

INCENTIVE REGULATION AND THE BUILDING BLOCK MODEL

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Most regulators in Australia make use of some variant of the “building block model” in the process of setting the prices of regulated firms. At the same time, these regulators are eager to use “incentive regulation” to ensure that regulated firms produce the required services as efficiently as possible. In order to implement incentive regulation in the context of the building block model, various modifications or embellishments to the building block model have emerged, such as the “efficiency carry over” mechanism which has recently been adopted by several regulators in Australia. However, these developments have arisen in an ad hoc fashion, without the benefit of a systematic framework for incentive regulation in the context of the building block model. This paper seeks to fill that gap by setting out a unified, comprehensive theory of incentive regulation in the context of the building block model. Such a framework yields a number of new insights in the operation of incentive regulation in the context of the building block model in general and of the efficiency carry-over mechanism in particular.

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1. Introduction

Public institutions, tasked with controlling the prices or revenues of a firm or enterprise are usually required to pursue some variant of the following two objectives:

- First, the regulated firm should expect to receive sufficient revenue to allow it cover all the expected prudent expenditure necessary to maintain a given level of service at each period into the future. In this paper I will refer to this objective as “financial capital maintenance”.
- Second, the regulated firm should be induced to pursue desirable objectives, such as maintaining and improving the quality and quantity of its services, and discovering new ways to provide the same quantity and quality of services at lower cost. The actions of the regulator in pursuit of this objective I will refer to as “incentive regulation”.

In practice, the first objective is usually pursued through the use of the so-called “building block model” which, as set out below, is a tool for spreading the expenditure of the regulated firm over time. The second objective has been pursued through the use of features such as the five-year regulatory period, and, more recently, through the use of “add-ons” such as the “efficiency carry-over” first adopted by the Essential Services Commission of Victoria.²

An efficiency carry-over mechanism rewards the regulated firm with higher revenue in future periods if it is revealed to have reduced its costs in the past. This mechanism is designed to offset the incentive that arises under some regulatory regimes, to reduce effort to cut costs – or to actively seek to raise costs – towards the end of the previous regulatory period. The efficiency carry-over mechanism may also enhance the overall incentive to reduce costs by increasing the financial reward for doing so.

The efficiency carry-over mechanism is an example of various modifications or embellishments to the basic building block model which are being considered or have been implemented by regulators around Australia. Such modifications and embellishments seem to be developing in an ad hoc manner, to address specific concerns, without the benefit of an over-arching framework for analysing how incentive regulation operates in the context of the building block model.

The primary purpose of this paper is to set out such a framework. As we will see, this framework yields several useful new insights into the operation of incentive regulation under the building block model. These insights include, for example:

- The key role played by the methodology for “asset base roll forward” in determining the incentive properties of the regulatory regime. As we will see, any desired incentive properties of the regulatory regime can be achieved through the choice of the asset-base roll-forward methodology alone (without the need for any “efficiency carry-over” or any other mechanism). Conversely, any incentive properties that might otherwise be desired from a mechanism such as the “efficiency carry-over” mechanism can be undone through a judicious choice of the methodology for asset-base roll-forward.

² See ESC (2000b), page 19, ESC (2000a), section 6, and ESC (2004), section 4.2. The efficiency carry-over mechanism has also been implemented by the ACCC (2002), section 10.1.5, ESCOSA (2002), OTTER (2003), section 3.10 and most recently by Ofgem in the UK, Ofgem (2004), page 21. The efficiency carry-over mechanism has also been considered by IPART (2002), page 38 and is being considered by the QCA (2003), section 6.1.

- The need, for incentive purposes, for a distinction in the treatment of two forms of expenditure - not the traditional distinction between “operating expenditure” and “capital expenditure” – but a distinction between recurrent expenditure and “non-recurrent expenditure” (as explained below) – and how incentives are appropriately applied to each.
- The observation that the incentive properties of a regulatory regime (especially for recurrent expenditure) depend critically on how information on past expenditure out-turns is used to set future recurrent expenditure targets. In practice, the process by which past expenditure out-turn information is used to set future recurrent expenditure targets is usually non-transparent (i.e., a “black box”). Regulators are understandably reluctant to commit to a mechanistic approach to using past expenditure out-turns in the setting of future targets. In the absence of such a mechanistic approach, the precise incentive properties of most regulatory regimes remain unclear.
- In particular, the need for a device such as the “efficiency carry-over” is unclear. It is possible to show that if the expenditure targets are set in a particular way (in such a way that the present value is proportional to the present value of expenditure out-turns in the previous regulatory period) the alleged problems that the “efficiency carry-over” is intended to solve disappear.

The remainder of this paper is divided into three sections. The first section introduces the basic equations of the building block model and the underlying principles of incentive regulation. The next section explores how incentive regulation applies in the context of the building block model with a regulatory period equal to a single year. The final section then extends this analysis to the case of a regulatory period of five years.

2. An introduction to the building block model and incentive regulation

The building block model could perhaps be characterised in many different ways. In my view, the most helpful definition of the building block model is as follows:

The building block model is 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.

Put another way, the building block model is a mathematical tool which assists in the pursuit of the first objective above – that is, the pursuit of “financial capital maintenance” on the regulated firm.

The building block model is entirely summarised in the form of two mathematical equations. The first equation relates the allowed revenue in a period to the return on capital, return of capital (or depreciation) and operating expenditure. I will call this equation the “revenue equation”.

Using mathematical notation, the revenue equation of the building block model is often expressed as follows: The maximum allowed revenue is equal to the sum of the return on capital, the return of capital and the allowed opex:

$$R_t = r_t K_{t-1} + O_t + D_t \quad \dots(1)$$

where R_t is the maximum allowed revenue in period t , r_t is the allowed regulated rate of return or “cost of capital” in period t (which, for the purposes of this paper is assumed to be set by the regulator equal to the firm’s true cost of capital), K_t is the closing “regulatory asset base” for period t , O_t is the operating expenditure and D_t is the “depreciation” or “return of capital”.

The second equation of the building block model expresses how the notion of the “regulatory asset base” (or “RAB”) evolves over time. I will refer to this equation as the “asset-base roll-forward equation”.

As we will see in the discussion below on incentive regulation, the precise form of the asset-base roll-forward equation matters a great deal. For the moment we will observe that this equation is usually presented in the following simple form: the closing RAB is equal to the opening RAB plus any (net) capital additions during the period less the depreciation (return of capital) during the period:

$$K_t = K_{t-1} + I_t - D_t \quad \dots(2)$$

where I_t is the capital expenditure during the period.

Formally, to complete the specification of the building block model we also need certain “boundary conditions” on the path of the RAB or the path of depreciation. Specifically we also need the condition that if, at period T , the firm ceases to exist, the RAB at that period is zero, i.e., $K_T = 0$. Alternatively, we need the requirement that the sum of the depreciation over the life of the firm is equal to the sum of the capital expenditure, i.e., $\sum_{t=1}^T D_t = \sum_{t=1}^T I_t$.

These two equations (the revenue equation and the asset-base roll-forward equation), together with the boundary conditions, specify a unique relationship between the path of the revenue stream, R_t , the path of the depreciation D_t and the path of the regulatory asset base K_t . Given any one of these paths, we can use the equations above to find the corresponding paths of the other two.³

The equations above have been expressed in a way which allows, given the path of depreciation, the path of the revenue stream and the regulatory asset base to be easily calculated. Alternatively, given the path of the revenue stream, the equations above show that depreciation must be given as follows:

$$D_t = R_t - r_t K_{t-1} - O_t \quad \dots(3)$$

hence the evolution (or “roll forward”) of the asset base can be calculated as follows:

$$K_t = (1 + r_t)K_{t-1} - (R_t - I_t - O_t) \quad \dots(4)$$

Equation 4 can be re-written in a manner which will prove useful in the later analysis. Specifically, using the fact that the firm ceases to exist in period T (i.e., $K_T = 0$) we can express the asset base as the present value of future cash-flows:

³ See Biggar (2004), page 172.

$$K_{t-1} = \sum_{s=t}^T \frac{(R_s - I_s - O_s)}{P_t^s} \quad \dots(5)$$

where P_t^s is the appropriate discount at the start of period t for a cash-flow which arises at the end of period s . $P_t^s = \prod_{i=t}^s (1 + r_i)$. When the interest rate is constant at r , $P_t^s = (1 + r)^{s-t+1}$. Note that for any choice of k that lies between t and s we have that $P_t^s = P_t^k P_k^s$. Finally, note that $P_t^t = 1 + r_t$ and $P_t^{t-1} = 1$.

At this point it is worth emphasising certain assumptions which underlie the equations as set out above. First, in the building block model as expressed here all payment flows (i.e., revenue received and expenditure incurred – whether opex or capex) are assumed to occur at the end of the relevant period. In practice, of course, revenue is received and payments are made throughout a regulatory period. This implies that some adjustment may need to be made in practice for the timing of cashflows. I will put this issue to one side.

Second, the equations set out above apply whether the building block model is used in a purely real (i.e., “constant dollar”) context or in a purely nominal context. As long as all the inputs to the building block model (i.e., the revenue, opex, capex, depreciation and allowed cost of capital) are expressed in real terms, the equations above correctly yield the revenue and/or regulatory asset base, also in real terms. Both the “real” and “nominal” approach yield the same result.

For most of the inputs into the building block model, the conversion from real to nominal values involves merely scaling up for inflation. This applies to the revenue stream R_t , the regulatory asset base K_t , opex O_t and capex I_t . The conversion from real to nominal cost of capital uses the formal version of the Fisher equation – one plus the nominal cost of capital is equal to one plus the real cost of capital multiplied by one plus the rate of inflation. $1 + r_t^N = (1 + r_t^R)(1 + i_t)$. Importantly, however, the conversion from real to nominal depreciation is not so straightforward. Nominal depreciation is equal to the real depreciation scaled up by inflation plus the inflation rate times the RAB, i.e., $D_t^N = (1 + i_t)D_t^R + i_t K_{t-1}$.

Third, and most importantly, it is worth emphasising that despite appearances, the building block model makes no inherent distinction between capex and opex. The model merely spreads the total expenditure (capex plus opex) over time. This can be seen clearly in equation 4. Given the path of the revenue stream, the rolled-forward asset base depends only on the total expenditure ($O_t + I_t$). Although I have used the conventional labels of “opex” and “capex” above there is nothing in the model itself which implies that any distinction of expenditure into different categories is meaningful.

Later we will see that a distinction of expenditure into two classes is helpful and useful, but these two classes do not correspond exactly to the traditional notions of “opex” and “capex”. For the moment, I will simply observe that the conventional application of the building block model makes a distinction between categories of expenditure labelled opex and capex, which I will continue to reflect here. At this stage I will not ascribe any meaning or significance to these labels.

Let's turn now to look at incentive regulation. Again, there are many possible definitions of incentive regulation. In my view, the most useful definition is the following:

Incentive regulation is the use of financial rewards or penalties which induce a regulated firm, operating with a degree of discretion, to pursue broadly-specified desirable outcomes. These desirable outcomes might include an enhancement in the quality or quantity of services provided at the same level of expenditure or the provision of the same level of services at a lower level of expenditure.

The key distinguishing feature of incentive regulation is not the use of financial rewards and penalties – after all, at some level, all actions by regulators can be converted into a financial reward or penalty – rather, the key distinguishing feature of incentive regulation is the combination of broad financial incentives and a degree of discretion on the part of the regulated firm. This is made clearest by considering what incentive regulation is not. The opposite of incentive regulation is a regime in which the regulator directly controls the actions of the regulated firm, specifying what it should and shouldn't do, leaving the firm little discretion as to how it operates its business. In other words, the opposite of incentive regulation is a regime of regulatory fiat or detailed command-and-control.

A regulator, in designing a regulatory regime, must determine the “power” or “strength” of the incentive to achieve each of the different objectives. The power of an incentive to achieve a given objective depends on the sensitivity (i.e., the slope or derivative) of the present value of the firm's profit stream to a change in effort directed at that desired objective. For example, if a small drop in quality of service leads to a very large drop in the present value of the firm's profit stream, the firm has strong incentives to (at least) maintain service quality. Similarly, if a small decrease in expenditure leads to a large increase in the present value of the firm's profit stream, the firm has strong incentives to reduce expenditure.

It is worth emphasising that, under this approach, the power of an incentive to achieve a desired objective depends *only* on the sensitivity (i.e., the derivative or rate of change) of the present value of the firm's profit stream to a change in the level of effort directed at a particular objective, and not on the absolute level of that profit stream. A firm which is already making a substantial profit will, in this view, still exert significant effort to increasing that profit if a small increase in effort will have a large effect on the profit. On the other hand, a firm which is losing money faces no necessary incentive to reduce that loss if its profit (loss in this case) is entirely unresponsive to changes in the effort it exerts to reduce its costs.

Another point worth emphasising is that the power of an incentive to achieve a particular objective is not necessarily either constant or symmetric. For example, it could be that a firm faces significant penalties if it allows service standards to fall below a given level, but no corresponding reward for enhancing service standards. Similarly, it could be that the power of the incentive to reduce expenditure increases (or decreases) in the level of expenditure.

Where (as is usually the case) there are multiple objectives the regulator would like the firm to pursue, the power of the incentives to pursue these different objectives should be equal. For example, if the incentive to maintain service standards is weak, introducing high-powered incentives greatly increases the risk the firm will cut service standards in order to cut expenditure. Conversely, if the incentive to improve service standards is strong and incentives to reduce expenditure is weak, the firm will likely increase expenditure in order to increase service standards.

This last observation can be viewed as simply an application of the “Equal Compensation Principle” of Milgrom and Roberts (1992). Paraphrasing the original text to apply to the context of regulation, Milgrom and Roberts define the equal compensation principle as follows:

“The Equal Compensation Principle: If a regulated firm’s allocation of effort to two different objectives cannot be monitored by the regulator, then either the power of the incentive for each objective is equal, or the objective with the lower power receives no effort”.⁴

Milgrom and Roberts go on to emphasise (again, paraphrasing the original):

“The equal compensation principle imposes a serious constraint on the incentive regulation mechanisms that can be effective in practice. In particular, if a regulated firm is expected to devote some effort in the pursuit of an objective for which performance cannot be measured at all, then incentive regulation cannot be effectively used for *any* of the objectives that the regulator might wish to pursue. The use of straightforward rate-of-return regulation can often be justified on these grounds”.⁵

This paper is, however, not primarily about achieving a balance in the power of different incentives. Rather, this paper focuses on how, in the context of the building block model, to use financial incentives to induce a regulated firm to pursue just one desirable objective – to minimise the expenditure required to produce a given quality and quantity of service.

Incentive regulation in the context of a one-year regulatory period

It is useful to begin this analysis by considering the benchmark case in which incentives to reduce expenditure are completely absent. This is the case where the regulated firm’s revenue stream is always exactly equal (in present value terms) to its expenditure stream. I will call this case strict “financial capital maintenance” or “FCM”.⁶ When strict FCM holds the firm’s excess profit (i.e., profit after a normal return on capital) is always precisely zero. Therefore the sensitivity of the profit stream to a change in expenditure is also zero – in other words, under strict FCM the power of the incentive to reduce expenditure is zero.

As a consequence, if a firm is to have any incentive to reduce its expenditure we must depart from strict FCM by allowing the firm to increase its profit (above the level required for a “normal” return on capital) by reducing its expenditure. Of course, departing from FCM will lead to “windfall” gains or losses to the regulated firm – but it is precisely these “windfall” gains or losses which give rise to incentives on the regulated firm to reduce its costs. Incentive regulation requires such departures from FCM – it is the task of the regulator to design those departures from FCM in such a way as to induce desirable incentives.

In order to make progress, therefore, it is necessary to specify precisely the equations of the building block model which correspond to “full capital maintenance”. This forces us to be much more precise than we have been up until now about the timing of the regulatory process and what information is known at each stage. I will assume the following sequence of events:

- (a) First, at the start of period t , the regulator sets the opening RAB equal to the closing RAB from the end of the previous period (K_{t-1}). The regulator then determines forecast levels for opex and capex for the current period (\hat{O}_t and \hat{I}_t), and, given the capex, the forecast level of depreciation (\hat{D}_t). The regulator then sets the forecast

⁴ Milgrom and Roberts (1992), page 228.

⁵ Milgrom and Roberts (1992), page 229.

⁶ This case is also sometimes referred to as “rate of return” regulation.

maximum allowed revenue for the period according to the following expression (this is the revised “revenue equation”):

$$\hat{R}_t = r_t K_{t-1} + \hat{O}_t + \hat{D}_t \quad \dots(6)$$

- (b) Second, at the end of period t , the regulator observes the actual or out-turn level of opex and capex (labelled O_t and I_t). The regulator then “rolls forward” the RAB to determine the closing RAB using the following expression (this is the revised “asset-base roll-forward equation”):

$$K_t = K_{t-1} + I_t - \hat{D}_t + (O_t - \hat{O}_t) + (R_t - \hat{R}_t) \quad \dots(7)$$

Equations 6 and 7 are similar, but not identical, to the “traditional” equations for the building block model (equations 1 and 2 above). The primary difference is in the roll-forward equation. As equation 7 shows, achieving strict financial capital maintenance requires that the roll-forward be based on *out-turn* capex and *forecast* depreciation. In addition, the roll-forward should include both the difference between out-turn and forecast opex and the difference between out-turn and forecast revenue (if one exists).

That these equations yield strict FCM can be checked by substituting equation 6 into equation 7, yielding equation 4, as before:

$$K_t = (1 + r_t)K_{t-1} - (R_t - I_t - O_t) \quad \dots(4)$$

There are at least two different ways in which the regulator can induce a departure from strict financial capital maintenance, corresponding to the two equations of the building block model set out above. Specifically, the regulator could depart from strict FCM by giving the regulated firm a higher level of revenue than that given by the revenue equation above (equation 6). This is the approach of those regulators which make use of an “efficiency carry-over” – the carry-over of any previous efficiency gains is treated as another component of the revenue allowance.

Alternatively, the regulator could depart from strict FCM by deviating from the asset-base roll-forward equation above (equation 7). This approach is sometimes used for handling differences between forecast and out-turn capex – if out-turn capex is less than forecast capex, it is common to only roll-forward the out-turn capex and out-turn depreciation (rather than out-turn capex and forecast depreciation as required in equation 7 – this is, for example, the approach of the Essential Services Commission of Victoria, as discussed later).

If we are going to depart from strict FCM is it better to do so through a deviation from equation 6 or from equation 7, or does it not matter?

Consider a departure from strict FCM consisting of adding terms X_t and Y_t to equations 6 and 7, respectively. X_t and Y_t are assumed to depend on out-turn and forecast values of opex and capex up to and including the out-turn values in period t (that is, X_t and Y_t are only realised at the end of period t). The basic equations of the building block model are now:

$$\hat{R}_t = r_t K_{t-1} + \hat{O}_t + \hat{D}_t + (1 + r_t)X_{t-1} \quad \dots(8)$$

(Note that since the forecast revenue is set at the beginning of the period it can only depend on the value of X_t from the previous period).

$$K_t = K_{t-1} + I_t - \hat{D}_t + (O_t - \hat{O}_t) + (R_t - \hat{R}_t) + Y_t \quad \dots(9)$$

(Note here that, in contrast, since the RAB is rolled forward at the end of the regulatory period, it can depend on the value of Y_t from the same period).

For convenience, I will assume that forecast revenue is equal to out-turn revenue, to keep the presentation as simple as possible.

With these equations it is convenient to define a new regulatory asset base as follows: $K'_t = K_t + X_t$. With this new RAB, equation 8 becomes:

$$\hat{R}_t = r_t K'_{t-1} + \hat{O}_t + \hat{D}_t + r_t X_{t-1} \quad \dots(8')$$

Substituting into equation 9 we find that:

$$K'_t = (1 + r_t)K'_{t-1} - (R_t - I_t - O_t) + (X_t + Y_t) \quad \dots(10)$$

Now, let's suppose that we are currently at the beginning of period t and suppose that at some future time T the firm will be wound up and the outstanding funds owed to the investors (reflected in the level of the RAB K'_T) simply paid as a lump sum to the investors. The profit stream of the firm from time t to time T is then:

$$\pi_t = \sum_{s=t}^T \frac{R_s - O_s - I_s}{P_t^s} + \frac{K'_T}{P_t^T}$$

Using equation (10) we can write:

$$\begin{aligned} \pi_t &= \sum_{s=t}^T \frac{R_s - O_s - I_s}{P_t^s} + \frac{K'_T}{P_t^T} = \sum_{s=t}^{T-1} \frac{R_s - O_s - I_s}{P_t^s} + \frac{R_T - O_T - I_T}{P_t^T} + \frac{K'_T}{P_t^T} \\ &= \sum_{s=t}^{T-1} \frac{R_s - O_s - I_s}{P_t^s} + \frac{1}{P_t^{T-1}} \left(K'_{T-1} + \frac{(X_T + Y_T)}{P_{T-1}^T} \right) \\ &= \sum_{s=t}^{T-1} \frac{R_s - O_s - I_s}{P_t^s} + \frac{K'_{T-1}}{P_t^{T-1}} + \frac{(X_T + Y_T)}{P_t^T} \\ &= K'_{t-1} + \sum_{s=t}^T \frac{(X_s + Y_s)}{P_t^s} \quad \dots(11) \end{aligned}$$

Since equation 11 depends only on the sum of both X_t and Y_t , we can immediately deduce that the deviation from strict FCM necessary to bring about desired incentives can be either by means of a variation to the revenue equation or by means of a variation to the asset-base roll-forward equation. As we might have expected, both approaches are entirely identical.

One of the implications of this observation is that we cannot determine the incentive properties of a regulatory regime through knowledge of the approach to calculating the allowed revenue (the "revenue equation") alone. Instead, we must understand both the

approach to calculating the allowed revenue and the approach to rolling forward the asset base. For example, the observation that a regulator makes use of an “efficiency carry-over” does not, in itself, allow us to make any inferences about the incentive properties of the regulatory regime – we also need to know the details of the asset-base roll-forward equation.

Indeed, if anything, the role of the asset-base roll-forward equation in determining the incentive properties of a regulatory regime has been ignored or downplayed. We can offset this tendency by emphasising that, as equation 11 shows, *any* desired incentive properties of the regulatory regime can be achieved by means of a particular approach to asset-base roll forward (i.e., a particular choice of Y_t) alone. Indeed, in a world in which there is no variation to the basic revenue equation (i.e., where X_t is zero), the asset-base roll-forward equation determines *all* the incentive properties of the regulatory regime. For example, it is possible to achieve all of the desirable properties of an efficiency carry-over through a suitable asset-base roll-forward equation alone.

Let’s suppose now that X_t depends only on out-turn and forecast opex from period t and Y_t depends only on out-turn and forecast capex in period t (i.e., $X_t = X_t(O_t, \hat{O}_t)$ and $Y_t = Y_t(I_t, \hat{I}_t)$).

In principle, the opex and capex forecasts could depend on expenditure out-turns from many years in the past (i.e., $\hat{O}_{t+1} = \hat{O}_{t+1}(O_t, O_{t-1}, O_{t-2}, \dots)$ and $\hat{I}_{t+1} = \hat{I}_{t+1}(I_t, I_{t-1}, I_{t-2}, \dots)$). But, in order to keep the analysis simple, let’s assume that the expenditure targets depend only on the most recent expenditure out-turn (i.e., $\hat{O}_{t+1} = \hat{O}_{t+1}(O_t)$ and $\hat{I}_{t+1} = \hat{I}_{t+1}(I_t)$).

Using this assumption, we can determine the power of the incentive to reduce expenditure by differentiating the present value of the profit (equation 7) with respect to I_t and O_t :

$$(1+r_t) \frac{d\pi_t}{dO_t} = \frac{\partial X_t}{\partial O_t} + \frac{1}{(1+r_{t+1})} \frac{\partial X_{t+1}}{\partial \hat{O}_{t+1}} \frac{\partial \hat{O}_{t+1}}{\partial O_t} \quad \dots(12)$$

$$(1+r_t) \frac{d\pi_t}{dI_t} = \frac{\partial Y_t}{\partial I_t} + \frac{1}{(1+r_{t+1})} \frac{\partial Y_{t+1}}{\partial \hat{I}_{t+1}} \frac{\partial \hat{I}_{t+1}}{\partial I_t} \quad \dots(13)$$

Equations 12 and 13 show clearly that the incentive to reduce opex or capex depends on two factors: First, there is a “direct” effect as changes in the out-turn capex lead to a direct change in the present value of the future revenue stream (either through a direct change to the revenue equation or through a change to the asset-base roll-forward equation). This is reflected in the first term on the right hand side in equations 12 and 13.

Second, there is an “indirect” effect which operates through the effect of past expenditure out-turns on future expenditure forecasts. A change in an expenditure out-turn today may affect the setting of forecast revenue tomorrow which, in turn, may have an impact on the present value of future revenue (again, either through a change in the revenue equation or through a change in the asset-base roll-forward equation). This is reflected in the second term on the right hand side in equations 12 and 13.

Recurrent and Non-recurrent Expenditure

Although I have used the terms “opex” and “capex”, up until this point nothing in the model has suggested that these two classes of expenditure should be treated differently – indeed, the discussion above could have proceeded identically with a single class of expenditure, or multiple classes of expenditure – the basic building block model treats all expenditure symmetrically.

At this point, however, it is useful to distinguish two different types of expenditure – expenditure which is recurring, on the one hand, and “one-off” or non-recurring on the other. The key distinction here is whether or not the observation of out-turn expenditure is likely to have an impact on the setting of future expenditure targets.

In the case of recurring expenditure (such as on-going staff-costs), past expenditure out-turns will often provide very useful information about likely future expenditure out-turns. In the case of one-off or non-recurring expenditure, on the other hand, past expenditure out-turns are of little use in forecasting likely future expenditure levels. Of course, in practice, the distinction between these two categories of expenditure is likely to be somewhat blurred.

The distinction between “recurrent” and “non-recurrent” expenditure is not the same as the traditional distinction between capex and opex. It is possible that many categories of operating expenditure are recurring, while a substantial part of capital expenditure may be non-recurring. But at the same time, some types of operating expenditure are one-off and therefore best classified as non-recurrent (such as the costs of entering the national electricity market for the Tasmanian TNSP). At the same time some types of capital expenditure are on-going and repetitive (such as many forms of refurbishment expenditure).

I will use the labels O_t and I_t to refer to recurrent and non-recurrent expenditure, respectively, but it should be understood that I imply little or no connection with the traditional concepts of opex and capex.

Let’s focus first on the case of one-off or non-recurring expenditure. By definition, past levels of non-recurrent expenditure are of little use in setting future targets for non-recurrent expenditure. Mathematically this implies that $\frac{\partial \hat{I}_{t+1}}{\partial I_t} = 0$. Therefore, the incentive properties of the regulatory regime depend only on the “direct” effect identified above. Using equation 13 we can observe that the power of the incentive to reduce non-recurrent expenditure depends only on how out-turn non-recurrent expenditure is treated in the function Y_t :

$$(1 + r_t) \frac{d\pi_t}{dI_t} = \frac{\partial Y_t}{\partial I_t} \quad \dots(14)$$

Since, under incentive regulation, an increase in the expenditure leads to a reduction in the present value of the future profit stream, I will define the power of the incentive to be the *negative* of the expression on the left hand side of equation 14 (i.e., $-(1 + r_t) \frac{d\pi_t}{dI_t}$).

Obviously when $Y_t = 0$, the power of the incentive to reduce non-recurrent expenditure is zero. On the other hand, when $Y_t(I_t, \hat{I}_t) = \hat{I}_t - I_t$ we find that $(1 + r_t) \frac{d\pi_t}{dI_t} = -1$, so the

power of the incentive to reduce non-recurrent expenditure is 100% (\$1 of reduction in expenditure increases the present value of the profit stream by \$1).

One approach, which is used, for example, by the Essential Services Commission of Victoria is to choose the function Y_t to be equal to the difference between forecast and out-turn depreciation $Y_t(I_t, \hat{I}_t) = \hat{D}_t - D_t$. This is justified on the basis that the asset-base roll-forward should be based on the out-turn capital expenditure, with no attempt to “claw-back” any excess revenue the firm might have received due to the fact that the out-turn depreciation was less than the forecast depreciation.

The power of the incentive mechanism in this case depends, of course, on how the depreciation is set. For example, let’s suppose that the regulator chooses to use a form of “straight-line” depreciation, with a remaining asset life of N years. In this case the depreciation might be simply set as the closing RAB plus the additional capex divided by the asset life, as in the following expression: $D_t(K_{t-1}, I_t) = (K_{t-1} + I_t)/N$. The power of the incentive to reduce non-recurrent expenditure therefore depends on the remaining asset life:

$$(1 + r_t) \frac{d\pi_t}{dI_t} = \frac{\partial Y_t}{\partial I_t} = -\frac{1}{N}$$

Clearly, the longer the life of the asset, the weaker the power of this incentive.

Recall that, as noted earlier, there often arises a need to balance the power of different incentives (such as the power of the incentive to reduce opex and the power of the incentive to reduce capex; or the power of the incentive to reduce expenditure and the power of the incentive to increase service quality). Balancing the power of different incentives may require that the regulator be able to “fine tune” the power of the incentive to reduce non-recurrent expenditure.

A regulator can choose a regulatory regime with any arbitrary power of incentive to reduce non-recurrent expenditure by “rolling-forward” a proportion of the difference between the out-turn and forecast capex. This can be achieved by using a function of the form $Y_t(I_t, \hat{I}_t) = \alpha(\hat{I}_t - I_t)$ so that:

$$(1 + r_t) \frac{d\pi_t}{dI_t} = \frac{\partial Y_t}{\partial I_t} = -\alpha$$

Let’s turn now to look at mechanisms which give rise to incentives to reduce recurrent expenditure. In the case of non-recurrent expenditure above, we saw above that the effect of past expenditure out-turns on future expenditure forecasts could be ignored. Therefore the incentive to reduce expenditure depended exclusively on the first or “direct” effect of the asset-base roll-forward. In the case of recurrent expenditure, however, the incentive properties depend on both the “direct” or roll-forward effect and on how future expenditure targets are set on the basis of past expenditure out-turns.

However, the analysis is made simpler by the observation that the most common approach is to roll-forward forecast and not out-turn recurrent expenditure (i.e., $X_t(O_t, \hat{O}_t) = \hat{O}_t - O_t$). This choice is made on the grounds that “claw-back” of recurrent expenditure over-spend or under-spend is undesirable.

Under this assumption, the power of the incentive to reduce recurrent expenditure depends only on the discount rate and how future expenditure targets are set on the basis of past expenditure out-turns:

$$(1 + r_t) \frac{d\pi_t}{dO_t} = -1 + \frac{1}{(1 + r_{t+1})} \frac{\partial \hat{O}_{t+1}}{\partial O_t} \quad \dots(15)$$

But this creates something of a problem. In most cases it is entirely unclear how past expenditure out-turn information will be used to set future expenditure targets. The process by which expenditure targets are set is usually a “black box”, involving input from a number of different parties. Furthermore, regulators are, understandably, reluctant to commit themselves to a single, mechanistic approach to setting future expenditure targets on the basis of past cost out-turns. Yet, in the absence of such a mechanistic approach, it is impossible to be certain as to the precise incentive properties of a regulatory regime.

To proceed, let’s make the assumption that the regulator acts in a mechanistic and/or predictable manner in setting future expenditure targets. In the simplest case, the expenditure target is simply set equal to the most-recent expenditure out-turn, $\hat{O}_{t+1}(O_t) = O_t$. In this case the power of the incentive to reduce recurrent expenditure reduces to the following:

$$(1 + r_t) \frac{d\pi_t}{dO_t} = \frac{-r_{t+1}}{(1 + r_{t+1})} \quad \dots(16)$$

In this case we can see that the power of the incentive to reduce expenditure depends on the discount rate and the length of the regulatory period. The lower the discount rate or the shorter the length of the regulatory period, the weaker the incentive to reduce recurrent expenditure.

In principle, the regulator can induce incentives of any power by choosing to set the expenditure target equal to the out-turn in the previous period plus a proportion of any over-spend or under-spend relative to the target in the previous period:

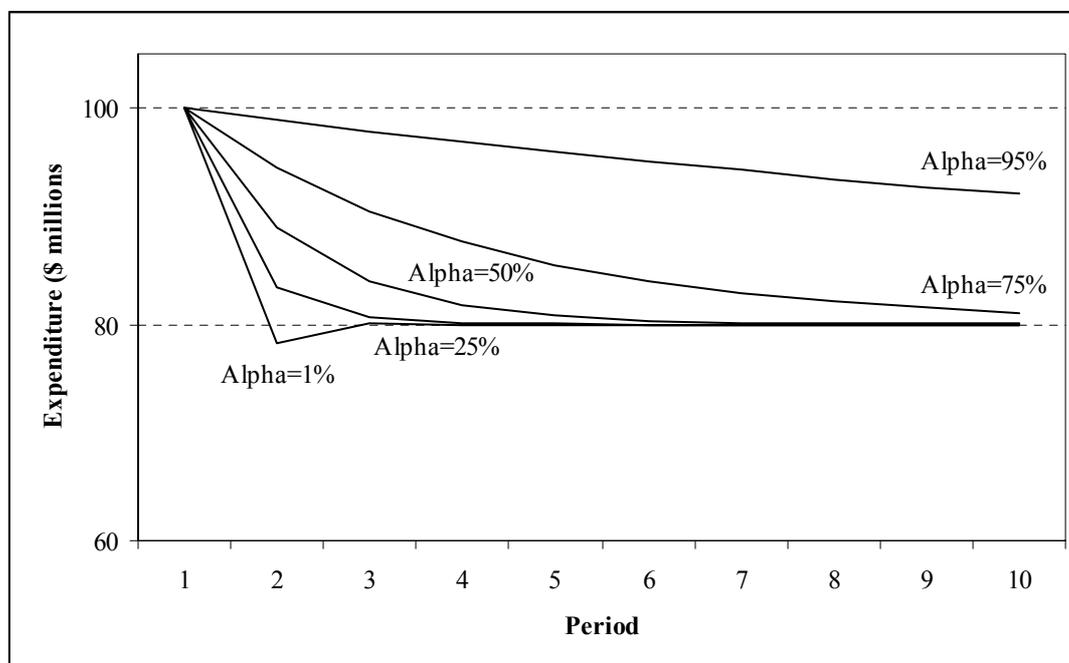
$$\hat{O}_{t+1}(O_t) = O_t + (\alpha(1 + r_{t+1}) - r_{t+1})(\hat{O}_t - O_t) \quad \dots(17)$$

In this case it is easy to verify that the power of the incentive to reduce recurrent expenditure is just equal to α (that is, $(1 + r_t) \frac{d\pi_t}{dO_t} = -\alpha$)

It is important to recognise that under the incentive mechanism described above, the higher the power of the incentive mechanism (i.e., the larger is α), the more prolonged may be deviations of the forecast expenditure from the out-turn expenditure. For example, in the extreme case in which $\alpha = 1$, the formula sets the forecast expenditure for the next period simply equal to the forecast expenditure from the previous period $\hat{O}_{t+1} = \hat{O}_t = \hat{O}_{t-1} = \dots$, entirely independent of any expenditure out-turn.

These deviations between forecast and out-turn expenditure are important because (since, by assumption $X_t(O_t, \hat{O}_t) = \hat{O}_t - O_t$), they result in an “excess” or “windfall” profit or loss for the regulated firm.

The next graph illustrates the evolution of the forecast expenditure under a scenario in which the forecast expenditure is initially equal to \$100 million. The out-turn expenditure then drops immediately to \$80 million and remains at the lower level. As can be seen, for high values of alpha, it may be many periods before the target expenditure approaches the out-turn expenditure – in other words, there may be many periods when the regulated firm appears to be earning excess returns. Such prolonged episodes may not be sustainable.



Conversely, of course, if there was an unexpected and permanent increase in the out-turn expenditure, with a high-powered incentive scheme it may be many periods before this is fully reflected in the forecast expenditure – and during those periods the regulated firm will be incurring an economic loss (i.e., returns below “normal” returns). A prolonged period of sub-normal returns is also probably not economically sustainable.

It might be the case that the regulator considers that a shorter period of adjustment would be sustainable even if it meant larger windfall gains or losses in that shorter period. This could be achieved by “amplifying” the firm’s benefits from under-spending through the roll-forward mechanism. For example, suppose that the roll-forward were carried using the function X_t defined in the following way: $X_t(O_t, \hat{O}_t) = \beta(\hat{O}_t - O_t)$ where β is some parameter. In this case it is easy to verify that the power of the incentive to reduce recurrent expenditure is equal to $\alpha\beta$ (i.e., $(1+r_t) \frac{d\pi_t}{dO_t} = -\alpha\beta$). Clearly if the regulatory chose the parameter β to

be greater than one, the regulator could still achieve a very high power of incentive even with the parameter α less than one. The effect is to bring about a much faster adjustment to a new expenditure level, by increasing the firm’s windfall gains or losses during the adjustment period.

In principle, if it were possible, the best way to overcome the problem of prolonged windfall gains or losses to the regulated firm is through careful use of accurate exogenous expenditure information when setting the expenditure targets. “Exogenous” information here refers to information which cannot be affected by the regulated firm itself, such as information on the expenditure out-turns of other firms in the same industry. Suppose that the exogenous

benchmark expenditure for period t is \bar{O}_t . The regulator could combine this information with information on the regulated firm's own expenditure out-turn using the equation set out above, namely:

$$\hat{O}_{t+1}(O_t) = O_t + (\alpha(1+r_{t+1}) - r_{t+1})(\bar{O}_t - O_t) \quad \dots(18)$$

Incentive Regulation in the Context of the Five-Year Regulatory Period

In the previous section we treated the regulatory period as a single entity, with no consideration of the information the regulator might obtain during the regulatory period or of how the incentives of the firm might change during the regulatory period. In this section we address these issues by assuming that the regulatory period consists of a number of distinct time intervals (usually five years). How does incentive regulation apply in this context, and what new issues arise?

Let's now suppose that every five years – in years which are a multiple of five - the regulator sets the revenue stream for the following five years. At the end of that five year period the asset base is then rolled forward using a version of the asset-base roll-forward equation. The mathematics for deriving the appropriate roll-forward equation in this context is not difficult, but as it is rather long, is relegated to the appendix. The appropriate asset-base roll-forward equation, in this context is:

$$K_{t+5} = P_{t+1}^{t+5} K_t - P_{t+1}^{t+5} PV_{t+1}^{t+5} (R - I - O) + F_{t+5} + G_{t+5} \quad \dots(19)$$

where $PV_i^j(X) = \sum_{s=i}^j \frac{X_s}{P_i^s}$ is the present value (at period i) of the stream X_i, \dots, X_j . Note that

for any k which lies between i and j , $PV_i^j(X) = PV_i^k(X) + \frac{PV_{k+1}^j(X)}{P_i^k}$. As before F_{t+5}

and G_{t+5} are functions which determine the incentive properties of the regulatory regime.

$F_{t+5} = F_{t+5}(O_{t+1}, \dots, O_{t+5}, \hat{O}_{t+1}, \dots, \hat{O}_{t+5})$ and $G_{t+5} = G_{t+5}(I_{t+1}, \dots, I_{t+5}, \hat{I}_{t+1}, \dots, \hat{I}_{t+5})$.

Now, as before, let's suppose that the firm ceases to exist in year T (which is assumed to be the end of a regulatory period – i.e., a multiple of 5). In that year, investors are paid an amount equal to the outstanding RAB K_T . As before, the present value of the profit stream is as follows (the derivation of this equation is set out in the appendix):

$$\pi_t = P_1^{t-1} (K_0 - PV_1^{t-1} (R - O - I)) + \frac{(F_5 + G_5)}{P_t^5} + \frac{(F_{10} + G_{10})}{P_t^{10}} + \dots + \frac{(F_T + G_T)}{P_t^T} \quad \dots(20)$$

where $t = 1, \dots, 5$.

Now, as before, we will make the simplifying assumption that the forecast expenditure depends only on the expenditure out-turn in the most recent regulatory period (i.e., that $\hat{O}_6 = \hat{O}_6(O_1, \dots, O_5)$, $\hat{O}_7 = \hat{O}_7(O_1, \dots, O_5)$, ..., $\hat{O}_{10} = \hat{O}_{10}(O_1, \dots, O_5)$, and similarly for the non-recurrent expenditure forecasts $\hat{I}_6, \dots, \hat{I}_{10}$).

Consider the position of the regulated firm at the start of period t . All of the out-turns O_1, O_2, \dots, O_{t-1} , I_1, I_2, \dots, I_{t-1} , and so on have already been realised. The firm is considering reducing its expenditure, O_t , say. What effect will this have on the present value of the profit stream? The first two terms in the expression above are independent of O_t , so the derivative of the profit function with respect to O_t is:

$$\frac{d\pi_t}{dO_t} = \frac{1}{P_t^5} \frac{\partial G_5}{\partial O_t} + \frac{1}{P_t^{10}} \sum_{s=6}^{10} \frac{\partial G_{10}}{\partial \hat{O}_s} \frac{\partial \hat{O}_s}{\partial O_t} \quad \dots(21)$$

$$\frac{d\pi_t}{dI_t} = \frac{1}{P_t^5} \frac{\partial F_5}{\partial I_t} + \frac{1}{P_t^{10}} \sum_{s=6}^{10} \frac{\partial F_{10}}{\partial \hat{I}_s} \frac{\partial \hat{I}_s}{\partial I_t} \quad \dots(22)$$

As before, it is conventional to not claw-back any opex savings during the regulatory period. This implies that

$$G_5 = P_1^5 PV_1^5 (\hat{O} - O) = P_1^5 \sum_{s=1}^5 \frac{(\hat{O}_s - O_s)}{P_1^s} = \sum_{s=1}^5 P_{s+1}^5 (\hat{O}_s - O_s)$$

Similarly, $G_{10} = P_6^{10} PV_6^{10} (\hat{O} - O) = \sum_{s=6}^{10} P_{s+1}^{10} (\hat{O}_s - O_s)$.

Hence, the power of the incentive to reduce recurrent expenditure in the current period reduces to:

$$(1+r_t) \frac{d\pi_t}{dO_t} = -1 + \sum_{s=6}^{10} \frac{1}{P_{t+1}^{s+1}} \frac{\partial \hat{O}_s}{\partial O_t} = -1 + \frac{1}{P_{t+1}^5} \frac{\partial PV_6^{10}(\hat{O})}{\partial O_t} \quad \dots(23)$$

Again we observe that the power of the incentive to reduce recurrent expenditure depends on how future expenditure targets depend on expenditure out-turns in the past. As before, I note that in practice, the mechanism by which future expenditure targets are set is usually a “black box”, involving input from many different parties. In practice, therefore, the precise incentive properties of most regulatory regimes are unclear.

As before, to proceed, let’s make the assumption that the regulator uses a particular mechanistic approach to setting the future expenditure targets.

One common approach is to set the forecast recurrent expenditure for the next regulatory period *equal to the expenditure out-turn in the last year of the last regulatory period*, plus an exogenous trend or offset: $\hat{O}_t = O_s + E_t$ for $t = 6, \dots, 10$ where E_t is an exogenous constant.

The power of the incentive to reduce recurrent expenditure is then:

$$(1+r_t) \frac{d\pi_t}{dO_t} = -1 + \frac{1}{P_{t+1}^5} \frac{\partial PV_6^{10}(\hat{O})}{\partial O_t} = \begin{cases} -1, & t = 1, \dots, 4 \\ -1 + \sum_{s=6}^{10} \frac{1}{P_5^s}, & t = 5 \end{cases} \quad \dots(24)$$

In this case the power of the incentives to reduce recurrent expenditure are clearly not constant over time – instead there are very powerful incentives to reduce recurrent expenditure in the first four years of the regulatory period and very strong incentives to *increase* recurrent expenditure in the last year of the regulatory period. The reason is intuitive – any increase in expenditure in the last year of the regulatory period by one dollar reduces profit in that period by one dollar but increases revenue in each of the next five periods.

To make this outcome even clearer, consider the following worked example, as set out in the table below. In this example, the expenditure forecast in the previous regulatory period was observed to be 110, 105, 100, 95 and 90. The expenditure out-turn was 108.53, 96.34, 95.20, 82.34 and 84.55. The regulator then (mechanistically) sets the expenditure out-turn for the next regulatory period equal to the expenditure out-turn in the last year of the previous regulatory period (which is 84.55) plus an “offset” (which in this case is 0, -5, -10, -15, -20).

With a WACC of exactly 10% we find that the power of the incentive to reduce recurrent expenditure is 100% in the first 4 years of the regulatory period and -244.6% in the final year of the regulatory period (i.e., a strong incentive to raise recurrent expenditure in this period).

Table 1: No Carry-over; target set equal to out-turn in last year of previous regulatory period

	Previous Regulatory Period					Subsequent Regulatory Period				
	1	2	3	4	5	6	7	8	9	10
Previous expenditure target	110	105	100	95	90					
Expenditure out-turn	108.53	96.34	95.2	82.34	84.55					
Underlying target						84.55	84.55	84.55	84.55	84.55
Exogenous offset						0	-5	-10	-15	-20
Total target						84.55	79.55	74.55	69.55	64.55
“Power” of incentive	100%	100%	100%	100%	-245%					

This effect – the changing incentive to reduce expenditure over time – is usually considered undesirable. One of the primary arguments in favour of the adoption of an “efficiency carry-over” mechanism is that it ensures constant incentives for efficiency over time.

Let’s suppose, therefore that the regulator wishes to ensure constant incentives for reducing recurrent expenditure over time i.e., $(1+r_t) \frac{d\pi_t}{dO_t} = A$ for some constant A and $t = 1, \dots, 5$.

From equation 23, this implies that the present value of the future recurrent expenditure forecasts must be a linear function of the brought-forward value of the recurrent expenditure out-turns in the previous regulatory period.

$$PV_6^{10}(\hat{O}) = (A+1)P_1^5 PV_1^5(O) + B \quad \dots(25)$$

where B is a constant.

For example, let’s suppose that the regulator simply chose to set the forecast recurrent expenditure targets equal to the weighted average of the expenditure out-turn in the previous regulatory period: $\hat{O}_t = \frac{(A+1)}{k} P_1^5 PV_1^5(O) + E_t$ where $k = \sum_{s=6}^{10} \frac{1}{P_6^s}$.

With this approach to setting the expenditure targets, we find that the expenditure targets are proportional to the brought-forward value of the recurrent expenditure out-turn in the

previous regulatory period $PV_6^{10}(\hat{O}) = (A+1)P_1^5 PV_1^5(O) + PV_6^{10}(E)$, so the conditions are satisfied for constant incentives for expenditure-reducing effort during the regulatory period.

$$\text{(i.e., } (1+r_t) \frac{d\pi_t}{dO_t} = A).$$

This is verified in the following worked example. The expenditure out-turn in this example is the same as in the previous example, and the WACC, as before, is 10%. The expenditure target is set equal to the weighted average of the expenditure out-turns in the previous regulatory period.

Table 2: No Carry-over; target set equal to weighted average of out-turn in previous regulatory period

	Previous Regulatory Period					Subsequent Regulatory Period				
	1	2	3	4	5	6	7	8	9	10
Previous expenditure target	110	105	100	95	90					
Expenditure out-turn	108.53	96.34	95.2	82.34	84.55					
Underlying target						94.58	94.58	94.58	94.58	94.58
Exogenous offset						0	-5	-10	-15	-20
Total target						94.58	89.58	84.58	79.58	74.58
“Power” of incentive	43.6%	43.6%	43.6%	43.6%	43.6%					

As this example, shows, when the expenditure targets are set in this way, there are constant incentives for reducing recurrent expenditure over time.

Let’s turn now to explore whether the same effect can be achieved with the “efficiency carry-over” mechanism Under the efficiency carry-over mechanism, the expenditure targets for the following regulatory period are set equal to the sum of an “underlying target” and a “carry-over”. Let B_t be the amount of the carry-over in year t ($t=6, \dots, 10$). It is straightforward to check that the amount of the carry-over is equal to $B_t = (\hat{O}_5 - \hat{O}_{t-5}) - (O_5 - O_{t-5})$ ⁷.

But how is the “underlying target” set? It turns out that the desirable properties of the efficiency carry-over only emerge when the underlying target is set in a particular way – specifically when the expenditure targets are set equal to the expenditure out-turn in the last year of the last regulatory period. Let’s therefore make this assumption. The “total” expenditure target is therefore given by the following expression:

$$\hat{O}_t = O_5 + B_t$$

Substituting in the expression for the efficiency carry-over above and simplifying, we find that under these assumptions the expenditure targets are set equal to the expenditure out-turn

⁷ Strictly speaking, this formula depends on the assumption that efficiency benefits are kept for a total of five periods (the year in which the efficiency saving was made and four further years). In some of the implementations of the efficiency carry-over it seems that the intention is to allow the regulated firm to keep the benefits for a total of six years (the year in which the saving was made and five further years). This latter approach complicates the analysis slightly as the expenditure target will now depend on expenditure out-turns not just from the most recent regulatory period but also from the regulatory period before that. The approach used above explains the key features of the efficiency carry-over more simply.

five periods earlier, plus an “offset” equal to the difference between the expenditure target for the last year of the last regulatory period and the expenditure target five years previously.

$$\hat{O}_t = O_{t-5} + E_t \text{ where } E_t = \hat{O}_5 - \hat{O}_{t-5}$$

Substituting into equation 23 gives the power of the incentive to reduce recurrent expenditure. We find that the power of the incentive to reduce recurrent expenditure depends, in each period, on the WACC over the next five periods.

$$(1 + r_t) \frac{d\pi_t}{dO_t} = -1 + \frac{1}{P_{t+1}^{t+5}} \quad \dots(26)$$

Note, that even under these assumptions the efficiency carry-over does not necessarily produce constant incentives to reduce recurrent expenditure over time – if the WACC varies over time, the power of the incentive to reduce recurrent expenditure will also vary.

However, if we make the additional assumption that the WACC is constant we find that the efficiency carry-over mechanism, when combined with setting the “underlying target” equal to the expenditure out-turn in the last year of the previous regulatory period, does yield constant incentives for efficiency over time. This can be seen in the following table:⁸

Table 3: Efficiency carry-over (4 periods); target set equal to out-turn in last year of previous regulatory period

	Previous Regulatory Period					Subsequent Regulatory Period				
	1	2	3	4	5	6	7	8	9	10
Previous expenditure target	110	105	100	95	90					
Expenditure out-turn	108.53	96.34	95.2	82.34	84.55					
Underlying target						84.55	84.55	84.55	84.55	84.55
Carry-over						3.98	-3.21	0.65	-7.21	0
Total target						88.53	76.34	75.2	62.34	64.55
“Power” of incentive	43.6%	43.6%	43.6%	43.6%	43.6%					

To summarise, we have shown that the efficiency carry-over mechanism can yield constant incentives for efficiency over time, but only under particular assumptions (namely when the “underlying” target is set equal to the expenditure out-turn in the last year of the previous regulatory period and when the WACC is assumed to be constant). If the expenditure targets are set in some other way, or if the WACC is not constant, the use of an efficiency carry-over mechanism will not ensure constant incentives for efficiency over time.

As we have seen, the desirability of the efficiency carry-over mechanism depends critically on how the “underlying” target is set. Recall, however, that in practice, the mechanism by which past expenditure out-turns will be used to set future expenditure targets is usually unclear. If this mechanism is unclear we cannot be certain how incentives for cost-reducing effort will change over time (if at all). Therefore we cannot be certain that introducing an efficiency carry-over will improve the overall outcome.

Even the regulator was certain that there was a problem with variation in the incentives for cost-reducing effort over time, it seems more sensible to address this problem directly by

⁸ Similar tables for other possible forms of carry-over mechanism (including the “glide path”) can be found in Biggar (2004b).

committing to an approach for setting the expenditure targets which has desired properties (such as constant incentives for cost-reducing effort over time) rather than to add-on a new mechanism in the form of a carry-over.

This discussion has proceeded on the assumption that inducing constant incentives for efficiency over time is a good thing. But this assumption can be questioned. To achieve constant incentives for efficiency over time requires that expenditure out-turns further in the past are given a higher weighting than expenditure out-turns in the more recent past. The regulator may have reason to believe that more recent expenditure out-turns are a better signal of future likely expenditure requirements than expenditure out-turns in the more distant past. For this reason, the regulator may consider that, when setting expenditure targets for the next regulatory period, it is desirable to give a higher weighting to expenditure out-turns towards the end of the previous regulatory period. This implies incentives for cost reducing effort which are diminishing over time.⁹

Conclusion

The building block model is a versatile and useful tool for effectively amortising the expenditure of a regulated firm over time. However, the building block model has been pressed into the service of incentive regulation with little theoretical foundation or framework. As a result, the modifications or embellishments of the building block model that have been developed to address the requirements of incentive regulation have arisen in an ad hoc fashion, without a broader context in which to assess alternatives or strengths and weaknesses. This paper is an attempt to correct that deficit by setting out a coherent and consistent framework for incentive regulation in the context of the building block model.

This framework has highlighted features of the building block model which were implicit but not widely acknowledged, such as the key role played by the asset-base roll-forward; the need for a distinction between recurrent and non-recurrent expenditure; and the importance of the mechanism for setting expenditure targets in determining the incentive properties of a regulatory regime.

This paper has also highlighted the lack of theoretical foundation for the use of an efficiency carry-over mechanism, an approach which is currently finding wide favour amongst regulators in Australia and overseas. The paper has emphasised that the efficiency carry-over mechanism only has desirable properties when the underlying targets are set in a particular way. But regulators are loathe to commit to setting the underlying targets in one mechanistic manner. Therefore it is impossible to be certain that the efficiency carry-over will improve the outcome and will not, in fact, make the regulatory outcome worse.

⁹ This can be viewed as an application of the “Incentive Intensity Principle” of Milgrom and Roberts (1992), page 221. The incentive intensity principle states (amongst other things) that the optimal intensity of incentives will be lower the lower the precision with which the desired activities are assessed.

Appendix

To derive equation 19: Starting from equation 10 we have:

$$K_{t+1} = (1+r_{t+1})K_t - (R_{t+1} - I_{t+1} - O_{t+1}) + X_{t+1} + Y_{t+1}$$

Hence we have that:

$$\begin{aligned} K_{t+2} &= (1+r_{t+2})K_{t+1} - (R_{t+2} - I_{t+2} - O_{t+2}) + X_{t+2} + Y_{t+2} \\ &= P_{t+1}^{t+2} K_t - P_{t+1}^{t+2} \sum_{s=1}^2 \frac{R_{t+s} - I_{t+s} - O_{t+s}}{P_{t+1}^{t+s}} + P_{t+1}^{t+2} \sum_{s=1}^2 \frac{X_{t+s} + Y_{t+s}}{P_{t+1}^{t+s}} \end{aligned}$$

Hence:

$$\begin{aligned} K_{t+5} &= P_{t+1}^{t+5} K_t - P_{t+1}^{t+5} \sum_{s=1}^5 \frac{R_{t+s} - I_{t+s} - O_{t+s}}{P_{t+1}^{t+s}} + P_{t+1}^{t+5} \sum_{s=1}^5 \frac{X_{t+s} + Y_{t+s}}{P_{t+1}^{t+s}} \\ &= P_{t+1}^{t+5} K_t - P_{t+1}^{t+5} .PV_{t+1}^{t+5} (R - I - O) + F_{t+5} + G_{t+5} \end{aligned}$$

where $F_{t+5} = P_{t+1}^{t+5} PV_{t+1}^{t+5} (X)$ and $G_{t+5} = P_{t+1}^{t+5} PV_{t+1}^{t+5} (Y)$

To derive equation 20:

$$\begin{aligned} \pi_{t-1} &= \sum_{s=t}^T \frac{R_s - O_s - I_s}{P_t^s} + \frac{K_T}{P_t^T} = PV_t^T (R - O - I) + \frac{K_T}{P_t^T} \\ &= PV_t^{T-5} (R - O - I) + \frac{1}{P_t^{T-5}} (PV_{T-4}^T (R - O - I) + \frac{K_T}{P_{T-4}^T}) \\ &= PV_t^{T-5} (R - O - I) + \frac{1}{P_t^{T-5}} (K_{T-5} + \frac{F_T + G_T}{P_{T-4}^T}) \\ &= PV_t^{T-5} (R - O - I) + \frac{K_{T-5}}{P_t^{T-5}} + \frac{(F_T + G_T)}{P_t^T} \\ &= PV_t^5 (R - O - I) + \frac{K_5}{P_t^5} + \frac{(F_{10} + G_{10})}{P_t^{10}} + \dots + \frac{(F_T + G_T)}{P_t^T} \\ &= \frac{1}{P_t^5} (P_t^5 .PV_t^5 (R - O - I) + P_1^5 .K_0 - P_1^5 .PV_1^5 (R - I - O) + F_5 + G_5) + \frac{(F_{10} + G_{10})}{P_t^{10}} + \dots + \frac{(F_T + G_T)}{P_t^T} \\ &= P_1^{t-1} K_0 + P_1^{t-1} .(\frac{1}{P_1^{t-1}} .PV_t^5 (R - O - I) - PV_1^5 (R - I - O)) + \frac{(F_5 + G_5)}{P_t^5} + \frac{(F_{10} + G_{10})}{P_t^{10}} + \dots + \frac{(F_T + G_T)}{P_t^T} \\ &= P_1^{t-1} .(K_0 - PV_1^{t-1} (R - O - I)) + \frac{(F_5 + G_5)}{P_t^5} + \frac{(F_{10} + G_{10})}{P_t^{10}} + \dots + \frac{(F_T + G_T)}{P_t^T} \end{aligned}$$

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