Is a WACC uplift appropriate for UCLL and UBA?

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Contents

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Executive summary

The New Zealand Commerce Commission (the Commission) has asked Oxera to advise on one aspect of its approach to estimating the cost of capital in the context of the pricing reviews for unbundled copper local loop (UCLL) and unbundled bitstream access (UBA) services. The cost of capital feeds into the forward-looking cost-based method used by the Commission to determine the price for each service.

In particular, the Commission is interested in whether there might be a case for supporting an uplift to the weighted average cost of capital (WACC)—i.e. using a WACC that is higher than the midpoint (central) estimate, taking into account the potential impact of allowed WACC on investment incentives.

The Commission has asked Oxera to consider whether the framework developed by Oxera in the context of Part 4 of the Commerce Act (applied to electricity lines and gas pipeline services) could be adapted to the context of UCLL and UBA pricing reviews. The basic argument in support of a WACC uplift in the context of Part 4 regulation is the principle that the costs of under-estimating the WACC outweigh the costs of over-estimating it. Under-estimating the WACC increases the probability of under-investment, and increases the potential for large costs from network outages and deteriorating network quality to be imposed on users.

While the costs of under-investment in the telecoms industry may not be as great as those in electricity and gas businesses, there is a question over whether a WACC uplift could have a positive effect on investment incentives and innovation, which in turn might be associated with material user benefits in excess of the direct costs of a WACC uplift.

Given the pace of technological innovation in the telecoms industry, the ‘under-investment problem’ could manifest itself in a slower pace or smaller scale of investment in new technologies and innovations throughout the value chain more generally. If innovation and faster adoption of new technologies have the potential to bring material benefits to users, and if there is some link between the level and/or pace of such investment and the WACC for UCLL and UBA services, then, depending on the potential size of the benefits, the costs of a WACC uplift might be justified.

The link between the allowed WACC for UCLL and UBA and the level and/or pace of investment across the value chain is difficult to assess precisely, although it is reasonable to assume that there is a link. The allowed WACC for UCLL and UBA can act as a signal to investors, in both Chorus (the provider of UCLL and UBA services) and other players throughout the value chain, of the regulatory commitment to promote and appropriately remunerate investment.

While it is unlikely that a WACC uplift for UCLL and UBA on its own will lead to the creation of significant user benefits from innovation, it could reasonably affect the time at which these benefits materialise. For example, most major innovations in telecoms have typically been adopted in most developed countries, regardless of the original source of the innovation; however, the timing and speed of deployment has generally varied from country to country.

With these considerations in mind, the framework used in the energy sector has been modified to capture the potential impact of a WACC uplift, by focusing on how a WACC uplift may influence the timing of innovative investment in telecoms.

Potential costs of a WACC uplift

In our framework, the costs comprise two elements. The first element is the direct cost incurred by consumers due to the higher UCLL/UBA price resulting from the WACC uplift. The second element is the additional direct cost resulting from the WACC uplift applied to the new ‘asset base’ created during the process of innovation. For simplicity, it is assumed that the new ‘asset base’ would be regulated in a similar way to UCLL/UBA—i.e. that a WACC uplift of similar magnitude would be applied. It is also assumed that the new ‘asset base’ would be of the same size as the existing UCLL/UBA asset base. In practice, a new technology/service is unlikely to be of the same size as the existing assets: it is more likely that the new technology will either displace some of the existing asset base, or will represent a fraction of the existing asset base. The cost estimates presented in this report are therefore relatively conservative (i.e. err on the high side).

Potential benefits of a WACC uplift

The framework focuses on the potential for a WACC uplift to bring forward investment in new technologies/services that are likely to be associated with material wider user benefits.

To illustrate the size of the potential benefits, we considered the following factors, drawing on historical evidence and estimates from the literature.

- The typical cycle of disruptive innovations in the telecoms industry. This is estimated to be 20 years—i.e. a major innovation is assumed to happen approximately every 20 years.
- The typical benefits to consumers once the investment is made, which are estimated to be around NZ$1.5bn annually.
- The typical timing of commercialising new innovations in developed countries relative to the leader (i.e. the country where the innovation is commercialised first). For illustration, we assume that a WACC uplift could have the effect of bringing the investment forward by either two or five years relative to when it would occur otherwise.

To estimate the potential benefits to users of a WACC uplift, we therefore compare the annualised difference in the net present value (NPV) of a 20-year benefit stream, assuming that the WACC uplift brings the investment forward by two or five years respectively. This produces a relatively wide range of potential benefits, depending on the strength of the acceleration effect and other underlying assumptions.

Comparing the potential costs and benefits

In order to compare the potential costs and benefits of a WACC uplift, for each choice of the WACC uplift it is necessary to understand how the WACC uplift influences the probability that the investment will indeed be brought forward (and that the estimated benefits can indeed be realised). Since there is uncertainty around the WACC itself, it is intuitive that a bigger uplift would make the ‘acceleration benefits’ more likely to be realised.

In our framework, it is assumed that, at the midpoint WACC (i.e. at the 50th percentile), there is no incentive for the players to bring investment forward—i.e. the potential benefit is zero. In other words, the investment in new technology or service happens at some optimal point in time from the investor’s perspective.

However, on average, this optimal point is associated with some natural industry and market ‘equilibrium point’, assumed to be either two or five years after a new technology or service becomes commercialised.

This approach does not rule out the possibility that New Zealand could be the first country to commercialise a new innovation—however, an assumption of later adoption is likely to be more realistic for most investments. If the allowed WACC is based on the midpoint of the range, then on average the expected NPV for the investor is zero. There is therefore no obvious strong incentive to bring investment forward. The investment will still happen in the future, but the framework of setting the WACC at the midpoint will not be the main driver of the timing.

Once the policy of a WACC uplift is introduced, assuming the WACC uplift will apply to new investment (e.g. it becomes regulated in a similar way), the expected NPV for the investor will be positive. The investor is now faced with a choice of getting this NPV two (or five) years from now, or earlier. Clearly, the earlier the investment takes place, the bigger the NPV will be in present value terms. At one extreme, this suggests that even a very small uplift will incentivise the investor to bring the investment forward by the full two (or five) years.

In practice, the effectiveness of the uplift might depend on two things: the bigger the uplift, the bigger the expected NPV will be; and the bigger the uplift, the more likely it is that the investor will actually realise a positive NPV given the uncertainty in the WACC. A more realistic scenario is therefore to assume that the likelihood of the investment being accelerated by two (or five) years is an increasing function of the WACC uplift.

We consider a range of possible options for how the likelihood of acceleration might increase as the size of the WACC uplift is increased. Under the assumption of a two-year acceleration, the case for a WACC uplift appears to be relatively weak; however, under a five-year acceleration, the case for a WACC uplift is stronger.

This highlights how there is significant uncertainty around the estimates of the potential benefits and costs of a WACC uplift. The overall concept of using a WACC uplift as a mechanism to increase the incentive to carry out innovative investments sooner rather than later is reasonable, but, in the particular case of UCLL/UBA, the decision of whether an uplift is justified depends heavily on the typical timing of the investment in the absence of a WACC uplift and on how a particular WACC uplift influences the likelihood that the investment will be brought forward.

All in all, the set of assumptions one would have to believe in order to conclude that a modest WACC uplift is justified seems quite plausible and can be used to inform the Commission’s decision. At the same time, the evidence is not strong, and requires significant speculation about the nature and scale of benefits of future innovation, and, therefore, does not contradict the continued use of a midpoint WACC for UCLL/UBA.

1 Introduction

The New Zealand Commerce Commission (the Commission) has asked Oxera to advise on one aspect of its approach to estimating the cost of capital in the context of the pricing reviews for unbundled copper local loop (UCLL) and unbundled bitstream access (UBA) services. The cost of capital feeds into the forward-looking cost-based method used by the Commission to determine the price for each service.

In particular, the Commission is interested in whether there might be a case for supporting an uplift to the weighted average cost of capital (WACC)—i.e. using a WACC that is higher than the midpoint (central) estimate, taking into account the potential impact of allowed WACC on investment incentives.

1.1 Background and scope

In the draft pricing decision published in December 2014, the Commission did not apply an uplift to the WACC; however, it asked stakeholders for their views on the issue.[1] The Commission has subsequently proposed a framework for assessing the case for a WACC uplift, in advance of the April 2015 conference.[2]

In estimating price-quality paths for electricity lines and gas pipeline services under Part 4 of the Commerce Act, the Commission has consistently applied an uplift to the midpoint of the WACC range. Based on the recent review of the appropriate uplift, the WACC is now based on the 67th percentile of the defined WACC range. The basic argument in support of an uplift in the context of Part 4 regulation is the principle that the costs of under-estimating the WACC outweigh the costs of over-estimating it. Under-estimating the WACC increases the probability of under-investment, and increases the potential for large costs from network outages and deteriorating network quality to be imposed on users.

The Commission has asked Oxera to consider whether the framework used under Part 4 could be adapted to the context of UCLL and UBA pricing reviews. In particular, while the costs of under-investment in this context may not be as great as those in electricity and gas businesses, there is a question over whether a WACC uplift could have a positive effect on investment incentives and innovation, which in turn might be associated with material user benefits in excess of the direct costs of a WACC uplift.

1.2 Areas outside the scope

There are many areas that are important in the choice of the WACC, but which are outside the scope of this review.

- **The approach to defining the WACC range**. We have assumed that the Commission correctly estimates the uncertainty around the WACC, as measured by the estimated standard error.
- **The accuracy of the capital asset pricing model (CAPM) approach**. We do not revisit whether the CAPM, as applied by the Commission, is accurate in determining the best estimate of the WACC.
- **The design of the regulatory framework**. We do not review the Commission's approach to modelling the total service long-run incremental

[1] New Zealand Commerce Commission (2014), 'Cost of capital for the UCLL and UBA pricing reviews', 2 December.
[2] New Zealand Commerce Commission (2015), 'Agenda and topics for the conference on the UCLL and UBA pricing reviews', 2 April.

cost (TSLRIC). Some stakeholders have commented on the specific application of the TSLRIC model in New Zealand and the extent to which it may result in a higher price than other approaches. The approach to pricing is taken as given and the arguments presented in this report do not depend on the pricing approach.

1.3 Structure of the report

The rest of this report is structured as follows.

- Section 2 outlines our framework for assessing the potential case for a WACC uplift.
- Section 3 discusses the direct financial consequences to users of a WACC uplift.
- Section 4 reviews the evidence on the potential benefits and frequency of innovation in the telecommunications industry.
- Section 5 discusses the uncertainty around the WACC and the impact that this may have on the choice of the WACC.
- Section 6 provides our overall assessment.

2 Assessment framework

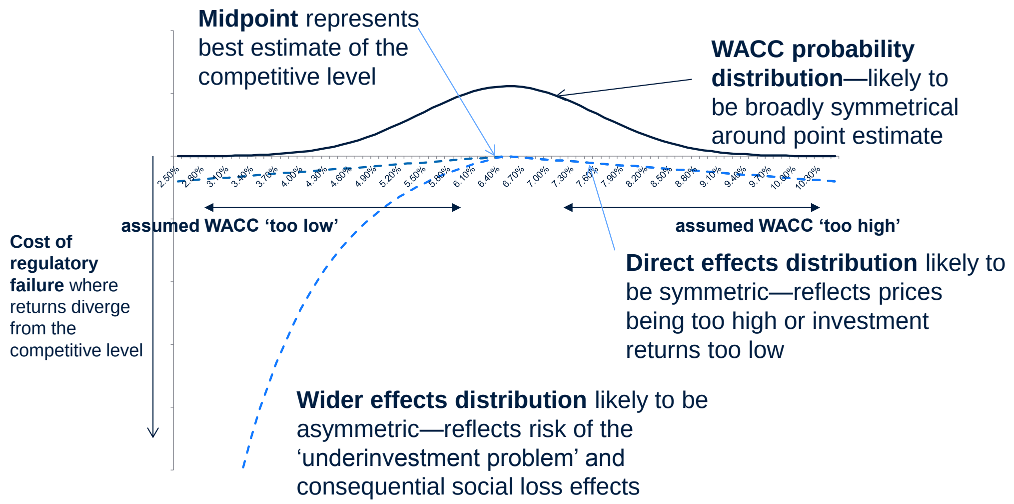
In assessing the potential rationale for a WACC uplift, and in reaching practical recommendations, it is necessary to develop a framework to consider the options.

First, we briefly review the approach used by the Commission under Part 4 of the Commerce Act. We then consider the key differences between services regulated under Part 4 and the telecoms industry, and propose an augmented framework for the current context.

2.1 Part 4 of the Commerce Act

Figure 2.1 summarises the principles behind the approach developed by Oxera in the context of electricity lines and gas pipeline services.

Figure 2.1 Framework applied in electricity and gas



Source: Oxera (2014), 'Input methodologies, review of the 75th percentile', June.

The basic underlying principle is the concept of a 'social loss function', which captures the wider effects on welfare of setting the WACC too high or too low and reflects the potential asymmetry of these effects.

The overall assessment of the appropriate choice of the WACC considered the following elements.

- **The direct cost to users**. If the allowed return differs from the central estimate of the WACC, there is a transfer of wealth between energy users (and potentially intermediaries) and investors in the network operator. There could also be indirect effects on the incentives to invest and/or competitive conditions in other industries; however, these indirect effects were generally found to be fairly immaterial.

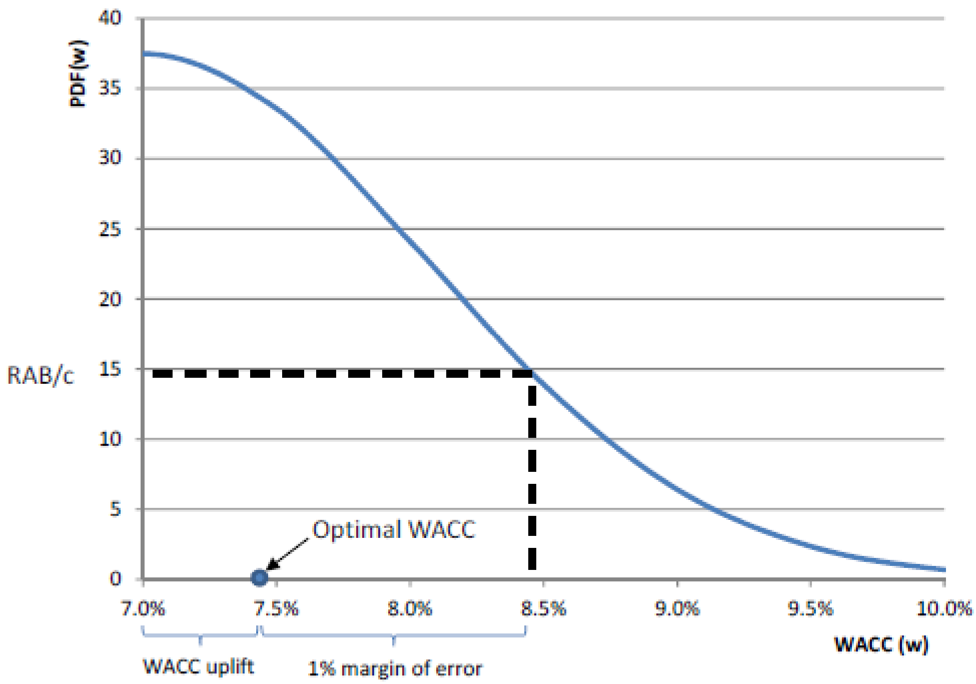
- **Wider social and economic costs (and therefore the risk of losing these benefits)**. The continuation of service provision in regulated industries has an economic value. In the case of energy, this economic value was judged to be fairly significant. Network interruptions would lead to material disruption to individuals' lives and hence a material welfare loss for consumers of the regulated services.

- **The 'probability of loss' for different levels of the WACC**. The higher the estimate of the WACC, the lower the probability that the true WACC will be above the assumed WACC, and the lower the probability that an under-investment problem will occur. We assumed that the allowed WACC would need to be 0.5–1.0% lower than the true WACC to trigger a material under-investment problem.

While the probability that a particular WACC will directly link to a level of under-investment that might subsequently cause network failure is difficult to assess reliably, such a framework still provides useful insight on the extent to which the costs of the WACC uplift might be justified.

In principle, under this framework, it is possible to solve for the optimal level of the WACC percentile based on the underlying WACC distribution and the estimated costs of under-investment, as shown in Figure 2.2.

Figure 2.2 WACC probability density function for energy networks



Note: 'RAB' is the regulated asset base to which the WACC uplift is applied; 'c' is the annualised net cost to users from under-investment.

Source: New Zealand Commerce Commission (2015), 'Agenda and topics for the conference on the UCLL and UBA pricing reviews', 2 April.

It is important to remember, however, that these relationships are subject to fundamental uncertainty, and any decision on the appropriate percentile will ultimately reflect judgement, as noted by the Commission:

> Although we now have significantly more information to assist us in making a decision, we must still exercise judgement when selecting the WACC percentile.[3]

These considerations will be equally important in the telecoms sector.

[3] New Zealand Commerce Commission (2014), 'Amendment to the WACC percentile for price-quality regulation for electricity lines services and gas pipeline services', Reasons paper, 30 October, para. X16.

2.2 Link between a WACC uplift and investment incentives

In the context of the telecoms industry, the potential costs of under-investment may, arguably, also be material and, therefore, a similar framework to Part 4 methodology may be used as a starting point. However, the potential costs of under-investment might be somewhat smaller than in the energy network businesses. Interruptions to Internet service or fixed-telephony provision are likely to have less impact on the lives of individuals than outages in electricity or gas supply, as there are alternatives (e.g. mobile) available. The outages are also likely to be more localised in nature. In addition, competitive pressure from other networks (mobile and fibre) might provide incentives on the incumbent to carry out necessary investments to maintain the copper network.

On the other hand, given the pace of technological innovation in the telecoms industry, the 'under-investment problem' could manifest itself in a slower pace or smaller scale of investment in new technologies and innovations throughout the value chain more generally. This could include investment in new fixed-line or mobile networks, or new services on these networks, and could include investment by the incumbent as well as other players.

If innovation and faster adoption of new technologies have the potential to bring material benefits to users, and if there is some link between the level and/or pace of such investment and the WACC for UCLL and UBA services, then, depending on the potential size of the benefits, the costs of a WACC uplift might be justified.

While the link between the allowed WACC for UCLL and UBA and the level and/or pace of investment across the value chain is difficult to assess precisely, it is reasonable to assume that there is a link, for the following reasons.

The allowed WACC for UCLL and UBA can act as a signal to investors, in both Chorus (the provider of UCLL and UBA services) and other players throughout the value chain, of the regulatory commitment to promote and appropriately remunerate investment.

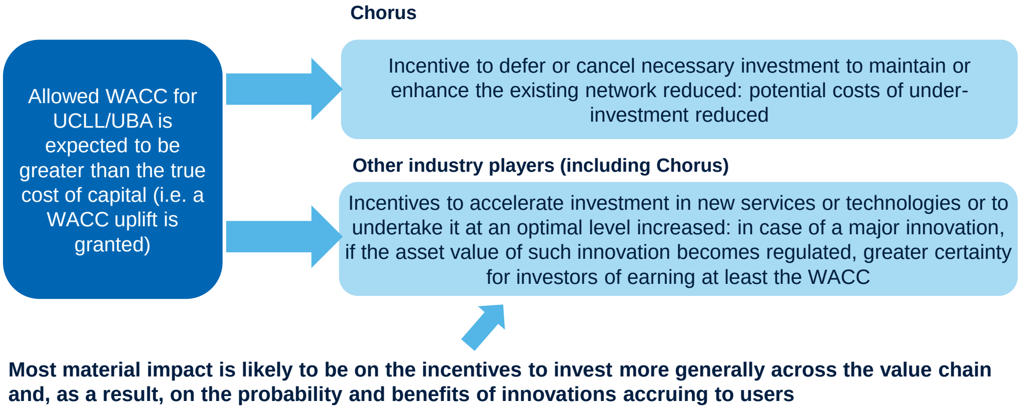
- **Investment in innovations directly linked to the provision of copper-based access**: these investments are most likely to be undertaken by Chorus and are likely to be taken into account in determining the regulated price for these services in the future.[4] In this case, a WACC uplift will reduce the risk of under-estimating the true cost of capital of such investments (assuming they are of similar risk to the existing services) and hence will reduce the risk of Chorus postponing or not undertaking the necessary investment. This could include investment in maintenance as well as enhancement investment on the existing network. However, for the reasons discussed above, generally there might be less need for a WACC uplift to reduce the probability of deteriorating network quality in telecoms relative to the energy sector.
- **Investment in innovations in the telecoms industry more broadly**: this might be undertaken by Chorus or other players. In this case, it is quite likely that a new service or technology (if developed and widely deployed) might become regulated in the future. If the existing framework includes a WACC uplift, it will signal to investors the regulator's commitment to minimising the risk of under-estimating the cost of capital and appropriately rewarding future investment. In turn, by explicitly committing to a WACC uplift and hence making the expected net present value (NPV) from an investment positive,

[4] Assuming that these investments are efficient and influence the regulator's assumptions about the network that would be deployed by a hypothetical efficient entrant in any future modelling of the TSLRIC price.

this could increase the incentives for the industry to bring forward new investment or to undertake the investment at an optimal scale.

These different types of investment effect are illustrated in Figure 2.3.

Figure 2.3 Link between UCLL/UBA WACC and investment



Source: Oxera.

One aspect that is not explicitly captured in the figure above is the possibility of a WACC uplift for copper-based services to distort investment incentives for access seekers in a way that would be detrimental to consumer welfare. We do not explicitly quantify this effect, but this is another factor that may need to be taken into account when coming to an overall view of the relative costs and benefits of a WACC uplift for UCLL and UBA.

The exact link between the WACC for UCLL and UBA and the pace and scale of investment is difficult to assess in practice, not least because there are several other factors simultaneously affecting investment incentives.

On the one hand, the default position of Chorus, as well as other industry players, might be not to invest in a new technology or service at the early stages of its development. By waiting, it is likely that better information about the investment will become available, including the associated costs and likely demand. Further, costs of deploying a particular technology or service may fall over time.

On the other hand, the competitive dynamics of the industry also mean that there could be a first-mover advantage in investing, which might be sufficient to ensure that the investment in innovation happens sooner rather than later.

The precise impact of the combination of these factors, together with any impact of a WACC uplift in the regulatory framework, is uncertain. However, on balance, it seems reasonable to assume that a WACC uplift could have a positive impact on investment incentives. While it is unlikely that a WACC uplift for UCLL and UBA on its own will lead to the creation of significant user benefits from innovation, it could reasonably affect the time at which these benefits materialise. For example, most major innovations in telecoms have typically been adopted in most developed countries, regardless of the original source of the innovation; however, the timing and speed of deployment has generally varied from country to country.

In addition, incentivising innovation through any other means in the regulatory framework is likely to be challenging. While maintaining appropriate network reliability standards can potentially be achieved using tools other than the

WACC, such as setting performance/quality of service targets, agreeing specific outputs, or having a more intrusive overview of companies' investment plans, it is arguably more challenging to ensure that new 'speculative' investment takes place. In this case, the WACC might be one of the few, albeit indirect, signalling mechanisms available to the regulator to influence the timing and scale of innovative investments.

On balance, we therefore consider that using a WACC uplift to influence investment incentives could be a reasonable approach, provided that it is supported by the analysis of the relative benefits and costs.

The relative assessment in this report focuses on reviewing the evidence on the frequency and end-user benefits of different types of innovations in the telecoms industry, and comparing these benefits with the potential costs of a WACC uplift based on reasonable assumptions about the impact of a WACC uplift on the timing and scale of investment.

2.3 Approach in telecoms

With these considerations in mind, the framework used in the energy sector is modified to capture these different types of effects. The approach consists of four key questions, as follows.

- **What is the direct financial impact of a WACC uplift**—i.e. what is the cost to users? The most material cost is the direct cost of a higher UCLL and UBA price and the associated loss in consumer welfare. Depending on the assumed future treatment of new investment, this cost may also need to factor in potential increases in the regulated asset base to which an uplift is applied. Acting to offset these costs, in this specific context, are potential positive externalities from increased migration to fibre.[5] We understand that the Commission is considering this latter effect separately in the context of the overall UCLL/UBA price; however, the Commission's overall judgement on the WACC will clearly depend on both the assumed effect on investment incentives and the assumed effect on migration to fibre.

- **What are the potential wider benefits of innovation in the telecoms industry?** What types of innovation characterise the telecoms industry, and how frequently do they occur? What is the range of estimated benefits to users?

- **What is the uncertainty around the WACC?** What is the probability of the true WACC being above or below the allowed WACC under different WACC uplifts, and how might this affect the probability that some of the wider benefits to users might materialise?

- **How do the estimated benefits compare with the costs, assuming a particular relationship between the WACC uplift and investment?** The overall assessment inevitably requires judgement, given the available evidence on the likely benefits of innovation. The assessment will also require reasonable assumptions to be made about the impact of a WACC uplift on investment incentives—i.e. the potential impact on the pace and scale of new investment.

[5] Professor Cambini is providing independent advice to the Commission on the potential scale of positive externalities of migration to fibre. Cambini, C. (2015), 'Economics aspects of migration to fibre and potential welfare gains and losses from an uplift to copper prices', 16 March.

A key difference between the framework for telecoms and the framework adopted in energy is the assumption of what happens when the WACC is set at the 50th percentile (i.e. the midpoint of the WACC range).

In the telecoms industry, we consider it reasonable to assume that the WACC uplift will mainly influence the timing of the investment, rather than whether the investment actually happens. At the 50th percentile (the midpoint WACC), we assume that the investment in new technology or service happens at some optimal point in time from the investor's perspective. However, on average, this optimal point is associated with some lag to when a new technology or service becomes commercialised.

This approach does not rule out the possibility that New Zealand could be the first country to commercialise a new innovation—however, an assumption that, on average, commercialisation happens with a lag relative to the first adopter is likely to be more realistic for most investments. If the allowed WACC is based on the midpoint of the range, then, on average, the NPV for the investor will be zero. There is therefore no obvious strong incentive to bring investment forward. The investment will still happen in the future, but the framework of setting the WACC at the midpoint will not be the main driver of the timing.

Once the policy of a WACC uplift is introduced, assuming the WACC uplift applies to new investment (e.g. it becomes regulated in a similar way to UCLL/UBA), the expected NPV for the investor will be positive, and a WACC uplift could therefore potentially bring a new investment forward. Understanding how likely it is that a WACC uplift could accelerate the investment, and what benefits this could generate for consumers, will therefore affect whether the costs of a WACC uplift are justified.

2.4 The Commission's proposed framework

At the April 2015 conference, the Commission outlined a potential framework for assessing the case for a WACC uplift.[6] The key components of the Commission's framework are quite similar to the ones discussed above.

In summary, the consumer costs that the Commission would like to minimise consist of three components:

- the direct cost to consumers from applying a WACC uplift;
- the potential additional costs to users from applying a WACC uplift to new investment;
- the potential forgone benefits from investment in new technology being delayed or not occurring.

This is captured in the following function.

$$f(w) = RAB(w - w_0) + p[RAB(w - w_0) + c(1 - CDF(w)]$$

Where:

RAB = the total asset value of the existing and the new networks (the investment is assumed to be of similar size to the existing asset base);

w_0 = midpoint WACC estimate;

[6] New Zealand Commerce Commission (2015), 'Agenda and topics for the conference on the UCLL and UBA pricing reviews', 2 April.

w = allowed WACC;

p = probability that a major innovation occurs, when it occurs, and whether the WACC for UCLL/UBA is influential on the investment in new technology;

c = annualised forgone consumer benefit if the new investment does not occur;

$CDF(w)$ = cumulative distribution function of the WACC.

While we do not explicitly use this formulaic expression in our framework, in section 6 we consider how the results of our analysis can be interpreted using the approach proposed by the Commission.

3 Financial consequences of a WACC uplift

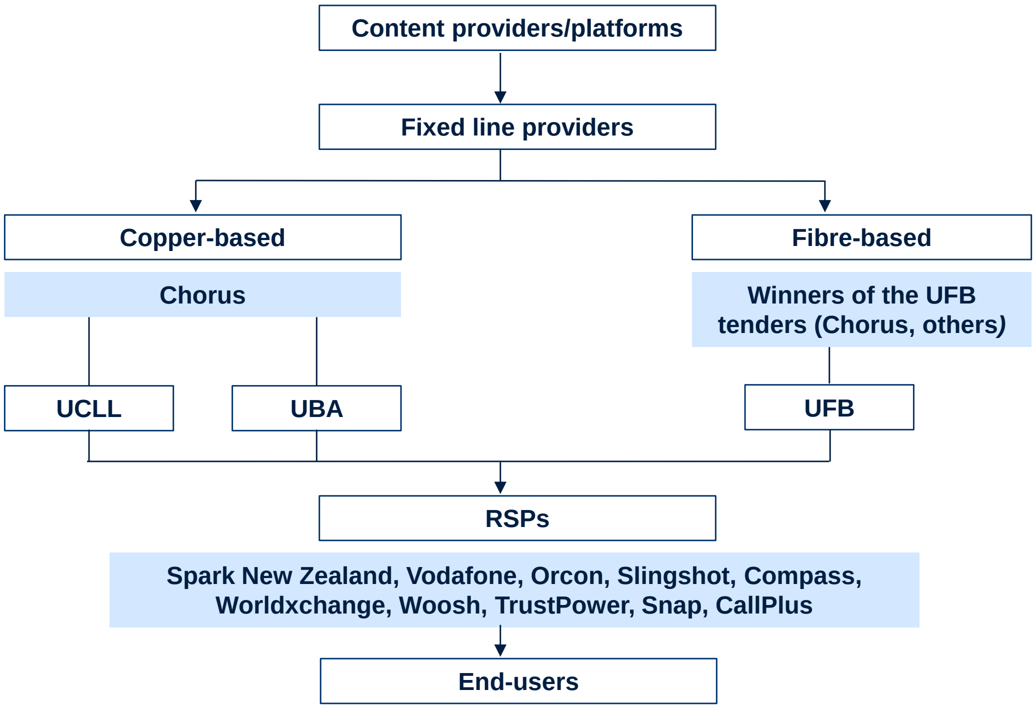
This section considers the direct and indirect financial consequences of the choice of WACC percentile for key players in the telecoms value chain.

First, we consider the structure of the telecoms industry and identify the parties that could be affected if the WACC were set too high. We then quantify the direct effects and consider whether they are likely to be material. We also briefly discuss the potential indirect effects.

3.1 The telecoms value chain

Figure 3.1 presents an overview of the telecoms value chain in New Zealand.

Figure 3.1 New Zealand telecoms value chain



Source: New Zealand Commerce Commission (2014), 'Annual Telecommunications Monitoring Report 2013', and Oxera analysis.

Retail service providers (RSPs) in New Zealand typically do not have local access in order to connect to the end-users. Instead, they use the copper-based access services provided by Chorus and the fibre-based services provided by winners of the UFB (ultra-fast broadband) tenders, which in the majority of cases has also been Chorus. The RSPs using UCLL are usually required to install their own infrastructure at exchanges, which gives them more control over the quality of the service and a cost-based price. The use of UBA requires less investment in infrastructure but gives less control over the service.

The draft determination published in December 2014 proposed a maximum monthly price of NZ$28.22 that Chorus can charge for UCLL services. The proposed total price for UBA services accounts for an additional UBA-specific cost component of NZ$10.17 and is equal to NZ$38.89 per month.

The total retail price for DSL/telephony services charged by Spark New Zealand and Vodafone is around NZ$79 per month.[7] This implies that the UCLL cost component accounts for around one-third of the total price paid by end-users. The total UBA cost component accounts for nearly half of that price.

3.2 Direct effects

The clearest impact of choosing a WACC above the midpoint of the range is the additional return earned by Chorus, which will feed through into access charges for copper, on the assumption that Chorus prices up to the FPP (final pricing principle) values. The impact of this on downstream firms and end-customers is determined by:

- the change in UCLL/UBA charges—the increase in capital cost is approximated by the value of the asset base multiplied by the additional WACC allowance;
- the extent of pass-through—the direct purchaser may be able to pass on the additional costs to its own customers;
- the demand effect—if higher charges are passed through to final prices, consumers will typically respond by purchasing fewer units.

3.2.1 The price effect

The price effect depends on the size of the WACC range (with a smaller range giving a smaller effect) and the size of the asset base to which the WACC is applied.

The midpoint estimate of the post-tax nominal WACC for UCLL and UBA provided by the Commission in its December 2014 draft decision is 6.47%. Based on the estimate of the standard error provided to us by the Commission,[8] for example, if the WACC uplift were based on the 67th percentile (as it is for energy networks), this would imply a WACC figure that is 0.54 percentage points higher than the midpoint of the range.

The total asset values relating to UCLL and UBA services provided by Chorus, based on the Commission's December 2014 draft decision, are NZ$6.8bn and NZ$572m, respectively.[9] On this basis, if the 67th percentile were adopted by the Commission, Chorus would be allowed to earn an additional return of around NZ$40m per year.

The increase in the WACC at the 67th percentile translates into an 8.4% increase in the price of the UCLL component. Assuming that these higher costs are fully passed through to end-users, and given that the UCLL service accounts for 36% of the retail price, average end-user prices for retail copper-based broadband would be 3.0% higher under the 67th percentile than under the midpoint estimate. The increase in the WACC for UBA services may also have some impact on the final user price, but, for ease of presentation, we focus on the impact of the UCLL price increase only. The additional cost of the electronics component of the infrastructure is relatively small, and not all RSPs purchase this service from Chorus.

[7] New Zealand Commerce Commission (2015), 'Agenda and topics for the conference on the UCLL and UBA pricing reviews', 2 April, p. 18, para. 55.
[8] Data provided to Oxera by the Commission.
[9] Data provided to Oxera by the Commission.

Table 3.1 outlines the high-level calculation of the additional cost for customers (per year) as a result of the WACC being set at different percentiles.

Table 3.1 Direct cost of a WACC uplift

Percentile	Approximate cost (NZ$m)	Increase in retail price, assuming 100% pass-through (UCLL-based)
50%	0	0%
55%	10	0.9%
60%	25	1.7%
65%	35	2.6%
70%	50	3.6%
75%	60	4.6%
80%	75	5.7%
85%	95	7.0%
90%	115	8.7%
95%	150	11.2%

Note: Figures are rounded to the nearest NZ$5m. The cost in the second column represents additional cost, taking into account the asset base of both UCLL and UBA. However, the increase in retail price (third column) assumes a full pass-through of the increase in the UCLL price only, to reflect the fact that not all RSPs purchase UBA services.

Source: Oxera calculations.

The direct price effect results in a transfer of wealth from end-users to investors in the UCLL and UBA services. This could be considered to be a redistribution of wealth as opposed to an overall welfare loss. However, to the extent that the primary purpose of regulation is to protect end-users from overpricing, the transfer of wealth away from consumers could be seen to be a welfare loss (see Box 3.1).

Box 3.1 Welfare function

The total welfare (TW) function is given by:

$$TW = \alpha CS + (1-\alpha)PS$$

where CS is the consumer surplus, PS is the producer surplus, and α is the weight given to each of these surpluses by society.

If one assumes that α is equal to 0.5 (i.e. consumer and producer surpluses are given equal weight) then a transfer of wealth from consumers to producers will have no impact on total welfare. A WACC uplift will have an impact on welfare only where it leads to a deadweight loss. Under a pure consumer welfare approach, on the other hand, it is assumed that α is equal to 1 and therefore that any reduction in consumer surplus is a welfare loss (even if there is an offsetting increase in producer surplus). In reality, it is likely that the value of α lies between 0.5 and 1. The consumer welfare is the most conservative approach to assessing the impact of a WACC uplift and thus provides an upper bound on the overall loss.

Source: Oxera.

The impact of the choice of WACC percentile is determined by the extent to which the direct purchaser of the services is able to pass on the additional costs to its own customers. There will be no effect on end-users if the ISP is unable to pass on any of the additional cost, or chooses not to.

In perfectly competitive markets, firms would typically pass through additional costs in full, as not doing so would require them to price below the new marginal cost (and therefore make a loss).[10]

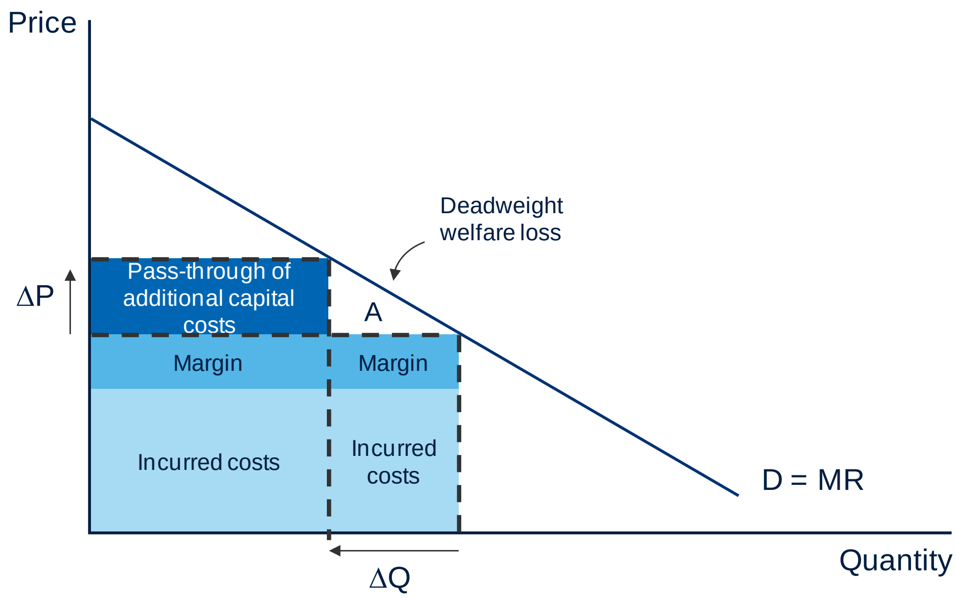
[10] See Appendix A1 for a more detailed discussion of the determinants of the level of pass-through.

Recognising that the Internet access market in New Zealand is fairly competitive, it might be appropriate to assume that RSPs will pass on the majority of additional costs due to higher UCLL/UBA WACC to consumers.[11] The calculations in the rest of this report are therefore based on an assumption of 100% pass-through of this cost. In other words, the cost estimates shown in Table 3.1 will be borne by users in full.

3.2.2 The demand effect

Where there is some pass-through of the cost increases in the form of higher downstream prices, there is likely to be an impact on demand for the final product. Unlike the price effect, the demand effect unambiguously creates a deadweight welfare loss (equal to area A in Figure 3.2).

Figure 3.2 Deadweight welfare loss from the demand effect



Note: 'Margin' denotes the capital cost based on the midpoint WACC. 'Quantity' relates to final user demand for copper-based access.

Source: Oxera.

The size of this demand effect is determined by two factors:

- the extent of pass-through by downstream firms;
- the own-price elasticity of demand for the product.[12]

Therefore, to calculate the impact of a WACC uplift on volumes sold, it is necessary to have an estimate of the elasticity of demand.

Table 3.2 summarises the results of several academic studies that have sought to estimate the own-price elasticity of demand for fixed-line copper-based services.

[11] The Commission makes the same assumption in its preliminary analysis of the welfare impact of increased migration to fibre. New Zealand Commerce Commission (2015), 'Agenda and topics for the conference on the UCLL and UBA pricing reviews', 2 April, p. 16.
[12] The own-price elasticity of demand measures how sensitive demand for a product is to changes in that product's price.

Table 3.2 Estimates of the own-price elasticity of copper-based services

Study	Methodology	Estimate of own-price elasticity
Grzybowski et al. (2014)	Country- and municipality-level elasticity of household demand in Slovakia, estimated using a mixed logit model and survey data collected in 2011. Elasticity is defined as a percentage change in the aggregate market share of DSL technology at country or municipality level as a result of a 1% increase in average monthly price for the 24-month commitment period.[1]	-4.18 to -3.02 (DSL)
Shinohara et al. (2011)	Elasticity of demand, estimated using panel data regression with instrumental variables and data from 30 OECD countries. Elasticity is defined as a percentage change in the number of DSL subscribers as a result of a 1% increase in price.	-0.95
Srinuan et al. (2011)	Elasticity of demand, estimated using multinomial logit model and survey data in Sweden in 2009. Elasticity is defined as a percentage change in the probability of customers choosing DSL technology as a result of a 1% increase in average monthly price for Internet connection.	-1.27
OECD (2008)	The long-run price elasticity of demand based on a cross-section model for OECD countries as at October 2007, using logged values. Elasticity is defined as a percentage change in the number of broadband subscribers per 100 inhabitants as a result of a 1% increase in average price for monthly subscriptions.	-0.43

Note: [1] The elasticity is calculated by first estimating the effect of the price increase on the level of an individual household's probability of choosing DSL technology, and then aggregating this at a country or municipality level.

Source: Grzybowski, L., Nitsche, R., Verboven, F. and Wiethaus, L. (2014), 'Market definition for broadband internet in Slovakia – are fixed and mobile technologies in the same market?', 20 February; Shinohara, S., Akematsu, Y. and Tsuji, M. (2011), 'Analysis of broadband services diffusion in OECD 30 countries: focussing on open access obligations', 8th International Telecommunications Society (ITS) Asia-Pacific Regional Conference, 26–28 June; Srinuan, P., Srinuan, C. and Bohlin, E. (2011), 'The mobile and fixed broadband battle in Swedish market: complementary or substitution?', EUI Working papers, June; OECD (2008), 'Price and income elasticity of demand for broadband subscriptions: a cross-sectional model of OECD countries', 7 February.

The range of estimates of the own-price elasticity for DSL services is quite wide. Overall, the price elasticity of broadband services would be expected to decrease over time as broadband becomes a more essential service. However, it is possible that demand for a particular type of service (e.g. copper versus fibre) could still be quite elastic, all else being equal, which might explain the range of estimates produced by different studies.

To estimate the potential deadweight loss, we use a range of -0.5 to -1.5 for the own-price elasticity for copper-based services. For a mature market, we would expect this to be a conservative assumption.

For example, to continue the example of a WACC uplift based on the 67th percentile, for UCLL-based retail services it would be 3.0% higher. Assuming an own-price elasticity of -0.5, this implies that the use of DSL services would be 1.5% lower. Using the estimates of Chorus's total number of subscriptions as of 30 June 2014,[13] the potential reduction in the number of subscriptions would be around 26,000. Given the expected change in the retail price of NZ$2.4 per

[13] New Zealand Commerce Commission (2015), 'Agenda and topics for the conference on the UCLL and UBA pricing reviews', 2 April, p. 22, Table 4.

month, the implied deadweight loss would be around NZ$0.4m. A higher price elasticity and/or a higher percentile would imply a higher deadweight loss. Table 3.3 shows the potential deadweight loss under different assumptions.

Table 3.3 Deadweight loss from a WACC uplift

Percentile	Deadweight loss (NZ$m): own-price elasticity of -0.5	Deadweight loss (NZ$m): own-price elasticity of -1.5
50%	–	–
55%	0.0	0.1
60%	0.1	0.4
65%	0.3	0.8
70%	0.5	1.6
75%	0.9	2.6
80%	1.3	4.0
85%	2.0	6.1
90%	3.1	9.4
95%	5.1	15.4

Source: Oxera calculations.

We do not explicitly quantify the lost producer surplus. However, if the RSPs have some fixed costs, there might be other welfare costs associated with reduced demand.

Generally, the potential welfare deadweight costs are in single million figures (which is significantly smaller than the direct price effect), unless a relatively high own-price elasticity is assumed and a high percentile for the WACC is chosen. Since the own-price elasticity of copper-based broadband is likely to be very small, these cost estimates are relatively conservative.

3.3 Indirect effects

In addition to direct effects on demand for copper-based services, changes in UCLL/UBA prices might affect demand for other technologies, such as fibre-based Internet services. The Commission is examining separately the potential positive externalities from increased migration to fibre, in the context of the overall UCLL/UBA price. We therefore do not explicitly factor this into our assessment in this report.

A WACC uplift for copper-based services may also distort investment incentives for access seekers (and potentially for other industries that consume copper-based services), which could be detrimental to consumer welfare. We have not sought to explicitly quantify this effect in this report. In the energy context, these effects were found to be relatively immaterial.

Further, in the telecoms context, a WACC uplift is assumed to have a positive effect on the investment incentives throughout the value chain. If the potential user benefits from increasing incentives to bring forward investment as a result of the WACC uplift are indeed material (which is discussed in the next section), any other potential distorting effects on investment of access seekers might be small relative to the innovation benefits. However, this is a factor that can be considered when forming an overall judgement about the relative benefits and costs of a WACC uplift.

3.4 Summary

Choosing a WACC above the midpoint has a direct price effect as well as a demand effect, and the combination of the two can be material. Table 3.4 outlines the approximate additional cost for customers (per year) as a result of the WACC being set at different percentiles, based on the existing asset values for UCLL and UBA. The numbers have been rounded to the nearest NZ$5m to reflect the 'high-level' nature of the calculations.

Table 3.4 Cost of setting WACC above midpoint

Percentile	Approximate cost (existing asset base), NZ$m
50%	0
55%	10
60%	25
65%	35
70%	50
75%	60
80%	80
85%	100
90%	120
95%	160

Note: Figures are rounded to the nearest NZ$5m. The estimates include the midpoint estimate of the deadweight loss shown in Table 3.3.

Source: Oxera calculations.

In addition, if there is a reasonable chance that a new technology or service will become regulated in a similar way (i.e. by applying a WACC uplift), consumers will also bear the direct costs of the uplift on any additional investment. In our framework, which assumes that the WACC uplift mainly influences the pace of investment and the innovation itself is assumed to take place at some stage in any case, this cost will materialise regardless of whether the WACC uplift is successful at influencing the pace of investment.

If we assume that the asset base of the new service/technology is the same as the existing UCLL/UBA asset base,[14] the direct costs would effectively be double the costs shown in Table 3.3.

In practice, an assumption of doubling of the asset base is likely to overstate the costs. The total annual investment in telecoms in New Zealand has fluctuated between NZ$1bn and NZ$1.5bn, and only a proportion of this has been investment by Chorus or other providers of infrastructure and retail services.[15] This implies that, first, building up an asset base of more than NZ$7bn would take quite a long time, and, second, a new technology of this size would be likely to displace some of the existing asset base—i.e. consumers are unlikely to be paying for both the existing and the new asset base in full.

All in all, our illustrations of the direct costs of a WACC uplift are conservative in all regards. In section 6, we consider these costs in the context of the overall likely benefits of accelerating investment, and the probability of them materialising.

[14] The Commission uses this assumption in its preliminary thinking on the framework for a WACC uplift.
[15] New Zealand Commerce Commission (2013), 'Annual Telecommunications Monitoring Report 2013', pp. 6–7.

4 Potential benefits of innovation

The previous section discussed the size of potential direct financial effects of a WACC uplift. In evaluating the wider social and economic effects of the choice of WACC, we focus on the potential for a WACC uplift to have a positive influence on the pace and scale of new investment, and, with that, increase the probability of firms innovating and deploying new technologies or services. This, in turn, may be associated with material wider benefits to end-users.

4.1 Innovation in the telecoms industry

Innovation in the telecoms industry appears to be cyclical, in that innovation tends to arrive in waves, with new developments separated by a period of years. This is different from a process of continuous innovation, where refinements are made at very short intervals. This could be due to the presence of large fixed investments requiring a relatively large change in technology in order to make improvements worthwhile.

We note that a WACC uplift on its own is unlikely to affect whether a given innovation is commercialised in New Zealand, and hence change the frequency of the cycle. However, a regulatory regime that promotes innovation (through a WACC uplift) could accelerate the process of innovation, such that a new technology will be introduced in New Zealand earlier than it otherwise might have been.

While telecoms innovation may be considered cyclical, it is not necessarily uniform in its adoption around the world. Despite the fact that technical standards and equipment are shared across borders, some countries have been quick to adopt broadband technologies, while others have lagged behind. Some technical developments might relate to platform alternatives, which could mean that some innovations do not get deployed in some locations, or get deployed at a different pace.[16] A variety of regulatory, economic and geographic factors could also influence this heterogeneity in adoption.

Another aspect of innovation is the distinction between incremental and disruptive innovation. The former describes gradual changes to an existing technology in order to improve its performance, cost or reliability. The latter describes the development of a new technology that either displaces old technology within a market or creates a new market entirely.

Both types of innovation are relevant to telecoms markets. However, there are differences from the Commission's perspective. First, the benefits from incremental innovations are likely to be far smaller than those from disruptive ones, and may therefore be less relevant when considering the advantages to promoting innovation through a WACC uplift. Further, it is likely that many of the benefits of incremental innovation accrue mostly to the network operators rather than consumers. This could apply to innovations that reduce costs or increase efficiency in network operations but do not alter the user experience.[17]

4.2 Methodology

Oxera's approach to quantifying the benefits of innovation is to estimate the impact of a disruptive innovation occurring sooner than it would otherwise. This reflects our assumption that the benefits of a new innovation are likely to be realised regardless of when it occurs, but a WACC uplift could help to bring

[16] Countries that have extensive cable infrastructure might not deploy ADSL technology.
[17] Operators may also have sufficient incentives to invest in these innovations.

these benefits forward by accelerating investment. This brings forward new deployments, but does not affect whether an actual innovation is commercialised. Our methodology is composed of the following steps.

1. Identify four types of telecoms technology—transmission, switching, mobile and wireless—and place relevant telecoms developments into these groups.
2. Further group these technologies into incremental and disruptive innovations.
3. Date each of the technologies identified in order to calculate the frequency of innovation for disruptive technologies within each technology type.
4. Use relevant academic literature to assess the benefits associated with an innovation in the telecoms sector.
5. Provide an estimate for the likely effect that an increased incentive to invest has on the time in which innovation takes place (the 'acceleration effect' of a WACC uplift). We do this by assessing the difference between the earliest adopters of telecoms technologies in the G20 countries and the latest adopters.
6. Calculate the NPV of the benefit (step 4) associated with introducing the technology earlier due to the acceleration effect (step 5).

Section 4.3 outlines in more detail Oxera's methodology for estimating the frequency of innovation; sections 4.4 and 4.5 do the same for the benefits analysis and the accelerated innovation analysis, respectively. Section 4.6 summarises the evidence.

4.3 Measuring the frequency of innovation

Estimating the frequency of innovation involves the following three steps.

1. Identifying disruptive innovations and classifying each identified innovation by technology type.
2. Estimating the time between innovations within each type of telecoms technology.
3. Choosing the timeframe over which past innovations in technology are relevant.

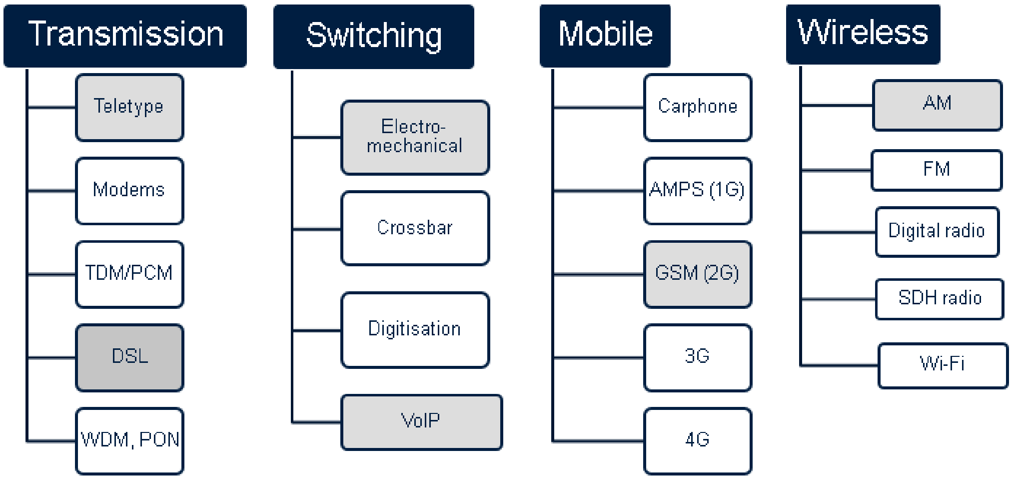
There is clearly an element of subjectivity associated with this methodology, particularly in terms of categorising innovations as disruptive or incremental. However, we have been cautious in the categorisation of these innovations, which has meant including only the most transformative innovations in our analysis. Our frequency estimate is therefore correspondingly conservative.

4.3.1 Innovation classification

In order to assess the frequency of innovation in the telecoms sector, it is first necessary to classify telecoms technologies by function. The reason for this is that, while there may be regular innovations in different areas of the telecoms sector, these may be completely unrelated to one another. For example, passive optical networking and 4G technology were commercialised at similar times (2008), but are essentially unrelated technologies. A method that does not separate such innovations would bias the estimate, since it would be classing disparate and unrelated innovations as being in the same cycle of innovation.

We have reviewed innovation events within four functions (transmission, switching, mobile and wireless/broadcast) that could be relevant to the context of UBA and UCLL services (Figure 4.1).

Figure 4.1 Types of telecoms technology



Note: Shaded boxes show disruptive innovations.

Source: Oxera.

4.3.2 Timing of innovation

Telecoms innovations are often developed in a laboratory or test environment before being deployed commercially. For this analysis, we have chosen to record the date of development as the date when the technology was commercialised. The reason for this is because laboratory findings may take years to commercialise and it is the commercialised innovations that result in changes in consumer and producer surplus. In addition, some innovations may not be commercially viable without additional investment, and it is this type of investment that the Commission may wish to ensure is brought forward. It is logical, therefore, to assess commercialised innovations.

4.3.3 Timeframe over which past innovations in technology are relevant

To assess the frequency of innovations in telecoms, it is necessary to look at past innovations in the industry. It is also necessary to assess whether the pace of innovation in the past is relevant to the pace of innovation today.

We note that there are two factors to balance when choosing the time horizon of telecoms technology developments. On the one hand, choosing too narrow a timeframe could cause the results to be biased by a particular period (such as the dot-com boom). On the other hand, too long a period would be likely to be affected by recall bias (i.e. the failure to observe innovations that happened) and might not reflect changes to the speed of innovation over time. We have chosen 40 years, which strikes a reasonable balance to mitigate these two concerns.

4.3.4 Results

Assessing the frequency of both disruptive and incremental innovations involves understanding the main innovations in the four types of telecoms technology identified by Oxera. The details of the types of innovations considered are presented in Appendix A2. It should be noted that this frequency analysis is somewhat subjective, as it involves characterising all the main technology innovations in telecoms as disruptive or incremental. The frequency estimate therefore provides only a proxy for the frequency of future innovations. A summary of the analysis is shown in the table below.

Table 4.1 Frequency of innovation (years)

Type of innovation	Transmission	Voice/call switching	Mobile telephony	Wireless	Min.	Max.	Average
Disruptive	13.3	40.0	13.3	20.0	13.3	40.0	21.7

Source: Oxera analysis.

On average, based on this relatively strict categorisation of innovations, a disruptive innovation happens once every 22 years. This takes into account the observed innovation patterns across the four technology types. However, the range for different functions is quite different. For example, innovations in the mobile category appear to have been more frequent than in other functions. The reason for taking an average across the different technology types is to account for the fact that the cycles of innovation attributable to different types of technology are often unrelated.

In our overall assessment of the possible benefits in section 4.6 below, we round to the nearest five years and assume that a major innovation happens every 20 years. It should be noted that the assumed length of the cycle does not have a material impact on our estimates of the benefits, as explained in more detail in section 4.6.

4.4 Benefits of innovation

To assess the benefits associated with innovation in the telecoms sector, we have conducted a review of the literature assessing the potential increase in GDP and/or consumer surplus associated with disruptive innovations, as well as the literature assessing the impacts of incremental changes in speed. We find that studies assessing the impact of innovation in telecoms tend to estimate the impact of broadband on consumer surplus and GDP.

Broadband is likely to be one of the innovations in telecoms that has been truly transformational for society overall and has created large consumer benefits. Any estimates of the benefits of innovation based on broadband may therefore overstate the benefits that might arise from other innovations in the future. At the same time, we consider that, given that many of the developments in telecoms technology may have similar kinds of benefits to high-speed broadband (e.g. the development of 3G technology), the estimates found in the literature are not completely unrepresentative of the benefits of disruptive innovation in general and are relevant to the WACC uplift context. The results of the literature review are discussed in detail in section 4.4.1.

We have looked at literature that considers all parts of the value chain when assessing the benefits of innovation. The reason for this is that focusing on specific parts of the value chain (e.g. wholesale or incumbent only) may miss some disruptive innovations.

4.4.1 Literature estimates of benefits to innovation

For the reasons outlined above (mainly the absence of alternative evidence), we focus on the literature that considers the potential benefits of broadband. There are two types of study into the impact of broadband:

1. those that measure the impact of introducing high-speed broadband to a particular country or locality. These studies are measures of the disruptive

benefits associated with disruptive innovations, because the introduction of broadband when compared with dial-up (or high-speed broadband when compared with low-speed broadband) represents a large technology change;

2. those that assess the effect of changes in broadband speed. These changes are more incremental in nature.

Studies that attempt to measure the direct consumer surplus associated with an adoption of high-speed broadband have been used to generate an estimate of the benefits associated with innovation. Several studies that estimate the benefits of broadband in terms of a change in GDP have also been used in order to provide a sense-check. The benefits from these latter studies are likely to over-estimate the effect that the Commission is interested in, as they take into account indirect benefits of technology (such as job creation, or changes in overall productivity) that do not necessarily accrue to the users of the technology. Nevertheless, such estimates can act as a benchmark to compare the estimates generated by the literature measuring consumer surplus only. A summary of all the relevant literature reviewed is presented in Appendix A3.

4.4.2 Results

Few papers directly estimate the benefits of the introduction of broadband in terms of consumer surplus; however, Oxera has identified two that do: Alcatel-Lucent (2011) and Criterion (2003).[18] It should be noted that the latter study estimated likely benefits to broadband prior to its widespread introduction. Alcatel-Lucent (2011) uses an approach that involves estimating cost savings associated with the introduction of the Internet in different industries to provide an estimate for the reduction of prices in those industries. This provides an estimate for the consumer surplus for each industry, which can then be summed to give an estimate for overall consumer surplus.

The methodology and results of these papers are summarised in Table 4.2. Both papers provide an estimate of the gross consumer surplus (i.e. before subtracting the relevant costs) associated with the introduction of broadband. To convert these numbers to those in Table 4.2, the Criterion estimate was converted into 2003 NZ dollars using a Purchasing Power Parity estimate to account for the spending power of local currency. Both were then converted into 2014 NZ dollars by correcting for inflation using an inflation calculator provided by the Reserve Bank of New Zealand.

[18] Alcatel-Lucent (2011), ‘Building the Benefits of Broadband: How New Zealand can increase the social & economic impacts of high-speed broadband’. Criterion Economics (2003), ‘The Effects of Ubiquitous Broadband Adoption on Investment, Jobs and the US Economy’.

Table 4.2 Consumer surplus estimates

Author	Title of study	Outline	Consumer surplus (NZ$ per person per year)	Total consumer surplus (NZ$m per year)
Alcatel-Lucent (2011)	Building the Benefits of Broadband	This study outlines an economic analysis undertaken by Bell Labs, the research department of Alcatel-Lucent, on the social and economic impacts for New Zealand of ultrafast broadband and the Rural Broadband Initiative. It estimates consumer surplus associated with broadband technology by estimating surplus in each industry in New Zealand and adding them together to generate a total estimate for the benefit to consumers.	366	1,616
Criterion (2003)	The Effect of Ubiquitous Broadband Adoption on Investment, Jobs and the US Economy	The authors make an ex ante assessment of the consumer surplus and GDP effects of ubiquitous take-up of broadband technology. Consumer surplus is estimated using data on the elasticity of demand for broadband.	352	1,680

Source: Criterion Economics (2003), 'The Effects of Ubiquitous Broadband Adoption On Investment, Jobs and the US Economy'; Alcatel-Lucent (2011), 'Building the Benefits of Broadband: How New Zealand can increase the social & economic impacts of high-speed broadband'.

Several papers measure the effect of broadband changes on GDP. The most relevant of these, since it looks at the adoption of high-speed broadband in a relatively sparsely populated area, is SQW (2007), which examines the effect of the adoption of high-speed broadband in Scotland. The estimate for the effect of broadband on GDP is NZ$930 per person per year.[19] As stated previously, one would expect a GDP estimate to be higher than the estimates for consumer surplus, which seems to be consistent with the estimates presented in Table 4.2.

Another cross-check on the results is a 2012 study conducted by the Commission, which estimated that non-business customers would be willing to pay an average of NZ$175 a year more for high-speed broadband.[20] This number is expected to be lower than any estimate generated by studies examining the effect of broadband on consumer surplus as a whole, because it ignores the benefits that business users receive from high-speed broadband. The Commission study also found that SME users would be willing to pay 7% more than they currently pay on average for their broadband connection if it were high-speed.

Overall, the estimates presented in Table 4.2 appear to provide a reasonable estimate of the likely consumer benefits of broadband. In the absence of clear evidence on the benefits of other technologies, we use these estimates in our overall benefits assessment.

The estimates from the two studies in Table 4.2 are relatively consistent with each other and suggest an annual total consumer surplus of around NZ$1.65bn. Most studies considered do not explicitly quantify the associated cost of the

[19] SQW (2007), 'Next Generation Broadband in Scotland'.
[20] New Zealand Commerce Commission (2012), 'High speed broadband services demand side study'.

technology. However, there is a cost estimate of broadband given in Criterion (2003), which implies a benefit–cost ratio in excess of 10—i.e. the costs are fairly small relative to the benefits. To ensure that we are capturing net benefits in our assessment, we use an estimate of NZ$1.5bn for the annual benefit of innovations in the analysis that follows.

4.5 Acceleration estimate

As explained above, it is likely that, in general, the frequency with which telecoms innovations are introduced in New Zealand will not be directly affected by a WACC uplift. The most likely difference between a regime that explicitly aims to reward innovation through a WACC uplift and one that does not is that, in the first case, innovations will be introduced to New Zealand sooner. The 'acceleration effect' is therefore the number of years by which an investment in a given innovation is brought forward.

To estimate this acceleration effect, we take the example of the year in which different developed countries have adopted ADSL2+ technology. The reason for choosing ADSL2+ is that its adoption is unlikely to have been affected by factors exogenous to investment levels and the regulatory framework (for the majority of countries[21]), which is not the case for many technologies (for example, before 3G was adopted most regulators organised a spectrum auction process), and because the data was readily available. The results of this acceleration analysis are presented in Table 4.3.

Table 4.3 Approximate dates of ADSL2+ adoption in developed countries

Country	Operator	Launch date
France	France Telecom, Illiad	Oct-2004
Finland	Saunalahti	Nov-2004
Sweden	TeliaSonera	Nov-2004
Australia	Internode	Apr-2005
Germany	Versatel	Apr-2005
Netherlands	Versatel	Sep-2005
UK	BE unlimited	Sep-2005
Czech Republic	Czech Online	Oct-2005
Ireland	Magnet	Jan-2006
Spain	Jazztel	Jun-2006
Hungary	Magyar Telecom	Jun-2006
New Zealand	Telecom New Zealand	Mar-2007
USA	Covad	May-2007
Italy	Tiscali	Nov-2007

Source: Oxera analysis.

The time between the first and last countries adopting ADSL2+ (in this selection of countries) is approximately three years. The average lag is approximately one year. New Zealand deployed ADSL2+ about 28 months after the leader (and this adoption was related to regulatory changes, in the absence of which the lag might have been longer). We note that a wider selection of countries would show a longer lag, especially where less-developed countries have trailed in broadband deployments.

[21] We understand that, in New Zealand specifically, the adoption of ADSL2+ was related to regulatory reforms.

On the basis of the observed deployment patterns for ADSL2+, an assumption that, on average, a particular technology or service might be deployed with a two-year delay seems reasonable.

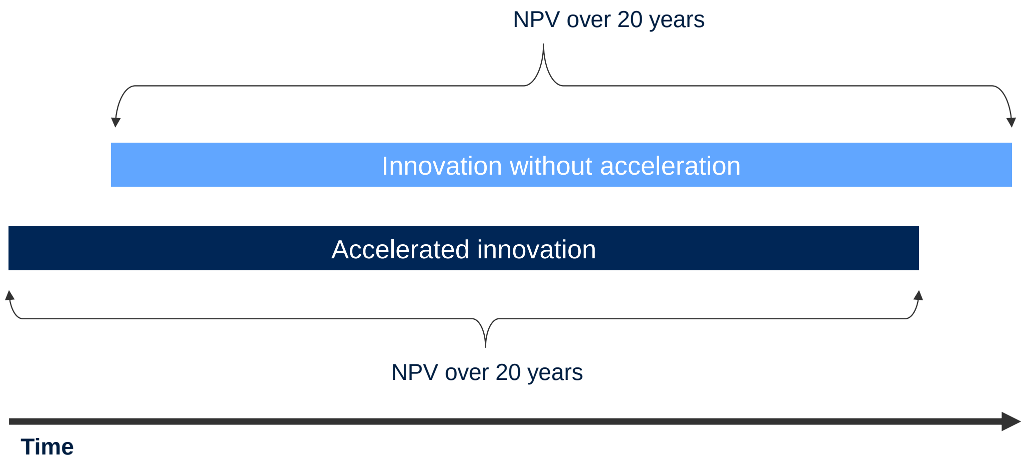
We note that, for more complex technologies (which are also more likely to be classified as disruptive innovation), the typical lag in deployment might be longer than for ADSL2+. In our overall assessment, in addition to a two-year period, we therefore also use a five-year period as our estimate of the potential acceleration effect of a WACC uplift on technology deployment.

4.6 Benefits illustration

Various approaches could be used to calculate the benefits that result from an acceleration effect. A simple way to think about it is to assume that a major innovation will happen once every 20 years (consistent with the frequency analysis presented in section 4.2). The net benefits of this innovation could be around NZ$1.5bn annually (consistent with the evidence presented in section 4.4).

Further, if we assume that a WACC uplift could have the effect of accelerating this investment by two years (consistent with the acceleration analysis in section 4.5), this means that consumers would get the 20-year stream of the annual benefit of NZ$1.5bn two years sooner than they would otherwise have done. In other words, assuming that the next innovation is two years away without acceleration, the extra benefit received by consumers is the difference in the NPV of the two benefit streams shown in Figure 4.2. Similar considerations apply in the case when investment is brought forward by five years.

Figure 4.2 Difference in benefits



Source: Oxera.

If the next innovation is two years away, the difference in the NPV of the two benefit streams will be between NZ$1.8bn and NZ$2.4bn depending on the discount rate. We have used a range for the discount rate of 5–10%.[22] If the next innovation is five years away, the difference in the NPV of the two benefit streams will be between NZ$4.2bn and NZ$5.3bn.

In practice, it is not known when the next wave of innovations will occur. However, assuming that the acceleration effect from a WACC uplift continues

[22] The 10% is the rate used by the Commission in the analysis of the positive externalities from fibre. We also use a lower estimate of 5% to reflect the fact that a social discount rate might be lower than 10%, and to illustrate the sensitivity of results to different discount rate assumptions.

into perpetuity, then on average every 20 years the consumers could get the above benefits in exchange for paying for a WACC uplift. Converting the estimated benefits into an annuity over a 20-year period produces a range of **NZ$150m** to **NZ$550m** a year (rounded to the nearest NZ$50m to reflect the high-level nature of these calculations), depending on the discount rate and the assumed acceleration effect. This is summarised in Table 4.4.

Table 4.4 Annualised net benefit of acceleration (NZ$m)

	Two-year acceleration	Five-year acceleration
Discount rate = 5%	150	300
Discount rate = 10%	250	550

Note: Figures are rounded to the nearest NZ$50m.

Source: Oxera calculations.

The assumptions on the relative strength of the acceleration effect (two versus five years) and the discount rate are the main factors that affect the estimates of the annualised benefits. The length of a typical innovation cycle (in this example, 20 years) makes little difference to the results. This is because a shorter cycle will reduce the overall NPV benefit to consumers of accelerating investment, although they will receive this benefit more often. Therefore, on an annualised basis, the length of the cycle is not a critical assumption.

Consistent with the discussion in section 3, if a WACC uplift is also applied to the new investment for 20 years, and if the asset base of the investment is equal to the asset base of the existing network, there will be an extra cost to consumers if a WACC uplift is applied (of the order of magnitude calculated in section 3). If a WACC uplift is applied, since we assume that the innovation will happen at some point in any case, this cost will be borne by consumers regardless of whether the uplift is successful in bringing the investment forward. We take these additional direct costs into account in our overall assessment in section 6.

5 Uncertainty around the WACC

In coming to a view on whether a WACC uplift is appropriate, it is important to understand both the scale of the impacts of the allowed WACC being 'too high' or 'too low' and the likelihood of this being the case. This section reviews the size of the risks associated with the choice of WACC.

5.1 The Commission's approach to measuring uncertainty

The Commission assumes that certain WACC parameters that cannot be observed directly from financial markets have a measurable uncertainty over their true values. Its assumptions are summarised in Table 5.1.

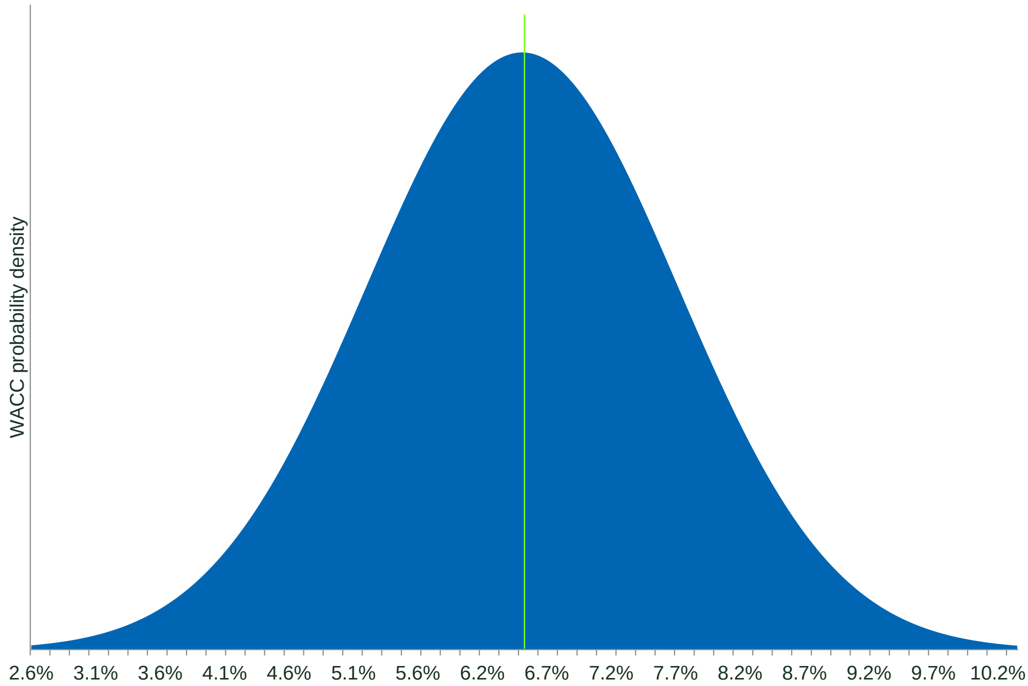
Table 5.1 The Commission's assumptions for the cost of capital, draft decision

Parameter	Midpoint estimate	Standard deviation
Leverage	43%	0%
Risk-free rate	4.19%	0%
Debt premium	1.85%	0.15%
Debt issuance cost	0.25%	0%
Asset beta	0.40	0.15
Equity beta	0.70	n.a.
Tax-adjusted market risk premium	7.00%	1.5%
Corporate tax rate	28%	0%
Investor tax rate	28%	0%
WACC (post-tax)	**6.47%**	**1.23%**

Source: New Zealand Commerce Commission (2014), 'Cost of capital for the UCLL and UBA pricing reviews: Draft decision', 2 December, p. 45. Standard deviations are based on data provided to Oxera by the Commission.

Figure 5.1 illustrates the impact of these assumptions. The range is estimated as a normal distribution, or 'bell curve', which recognises that there is no strict limitation on the extent to which the WACC could differ from expectations, but that the probability of a small error is greater than the probability of a larger error. For example, given the midpoint estimate of the WACC of 6.47% and standard error of 1.23%, the probability that the true WACC is as low as 3% or as high as 10% is so small that it can be discounted. However, there is a reasonably material probability that the true WACC is 1% above or below the allowed WACC.

Figure 5.1 WACC uncertainty based on the Commission's approach



Source: Oxera analysis, based on New Zealand Commerce Commission (2014), 'Cost of capital for the UCLL and UBA pricing reviews: Draft decision', 2 December, p. 45.

5.2 Difference between 'risk' and 'uncertainty'

There are two potential reasons why the true WACC might differ from the allowed WACC. These reflect the difficulty both in measuring the WACC today and in assessing changes in the WACC over time in response to changes in market conditions. These can be characterised as:

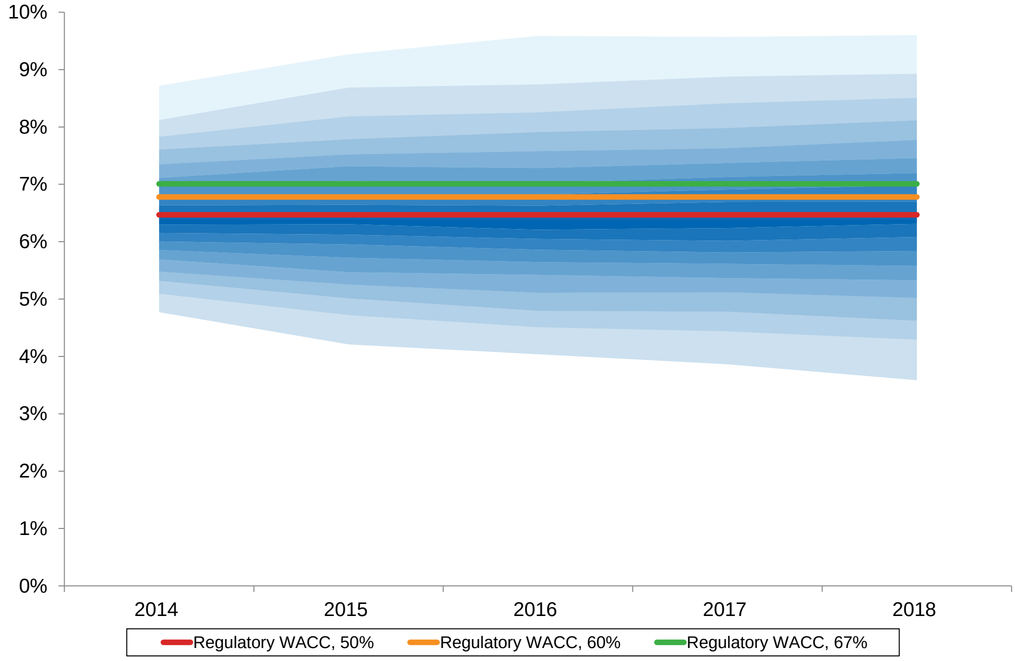
- **'risk', or changes in market conditions**. Risk is generally the term applied in this context to measurable, known reasons why the WACC will change over time. The simplest example is that the cost of debt, including the risk-free rate, will change over time. As a result of these changes, the WACC that investors actually require will be different from that estimated at the start of the period;
- **'uncertainty', or measurement error**. Uncertainty is the term applied when an input to a calculation cannot be ascertained with certainty, and there is clear evidence as to why not. This is the case with the beta. The beta is a 'known unknown' where it can be estimated with only a certain degree of accuracy, and the standard error applied by the Commission is a measure of the range of uncertainty.

The Commission's approach to estimating the WACC range takes into account the second component only ('uncertainty', or measurement error).

The difference between risk and uncertainty is potentially relevant in considering a WACC uplift. The presence of uncertainty is likely to be the reason for regulators' tendency to 'aim high' on a case-by-case basis.

However, where there is 'risk' rather than uncertainty, choosing a point above the midpoint may not be appropriate, as the company and its investors should be able to manage the risk, as with other factors such as input price inflation or demand risk.

Figure 5.2 Risk to the WACC—the combination of risk and uncertainty



Source: Oxera analysis, based on New Zealand Commerce Commission (2014), 'Cost of capital for the UCLL and UBA pricing reviews: Draft decision', 2 December, p. 45.

The Commission's approach is designed to compensate for uncertainty only, not risk. It explicitly assumes zero risk for other factors, including the risk-free rate. In effect, this approach assumes that these risks are best managed by the company, rather than through additional costs to customers. However, this does mean that the true range of the possible difference between the allowed and the true WACC will be greater within the period than implied by the WACC range used in the Commission's decision.

5.3 Impact of uncertainty on investment incentives

In the Part 4 context for electricity and gas, we assumed that a sustained differential of 0.5–1% between the true cost of capital and the allowed WACC could trigger a material under-investment problem. In other words, it is not necessarily the case that companies would stop carrying out all investment necessary to maintain service levels and reduce the risk of network outages as soon as the allowed WACC was expected to be below the true WACC. Rather, there needed to be a sustained margin between the allowed WACC and the true WACC for the under-investment problem to be triggered. We used the concept of 'probability of loss' to capture this effect in our assessment.

In the current context, we are focusing on the impact of a WACC uplift on incentives to invest in new networks and services—in particular, on the pace and scale of these investments. As shown in the previous section, the gross benefits to end-users of innovations in the telecoms industry could be quite material. Any impact that a WACC uplift may have on bringing forward this type of investment needs to be weighed against the direct costs to users resulting from the higher price of copper-based services.

In performing this relative assessment, as in the energy context, it might also be relevant to consider the uncertainty around the WACC and the probability of the true WACC being either above or below the allowed WACC.

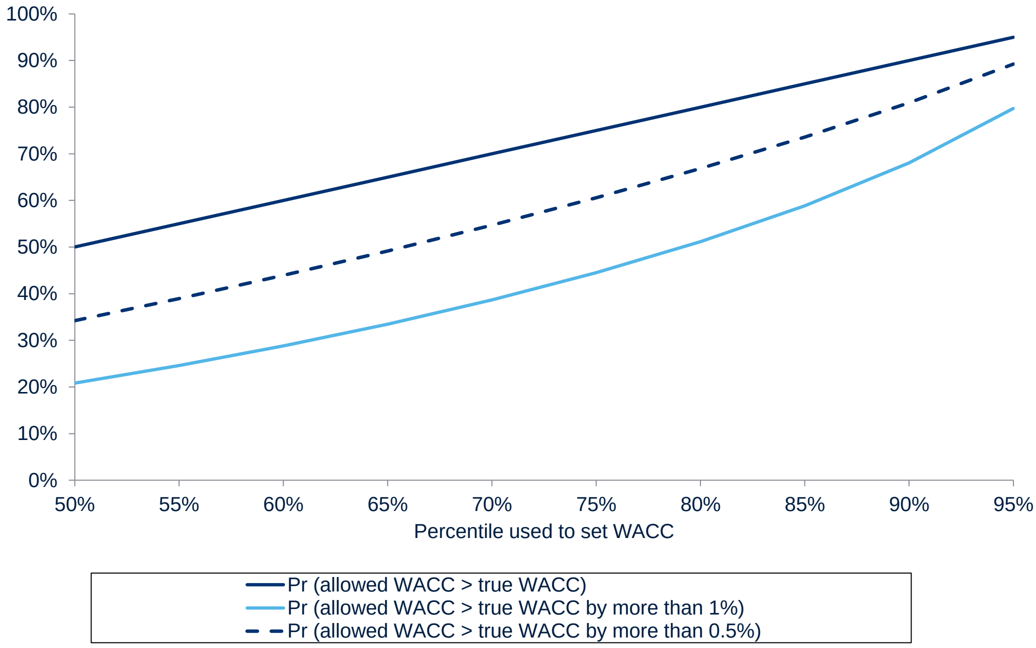
In principle, companies will undertake only those investments that have a positive NPV—i.e. where the expected rate of return is higher than the cost of capital. If a WACC uplift is used as a signal of regulatory commitment to providing investment incentives, the size of the uplift may affect the expected NPV of such additional investments. The size of the expected differential may therefore determine the strength of incentives to invest in new technologies and services.

As discussed in section 2 in more detail, while a number of factors influence the incentives to invest, it is plausible that the default industry position might be not to bring the investment forward unless the incentives are sufficiently strong. Given the underlying uncertainty around the WACC, it could be that investment timing incentives will be sufficiently affected by a WACC uplift only if there is a margin between the expected and the true WACC. For example, it is common for companies to use hurdle rates to assess investment opportunities that are in excess of the estimated cost of capital. This often reflects potential asymmetry in cash-flow forecasts, which in theory should be dealt with by properly adjusting the expected cash flows, but in practice may be dealt with through the choice of the hurdle rate.

What this means is that, for the WACC uplift to have the intended investment acceleration effect, there may need to be a sufficiently high probability that the allowed WACC is not only higher than the true WACC, but higher by some margin (such as 0.5–1%).

Figure 5.3 shows how the probability of the allowed WACC being higher than the true WACC changes depending on the WACC uplift. It also illustrates the changes in the probability of the allowed WACC being higher than the true WACC by 0.5% and 1% respectively.

Figure 5.3 Probability of the allowed WACC being above the true WACC for different WACC percentiles



Note: Based on the Commission’s approach to measuring uncertainty.

Source: Oxera analysis, based on New Zealand Commerce Commission (2014), ‘Cost of capital for the UCLL and UBA pricing reviews: Draft decision’, 2 December, p. 45.

As the size of the WACC uplift increases (measured by the percentile of the WACC range), the probability of accelerating investment in new technologies will increase, increasing the probability that the user benefits from accelerating this investment will be realised.

The direct relevance of the probabilities shown in Figure 5.3 to the probability of the accelerating investment is discussed further in section 6. When the WACC is set at the midpoint, in our framework, it is assumed that investment happens at some optimal point in time from the investor’s perspective. However, on average, this optimal point is associated with some lag to when a new technology or service becomes commercialised. This is somewhat different to the context underpinning the framework developed for Part 4. The probabilities shown in Figure 5.3, while still relevant, do not necessarily map directly onto the probability of the investment being accelerated. This is discussed further in section 6.

5.4 Summary

This section has considered the scale of risks and uncertainty around the WACC. The key findings include the following.

- The impact of the size of the WACC uplift on accelerating investment incentives may have some relationship with the implied probability of the allowed WACC being above the true WACC, which in turn depends on the assumptions around how uncertain the WACC is.
- In some circumstances, the Commission’s approach of focusing on measurement error only in defining the WACC range might not reflect the total in-period risks of the true WACC rising above the allowed WACC, as other factors, such as the risk-free rate, will also vary over time.

6 Overall assessment

The analysis and the framework presented in this report cannot provide complete assurance that a particular uplift (if any) is most appropriate, as the strength of the signalling mechanism of the uplift on the investment incentives across the value chain is not known with certainty.

However, assuming that there is some link between the allowed WACC for UCLL and UBA and the pace and/or scale of investment, this analysis enables an understanding of the potential relationship between the benefits of innovations, the probability that additional investment will be undertaken sooner rather than later, and the costs to customers of a WACC uplift. Here we summarise the illustrations of the relative benefits and costs presented in the previous sections.

The costs comprise two elements: the direct costs incurred by consumers due to the higher UCLL/UBA price resulting from the WACC uplift; and the additional direct costs resulting from the WACC uplift applied to the new ‘asset base’, which is assumed to be of the same size as the existing UCLL/UBA asset base. In practice, a new technology/service is unlikely to be of the same size as the existing assets: it is more likely either that the new technology will displace some of the existing asset base, or that it will represent a fraction of the existing asset base. Therefore, our cost estimates are relatively conservative (i.e. err on the high side).

The illustration of the benefits is based on the annualised difference in the NPV of a 20-year benefit stream, assuming that the WACC uplift brings the investment forward by two or five years. For each choice of the WACC percentile, the potential annual benefits depend on how the WACC uplift influences the probability that the investment will indeed be brought forward. Since there is uncertainty around the WACC itself, it is intuitive that a bigger uplift would make the ‘acceleration benefits’ more likely to be realised.

Consistent with our framework, it is assumed that, at the 50th percentile (the midpoint WACC), there is no incentive for the players to bring investment forward—i.e. the potential benefit is zero. In other words, the investment happens at some optimal point in time from the investor’s perspective. On average, however, this optimal point is associated with some natural industry and market ‘equilibrium point’ assumed to be either two or five years after a new technology or service becomes commercialised.

This approach does not rule out the possibility that New Zealand could be the first country to commercialise a new innovation. However, an assumption of later adoption is likely to be more realistic for most investments. If the allowed WACC is based on the midpoint of the range, then on average the expected NPV for the investor will be zero. There is therefore no obvious strong incentive to bring investment forward. The investment will still happen in the future, but the framework of setting the WACC at the midpoint will not be the main driver of the timing.

Once the policy of a WACC uplift is introduced, assuming that the WACC uplift will apply to new investment (e.g. if it becomes regulated in a similar way), the expected NPV for the investor will be positive. The investor is now faced with a choice of getting this NPV two (or five) years from now, or earlier. Clearly, the earlier the investment takes place, the bigger the NPV will be in present value terms. At one extreme, this suggests that even a very small uplift will incentivise the investor to bring the investment forward by the full two (or five) years.

In practice, the effectiveness of the uplift might depend on two things: the bigger the uplift, the bigger the expected NPV will be; and the bigger the uplift, the more likely it is that the investor will actually realise a positive NPV, given the uncertainty in the WACC. A more realistic scenario is therefore to assume that the probability of the investment being accelerated by two (or five) years is an increasing function of the WACC uplift.

This raises the question of how to define this function. In our framework, the ‘acceleration probability’ is defined relative to the optimal timing at which the investment would occur in a scenario where the midpoint WACC is chosen—i.e. where the ‘acceleration probability’ is zero at the 50th percentile.

For illustration, we assume that this probability increases linearly (starting from zero at the midpoint of the WACC range) as the percentile is increased. Defining the function linearly is likely to be a simplification, but it can still provide some useful insight about the relative costs and benefits of a WACC uplift.

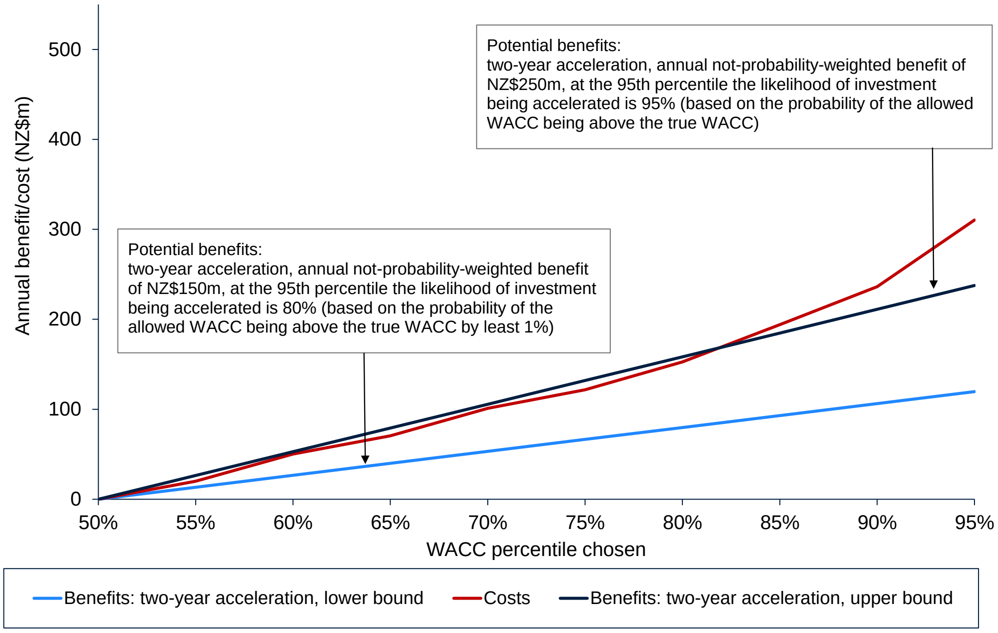
To define how quickly the ‘acceleration probability’ increases as the WACC uplift increases, one option is to consider what happens when a very high percentile is chosen (e.g. the 95th percentile). In this case, we can be fairly confident that the investment will be brought forward to the earliest possible date. Choosing such a high percentile would send quite a strong signal to investors about the regulator’s commitment to ensuring that investors recover their costs. In addition, the probability of the true WACC being above the allowed WACC is small at the 95th percentile.

To define the ‘acceleration probability’ at the 95th percentile, we can use the probabilities of the allowed WACC being above the true WACC presented in section 5. At the 95th percentile, the probability of the allowed WACC being above the true WACC is 95%, and the probabilities of the allowed WACC being above the true WACC by 0.5% or 1.0% are 89% and 80% respectively. We use these probabilities (of 95%, 89% and 80%) as possible anchor points for how likely it is that the investment will be brought forward if the WACC is set at the 95th percentile. The probability of the investment being brought forward is then assumed to increase linearly from zero at the 50th percentile of the WACC range to 95%, 89%, and 80% respectively at the 95th percentile.

The three sets of assumptions for how the acceleration probability changes between the 50th and the 95th percentile represent three possible scenarios. Other assumptions might also be used. However, for the purposes of gaining a high-level understanding of the likely range of benefits, these simple illustrations are useful.

A summary of the potential benefits for different WACC uplifts under the chosen assumptions is shown in Figure 6.1, Figure 6.2 and Table 6.1. Appendix A4 provides more detail on all of the scenarios considered.

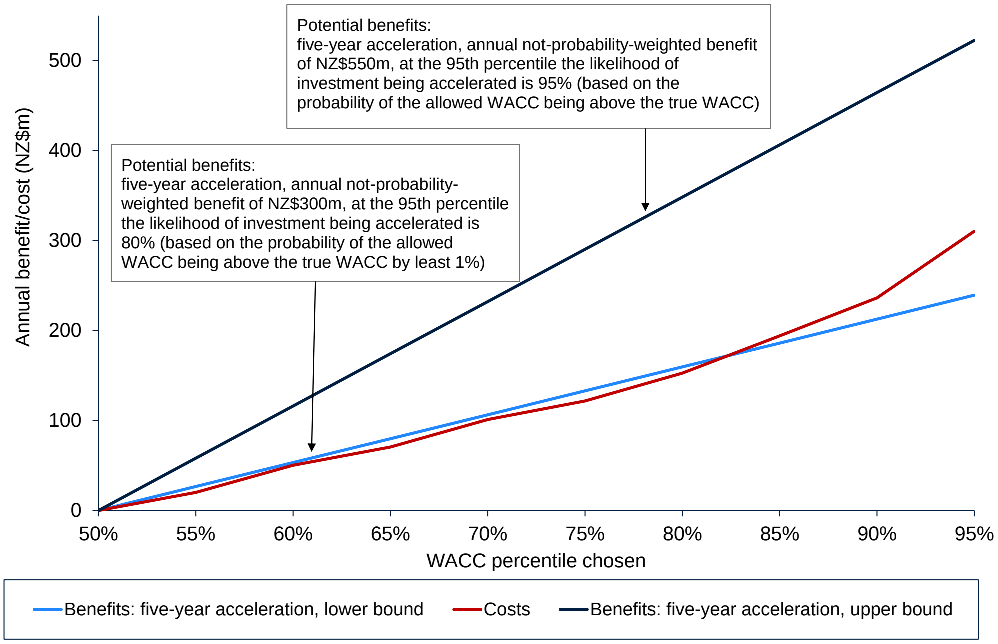
Figure 6.1 Benefits versus costs, two-year acceleration



Note: Lower and upper bounds of the annualised net benefit estimates of 150m and 250m correspond to the values shown in Table 4.4.

Source: Oxera.

Figure 6.2 Benefits versus costs, five-year acceleration



Note: Lower and upper bounds of the annualised net benefit estimates of 300m and 550m correspond to the values shown in Table 4.4.

Source: Oxera.

Figure 6.1 assumes that investment might be brought forward by two years. The potential benefit for modest values of the WACC uplift is fairly similar to our estimates of the cost. For example, at the 55th percentile, the annual cost of the WACC uplift is NZ$20m relative to the probability-adjusted potential benefit of

NZ$15m–NZ$25m. At the 75th percentile, the potential annual cost of NZ$120m is comparable to the upper bound of the potential benefits range of NZ$65m–NZ$130m.

Considering that the cost estimate is quite conservative (i.e. the cost is likely to be overstated), there might be some benefit, albeit relatively small, to consumers from a modest WACC uplift, but the evidence is not conclusive to definitely support an uplift.

Figure 6.2 assumes that investment might be brought forward by five years. In this case, the benefits of accelerating investment generally exceed the cost, unless a very high percentile is chosen. For example, at the 75th percentile, the additional costs to consumers would be NZ$120m compared to the potential benefits of NZ$135m–NZ$290m. Under this scenario, the case for an uplift is stronger.

In reality, the acceleration probability is unlikely to increase linearly as the size of the WACC uplift is increased. Rather, it seems more likely that the increase in the incentive to bring investment forward is bigger for modest values of the uplift than implied by the linear projection. The introduction of the policy of applying a WACC uplift, even a relatively small one, could provide a powerful signal to investors that, on average, they will recover more than their costs. This intuition may support the case for some uplift.

What this type of assessment highlights is that there are many uncertainties around the estimates of the potential benefits and costs of a WACC uplift. The overall concept of using a WACC uplift as a mechanism to increase incentives to carry out innovative investments sooner rather than later is reasonable, but, in the particular case of UCLL/UBA, the decision of whether an uplift is justified depends heavily on the assumed ‘acceleration effect’ on adopting innovations in New Zealand, and on whether the incentive impact on acceleration is non-linear (i.e. is stronger for modest values of the uplift).

All in all, the set of assumptions one would have to believe in order to conclude that a modest WACC uplift is justified seems quite plausible and can be used to inform the Commission’s decision. At the same time, the evidence is not strong, and requires significant speculation about the nature and scale of benefits of future innovation, and, therefore, does not contradict the continued use of a midpoint WACC for UCLL/UBA.

Table 6.1 Summary of analysis

Step:	Measuring the direct costs, NZ$m		Defining potential annual benefits of innovation (not probability-weighted, NZ$m)		Measuring the benefit: what is the probability of the benefits being realised?		
Percentile	Existing asset base	New asset base	Two-year delay	Five-year delay	At the 95th percentile based on Pr (allowed WACC > true WACC)	At the 95th percentile based on Pr (allowed WACC > true WACC by more than 0.5%)	At the 95th percentile based on Pr (allowed WACC > true WACC by more than 1%)
50%	0	0	150–250	300–550	0%	0%	0%
55%	10	10	150–250	300–550	11%	10%	9%
60%	25	25	150–250	300–550	21%	20%	18%
65%	35	35	150–250	300–550	32%	30%	27%
70%	50	50	150–250	300–550	42%	40%	35%
75%	60	60	150–250	300–550	53%	50%	44%
80%	80	80	150–250	300–550	63%	59%	53%
85%	100	100	150–250	300–550	74%	69%	62%
90%	120	120	150–250	300–550	84%	79%	71%
95%	160	160	150–250	300–550	95%	89%	80%

Source: Oxera.

6.1 The Commission's approach

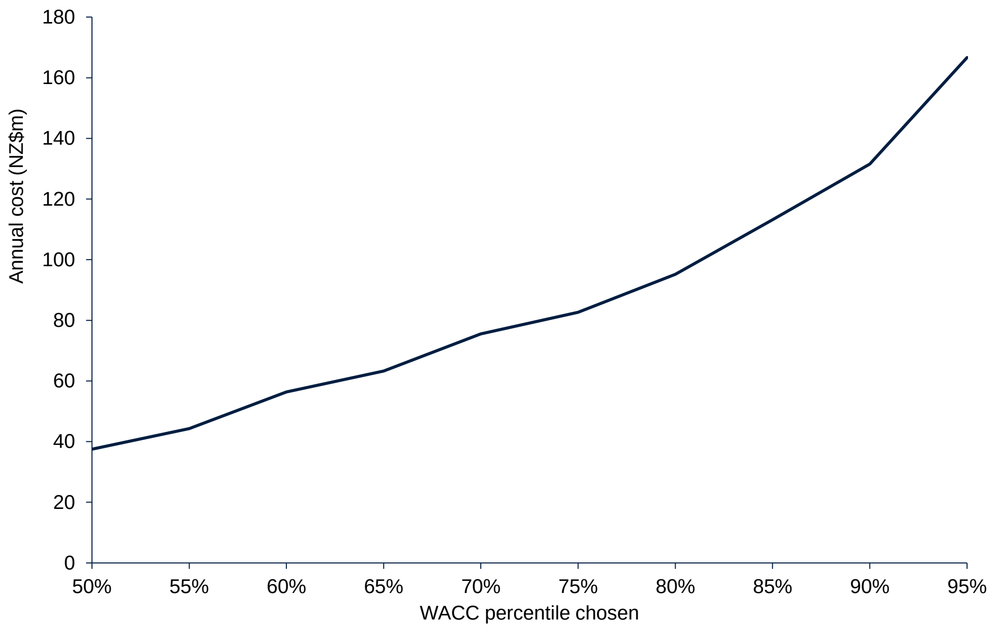
We also compare the results of our approach with the framework proposed by the Commission in the pre-conference paper and as discussed in section 2. As a reminder, the Commission suggested that the optimal WACC could be solved for by minimising the function below.

$$f(w) = RAB(w - w_0) + p[RAB(w - w_0) + c(1 - CDF(w)]$$

The first term of this function, $RAB(w - w_0)$, corresponds to the direct costs of a WACC uplift to users, as estimated in section 3. The term $p * RAB * (w - w_0)$ represents the probability-adjusted additional costs to users from applying a WACC uplift to the new investment. The term $p * c * (1 - CDF(w))$ represents the probability-adjusted forgone benefits if the new investment does not occur.

One way to map our results onto this framework is to assume that p, which, in the Commission's framework, corresponds to the probability that a major innovation occurs, when it occurs, and whether the WACC for UCLL/UBA is influential on the investment in new technology, is equal to 5% (based on our assumption that a major innovation occurs every 20 years). Since c measures the forgone benefits to customers if the investment does not occur at all, it is comparable to the net benefit estimate of NZ$1.5bn from section 4. The cost function implied by these assumptions is shown in Figure 6.3.

Figure 6.3 Cost function proposed by the Commission



Source: New Zealand Commerce Commission and Oxera.

Under these assumptions, the cost function is minimised at the midpoint of the WACC, and it therefore appears that there is no rationale for applying a WACC uplift.

One important difference between this approach and our framework is that, in this example, the size of the uplift affects whether the investment happens at all, rather than the timing of the investment.

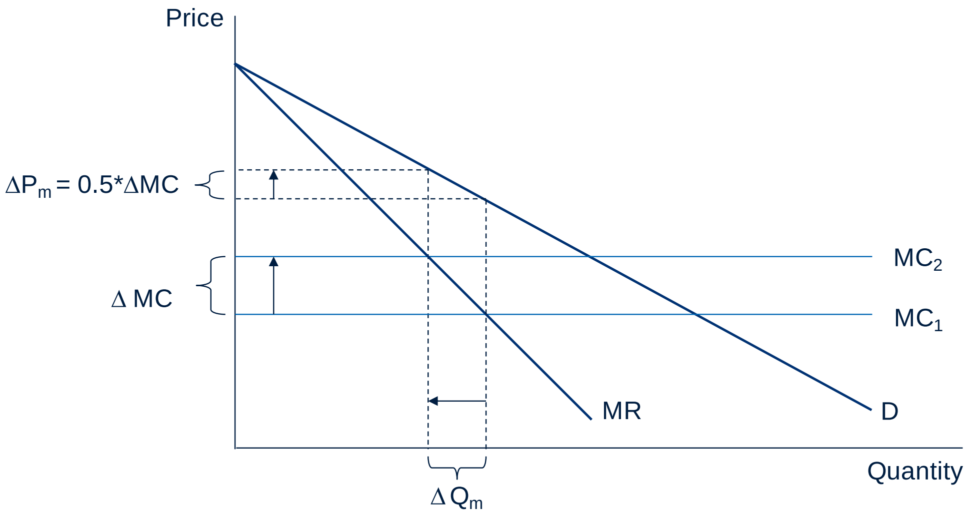
Another key difference is the way the probability distribution of the WACC feeds into the probability of the benefits being realised. If the WACC is set at the midpoint, then the probability of the investment happening and the benefits being realised is assumed to be 50% (before taking into account the probability of the innovation occurring in the first place captured by p). As the WACC uplift is applied, this probability increases in the same way as does the probability of the allowed WACC being above the true WACC.

In contrast, in our framework, the investment in the new technology or service happens regardless of the WACC framework. Once it is commercialised in a different country, the technology comes to New Zealand with some lag relative to when it is first commercialised. However, the benefits of accelerating investment can be realised (with some probability) only if a WACC uplift is applied.

A1 Level of pass-through

Standard economic models suggest that the extent of pass-through of an increase in input costs into the final end-user price will be determined by the structure of the downstream market. Figure A1.1 considers the situation in which the direct purchaser is a downstream monopolist. The monopolist maximises its profits by setting its price where the marginal cost (MC) is equal to the marginal revenue (MR). Under the assumption that the demand curve (D) is linear, the monopolist's marginal revenue curve is exactly twice as steep as the demand curve. If there is an overcharge by the upstream firm as a result of the WACC being set too high, the downstream monopolist's marginal cost curve will shift upwards. With linear demand, the monopolist's price will increase by exactly half the increase in cost.

Figure A1.1 Cost pass-through by a downstream monopolist



Source: Oxera.

Where the downstream market is instead characterised by perfect competition, competitive pressures will mean that all firms will set their prices equal to marginal cost. Firms will be unable to absorb any of the additional cost, as to do so would require them to price below the new marginal cost (and therefore make a loss). As such, a perfectly competitive downstream firm will pass through the additional cost in full.

Standard economic theory therefore dictates that a downstream monopolist will bear a greater cost from the WACC being set too high than would a firm in a more competitive downstream market. An oligopolistic market (under Cournot competition) produces a level of pass-through that is between the monopoly and perfectly competitive outcomes.

In practice, the actual pass-through might be different from the levels indicated by the standard economic theory. For example, the companies using cost-plus pricing might increase the prices by more than the increase in their costs.

A2 Summary of innovation frequency data

Table A2.1 Frequency analysis of transmission

Innovation	Date	Disruptive or incremental innovation
Morse code	1850	Disruptive
Teletype	1900	Disruptive
Frequency division multiplexing	1930	Incremental
Modems	1940	Incremental
Time division multiplexing (TDM)	1960	Incremental
Synchronous TDM	1980	Incremental
Digital subscriber line	1990	Disruptive
Wavelength division multiplexing	1995	Incremental
Two-way cable modem	1997	Incremental
Passive optical networking	2008	Disruptive
Carrier Ethernet	2009	Incremental

Table A2.2 Frequency analysis of switching

Innovation	Date	Disruptive or incremental innovation
Manual exchanges	1890	Disruptive
Electro mechanical	1920	Incremental
Cross bar	1950	Incremental
Digital/AXE	1980	Disruptive
Voice over IP switching	2005	Incremental

Table A2.3 Frequency analysis of mobile

Innovation	Date	Disruptive or incremental innovation
Carphones	1946	Incremental
AMPS	1980	Incremental
GSM	1991	Disruptive
3G	1998	Incremental
4G	2008	Incremental

Table A2.4 Frequency analysis of wireless

Innovation	Date	Disruptive or incremental innovation
Amplitude modulation, amplifiers	1920	Disruptive
Frequency modulation	1940	Incremental
Transistorisation	1955	Disruptive
Digital/PDH radio	1975	Incremental
SDH Radio	1993	Incremental
DAB Radio	1995	Incremental
Wi-Fi	2000	Disruptive

Source: Oxera analysis.

A3 Literature review

Table A3.1 New Zealand-based studies

Author	Outline	Results
Alcatel-Lucent (2011)	The study outlines an economic analysis undertaken by Bell Labs, the research and innovation engine of Alcatel-Lucent, on the social and economic impacts for New Zealand of ultra-fast broadband and the Rural Broadband Initiative in New Zealand.	The study finds a total surplus of high-speed broadband of $32bn over 20 years.
New Zealand Commerce Commission (2012)	A study of the demand for high-speed broadband in New Zealand. Pertinent data from surveys with SMEs and customers.	The surveys conducted by the Commission find that: • consumers are willing to pay an average of $14.03 a month more for high-speed broadband than for regular broadband; • SMEs are willing to spend an average of 7.6% more a month for high-speed broadband.
Sapere Research Group (2014)	The study estimates the effect of high-speed broadband on the productivity of firms outside the ICT sector.	Across the economy, firms that make more extensive use of Internet services are 6% more productive than average firms in their industry.

Source: Alcatel-Lucent (2011), 'Building the Benefits of Broadband'; New Zealand Commerce Commission (2012), 'High speed broadband services demand side study'; Sapere Research Group (2014), 'The value of internet services to New Zealand Businesses'.

Table A3.2 Studies from other countries

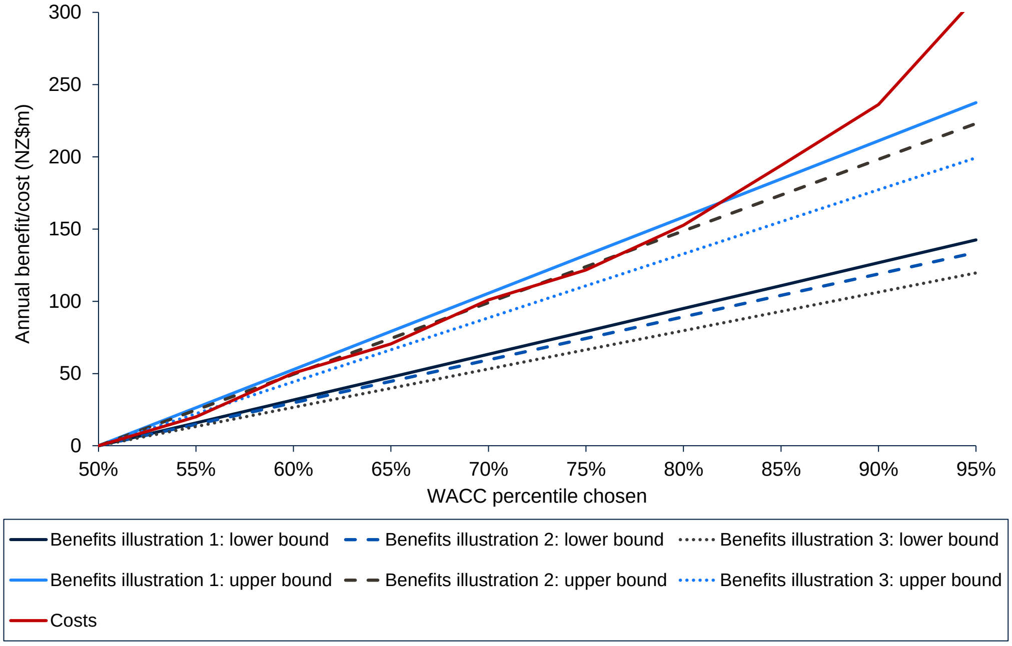
Paper	Description	Results
LECG (2009)	Investigated the impact of broadband on productivity growth and, in turn, on GDP.	$160m (Finland)—$12bn (USA) in 2009 (2000 US dollars) impact per 1 additional broadband line per 100 persons. These are impacts in 'medium or high ICT' countries.
Forzati and Mattsson (2011)	Examined the socio-economic effects from FTTH deployments—sample of 290 Swedish municipalities for the period 2007–10.	Estimated total (direct + indirect) cumulative return of SEK59bn over five years. Also estimates SEK2.3bn per year direct effect on Sweden's 4.2m homes connected to fibre-optic network (classified this as indirect effect). Note that direct effect (building the fibre network) makes up most of the effect.
Gruber and Koutroumpis (2013)	Small but statistically significant impact from countries that offered higher broadband speeds.	Estimated a 0.2% increase in economic growth for countries with average speeds above 2Mbps compared to countries with average speeds lower than that threshold.
Czernich et al. (2009)	Data covered 25 OECD countries in the 1996–2007 period; instrument variable approach to address reverse causality.	Robust evidence: a 10% increase in the broadband penetration rate raises annual per-capita growth by 0.9–1.5%

Paper	Description	Results
Chalmers University and Little (2011)	Found that the coefficient of broadband speed *squared* was significant and positive—suggesting a non-linear relationship between broadband speeds and GDP per-capita growth (increases at low speeds help, but increases at higher speed levels less helpful).	They interpreted their findings as suggesting that doubling the connection speed would contribute an additional 0.3 percentage points to annual GDP growth (the mean speed in the sample was 8.3Mbps).
Koutroumpis (2009)	There is evidence that the impacts of growth in broadband are greater in countries with relatively high levels of take-up—telecoms networks in general exhibit 'network effects', whereby the value of the network becomes greater to each subscriber, as more subscribers become connected (for example, it is more valuable to have a phone if many other people also have one).	The marginal impacts associated with *growth* in broadband penetration were greater for higher-penetration countries: an additional 10 lines per 100 people led to 0.7% additional annual GDP growth in low-penetration countries, 0.8% in medium-penetration countries, and 1.0% in high-penetration countries.
SQW (2007)	Estimated impacts of moves from first generation to second generation to third generation broadband.	Estimated that the annual gross value added in 2015 will be £3.35bn. Total impact due to incremental increases in speed from 2002 to 2015 of £28bn. Discussed social impacts, but remain unquantifiable (BT estimated in 2004 that tele-working could reduce mileage by 10%).
Katz et al. (2010)	Considered the potential economic impacts associated with a two-stage investment in broadband: an initial investment of €20.2bn to ensure that 75% of German households have access to connections higher than 50Mbps by 2014; and €15.7bn invested in 2015–20 to bring FTTH connections to 50% of all households.	€33.4bn between 2010 and 2020 from the network construction, and €137.5bn between 2010 and 2020 from network externalities.
SNG (2013)	Potential economic benefits that can be derived from recent investments in fibre broadband services in Northern Ireland—across five key sectors—advanced manufacturing, creative & digital, financial services, retail, and agri-food.	The economic impact estimates for Northern Ireland show that a 10% increase in utilisation of broadband-enabled services would result in a 15-year gross value added impact of £422m ($640m).
SQW (2013)	Looked at impact of faster broadband speeds relative to a 2008 base.	Estimated that the availability and exploitation of faster broadband will lead to a net annual gross value added impact of £17bn by 2024 (labour force participation carers & disabled—£0.2bn per year, teleworker productivity—£0.3bn per year, network construction—£1.5bn over period, vast amount is productivity growth of broadband-using enterprises), mostly through the enhancement of productivity of broadband-using firms.
Criterion Economics (2003)	Estimated the impact of universal residential first generation broadband adoption on potential consumer surplus.	Effect of ubiquitous broadband adoption on **consumer surplus—** $32bn to $71bn per year—equivalent to around $1,000 (circa £500) per head of the entire US population in 2003 prices. This is if broadband service were to become truly ubiquitous (most of the estimate is due to shopping/entertainment).

Source: LECG Corporation (2009), 'Economic Impact of Broadband: An Empirical Study'; Forzati, M. and Mattsson, C. (2011), 'Socio-economic effects of FTTH/FTTX in Sweden'; Gruber, H. and Koutroumpis, P. (2013), 'Mobile telecommunications and the impact on economic development'; Czernich, N., Falck, O., Kretschmer, T. and Woessmann, L. (2009), 'Broadband infrastructure and economic growth', CESifo Working Paper No. 2861; Chalmers University and Little, A.D. (2011), 'Analysing the effect of broadband on GDP'; Koutroumpis, P. (2009), 'The Economic Impact of Broadband on Growth: A Simultaneous Approach'; SQW (2007), 'Next Generation Broadband in Scotland'; Katz, R., Vaterlaus, S., Zenhausern, P., Suter, S. and Mahler, P. (2010), 'The impact of broadband on jobs and the German economy'; Strategic Networks Group (2013), 'Northern Ireland's Fibre Future'; SQW (2013), 'UK Broadband Impact Study'; Criterion Economics (2003), 'The effects of Ubiquitous Broadband Adoption On Investment, Jobs and the US Economy'.

A4 Additional cost–benefit illustrations

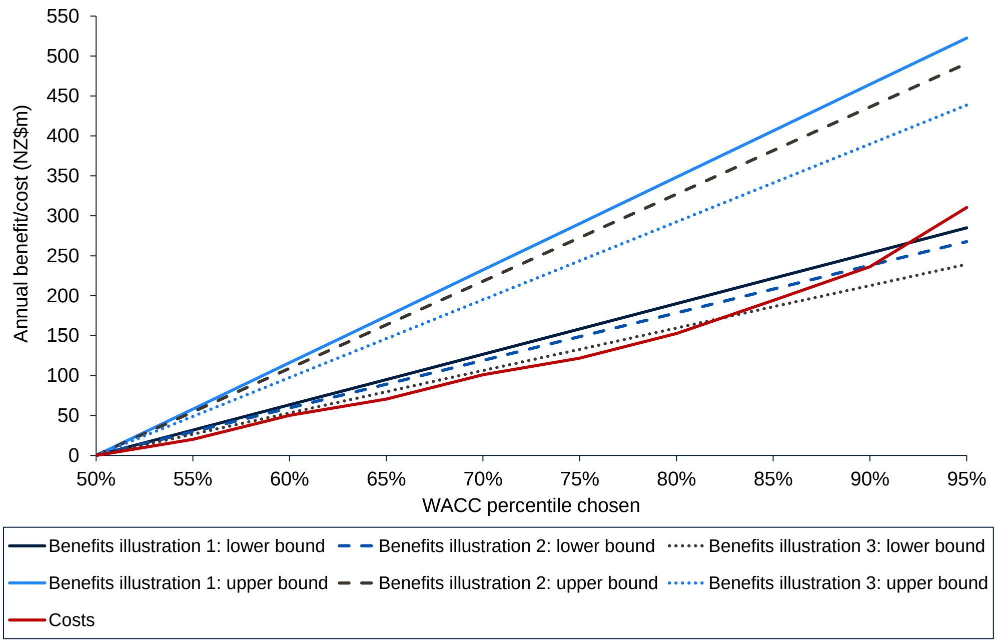
Figure A4.1 Benefits versus costs, two-year acceleration



Note: The following assumptions are used for each illustration of the benefits. Illustration 1: acceleration probability at 95th percentile = Pr (allowed WACC > true WACC) = 95%. Illustration 2: acceleration probability at 95th percentile = Pr (allowed WACC > true WACC by more than 0.5%) = 89%. Illustration 3: acceleration probability at 95th percentile = Pr (allowed WACC > true WACC by more than 1%) = 80%. Lower and upper bounds correspond to the lower and upper bounds of the annualised net benefit estimates of 150m and 250m respectively from Table 4.4.

Source: Oxera.

Figure A4.2 Benefits versus costs, five-year acceleration



Note: The following assumptions are used for each illustration of the benefits. Illustration 1: acceleration probability at 95th percentile = Pr (allowed WACC > true WACC) = 95%. Illustration 2: acceleration probability at 95th percentile = Pr (allowed WACC > true WACC by more than 0.5%) = 89%. Illustration 3: acceleration probability at 95th percentile = Pr (allowed WACC > true WACC by more than 1%) = 80%. Lower and upper bounds correspond to the lower and upper bounds of the annualised net benefit estimates of 300m and 550m respectively from Table 4.4.

Source: Oxera.

www.oxera.com