of access is close to pure resale. Of the four scenarios considered here, we see bitstream access as the only sensible exception from the LRAIC concept, and recommend that this be priced using the retail-minus method. The rationale draws on our thinking in section 5.2 above. While regulations that have the effect of cutting retail prices and improving competitive access to existing services *can* certainly increase long-run welfare, major dynamic efficiency gains require new services. Thus it seems sensible to direct access seekers towards avenues that are likely to provide larger potential gains to end-users over the long run.

5.4. Recommendations

The practical issues discussed in this section lead us to make the following recommendations with regards to prices for unbundled services other than bitstream access:

- *Method of Cost Capture:* Bottom-up.
- *Cost Base:* Forward-looking costs.
- *Cost Standard:* LRAIC.
- The Commission's TSLRIC model could be adapted to derive final prices for unbundled services.

For bitstream access we recommend retail-minus as the final pricing principle.

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[7] In the USA, a similar method known as total element long run incremental cost (or TELRIC) is used, in which the costing problem starts by specifying all of the incremental elements required (and proportions of their use) to provide the service at issue, and then aggregates these up.

5.5. International final pricing principles

As a matter of comparison, we have produced Table 5 to show the final pricing principles adopted internationally for unbundled local loop (ULL) prices.

Table 5 International approaches to determining final ULL prices.

Country	Cost Base	Cost Standard
Belgium	Historic	Retail minus
Denmark	Historic & Best practice	FDC
Germany	Forward-looking	LRAIC
Greece	Current	LRAIC
Spain	To be determined[8]	
France	Current	LRIC +mark-up for common costs + specific costs
Ireland	Historic	FDC
Italy	Historic	FDC
Luxembourg	-	-
The Netherlands	Current	EDC
Austria	Current	FDC
Portugal	Flexible[9]	
Finland	Historic/Current	Company specific
Sweden	Historic	FDC
UK	BT: Forward-looking/current Kingston: Forward-looking/current	BT: LRIC + FDC Kingston: CCA + FDC

Source: Eighth Report of the Commission of the European Communities on the Implementation of the Telecommunications Regulatory Package (Annex 2).

[8] The prices of the unbundled local loops have been set by the Comisión Delegada del Gobierno in December 2001. The collocation prices have been established by CMT, taking into account average costs, on the basis of a study carried out by independent consultants with a specific expertise on the subject, who gave to the CMT the market value of a cost. The associated services and the peak rate (modified by CMT by Resolution of 29 April 2002), have been determined taking as a basis a study of an independent consultant applying the "bottom-up"

9 When establishing costs / prices for a new service, ANACOM identifies in the accounting system of PTC (ABC), the resources used and the activities necessary to supply the new service. The actual expenses and budget are also used to determine a cost for the local loop.

6. Initial Prices

In this section we develop initial (wholesale) prices for the four unbundling scenarios set out by the Commission. We separate these into prices for scenarios that use the copper local loop (scenarios A and B) and those that use the fixed public data network (scenarios C and D).

For all scenarios, we estimated two-part tariffs, consisting of a one-off connection charge and a monthly rental. For scenarios A, C, and D these tariffs are based on international benchmarks and we have endeavoured to obtain the latest publicly available data. This is particularly important since prices for such services have been steadily declining. The international prices have been compiled from multiple sources and have been converted to New Zealand dollars using long-run average exchange rates, as detailed in the appendix. The data reveals there is great variation in international prices for unbundled services. To some extent this reflects the different pricing principles upon which they are based.

Although access to unbundled network elements has been mandated in many countries, prices are not yet available for some services, for example shared access to the local loop in Australia.

6.1. Unbundled Local Loop Prices

In this section we develop initial prices for unbundled local loop services for the purpose of the cost-benefit analysis (scenarios A and B).

6.1.1. Physical Access to Copper Loops (Scenario A)

These prices are based on the available local loop prices from a variety of countries that have mandated unbundling. These prices are shown in Table 6. As the Commission has not ruled out shared access, we include both full and shared access prices.

The similarity in means and medians indicates that the data is not significantly skewed, and so we adopt the sample means as the benchmark prices in this case. For full unbundling, this gives a monthly rental of **$23.85** and a connection fee of **$172.46**. For shared access, this gives a monthly rental of **$11.21** and a connection fee of **$203.68**.[10]

[10] A comparison between countries that use historic costs versus those that use current or forward-looking costs reveals no statistically significant difference in the means.

Table 6 Unbundled Local Loop Benchmarking
(all prices in NZ$ excluding GST).

	Full Unbundling		Shared Unbundling	
	Monthly Rental	**Connection**	**Monthly Rental**	**Connection**
Australia	23.53	119.51	NA	NA
Austria	24.72	97.62	9.85	195.23
Belgium	24.07	144.57	5.79	156.51
Canada	29.28	NA	NA	NA
Denmark	13.14	71.86	6.49	282.37
Finland	25.23	370.77	12.02	274.64
France	18.70	140.18	5.17	140.18
Germany	21.92	123.82	8.42	131.36
Greece	16.58	177.91	9.95	204.58
Hungary	31.57	NA	30.99	NA
Iceland	21.70	64.88	7.81	64.88
Ireland	28.80	208.30	15.43	211.56
Italy	21.34	175.74	5.38	155.74
Japan	26.63	NA	2.38	NA
Korea	17.69	NA	11.73	NA
Luxembourg	27.10	318.32	12.86	336.50
Netherlands	31.14	224.75	23.18	224.41
Norway	22.82	173.55	16.54	363.86
Portugal	24.94	39.59	9.50	53.44
Spain	19.01	277.93	9.09	198.52
Sweden	24.10	141.01	10.00	159.21
U.S. (avg)	27.49	NA	NA	NA
UK	27.01	233.95	11.67	309.49
Average	**23.85**	**172.46**	**11.21**	**203.68**
Median	**24.10**	**159.06**	**9.90**	**198.52**

Sources: Eighth Report of the Commission of the European Communities on the Implementation of the Telecommunications Regulatory Package, Development in Local Loop Unbundling (OECD), Pricing of Unconditioned Local Loop Services (ACCC), and A Survey of Unbundled Network Element Prices in the United States (Public Service Commission of West Virginia).

6.1.2. Access to Bitstream ADSL Service (Scenario B)

Given the lack of comparable international data upon which to develop benchmark prices and difficulties in aligning service definitions, for this scenario we use a retail minus approach. Following standard practice in the European Union, we adopt a 20% reduction factor for retail prices.[11]

Telecom's retail ADSL offerings fall into residential and commercial categories. Since any given phone line is charged as either residential or commercial, we maintain this separation and present two sets of initial prices.

Within the residential and commercial categories, Telecom offers a number of services. These services are differentiated according to the bundled monthly data quota, as well as (for residential services) the transmission speed. So as to provide single initial tariffs for residential and commercial, we have formed expectations over the proportions of users that will subscribe to the different plans on offer. For the cost-benefit analysis, we will provide to OXERA an Excel model which allows these parameters to be manipulated in case their expectations differ from ours.

Residential Prices

Telecom's current retail prices for residential ADSL services and the weightings that we have applied are shown in Table 7. From the weightings and prices in Table 7 we determine an average residential ADSL connection fee of $220.44 and an average monthly fee of $31.79. Applying the 20% regulatory discount gives benchmark prices for residential services under scenario B of **$176.35** for the connection fee and **$25.43** for the monthly charge.

Table 7 Retail Residential ADSL Prices (excluding GST) as at August 2003.

Plan	Speed	Data cap	Connection Fee[1]	Monthly Fee[2]	Weight
Starter	128kbps	Unlimited*	$220.44	$26.62	0.8
Home 500	Full rate	500Mb	$220.44	$43.56	0.1
Home 1000	Full rate	1,000Mb	$220.44	$61.33	0.1

Source: www.xtra.co.nz

[11] See, for example, the Ovum report, *Partial Private Circuits in the EU*. This is quite close to the 16% value that the Commission used in its Final Determination on wholesaling of services to TelstraClear by Telecom. While we feel that an appropriate figure lies in the range of 16% to 20% we do not have strong views as to the selection of a value from this range.

*: Data caps may be imposed by the ISP.

1: Full wiring and connection fee, excludes ISP joining fee.

2: Excludes ISP's fee.

Commercial Prices

Telecom's current retail prices for commercial ADSL services and the weightings that we have applied are shown in Table 8. These do not differ by speed and all are full-rate ADSL services. From the weightings and prices in Table 8 we determine an average commercial ADSL connection fee of $220.44 and an average monthly fee of $283.29. Applying the 20% regulatory discount gives benchmark prices for commercial services under scenario B of **$176.35** for the connection fee and **$226.63** for the monthly charge.

Table 8 Retail Commercial ADSL Prices (excluding GST) as at August 2003.

Plan	Data cap	Connection Fee[1]	Monthly Fee[2]	Weight
Jetstream 600	600Mb	$220.44	$61.33	0.10
Jetstream 1200	1200Mb	$220.44	$120.00	0.15
Jetstream 1800	1800Mb	$220.44	$176.89	0.24
Jetstream 3000	3000Mb	$220.44	$292.00	0.30
Jetstream 5000	5000Mb	$220.44	$458.00	0.15
Jetstream 10000	10000Mb	$220.44	$888.00	0.05
Jetstream 20000	20000Mb	$220.44	$1600.00	0.01

Source: www.xtrabusiness.co.nz

1: Full wiring and connection fee, excludes ISP joining fee.

2: Excludes ISP's fee.

6.2. Fixed Public Data Network Prices

In this section we develop benchmark prices for the fixed public data network services (scenarios C and D). Wholesale data tail services are available to some extent in the European Union (where they are known as Partial Private Circuits, or PPCs), and so we use the available data from European Union countries for generating benchmark prices for these services.

PPCs are differentiated according to the length of the tail and the speed of transmission. Accordingly, we report prices for two lengths (2km and 5km) and two speeds (2Mbit/s and 34Mbit/s). The two speeds map directly to scenarios C and D respectively. Data for comparable services for Australia and the United States were not readily available in the public domain and consequently have not been used in the benchmarking of PDN prices.

Due to the large variation in the prices for these services, we have adopted the medians as the benchmark prices.

6.2.1. Access to 2Mbit/s Data Tails (Scenario C)

Table 9 presents data on the prices of 2Mbit/s PPCs for European Union countries after converting to New Zealand dollars using the exchange rates in the Appendix. This gives a connection fee of **$2,060** for either a 2km or 5km tail, and a monthly rental of **$519** for a 2km tail and **$651** for a 5km tail.

Table 9 2Mbit/s Partial Private Circuit Prices in the EU
(all prices in NZ$, excluding GST).

	2km Tail		5km Tail	
Country	**Monthly Rent**	**Connection**	**Monthly Rent**	**Connection**
Belgium	527	4,486	950	4,486
Denmark	130	1,341	130	1,341
Germany	296	2,894	651	2,894
Greece	519	3,385	505	3,385
Spain	1,140	1,265	1,386	1,265
France	869	2,189	980	2,189
Ireland	300	6,007	1,174	6,007
Italy	673	1,092	673	1,092
Luxembourg	491	2,550	737	2,550
Netherlands	589	892	589	892
Austria	573	2,687	627	2,687
Portugal	651	1,566	651	1,566
Finland	271	2,060	271	2,060
Sweden	373	64	490	64
UK	517	931	582	931
Average	**528**	**2,227**	**693**	**2,227**
Median	**519**	**2,060**	**651**	**2,060**

Source: Eighth Report of the Commission of the European Communities on the Implementation of the Telecommunications Regulatory Package.

6.2.2. Access to Bitstream Services at Speeds in Excess of Standard ADSL (Scenario D)

Table 10 presents data on the prices of 34Mbit/s PPCs for European Union countries after converting to New Zealand dollars using the PPP exchange rates in the Appendix. This gives a connection fee of **$4,763** for either a 2km or 5km tail, and a monthly rental of **$2,595** for a 2km tail and **$3,927** for a 5km tail.

Table 10 34Mbit/s Partial Private Circuit Prices in the EU (all prices in NZ$, excluding GST).

	2km Tail		5km Tail	
Country	**Monthly Rent**	**Connection**	**Monthly Rent**	**Connection**
Belgium	1,628	4,486	4,252	4,486
Denmark	1,394	36,645	3,731	87,780
Germany	1,666	8,769	4,078	8,769
Greece	2,595	12,693	3,748	12,693
Spain	4,820	5,354	6,483	5,354
France	4,757	3,965	4,757	3,965
Ireland	2,436	11,094	7,435	11,094
Italy	3,461	2,086	4,999	2,086
Luxembourg	2,333	5,145	2,634	5,145
Netherlands	3,927	857	3,927	857
Austria	2,955	2,687	3,358	2,687
Portugal	4,882	2,089	4,882	2,089
Finland	1,040	4,763	1,040	4,763
Sweden	2,588	7,221	2,912	7,221
UK	3,197	4,359	3,879	4,359
Average	**2,912**	**7,481**	**4,141**	**10,890**
Median	**2,595**	**4,763**	**3,927**	**4,763**

Source: Eighth Report of the Commission of the European Communities on the Implementation of the Telecommunications Regulatory Package.

6.3. Summary of Initial Prices

Table 11 summarises the initial prices that we recommend for the purpose of the cost-benefit analysis.

Table 11 Initial Prices for the Cost-Benefit Analysis
(all prices in New Zealand dollars, excluding GST).

Scenario	Service	Monthly Fee	Connection Charge
A	Full access	23.85	172.46
	Shared access	11.21	203.68
B	Residential	25.43	176.35
	Commercial	226.63	176.35
C	2km tail	519.00	2,060.00
	5km tail	651.00	2,060.00
D	2km tail	2,595.00	4,763.00
	5km tail	3,927.00	4,763.00

In addition, Appendix 1 contains a selection of supplementary charges that comprise the multi-part tariffs in European Union countries for unbundled services. Although they do not fit with the two-part tariff structure of the cost-benefit analysis, some prices of this nature will be relevant for the Commission’s final determination.

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Appendix

Table 12 contains a selection of supplementary charges associated with unbundled telecommunication services in European Union countries.

Table 12 Supplementary Charges for Unbundled Services in EU countries (all prices in Euros, excluding VAT).

Country	Fee Type	Fee
The Netherlands	Access Line Test Fee	39
Portugal	Assessment of Eligibility	29.33
Belgium	Cancellation Fee	20.97
France	Cancellation Fee	40.7
Portugal	Cancellation Fee	61.9
Spain	Cancellation Fee	18.03
Belgium	Deactivation Fee	28.28
Italy	Deactivation Fee	45
Greece	Disconnection Fee	42.55
The Netherlands	Disconnection Fee	134
Ireland	Disconnection Fee (line share only)	51.68
Ireland	Fault Clearance	59.61
Italy	Fault Elimination Fee	23.65
Italy	Fault Identification Fee	228.89
Austria	Information on Loop Boundaries	54.07
Belgium	Inquiry Fee	19.78
Norway	Inquiry Fee	18.73
Portugal	Lawful Intervention	44.89
Ireland	Line testing fee	27.36
Spain	Line testing fee	73
The Netherlands	Migration Fee	134
Spain	Notification of Non-existent Fault	38
Iceland	Site Inspection Fees (per hour)	45
France	Wrongful Intervention	125.77

Source: Squires Sanders “Legal study on part II of the local loop sectoral inquiry”

Exchange rates were calculated using a similar methodology to that employed by the Commission in its first interconnection determination. In particular, we calculate 3-year averages of PPP exchange rates and spot rates for each currency against the New Zealand dollar.[12] We then take the mid-point of these two average rates to determine the final exchange rate.

The PPP exchange rates were obtained from www.oecd.org/std/ppp and the spot rates from www.oanda.com.

The following table shows the exchange rate data and the calculated exchange rates for each country.

Country	PPP to NZ$			Average PPP	Average Spot	Midpoint
	2002	2001	2000			
Australia	0.921	0.906	0.928	0.919	0.839	0.879
Austria	0.633	0.627	0.634	0.631	0.485	0.558
Belgium	0.636	0.607	0.617	0.620	0.485	0.553
Canada	0.843	0.813	0.820	0.825	0.703	0.764
Denmark	5.798	5.747	5.784	5.776	3.611	4.694
Finland	0.690	0.671	0.678	0.680	0.485	0.583
France	0.655	0.624	0.634	0.638	0.485	0.561
Germany	0.657	0.649	0.658	0.655	0.485	0.570
Greece	0.488	0.500	0.517	0.502	0.886	0.694
Hungary	73.399	73.629	81.312	76.113	121.803	98.958
Iceland	57.857	61.168	64.103	61.043	41.135	51.089
Ireland	0.666	0.673	0.705	0.681	0.485	0.583
Italy	0.560	0.546	0.559	0.555	0.485	0.520
Japan	108.209	101.667	99.758	103.211	55.432	79.322
Korea	508.301	497.215	504.341	503.286	568.182	535.734
Luxembourg	0.684	0.680	0.678	0.681	0.485	0.583
Norway	6.261	6.238	6.180	6.226	3.799	5.013
Portugal	0.468	0.461	0.481	0.470	0.485	0.478
Spain	0.526	0.514	0.535	0.525	0.485	0.505
Sweden	6.584	6.649	6.721	6.651	4.428	5.539
The Netherlands	0.644	0.622	0.640	0.635	0.485	0.560
U.S. (average)	0.695	0.679	0.686	0.687	0.460	0.573
UK	0.449	0.435	0.448	0.444	0.308	0.376

[12] The PPP rates are averaged over the years 2000 – 2002. The spot rates are averaged from September 2000 to September 2003. All PPP and spot exchange rates for Euro currencies are in Euros.

APPENDIX 4: International definitions of 'broadband'

International Telecommunications union ITU-T Recommendation I.113

The ITU is the major standard setting body for the telecommunications industry. ITU-T Recommendation I. 113 defines broadband as transmission capacity that is faster than primary rate ISDN, i.e. 1.5 or 2 Megabits per second (Mbps).[1]

OECD

The OECD uses the term "broadband" as short-hand for high speed internet access. The OECD sets the threshold for broadband at 256 Kilobits per second (Kbps) in respect of downstream access because that is the most basic speed being offered by DSL providers in OECD countries. However, it sets a lower threshold for upstream speeds, noting that the most common upstream speed offered with DSL options aimed at residential users is 128 Kbps, with a large number of basic ADSL options only including upstream access at 64 Kbps.[2]

FCC

The FCC defined "broadband" as having the capacity to support, in both provider-to-consumer (downstream) and consumer-to-provider (upstream) directions, a speed (i.e. bandwidth) in excess of 200 Kbps in the last mile because this speed is enough to provide the most popular forms of broadband: to change web pages as fast as one can flip through the pages of a book; and to transmit full-motion video.[3]

Oftel

Oftel defines broadband as products available with downstream capacity at speeds greater than 256 Kbps because such products allow different content such as streaming video to be practically delivered.[4] These services may be either symmetrical or asymmetrical i.e. the latter allows for a slower upstream speed.

ACCC

In the context of its series of snapshots of broadband deployment, the ACCC defines broadband to mean "any high speed internet connection greater than 200 kbps over a mix of media. This definition of broadband excludes PSTN dial up connections that run at 56 kbps and ISDN dial up connections which run at either 64 or 128 kbps."[5]

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[1] OECD, The Development of Broadband Access in OECD Countries, 29 October 2001, p. 6.
[2] *ibid.*
[3] *ibid.*
[4] Oftel, Review of the Wholesale Broadband Access Market, 28 April 2003.
[5] ACCC, Snapshot of broadband deployment as at 31 March 2003, p. 6.

European Commission

The European Commission has stated that "broadband" internet services may be characterised as allowing downstream capacity to end-users in excess of 128 kbps.[6]

Project PROBE[7]

The joint MED and Ministry of Education Project PROBE requires that "the Broadband Access Service and Customer Network Equipment shall support the requirement for delivery of symmetrical 512 kbps service. The Broadband Access Service shall be capable of delivering the expansion capacity defined below."

Bandwidth kbps	Category	
	Primary	Secondary
Initial Minimum	512	512
Expansion Capability	1,024	4,096

However, those tendering are encouraged to submit alternative proposals where these offer significant benefits to the Ministry. These may include solutions delivering a lower initial minimum specification in the initial stage of the project provided there is a clear technology upgrade path that will see the initial minimum service specification met for all deployed connections.

[6] Oftel, Review of the Wholesale Broadband Access Market, 28 April 2003, paragraph 1.15.
[7] MED, Request for Proposals: Probe – Provincial Broadband Extension, 18 December 2002.

APPENDIX 5: International Summary Statistics

International Summary Statistics

Country	OECD Rank[1]	Broadband Access per 100 inhabitants[2]	GDP per capita[3]	Pop. (m)[4]	Pop. Density[5]	Urban %[6]	Rural %[7]	Internet Hosts per 10,000 Inhab. 2002[8]	Internet Users per 10,000 Inhab. 2002[9]	Estimated PC's per 100 inhab. 2002[10]	Total Telephone subscribers per 100 [11]	LLU? [12]	Line Sharing? [12]	Bitstream Access? [12]	Sub-loop Unbundling? [12]
Australia	18	1.3	$18,481	19.66	3	91.20%	8.80%	1304.16	4272.03	51.58	117.83	✓	✓	✓	✗
Austria	8	4.2	$23,243	8.16	97	67.40%	32.60%	450.95	4093.64	33.54	128.5	✓	✓	✓	✓
Belgium	5	6.3	$22,022	10.35	338	97.40%	2.60%	325.35	3286.29	24.16	128.24	✓	✓	✓	✓
Canada	2	10.2	$23,484	31.41	3	78.90%	21.10%	963.2	4838.61	48.7	101.26	✓	✓	✗	✗
Denmark	4	6.7	$30,146	5.37	125	85.10%	14.90%	1556.74	4651.81	57.68	152.9	✓	✓	✓	✓
Germany	13	3.1	$22,267	82.6	231	87.70%	12.30%	314.08	4237.29	43.49	136.71	✓	✓	✓	✗
Iceland [1]	7	4.7	$26,617	0.29	3	92.70%	7.30%	2370.17	6076.39	45.14	152.85	✓	✓	✗	✗
Ireland	26	0.1	$26,829	3.93	57	59.30%	40.70%	347.21	2709.23	39.07	125.82	✓	✓	✓	✓
Italy	20	1.2	$18,689	56.46	187	67.10%	32.90%	119.13	3010.77	19.48	141.27	✓	✓	✓	✓
Japan	9	3.9	$32,554	127.3	337	78.90%	21.10%	559.22	4492.62	38.25	117.36	✓	✓	✗	✓
Korea (Rep)	1	19.1	$9,023	47.6	484	82.50%	17.50%	148.37	5518.91	55.58	116.8	✓	✓	✓	✗
Netherlands	10	3.9	$23,793	16.2	393	89.60%	10.40%	1937.14	5304.11	42.84	138.81	✓	✓	✗	✗
New Zealand	21	1.1	$13,197	3.94	15	85.90%	14.10%	1099.13	4843.75	39.26	106.65	✗	✗	✗	✗
Norway	14	2.7	$37,116	4.56	14	75.00%	25.00%	561.33	5048.29	50.8	157.31	✓	✓	✓	✓
Sweden	3	7	$23,546	8.94	20	83.30%	16.70%	949.54	5730.74	56.12	160.53	✓	✓	✓	✓
Switzerland	11	3.9	$33,884	7.28	176	67.30%	32.70%	770.34	3261.79	53.83	152.02	✗	✗	✗	✗
UK	19	1.3	$23,694	59.09	241	89.50%	10.50%	485.03	4061.74	36.62	135.78	✓	✓	✓	✓
US	6	5.6	$35,843	288.4	31	77.40%	22.60%	3728.74	5375.06	62.5	114.7	✓	✗	✗	✓

The countries appearing in this table are those identified by the Commission in the Issues Paper:

Australia, Austria, Belgium, Canada, Denmark, Germany, Ireland, Italy, Japan, Netherlands, Norway, South Korea, Switzerland, United Kingdom & United States

TelstraClear submitted further international experience on: *Iceland & Sweden*

Notes

1 OECD Broadband access per 100 inhabitants, June 2002
2 OECD Communications Outlook 2003, Broadband access per 100 inhabitants, June 2002, p. 136, www1.oecd.org/publications/e-book/9303021E.PDF
3 ITU Basic Indicators US$ 2001, 24 April 2003, http://www.itu.int/ITU-D/ict/statistics/at_glance/basic02.pdf
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9 ITU Information Technology Summary Statistics 2002, 24 April 2003, http://www.itu.int/ITU-D/ict/statistics/at_glance/Internet02.pdf
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12 OECD Working Party of Telecommunication and Information Services Policies "Developments in Local Loop Unbundling", 7 August 2003 JT00148010