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Reducing uncertainty in price regulation for fibre-based, open-access platforms

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1. Introduction

In many countries, regulation of telecommunications operators has been based on analysis of the forward-looking costs over the long run of an efficient operator. Known as TSLRIC or Total Services Long Run Incremental Cost, this method is defined as the forward-looking costs over the long run of the total quantity of the facilities and functions that are directly attributable to the service. (NZ Government, 2018). It also includes an allocation of forward-looking common costs.

This regulatory approach, which focusses on the forward-looking replacement cost of an operator's network, has been viewed as assisting achievement of a number of objectives including incumbents' decisions on technology choices and also competitors' decisions on efficient ways to bypass the incumbent's network.

Common in Australia and New Zealand the Building Blocks Model (BBM) methodology is used in the regulation of electricity transmission and distribution, gas transmission and distribution, railways, urban water and sewerage services, and port access. BBM is a regulatory tool that assures the regulated firm a path of revenues or prices by spreading its expenditures over time. It aims to ensure that the net present value of the firm's cash-flow stream equals zero. BBM can be forward-looking when it contemplates expected expenditures. As long as it does not direct the firm to specific operating costs, BBM may establish a benchmark forecast that signals the efficient expenditure path.

Following suit with dissatisfaction with practicalities, including a conclusion that the TSLRIC methodology involves too much arbitrariness at the expense of predictability, the New Zealand government's review of its Telecommunications Act has already changed the method of regulation of fixed-line telecommunications to the BBM methodology. In New Zealand's case the government has introduced amendments to the Act largely adopting existing BBM regulatory guidelines and decisions that currently apply to electricity lines and airports.

The context of the application of BBM is that of the nationwide fibre-to-the-home (FTTH) network known as the Ultra-Fast Broadband (UFB) network, which has reached 85% of premises in its tenth and final year of construction. A major fixed-line network provider and three new fibre companies, all known as Local Fibre Companies (LFCs), with the assistance of government financing, undertook construction of the network as each company was designated as the sole government-assisted UFB fibre provider for specific, non-overlapping geographical regions after submission of competitive bids.

Conditions imposed on the new fibre networks limit them to the wholesale market by prohibiting sale of services to end-users. Instead they must sell wholesale access to any service retailer that wants to operate end-user services on the UFB network. The technical and regulatory conditions imposed on the fibre networks turn them into open access, broadband platforms.

The initial pricing of wholesale services, up until 2020 and later extended to 2021, was covered by the contracts under which the financial assistance was provided. The NZ government has now decided that after the initial period, the pricing of the fibre services by the monopoly provider in each region will be regulated by a BBM regulatory framework.

In the context of the transformed telecommunications market in which four regional open-access, monopolistic broadband platforms, the LFCs, provide access to telecommunications services by competing retailers, this paper analyses the incentives provided by such a BBM regulatory methodology, using the (non-finalised) consultation papers and some final decisions already made in the process of establishing the full regulatory framework. Ultimately, this work aims to identify the conditions and regulatory decisions that lead, as claimed in the promulgation of the review of the Ac, to limit the sources of uncertainty to the regulated firms and consumers.

The literature on regulation of monopolistic utilities is extensive and well known. In a particularly seminal paper, Averch and Johnson established a critique of the application of **rate-of-return regulation**. In summary, their paper observed that if the regulator allows a rate of return higher than the market required return (which would generally occur given uncertainty) the regulated supplier has an incentive to invest more than is socially optimal. Such investment increases the regulated asset base and thus the allowed price so as to provide a return on the increased base. Unless constrained by the regulator, excess investment could continue until the price reached the level an unregulated monopolist would charge.

A regulated supplier can be incentivised to constrain both operating and capital expenditure by switching to **incentive regulation** in which price or revenue caps are set ahead of time for a regulatory period (the caps being set at levels forecast to provide a normal return) with the supplier retaining all or part of any cost savings achieved.

The determination of the price caps under incentive regulation can be either independent of the past costs experienced by the regulated supplier, for example the regulated asset base can be TSLRIC or be based on comparators, or can reflect historic costs, as for example is typical under the BBM approach. Price or revenue caps independent of the supplier's actual costs (sometimes described as "price-based" incentive regulation) in principle better promote static efficiency but at the cost of potentially delaying or indeed suppressing investment and, therefore, "dynamic" efficiency. The alternative is one form or another of (historic) cost-based incentive regulation.

Since the advent of incentive regulation, a number of analyses have articulated critiques of price-based incentive regulation. Guthrie, Small and Wright (2006) argue that, given demand uncertainty, price-based incentive regulation (in their terminology "Forward looking price rules") is inferior to cost-based incentive regulation ("Backward looking price rules") whenever investment is desired (unless the cost of investment is trending upwards with low volatility). With telecommunication electronics costs falling rapidly, regulators favoured forward looking cost rules as likely to result in cost reductions benefiting end users. Thus the assessment was that the Guthrie, Small and Wright (2006) argument in favour of backward looking price rules was outweighed by the expected cost reduction benefits of forward looking price rules.

Two factors have subsequently been important in encouraging a switch away from forward looking price rules (price-based incentive regulation) towards backwards looking (historic cost-based incentive regulation). The first factor is the shift in focus to encouraging investment in fibre networks which involve very large infrastructure investments and second is, as noted earlier, disenchantment with the complexities and uncertainties of TSLRIC and other forward-looking price rules.

Reflecting this shift in focus, Borrmann and Brunekreeft (2011b) point at the short-term, cost-reducing characteristics of price-based regulation in contrast to the current needs of firms, in the electricity as well as the telecommunications sectors that face cost-increasing investments. They imply that this situation calls for a renewed approach to long-run, cost-based incentive regulation.

The latter claim can be fully appreciated as one reviews the contents of two survey papers that have recently appeared in the literature on broadband investment and regulation. In their review of the literature on regulation of broadband networks, Cambini and Jiang (2009) state their

paper's commanding question: *"what impacts regulation imposes on firms' investment behavior in broadband communications, impetus or hindrance, and how regulatory regimes should be designed to foster the incentive to invest?"* The second paper by Briglauer et al, (2014), on the other hand, reviews the theoretical and empirical literature on alternative policies that promote the deployment of new high-speed, broadband infrastructure as it is expected that investment in such networks induce substantial positive externalities. Their analysis is based on three alternative policies, and in particular cost-based access regulation, among a number of "sector-specific" regulations.

The rest of this paper unfolds as follows: section 2 gives a historic perspective of New Zealand's Ultra-Fast Broadband network, whereas section 3 provides the elements to understand the recent regulatory framework – too be deposed - and the new regulatory apparatus passed as an amendment to the Telecommunications Act in 2018. Next, building on Biggar (2004), section 4 explains the foundations of the Building Blocks Model, with particular emphasis on the revenue equation and the asset-based roll-forward equation. Section 5 discusses the Input Methodologies, the processes that determine the entries to the BBM equations mentioned above. In sections 6 and section 7 the paper discusses two specific application of models we have found useful to understand the impact of incentives incorporated identifiable in the design of the specific NZ approach to utilizing the BBM method. Finally, section 8 draws some conclusions.

2. The UltraFast Broadband network

Broadband access encompasses the deployment of a range of technologies with Fibre-to-the-Home (FTTH) being favoured by several worldwide projects; the main goal is to bring higher speed and reliability to consumers. As access to a broadband connection has been deemed essential/fundamental to citizens of a country, some governments embark in improving and expanding the reach of current communications facilities by means of regional or nationwide broadband plans. The deployment of fibre-based access networks has seen a return of the government's role in their financing and construction. In Australia, by purchasing the network, and in New Zealand by means of a mixture of public initiative and private entrepreneurship, known as Public-Private Partnership (PPP), respective governments have stepped into the fibre-to-the-home broadband markets, becoming owners or co-owners and operators of the facilities the wholesale fiber connections to retail companies serving end-users.

In 2009, New Zealand created Crown Fibre Holdings (CFH) – today known as CIP or Crown Infrastructure Partners, a company charged with managing a PPP between the government and four Local Fibre Companies (LFCs) - Chorus, Ultrafast Fibre, NorthPower and Enable Services Ltd., for the deployment of FTTH-based network to 75% of the population. This project, referred to as Ultra-Fast Broadband (UFB), is complemented by the Rural Broadband Initiative (RBI). This second infrastructure project covers a further 22.8% of households with alternative technologies (VDSL, fixed-wireless, satellite).

CFH and the LFCs signed up agreements that sought to lay a fiber backbone on urban centers across the country. Main aspects of the signed contracts can be summarized as follows (Beltran & Van der Wee 2015):

- LFCs are obliged to deploy a Gigabit Passive Optical Network (GPON) and offer Layer-2 bit-stream access to all service providers on equal terms.
- The network should also be capable to offer Point-to-Point (P2P) access on request (albeit for a relatively high price).
- Unbundling of the Layer-1 infrastructure (dark fiber access) should be possible from 2022 onwards.
- Wholesale offers are fixed in terms of download and upload speed (30/10 and 100/50 Mbps), and price.

- The deployment should be focused on priority users first (e.g. schools, hospitals, large businesses); residential homes are targeted in a second stage.

The RBI aims to improve the conditions of connectivity and access to broadband services for less densely populated areas. Costs incurred in deploying FTTH to each home in those areas would have been prohibitively high, so alternative solution had to be found. CFH also negotiated with the established companies to upgrade the network on those locations. The main aspects of the deployment are (MBIE 2015):

- connecting 252,000 rural households (about 90% of homes and businesses outside UFB areas),
- with speeds of at least 5Mbps by 2016 through a mix of VDSL and fixed-wireless services,

The two mobile operators, Spark and Vodafone, selected as RBI partners would be deploying fiber to cabinets and improved copper-based broadband (VDSL and ADSL respectively), and upgrading towers and transmitters for the provision of fixed-wireless service, respectively.

In early 2015 the UFB and RBI initiatives described above were renamed as Phase 1 to distinguish them from plans to extend their scope by increasing the percentage of New Zealanders able to access fiber technologies from 75% to least 80% of households. Additional funding of up to \$210 million for the UFB extension and \$100 million for the RBI extension has been announced. In 2019 Phase 1 was completed.

With more than 1.19 million businesses, schools, health centres and homes who can connect to the network as of early 2021, the UFB network is one of the largest infrastructure projects ever undertaken in New Zealand, covering over 340 towns. Completion of the whole project, including the second stage is expected by 2022. Once completed it is expected New Zealand will advance in the OECD country rankings for population coverage with fibre available from 14th in 2015 into the top five in the OECD for fibre availability (CIP 2021).

3. New regulatory framework in New Zealand

The government's review of the 2001 Telecommunications Act delivered a new regulatory framework largely based on the Commerce Act of 1986, Part 4, which regulates utilities such as electricity lines, gas pipelines and airports. The new framework is aimed to regulate Fibre Fixed-Line Access Services or FFLAS.

Technically, and according to Part 6 of the Telecommunications Act, FFLAS means *"a telecommunications service that enables access to, and interconnection with, a regulated fibre service provider's fibre network"*, excluding provision of such service by a regulated provider to itself or a related party of the provider and services provided, on any part but the end-user's premises, over a copper line. The Commission has also stated that, in their view, FFLAS can extend *"beyond the boundaries of the fibre network"*, but is careful to stress that *"enabling access to ... a fibre network"* needs to be understood in a narrower sense than that used in the definition of telecommunication services.

Such intent on producing a balanced inclusion is visible in the Commission's decision that services such as DFAS¹ and ICABS² are both FFLAS as well as acknowledging that the policy intent is to also include services that extend past the point of aggregation. The most likely service candidates to be considered FFLAS, while the Commission makes its PQ and ID determinations, are: voice

¹ According to Commerce Commission (2021), "Point-to-point FFLAS include single, multi-layer or layer 1 backhaul services. For example, the direct fibre access service (DFAS) carries traffic from large single site customers such as schools, hospitals or mobile towers or fixed wireless access sites, to a central office."

² ICABS or Intra Candidate Area Backhaul is a backhaul service that 'transport traffic from the mobile cell site or fixed wireless access site back to the point of interconnection where the access seeker will connect to its network'.

services, bit-stream PON services, unbundled PON services, point-to-point services, transport services, co-location and interconnection services and connection services.

Regulation is to be achieved by using “price-quality paths” (PQ) and “information disclosure determinations” (ID). Under PQ regulation the regulators must determine the maximum revenue and/or prices is allowed to earn from its FFLAS (known as PQ FFLAS) and the minimum quality at which they are to be provided. Under ID regulation, regulated providers must disclose the information about their FFLAS (known as ID FFLAS) that will allow the Commission to assess whether regulatory objectives are met.

Who is to be regulated by these two? Chorus, the largest telecommunications company in the country and the owner of all fixed-line copper connections is to be regulated by both, PQ and ID regulations, whereas the other three LFCs will be regulated through ID only.

The new framework has been introduced with several purposes in mind; they are:

- promoting competition for benefit of end-users;
- promoting the legitimate commercial interests of access providers;
- encouraging efficient investment;
- supporting innovation in telecommunications markets or deregulation where sufficient competition exists.

The purpose of the new regulatory framework rests on two section of Part 6: section 162 and section 166b. Section 162 introduces the concept of “workably competitive market”, and uses it to state that regulation must promote outcomes consistent with outcomes produced in workably competitive markets. On the other hand, Section 166 mandates that, in promoting competition, the Commission take into account the interests of end-users of telecommunications market services, directing the Commission to promote workable competition in the markets.

When implementing PQ paths and ID determinations the Commission will follow the BBM approach. The next two sections discuss in general terms and as intended to be applied in New Zealand the elements, components and incentives in the BBM approach.

4. The Building Blocks Model

Biggar (2004) defines the BBM approach to regulation as *“a tool for spreading (or amortising) the expenditure of the regulated firm over time so as to ensure a path of revenue or prices which has the property that the present value of the firm’s allowed revenue is equal to the present value of the firm’s expenditure”*.

BBM regulation is based on valuation of the asset base by assessment of the actual historic costs incurred by the regulated operator upon deployment of its network. The resulting value of the asset base is usually referred to as the Regulatory Asset Base, or RAB.

The BBM regulation is a form of “incentive regulation” in which the regulated entity is constrained by requiring that either its weighted average price or revenue complies with a cap specified by the regulator and that quality requirements are met. In New Zealand, the regulatory constraints are referred to as PQ (or path-quality) paths, as introduced in section 3.

Biggar summarises BBM in two equations: the Revenue equation and the Asset-based Roll-forward equation.

The Revenue equation can be stated as:

$$R_t = r_t K_{t-1} + O_t + D_t \quad [1]$$

while the Asset-based Roll-forward equation is written as:

$$K_t = K_{t-1} + I_t - D_t \quad [2]$$

where - the subscript t refers to the current period (say, a given year) - R is the maximum allowed revenue; r is the rate of return on capital; K is the regulatory asset base (at the end of the period t); O is the operating expenditure; and D is the depreciation or “return of capital”. In addition, I is the capital expenditure. The equations are complemented with a boundary condition that states that if at period T the firm ceases to exist the RAB at the end of that period is zero, i.e., $K_T = 0$.

As can be appreciated, once one path is determined, that is, either K_t , D_t or R_t , equations [1] and [2] and the boundary conditions can be used to find the other two. The latter allows us to see how a regulator using a BBM approach would set the revenue path so that, in particular, incentives are built into the resulting investment path that determines the future asset base.

A crucial component of this estimation is determination of the asset base on which a normal return will be calculated. Under BBM regulation, investment undertaken by the regulated entity during the regulatory period is added to the RAB at the beginning of the next regulatory period (subject to a test of the efficacy of that investment in some types of BBM regulation).

The redetermination of the price-quality path for the next regulatory period provides for a normal return on the RAB, including the addition corresponding to investment during the previous period and taking into account a forecast of operational expenditure (and in case of a weighted average price path a forecast of demand).

Biggar’s work develops a framework for incentive regulation under BBM, which is aimed to gather ad-hoc approaches to incentive regulation adopted by regulators around Australia under a single conceptual umbrella. The framework is intended to provide insights into the role of the Asset-based Roll-forward method in determining incentives, and the distinction between recurrent expenditure and non-recurrent expenditure – as opposed to the traditional view of operational costs and investment expenditures.

The incentive characteristic of this type of regulation is that the regulated entity retains part or all of any cost savings it achieves relative to the price or revenue caps. Thus the management of the regulated entity have an incentive to seek efficiency gains by way of cost savings. The implementation of such savings reveals to the regulator the extent of achievable efficiency improvements. This can then be taken into account when the price-quality price is redetermined. The redetermination of the price-quality path is based on estimation of the price or revenue path that would provide the regulated entity with a normal return taking into account the forthcoming regulatory period and the expected future price-quality path in future periods.

5. BBM in New Zealand: The Input Methodologies

The New Zealand Commerce Commission New Regulatory Framework adopts the BBM approach already used in the regulation of electricity lines, gas pipelines and airports. In such sectors, notably, the regulator is required to develop and publish full details of the specifics of its BBM methodologies, also known Input Methodologies (IMs), as a preliminary step in applying regulation.

In essence, setting a maximum revenue allows the provider subject of regulation to *ex-ante* earn its allowed return. This is the best estimate of a normal return, that is, an estimate of the return that an efficient operator has the opportunity “to earn in a workably competitive environment”. Higher efficiencies will allow the provider to earn higher profits, which will be shared with end-users as lower prices in the next regulatory period.

Part 6 has determined that a revenue cap will apply for the first two regulatory periods. The first regulatory period will last for three years. Part 6 also commands the Commission to perform a PQ review and make recommendations not before three years after the new regulatory framework is first implemented on January 1st 2022. Any determination on maximum prices will only be made

as early as some time during the second regulatory period, which means that price regulation of FFLAS will only start on the third regulatory period.

PQ regulation is a revenue cap with a “wash-up” mechanism for the first period. Individual caps will apply to anchor services and DFAS (Layer 1 point-to-point lines). Anchor services, the basic services Chorus provides, are 100/20 Mbps broadband and voice. The Commission will determine the maximum revenues or prices Chorus is allowed to earn from its FFLAS, as well as the quality.

The IMs are regulatory rules, requirements and processes that support the Commission’s specific choice of regulation of FFLAS. One of the most important aspects about the introduction of IMs is their intended role in promoting certainty for regulated fibre service providers, access seekers and end-users. The IMs are applied when the Commission makes its PQ and ID determinations. The IMs determined by the Commission and their intended use are:

- the cost of capital, which defines how the WACC will be determined;
- the asset valuation, which dictates how to value the regulated provider’s assets used to provide FFLAS;
- the cost allocation, which determines how asset values and operating expenses are allocated between regulated and non-regulated services;
- tax;
- Chorus capex, which defines requirements and processes supporting the evaluation of Chorus’ capital expenditure projects;
- regulatory processes and rules, which specify and define the revenues.

6. Optimal time of investment: “cost based” versus “price based”

The standard analysis of an unregulated profit maximising monopolist when applied to both replacement investment in response to raising maintenance costs and to investment required to cater for growing demand indicates that the monopolist will undertake both types of investment later than is optimal in terms of social welfare.

An analysis by Borrmann & Brunekreeft (2011b) confirms this result. They derive a mathematical analysis of the extent of the timing difference in terms of some key parameters relating to the growth rate of maintenance with the age of the network assets in the case of replacement investment and the growth of demand in the case of capacity increasing investment.

In their article the authors propose that the firm faces a regulated price p_1^R , before investment is done, and a regulated price p_2^R , after investment. Then the firm maximises the regulated discounted profit, $VR(\cdot)$, to find the optimal investment time TR :

$$\max V^R(T) = \int_0^T (p_1^R - c)Q_1^R(t)e^{-rt}dt + \int_T^\infty (p_2^R - c)Q_2^R(t)e^{-rt}dt - Ie^{-rt} \quad [3]$$

The market quantities Q_1 and Q_2 are then determined by the market clearing prices, p_1 and p_2 while profits of the regulated firm are determined by the regulated prices, p_1^R and p_2^R .

They assume that right before demands reaches maximum capacity, that is $Q_1 = K_{\max}$, regulated price is such that $p_1^R < p_1$, and for the post-investment period $p_2^R = p_2$ at $Q_2 = Q_1(p_2)$.

The quantities from the binding capacity condition at the end of period 1 and demand function for the post-investment period are as follows:

$$Q_1^R = K_{\max} \quad \text{and} \quad Q_2^R(t) = \frac{(a - p_2^R)e^{gt}}{b}$$

The latter follows from the assumption that demand is linear and grows over time at rate g , or

$$P(Q, t) = a - be^{-gt}Q$$

Bormann & Brunekreeft (2011b) go on to use the latter two expressions in [3] and find the optimality condition for the investment time T^R :

$$\frac{(p_2^R - c)(a - p_2^R)}{b} - (p_1^R - c)K_{max} = rI \quad [4]$$

Their interpretation of cost-based regulation and price-based regulation puts the two approaches on extreme opposites in the sense that the two differ by assuming that in cost-based-regulation prices are allowed to change from the ante-investment time to the post-investment time, whereas in price-based regulation, regulated prices do not change on the time range of our interest.

As observed above Bormann & Brunekreeft (2011b) are able to model the effect of regulation. They demonstrate that “cost based” regulation – where investment results in higher regulated prices – incentivised earlier investment than “price based” regulation – where regulated prices are independent of the timing (and level) of investment. These results are intuitively correct.

Intuitively, the extent to which investment increases the regulated prices in the case of “cost based” investment is a key factor determining the extent to which investment is accelerated relative to the case of “price based” regulation.

Bormann & Brunekreeft (2011b) suggest that if investment increased regulated prices sufficiently it would be possible to achieve the socially optimal timing for replacement investment (or indeed to accelerate the timing even further which would be inefficient) but acceleration to this extent is not possible in the case of capacity increasing investment.

7. Analysis of the proposed regulation of New Zealand’s fibre network

With the full regulatory toolbox still to be completed, we would like to undertake a preliminary analysis of some aspects of either regulatory decisions already made or proposed regulatory measurements most likely to be approved shortly. The latter are in a very advanced state and, barring determinations on some minor points, can be already counted as part of the regulatory framework.

7.1. A model to estimate the power of an incentive under BBM

What is the scope for incentive regulation within the constraints provided by the application of the BBM methodology?

Before delving into the question let us remember what the power or strength of an incentive is. For instance, in relation to a regulatory objective such as maintaining or raising the quality of service, the power of the incentive of a regulatory scheme to achieve such objective depends on the sensitivity of the present value of the operator’s profit stream to the change in effort exerted on maintaining or raising the quality of service. Sensitivity here is identified with the value of the derivative of the profit stream on the effort to change the quality.

In the context of a one-year regulatory period Biggar (2004) model analyses the case where the net present value of the operator’s revenue stream is equal to that of its expenditure stream. The latter is a scenario where incentives are absent and is also known as the Financial Capital Maintenance (FCM) case.

Acknowledging the fact that the timing of establishing the inputs to equations [1] and [2] leads to using forecast or actual values, Biggar modifies the equations noting that the regulator estimates forecast levels of opex \hat{O}_t and capex \hat{I}_t at the beginning of the regulatory period, and a forecast level of depreciation \hat{D}_t that depends on the forecast capex, to determine the forecast maximum revenue \hat{R}_t , as follows:

$$\hat{R}_t = r_t K_{t-1} + \hat{O}_t + \hat{D}_t \quad [3]$$

Once the regulator learns the actual levels of opex O_t and capex I_t , the RAB is rolled forward to determine the closing RAB for the period, as in:

$$K_t = K_{t-1} + I_t - \widehat{D}_t + (O_t - \widehat{O}_t) + (R_t - \widehat{R}_t) \quad [4]$$

In order to explore how the regulator could bring desired incentives, Biggar proposes further modifications to equations [3] and [4] that represent an intentional regulator's departure from FCM. A regulator can opt for allowing higher revenues to the regulated operator, which can be regarded as intervening the revenue question [3], or it could deviate from the asset-based roll-forward equation [4] by intervening on the difference between actual capex I_t , and forecast capex \widehat{I}_t . This naturally leads to asking what the better way, either via revenue or via RAB, to depart from FCM is.

Biggar conveniently assumes that forecast revenue and actual revenue are equal. He also defines a new regulatory asset base, $K'_t = K_t + X_t$, where X_t represents the amount the regulator departs from FCM in the revenue equation, and uses Y_t to represent the deviation from FCM in the asset-based roll-forward equation. Then equations [3] and [4] become:

$$\widehat{R}_t = r_t K'_{t-1} + \widehat{O}_t + \widehat{D}_t + X_{t-1} \quad [5]$$

$$K'_t = (1 + r_t)K'_{t-1} - (R_t - I_t - O_t) + (X_t + Y_t) \quad [6]$$

Further assuming that the regulator at the beginning of period t considers that at some future time T the operator ceases to exist while ending with a RAB value of K'_T , an expression for the profit stream π_t is found as:

$$\pi_t = K'_{t-1} + \sum_{s=t}^T \frac{(X_s + Y_s)}{\prod_{i=t}^s (1 + r_i)} \quad [7]$$

Equation 7 reveals that the regulated operator's profit stream only depends on the sums of X_t and Y_t . Hence, Biggar concludes that bringing desired incentives to the regulatory exercise would have identical results regardless of whether the regulator intervenes the revenue condition or the asset-based roll forward condition.

In New Zealand, the Commerce Commission has released its proposed price-quality-path approach that would apply from January 1, 2022 (Commerce Commission, 2021). Figure 1, below, shows the current Commerce Commission's proposed components (blocks) to be included in its calculation of RAB and the BBM revenue, applicable to Chorus.

Several determinations are already found in the public domain, which refer to the Commission's decisions on the values of specific blocks for the first price-quality regulatory period PQP1. The inputs for which information is available as referred to as shown in Figure 1. In particular, on the asset-based roll-forward equation, since Chorus has not forecast any asset disposal for PQP1, the value of Disposed Assets is zero. Also, on the BB revenue equation, Revenue Smoothing will only be applied on period PQP1, consisting of increases by forecasts of weighted average demand growth (proposed by Chorus) and the latest Consumer Price Index by the Reserve Bank. The quantities for the three years of PQP1 are -\$85M for year 1, +\$15.6M for year 2 and +\$76.9M for year 3. These values can be entered as constants in our analysis, simply producing an off-set to the RAB of a given year by the amount determined for that year.

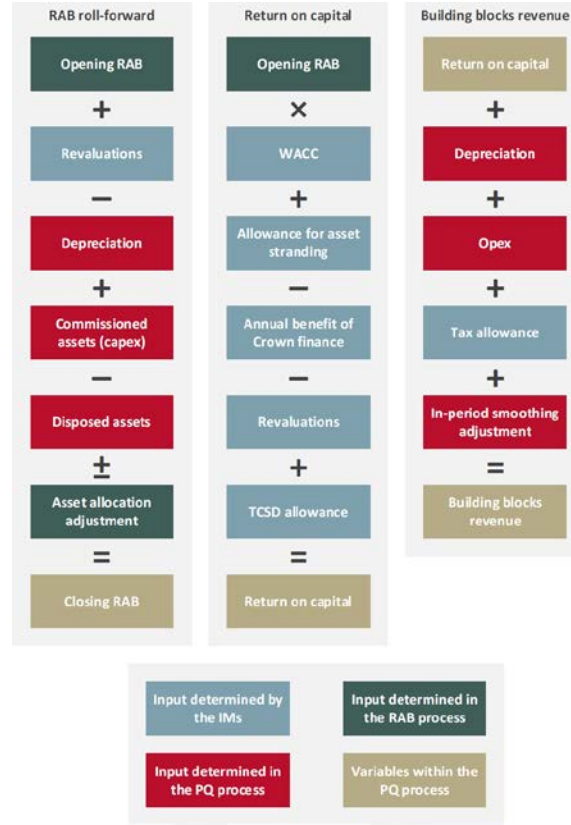


Figure 1. Calculation of the revenue cap using the BBM approach (Source: Commerce Commission 2021)

Next, since the regulatory allowance on taxes, Tax Allowance, has been set to zero for every year of the period, no amount for such allowance shows in the equations. We notice too that the Revaluations block is added in the calculation of the Closing RAB but is subtracted in the calculation of Return on Capital. Consequently, its net effect on the BB Revenue is zero.

Next, let us assume the regulator decides to use the remaining blocks as the elements through which it wants to exert its ability to provide incentives to Chorus. This case leads equations [5] and [6], when applied to the calculation of the PQ path for Chorus, to become:

$$\hat{R}_t = r_t K'_{t-1} + \hat{O}_t + \hat{D}_t + \text{Allowances}_{t-1}$$

$$K'_t = (1 + r_t)K'_{t-1} - (R_t - I_t - O_t) + (\text{Allowances}_t + \text{Asset adjustment}_t)$$

and equation [7] to be:

$$\pi_t = K'_{t-1} + \sum_{s=t}^T \frac{(\text{Allowances}_s + \text{Asset adjustment}_s)}{\prod_{i=t}^s (1 + r_i)}$$

Allowance for asset stranding

Some assets used in the production of digital telecommunications services are at risk of suffering from unanticipated or premature devaluations, which are usually caused by technology upgrades. This type of risk is considered non-systematic as it relates to technological change and asymmetric due to the operator's inability to set a floor that responds to the decrease in value of the asset. The Commission has signalled its intention of provide some mode of compensation to the operator. The compensation is intended to a combination of retaining the stranded assets in the RAB and allowing for the possibility of shortening the economic lives of assets. The compensation

also combines an ex-ante allowance to be implemented through cash flows at the time of setting the PQ path. However, in the consideration of the Commission the regulated provider will have to bear some of the risk associated with the stranded assets.

A preliminary take on the power of an incentive

Let us remember that our approach, following Biggar, is to understand how the regulator can depart from FCM in order to provide incentives to the regulated operator. Here, we use the application of the profit stream equation ([7]) to the situation where the regulator could act through an adjustment in asset allocation or an allowance for asset stranding. Only the latter is next analysed as the Commission's decisions on asset allocation will remain pending for most of 2021 (until a final decision is announced in November 2021).

The regulator expects the operator to reduce costs and to, at least, keep the level of its investments. Cost reductions can be passed on to users as better prices and investments are necessary to keep the quality of services provided.

Let's suppose the regulator wants to determine the power of the incentive to reduce expenditure (either opex or capex). Biggar assumes that any amount, either X_t or Y_t , the regulator departs from FCM depends only on actual and forecast capex and opex in period t . In addition, in order to keep the analysis simple, forecast opex and capex are assumed to depend only on most recent actual opex and capex. Rationally, the effect of X_t or Y_t must be measured on the operator's profits. Hence, as argued in Biggar (2004) using equation [7]:

$$(1 + r_t) \frac{d\pi_t}{dE_t} = \frac{\partial X_t}{\partial E_t} + \frac{1}{(1+r_{t+1})} \frac{\partial X_{t+1}}{\partial \hat{E}_{t+1}} \frac{d\hat{E}_{t+1}}{dE_t} \quad [8]$$

where E represents either opex (O) or capex (I) and \hat{E} represents the forecast expenditure (forecast opex or forecast capex); equation [8] holds similarly for Y_t .

Equation [8] is an expression for the power of incentive to reduce expenditures. It can be seen that a change in the expenditure directly affects profits through its effect on the amount the regulator has decided to depart from FCM (either through the revenue equation or the asset-based roll-forward equation). However, this is not the whole extent of the effect. There is also an indirect effect through the forecast expenditure. In fact, as shown on the second term of [8], the power of incentive to reduce expenditures also depend on the effect that actual expenditure has on the next-period forecast expenditure and the effect of such next-period forecast expenditure on the present value of profit (either through the revenue equation or the asset-based roll-forward equation).

7.2. Modelling the impact of regulatory price decision on the optimal time of investment

The situation studied in this section is that of the regulatory scheme already in place and the regulator using prices, and not only revenues, as regulatory instruments. This will be the situation in New Zealand as the first regulatory period only allows the regulator to constraint the revenue, but later periods might see the determination of prices. How such determination affects the optimal time at which investment must done is the subject of our analysis.

Our analysis follows that of Borrmann & Brunekreeft (2011b) (referred to earlier) which involves formulating how the profitability of an entity regulated under the BBM approach depends on (i.e. as a function of) its replacement and capacity expansion investment decisions and then examining what decisions would maximise that profitability expression. The profitability analysis is complemented by formulating an expression for how social welfare depends on (i.e. as a function of) the same investment decisions. The difference between the decisions that would maximise profitability and those that would maximise social welfare is then determined.

Thus the key focus of the analysis is a comparison of the level of replacement and capacity expansion investment that would maximise the regulated entity's profitability under a BBM

regulatory approach versus the levels of such investments that would be socially optimal. Therefore, the analysis provides an indication of the risk of regulatory outcomes deviating from the social welfare maximising outcome. It thus provides regulatory policy makers, and the regulators who implement that policy, with information that may help reduce the deviation of regulatory outcomes from the socially welfare maximising outcome. While unresolvable uncertainties and practicalities make elimination of the deviation unachievable the analysis may be helpful in limiting the deviation.

We use the model by Borrman & Brunekreeft (2011b) to afford analytical indications of the relationship between the timing of investment decisions and the firm's profitability as well as the effect of capacity expansion investment decision on social welfare. We illustrate how their model works by considering how it can be used to provide insights into the implications of the New Zealand regulatory framework.

In order for such a model to be mathematically tractable, a set of simplifying assumptions are adopted in this paper. These assumptions reflect, to the extent possible, the key features of the New Zealand UFB FTTH network.

Firstly, the number of end users is held constant. Consistent with this assumption, the "last mile" fibre connections from the aggregation cabinets to individual premises are assumed to be in place. While there will be a need for maintenance, in particular repair to damage cause by roadworks and related construction activities, this expenditure is not the focus of attention in the modelling. Specifically, the need for this expenditure and the level of it is not a function of end user busy hour traffic, which is the focus of attention.

For the purposes of the modelling considered in this paper the exact details of the source of the throughput constraint are not examined in detail. The key assumption is that increasing throughput capacity requires expenditure. The expenditure could be categorised into investment and increases in operating expenditure but for the purpose of the current analysis there is no need to make such a distinction. The increased expenditure required to provide and support an increase in throughput capacity can be treated as investment with any increase in ongoing operating expenditure being captured as a present value amount.

In summary, for the purpose of the analysis in this paper, the focus of attention is on the components that determine busy hour throughput. The decision variable controlled by the regulated entity is the scale of investment in those components.

The second major simplifying assumption is that the end user demand for busy hour throughput grows at a constant rate. This is adopted as an assumption because it reflects the current situation in regard to busy hour throughput. This assumption could be replaced by a more general form of growth in a future analysis albeit at the cost of complicating the solution of the equations.

We analyse the BBM regulatory framework by, first, using Borrman & Brunekreeft (2011b)'s approach and then assuming that post-investment regulated price is defined as responding to investment in capacity expansion by allowing a mark-up over ante-investment regulated price that depends on the size of investment I , the capacity constraint K_{max} , the weighted average costs of capital W , and μ , a term that reflects a possible regulator's inclusion of an additional margin in deriving the cost of capital as follows³:

$$p_2^R = p_1^R + \frac{I \cdot (W + \mu)}{K_{max}}$$

Using the preceding relation equation, [4] is now:

³ The purpose of including μ is to recognise that an underestimate would be more detrimental than an overestimate.

$$\frac{(p_2^R - c)(a - p_2^R)}{b} e^{gT^R} - \left(p_2^R - \frac{I \cdot (W + \mu)}{K_{max}} - c \right) K = rI$$

Which can be solved for T^R , defining a function of the post-investment price p_2^R :

$$T^R = \ln \left(\left[\frac{b(r - W - \mu)I + (p_2^R - c)K_{max}}{(p_2^R - c)(a - p_2^R)} \right]^{\frac{1}{g}} \right)$$

We want to investigate how the optimal investment time T^R is affected by decisions on the value of the post-investment price; in other words we calculate $\frac{\partial T^R}{\partial p_2^R}$.

By renaming $b(r - W - \mu)I + (p_2^R - c)K_{max}$ as $f(p_2^R)$ and $(p_2^R - c)(a - p_2^R)$ as $h(p_2^R)$ the derivative of T is expressed as:

$$\frac{\partial T^R}{\partial p_2^R} = \frac{\partial \ln \left(\left[\frac{f(p_2^R)}{h(p_2^R)} \right]^{\frac{1}{g}} \right)}{\partial p_2^R} = \frac{1}{g} \frac{h(p_2^R)}{f(p_2^R)} \left[\frac{f'(p_2^R)h(p_2^R) - f(p_2^R)h'(p_2^R)}{(h(p_2^R))^2} \right]$$

Which simplifies to

$$\frac{\partial T^R}{\partial p_2^R} = \frac{1}{g} \left[\frac{f'(p_2^R)}{f(p_2^R)} - \frac{h'(p_2^R)}{h(p_2^R)} \right]$$

Now, returning to the full expressions for f and h ,

$$\frac{\partial T^R}{\partial p_2^R} = \frac{1}{g} \frac{K_{max}}{b(r - W - \mu)I + (p_2^R - c)K_{max}} + \frac{1}{g} \frac{2p_2^R - c - a}{(p_2^R - c)(a - p_2^R)} \quad [5]$$

From the equation above we observe that p_2^R is constrained to be in the interval (c, a) , that is, $c < p_2^R < a$. With this in mind the critical point here is the middle point between c and a .

When p_2^R is exactly that point, the second term in [5] vanishes. TR displays an increasing trend with a small increase in p_2^R , that is, as p_2^R moves away from c , approaching a . The latter suggest an incentive for the firm to delay investment if it knows the regulated price is set larger than the middle value between c and a .

In contrast, as p_2^R moves towards c the second term in [5] negatively increases, while the first term positively grows. The two effects render the situation ambiguous, at least from a first-order approach; we need to further look into the relative sizes of the two terms in [3] as a function of changes in p_2^R .

We also want to investigate how the optimal investment time T^R is related to m , the correction in the cost of capital that the regulator allows to account for any underestimation.

We assume that the rate or return is comparable to the WACC, $r \cdot K_{max} = W$, and the regulated price p_2^R , after investment, is such that $c \leq p_2^R \leq a$.

From

$$T^R = \frac{1}{g} \ln \left(\left[\frac{b(r - W - \mu)I + (p_2^R - c)K_{max}}{(p_2^R - c)(a - p_2^R)} \right] \right)$$

if T^R is to be non-negative then, renaming $p_2^R - c$ as m_c and $a - p_2^R$ as m_a the following condition must be met:

$$\frac{-b\mu I + bm_c K_{max}}{m_c m_a K_{max}} \geq 1$$

From which it follows that:

$$\mu \leq \frac{m_c(b-a)K_{max}}{bI} \equiv \mu_1$$

Notice, we've renamed the upper bound of μ as μ_1 .

Since μ has to be non-negative, finding the value of when $\mu = 0$, we obtain:

$$T^R = \frac{1}{g} \ln\left(\frac{b}{m_a}\right)$$

which means that either $b \geq m_a$ or $b \geq a - p_2^R$. Figure 2 shows graphically the relation between T^R and μ .

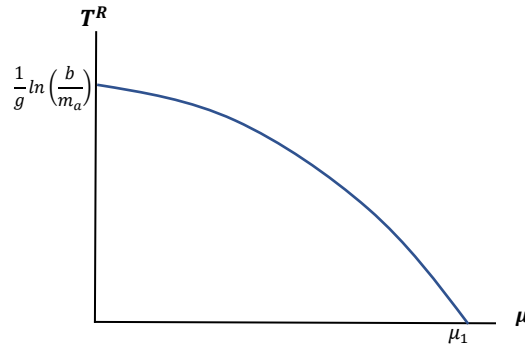


Figure 2. The effect of a regulator's added margin to the cost of capital on the optimal time of investment

For the reasons discussed earlier in this paper, the change to BBM regulation in New Zealand may potentially reduce the incentive for the network operators to delay investment compared to the case of TSLRIC regulation. Furthermore, they will still face an incentive to economise on investment – that being an intended incentive under BBM regulation.

Specific features of the New Zealand implementation of BBM regulation could however be particularly relevant in regard to the timing of investment.

Firstly, the precedent is that the regulator will implement some form of quality regulation. This quality specification may include a form of obligation to expand throughput capacity to accommodate the rapid growth in demand for throughput, which is a conspicuous feature of traffic on current IP networks, specifically video traffic. It is yet to be decided, however, what form of quality regulation will be applied. This is likely to be intensively debated in submissions of the regulator's proposed implementation of BBM regulation.

Secondly, the implementation of BBM regulation of the electricity lines, gas pipelines and international airports regulation in New Zealand have included an "uplift" in the cost of capital estimates used. This uplift is the addition of a margin above the central estimate of the weighted average cost of capital (WACC). The rationale for this margin is that it takes into account the asymmetry whereby underestimation of the WACC would be more detrimental to end users – as a result of depressing investment – than overestimation.

One effect of the uplift is that the increase in regulated prices as a result of investment (given the BBM regulation is "cost based") is likely to be greater than the cost of investment, on a probabilistic basis.

This effect of the uplift should (on a probabilistic basis) accelerate the timing of investment.

The overall effect on the timing of investment will reflect the combination of the form of quality regulation obligation to accommodate growth in the demand for capacity and the size of the uplift.

As noted in the previous section, the use of cost-based BBM regulation could in principle overcome the delay in investment (compared to the socially optimal timing) that would result from “price based” BBM regulation. As also noted that acceleration could in principle be excessive in regard to replacement investment.

Clearly, the actual outcome in New Zealand will depend on the decisions of the regulator regarding the form of quality regulation and the size of the uplift applied.

8. Conclusions

The application of the BBM approach to regulating Local Fibre Companies in New Zealand deserves analysis and assessment, to the extent that is possible, of the incentives introduced on the regulated provider’s ability to reduce its costs and achieve high service quality.

Two representative aspects of the fundamental issue, the power of incentive to reduce expenditure and the optimal timing of investment, were analysed within the current (non-finalised) regulatory framework for the telecommunications sector. In particular, the problems studied correspond to the regulatory approach known as PQ-path by which Chorus, the largest telecommunications provider and owner of the largest fibre facilities in the country, will be regulated from January 1, 2021.

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