Asset valuation and productivity–based regulation taking account of sunk costs and financial capital maintenance

Report prepared for
Commerce Commission

11 June 2009

Erwin Diewert, Denis Lawrence and John Fallon

Economic Insights Pty Ltd
6 Kurundi Place, Hawker, ACT 2614, AUSTRALIA
Ph +61 2 6278 3628 Fax +61 2 6278 5358
Email denis@economicinsights.com.au
WEB www.economicinsights.com.au
ABN 52 060 723 631

CONTENTS

EXECUTIVE SUMMARY

Background

Section 53P of the Commerce Amendment Act 2008 stipulates that rates of change in default price paths 'must be based on the long–run average productivity improvement rate achieved by either or both of suppliers in New Zealand, and suppliers in other comparable countries, of the relevant goods or services, using whatever measure of productivity the Commission considers appropriate'.

The Commerce Commission ('Commission') has engaged Economic Insights Pty Ltd ('Economic Insights') to prepare a report which considers the interrelationship between the choice of asset valuation method and CPI–X price paths set using productivity analysis. Specifically, Economic Insights has been asked to evaluate the optimised deprival value (ODV), depreciated historic cost (DHC) and indexed depreciated historic cost (IHC) asset valuation methods where CPI–X incentive regulation uses productivity analysis.

To adequately address this topic it has been necessary to revisit the theory of regulation and fill in some important gaps which have existed until now. In particular, two major limitations of the theory underlying productivity–based regulation to date have been that it has not recognised the sunk cost nature of network assets nor adequately allowed for the principle of real financial capital maintenance (FCM). Real FCM means that a controlled business is compensated for efficient expenditure and efficient investments such that, on an ex–ante basis, its financial capital is at least maintained in present value terms. A general measure of inflation (such as the CPI) is used as it maintains the purchasing power of investors' funds. The sunk cost characteristic of network assets and the desirability of ensuring real FCM both have important implications for how productivity analysis is used in network regulation. Similarly, the theory of network regulation has evolved in a relatively piecemeal way that has not adequately addressed key economic welfare issues.

A large part of this project has, therefore, involved developing a unified theory of network regulation using productivity analysis. The detailed analysis is, by necessity, relatively technical in nature and is presented in an accompanying technical report (Economic Insights 2009). This report presents the main findings and discusses implementation issues.

Productivity analysis

Productivity indexes are formed by aggregating output quantities into a measure of total output quantity and aggregating input quantities into a measure of total input quantity. The productivity index is then the ratio of total outputs to total inputs or, if forming a measure of productivity growth, the change in the ratio of total outputs to total inputs.

To form the total output and total input measures we need a price and quantity for each output and each input, respectively. The quantities enter the calculation directly as it is changes in output and input quantities that we are aggregating. The prices are used to weight together changes in all output quantities and all input quantities into measures of total output quantity and total input quantity using revenue and cost measures, respectively. Like other inputs and outputs, we thus need a quantity and cost for capital inputs.

Asset values will affect the cost of using capital inputs and can affect the capital input quantity if a constant price depreciated asset value series is used as a proxy for capital input quantities.

The appropriate measure to use for the capital input quantity in productivity analysis depends on the change in the physical service potential of the asset over time. For long–lived network assets such as poles, wires, transformers and pipelines, there is likely to be relatively little deterioration in physical service potential over the asset's life. In this case using a measure of physical asset quantity is likely to be a better proxy for capital input quantity than using the constant price depreciated asset value series as a proxy. If this approach is adopted then the input quantity (which is the primary driver of productivity results) will be unaffected by which asset valuation method is used. Rather, the asset value will only affect the secondary driver of what weight is allocated to the capital quantity changes in forming the productivity measure.

The traditional approach to measuring the annual user cost of capital in productivity studies uses the Jorgenson (1963) user cost method. This approach multiplies the value of the capital stock by the sum of the depreciation rate plus the opportunity cost rate minus the rate of capital gains (ie the annual change in the asset price index).

For traditional productivity studies with a limited history of investment data available, the asset value series is typically rolled forwards and backwards from a point estimate using investment and depreciation series. The point estimate would typically reflect the market value of assets at that point in time. It would be standard practice to take the earliest point estimate of the capital stock available, provided there was reasonable confidence in the quality of the valuation process. Existing or, in the case of energy distribution, sunk assets and new investment have traditionally been treated symmetrically.

Traditional incentive regulation

Because infrastructure industries such as the provision of energy transmission and distribution networks are often subject to decreasing costs in present value terms, competition is normally limited and incentives to minimise costs and provide the cheapest and best possible quality service to users are not strong. The use of CPI–X regulation in such industries attempts to strengthen the incentive to operate efficiently by imposing similar pressures on the network operator to the process of competition. It does this by constraining the operator's output price to track the level of estimated efficient unit costs for that industry. The change in output prices is 'capped' as follows:

(ES1) $$\Delta P = \Delta W - X \pm Z$$

where Δ represents the proportional change in a variable, P is the maximum allowed output price, W is a price index taken to approximate changes in the industry's input prices, X is the estimated total factor productivity (TFP) change for the industry and Z represents relevant changes in external circumstances beyond managers' control which the regulator may wish to allow for. Ideally the index W would be a specially constructed index which weights together the prices of inputs by their shares in industry costs. However, this price information is often not readily or objectively available, particularly in regulatory regimes that have yet to fully mature. A commonly used alternative is to choose a generally available price index such as the consumer price index or GDP deflator.

There are two common alternative ways of implementing price cap regulation – the buildings blocks method (BBM) and productivity–based regulation. BBM relies on forecasts of the firm's own costs and draws on financial capital maintenance concepts to set prices so that the net present values of forecast revenues and costs over the regulatory period are equal.

Productivity–based regulation, as it has been applied to date, argues that in choosing a productivity growth rate to base X on, it is desirable that the productivity growth rate be external to the individual firm being regulated and instead reflect industry trends at a national or even international level. This way the regulated firm is given an incentive to match (or better) this productivity growth rate while having minimal opportunity to 'game' the regulator by acting strategically. The latter can be a problem with the building blocks method for setting X which relies more heavily on information on the firm's own costs and likely best practice for that firm.

Traditional productivity–based regulation has typically been implemented using CPI–X price caps where the formula for the X factor takes on the following 'differential of a differential' form:

(ES2) $$X \equiv [\Delta TFP - \Delta TFP_E] - [\Delta W - \Delta W_E] - \Delta M.$$

where the E subscript refers to corresponding variables for the economy as a whole and M refers to monopolistic mark–ups or excess profits. What this formula tells us is that the X factor can effectively be decomposed into three terms. The first differential term takes the difference between the industry's TFP growth and that for the economy as a whole while the second differential term takes the difference between the firm's input prices and those for the economy as whole. Thus, taking just the first two terms, if the regulated industry has the same TFP growth as the economy as a whole and the same rate of input price increase as the economy as a whole then the X factor in this case is zero. If the regulated industry has a higher TFP growth than the economy then X is positive, all else equal, and the rate of allowed price increase for the industry will be less than the CPI. Conversely, if the regulated industry has a higher rate of input price increase than the economy as a whole then X will be negative, all else equal, and the rate of allowed price increase will be higher than the CPI.

The change in mark–up term in (ES2) could be set equal to zero under normal circumstances but if the target firm was making excessive returns, then this term could be set negative (leading to a higher X factor).

Productivity–based regulation in the presence of sunk costs and FCM

Introducing sunk costs means that we can no longer use the standard Jorgenson user cost approach to measuring the annual cost of using capital or the total cost function in deriving parameters for optimal regulation. This is because sunk assets, by definition, cannot be freely traded in a second–hand market which is a key assumption of the standard user cost approach. Rather, as demonstrated in the accompanying technical report, it is necessary to change to using operating expenditure (opex) cost functions for the regulated firm.

An opex cost function minimises the variable input costs associated with producing an output target, conditional on the availability of a fixed quantity of capital stock components. In other words, we need to recognise that the firm's relevant decision making options each period are to alter its level of opex given the quantity of sunk investments it has that period. It can opt to change the level of sunk investments gradually over time by undertaking additional investment or allowing the existing stock to run down but it cannot treat capital stocks as freely variable from period to period as has been the implication of past theory developed in this area.

The term opex or variable cost is used here to refer to all non–capital costs. This includes operating expenditure whose benefits are confined to the current period and routine maintenance associated with original anticipated asset lifetimes. Items such as refurbishment and remedial action which extend asset lives should be treated as capital expenditure and not as opex, ie they should be capitalised and expensed over the subsequent periods they give a benefit for.

Instead of the Jorgenson user cost playing a key role, we now have a user benefit defined as the negative of the change in the opex cost function in response to a change in the sunk cost capital stock playing an analogous role. Put another way, the user benefit is the marginal saving in opex that could be obtained by increasing sunk capital by one unit while holding output constant. The (discounted) sum of these anticipated user benefit terms is set equal to the purchase price of the capital input.

The sunk costs counterpart to the traditional 'differential of a differential' X factor formula in (ES2) becomes:

$$\text{(ES3)} \quad X \equiv \{[C/R]\,\Delta TFP - \Delta TFP_E\} + \{\Delta W_E - [C/R](s_X \Delta w_X + s_K \Delta P_{kD})\} + [\Pi/R]\,\Delta Y - \Delta\Pi/R$$

= TFP differential growth rate term + input price differential growth rate term

+ nonzero profits adjustment term − rate of change of regulated profits term.

The first term in (ES3) is the differential rate of TFP growth between the regulated firm, ΔTFP, and the rest of the economy, ΔTFP_E. However, the TFP growth rate of the regulated firm must now be weighted by the ratio of the regulated firm's costs (including its cost of capital), C, to its revenues, R. The second term is the differential rate of growth of input prices in the rest of the economy, ΔW_E, less C/R times a share weighted rate of the growth of opex input prices for the regulated firm, Δw_X, and the rate of growth of allowable amortisation charges for sunk cost capital inputs, ΔP_{kD} (not the Jorgenson user costs which use capital goods prices as in (ES2)). Total cost for the regulated firm, C, is defined as the sum of variable or opex input costs plus allowable amortisation costs for sunk cost capital inputs. The regulated firm input cost shares which appear in the input price differential term, s_X and s_K, are defined as the ratio of variable or opex cost to total cost and the ratio of allowable amortisation costs to total cost, respectively.

The last two terms on the right hand side of (ES3) involve the level of excess profits of the regulated firm, Π, the rate of change of excess profits, $\Delta\Pi$ and output, Y. If the excess profits of the regulated firm are not close to zero, then if excess profits were markedly positive, the regulator will likely want to set $\Delta\Pi$ equal to a negative number in order to reduce these excess profits over time. On the other hand, if excess profits were substantially negative, then the regulator will likely want to set $\Delta\Pi$ equal to a positive number in order to maintain the financial viability of the regulated firm. Thus, when excess profits are substantially different from zero, the regulator will typically want to set a glide path for profitability so that either profits in excess of what is required to raise capital in the industry are eliminated or, in the case of negative profits, a glide path must be set to restore the long term solvency of the regulated firm. In the case where excess profits are positive, typically the regulator will set $\Delta\Pi$ in the price cap formula (ES3) equal to a negative number, which will cause the proportional change in regulated prices to become smaller, ie under these conditions the price cap will become more stringent.

When regulation involves several firms and past average rates of technical progress or of TFP growth are used in setting a common rate of change going forward, then the measurement of these rates becomes critical. In particular, the use of average TFP growth rates across a number of regulated firms can create an uneven playing field since the ingredients which go into TFP growth, as shown in the accompanying technical report, can contain terms which are beyond the control of the individual regulated firm.

If a common rate of productivity growth is to be used in setting the price cap when regulating a group of firms using productivity–based regulation, then output specification becomes critical since different output concepts can lead to very different estimates of both technical progress and TFP growth. In particular, it is necessary for the output measure to capture as fully as possible what regulated services are being provided by the firms in the group, independently of the institutional and historical factors that determine how the firms happen to charge consumers. As well as it being necessary to use comprehensive measures of output in this instance, it will also be necessary to use output cost share weights rather than revenue weights in forming the productivity measure.

As noted above, when there are significant sunk costs the appropriate annual cost of capital inputs becomes the series of amortisation charges for the capital good approved by the regulator. These approved amortisation charges should ideally be the marginal user benefits from the sunk capital (ie the opex savings from an increase in sunk capital while holding output constant). They can be readily structured to achieve FCM.

A range of asset valuation methodologies can be consistent with FCM, provided that the allowed cost of capital interest rates are equal to the firm's opportunity cost of financial capital. Each methodology will generate a time–series of asset values and the series of amortisation charges are used to ensure financial capital maintenance is achieved. The main difference between asset valuation methods (assuming standard regulatory depreciation approaches such as straight–line) is on the timing of revenue receipts rather than their net present value. The important requirements are that the amount actually invested is the opening asset value in the first period and the scrap value is the closing asset value in the last period. Efficiency considerations would further suggest the amount actually invested should have been an efficient amount.

This makes the approach to measuring capital costs in productivity–based regulation in the presence of sunk costs and the achievement of FCM similar to that typically used in building blocks regulation.

Criteria for assessing asset valuation methodologies used in productivity–based regulation

As highlighted in the project's terms of reference, in this report we assume that ex ante financial capital maintenance (FCM) will be adopted as a key regulatory principle. This is an important part of ensuring there is dynamic efficiency and adequate incentives for efficient investment. One of our preferred principles for selecting asset valuation methods is, thus, that the method used should be effective in allowing NPV=0 to be implemented on an ex ante basis, which is equivalent to supporting the implementation of ex ante FCM.

As well as supporting the economic efficiency goals identified in Section 52A of the Commerce Amendment Act 2008, the use of FCM is also an important aspect of identifying excess returns and, hence, limiting producers' ability to extract excessive profits (as also identified in Section 52A of the Act). The asset valuation method used in productivity–based regulation should, thus, be consistent with the setting of default productivity–based price paths that limit the ability to extract excessive profits.

There is also a range of economic efficiency considerations that are not captured by the simple FCM rule and which need to be considered along with other regulatory and practical considerations. For example, the efficiency implications of the different methods for the time profile of prices need to be considered.

The relevant criteria for assessing asset valuation methodologies in the context of productivity analysis and productivity–based regulation are as follows:

1. **Supports economic efficiency.** The asset valuation methodology used in productivity analysis and productivity–based regulation should support outcomes that are dynamically, productively and allocatively efficient as required by Section 52A of the Commerce Amendment Act 2008.
2. **Facilitates FCM for prudent investment.** The asset valuation methodology should be effective in avoiding excess profits on an ex ante basis which is equivalent to allowing ex ante FCM.
3. **Cost effectiveness.** The asset valuation methodology used in productivity analysis should not be unduly costly and should draw on available information as much as possible.
4. **Consistency and accuracy.** The asset valuation methodology should be consistent and accurate to the maximum extent appropriate for the circumstances.
5. **Transparency.** The asset valuation methodology used in productivity analysis should be readily understood and be capable of being independently replicated with minimal need for judgemental assessments.
6. **Enables ready conversion of asset values from current to constant prices and vice–versa.** This principle is relevant for facilitating measurement of capital input prices and quantities in productivity analysis.

Optimised deprival value (ODV)

ODV as applied by the Commerce Commission in relation to network assets in New Zealand is defined as the minimum of optimised depreciated replacement cost (ODRC) and economic value (EV). The ODRC is defined as the depreciated cost of replicating the system using modern equivalent asset (MEA) values in the most efficient way possible from an engineering perspective, given the network's service capability, with depreciation based on the age of the existing assets. The EV of any network segment is defined as the maximum of the net realisable value (NRV) of the segment and the present value of the notional after–tax cash flows that would be attributable to that segment (limited by the cost of alternatives, and net of any initial investment in working capital and fixed assets other than system fixed assets associated with the segment). In practice, most parts of the asset base rest on the ODRC component of ODV.

The ODRC method received considerable support in Australia and New Zealand as publicly owned business enterprises where being reformed through a process of corporatisation and, in some cases, privatisation in the late 1980s and through the 1990s. However, the approach is based on some strict theoretical assumptions and, in practice, allows considerable discretion in arriving at an asset value for regulated networks.

Many advocates of ODV have argued it provides a relevant hypothetical new entrant benchmark. This refers to a methodology for determining allowable costs for the purpose of regulating prices based on the costs a hypothetical efficient new entrant would face in providing the regulated service. Some regulatory authorities in the past have argued that the approach is justified as it is a relevant application of the theory of contestable markets in the valuation of assets. The idea is that a valuation of assets based on an estimate of forward looking efficient capital costs to serve the regulated market will justify a price for the regulated services at which a new entrant would have the incentive to compete for the provision of the regulated services at the regulated price.

More recently, regulatory authorities have recognised that the underlying theory of contestable markets is not applicable to network businesses because it assumes there are no sunk costs in a situation where the market or regulated service at issue involves substantial sunk costs. Furthermore, assuming the price adjustment implied by the theory of contestability is not relevant when there are significant sunk costs. This is because there needs to be a mechanism to ensure that sunk costs are recovered in an economically efficient manner and the theory of contestability does not specify such a mechanism when there are substantial sunk costs. The accompanying technical report highlights the importance of allowing for the existence of sunk costs in productivity–based regulation.

While ODV is useable for productivity–based regulation, it is unlikely to be the preferred asset valuation method. There may be little difference in practice in resulting industry productivity growth estimates between ODV and historic cost methods given that both would, in practice, have to use an early replacement cost–based valuation as a starting point given the unavailability of original cost information. This would particularly be the case where productivity estimates use direct or physical measure based capital quantity proxies (as opposed to constant price depreciated asset value quantity proxies). While the methodology developed in the accompanying technical report is capable of allowing ex ante FCM to be implemented via the calculation of a stream of amortisation charges which would then be used for productivity, input price differential and excess profit calculations, the implementation of this framework in practice would be considerably more difficult under ODV than historic cost methods. As the ACCC (2004b) has noted, periodic replacement cost–based revaluations can lead to unpredictable revenues and prices, and the prospect of windfall gains or losses. Unless appropriate adjustments are made to regulated income, which may be difficult to reach agreement on and implement in practice, this will make it difficult to limit the ability to extract excessive profits and ensure that efficiency gains are shared with consumers.

Depreciated historic cost (DHC)

Under a depreciated historic cost method of asset valuation, the actual written down book value of the assets, defined under standard historic cost accounting conventions, ie the standard accounting book value of the assets adjusted for accumulated depreciation, is used as a basis for determining the regulatory asset base – hence the term depreciated historic cost (DHC). In some jurisdictions the terminology depreciated actual cost (DAC) is used. DHC has tended to be used in the United States to value regulated assets.

Where DHC is used to value regulated assets, the use of a nominal allowable rate of return (as incorporated into a nominal WACC) provides compensation for expected inflation.

The historic cost approach has the advantage that it is based on actual accounting information which greatly reduces the need for the application of judgement in asset valuation.

Under standard regulatory depreciation provisions while still preserving FCM, however, DHC will imply more front loading of capital charges over the lifetime of assets compared to ODV and IHC (for the same dollar value asset base). This will mean higher real prices in the early stages than in the later stages of an asset's life. Such a price profile would be preferred by investors where they considered there was some probability that regulatory arrangements could change. But a higher real price in the early years of an asset's life could contribute to under–utilisation of the asset which would be inconsistent with allocative efficiency. Furthermore, network assets are typically characterised by economies of scale in construction so that it is optimal to have some excess capacity until demand increases to make better use of that capacity. Thus, contrary to the DHC price profile, intertemporal economic efficiency considerations are likely to imply smaller real charges in the early periods of the lifetime of network assets reflecting the low marginal cost of usage and to encourage use of the asset but progressively increasing as demand and utilisation of the network increased.

DHC would be a suitable asset valuation method for productivity–based regulation. Its use would promote dynamic efficiency and facilitate the application of ex ante FCM. It would also facilitate ready identification of excess returns and would accordingly allow more accurate determination of the X factor components associated with excess returns. Its main disadvantages are that it does not allow ready conversion between current and constant price asset values and hence reduces the range of productivity specifications that can easily be used and that it implies front loading of capital charges over the asset's lifetime.

Indexed depreciated historic cost (IHC)

The indexed historic cost (IHC) methodology for valuing assets requires the estimation of the asset base in real (inflation adjusted) terms and then the indexing of that asset base by a suitable deflator. In practice, this requires the selection or estimation of an initial asset base and then the estimation of the time profile of that asset base over time by incorporating annual capital expenditure and depreciation. The indexing of the asset base converts it to nominal terms which provides compensation for inflation. An allowable real rate of return and allowable depreciation are then defined to determine allowable capital charges. Note that in order to achieve ex ante FCM the asset base would need to be indexed by the same deflator as used in measuring the allowed expected real return from the investor's perspective. This would normally be a general deflator such as the consumer price index as this would be most relevant in ensuring capital was maintained in real general purchasing power terms.

IHC is considered to be superior to DHC in terms of intertemporal economic efficiency considerations that relate to the time profile of prices. It effectively 'back–end loads' the profile of receipts which encourages utilisation of the asset in the early stages of its life while serving to ration use once the asset becomes fully utilised towards the end of its life. This reflects the likelihood of network assets having scope to accommodate demand growth.

IHC would be a suitable asset valuation method for productivity analysis and productivity–based regulation. Its use would promote dynamic efficiency and facilitate the application of ex ante FCM. The implied time profile of prices is also consistent with that required by economic efficiency with 'back loading' of prices which is close to that required by the user pays principle. It would also facilitate ready identification of excess returns and would accordingly allow more accurate determination of the X factor components associated with excess returns. It also allows ready conversion between current and constant price asset values and hence increases the range of productivity specifications that can easily be used.

Assessment of the three valuation methods for use in productivity–based regulation

A summary comparison of the performance of each of the three asset valuation methods against the criteria required for use in productivity–based regulation is presented in table ES1. Both IHC and DHC are clearly preferred to ODV and of particular importance is that both these methods are seen as superior in terms of economic efficiency, ability to identify excess returns, cost effectiveness, consistency and accuracy, and transparency. IHC is clearly preferred to DHC in terms of the criterion for ready conversion of asset values from current to constant prices and vice–versa which increases the range of productivity specifications that can be readily used.

The assessment of the methods supports the use of historic cost rather than replacement cost–based valuations as the preferred valuation method for use in productivity–based regulation. IHC is the only one of the three methods which satisfies all 6 evaluation criteria and so is preferred over DHC. However, given the non–commercial nature of the origins of many utilities and the long–lived nature of their assets, in many cases historic cost information does not exist or cannot be recovered. In these cases, the use of the earliest available comprehensive asset valuation – which will usually be a replacement cost–based valuation – can be justified as the starting point. There is then a case for 'locking in' the starting valuation and rolling the asset value for use in productivity–based regulation forward from that point using data on investment and depreciation under the IHC framework.

Table ES1: **Assessment of ODV, DHC and IHC for use in productivity–based regulation**

Principle	ODV	DHC	IHC	Comment
1. Supports economic efficiency	x	√	√ √	IHC is superior when constant real prices are required for intertemporal efficiency or when front loading of capital charges is considered to be economically inefficient and conventional depreciation is adopted, making it difficult to make offsetting adjustments in defining allowable capital income.
2. Facilitates NPV=0	x	√ √	√	DHC is superior if there is a significant divergence between actual and expected inflation. ODV is more likely to lead to windfalls gains and losses.
3. Cost effectiveness	x	√	√ √	IHC is clearly superior if ready conversion from nominal to real magnitudes is required (principle 6). ODV requires expensive periodic valuations.
4. Consistency and accuracy	x	√√	√	DHC is superior if there is a significant divergence between actual and expected inflation. The need for extensive judgements to be made makes ODV less likely to be consistent and accurate.
5. Transparency	x	√	√√	DHC would be more difficult to be replicated than IHC because of the difficulty in converting from nominal to real magnitudes (principle 6). The need for extensive judgements to be made makes ODV less transparent and less replicable.
6. Conversion of nominal to real	√	x	√	DHC performs poorly on this principle which would be important for total factor productivity measurement if a constant price asset value is used as a proxy for the capital input quantity.

Notes: x = performs poorly. √ = performs well. √ √ = performs very well.

1 INTRODUCTION

The Commerce Commission ('Commission') has engaged Economic Insights Pty Ltd ('Economic Insights') to prepare a report which considers the interrelationship between the choice of asset valuation method and CPI–X price paths set using productivity analysis. Specifically, the report is to evaluate the optimised deprival value (ODV), depreciated historic cost (DHC) and indexed depreciated historic cost (IHC) asset valuation methods where CPI–X incentive regulation uses productivity analysis.

The terms of reference ask Economic Insights to:

1) identify interrelationships between asset valuation methods and CPI–X price paths set using productivity analysis, including:
   - a review of how asset valuation is used in productivity analysis, and the assumptions underpinning such use (eg the treatment of sunk costs), including (but not limited to) the relevance of the monopolistic mark–up term;
   - a discussion on the rationale and assumptions behind CPI–X incentive regulation, including a comparison of similar assumptions between that wider concept and the analytical frameworks of productivity analysis and building blocks analysis; and
   - a discussion on the rationale, assumptions and the historic development of building blocks analysis;
2) evaluate the pros and cons of ODV, IHC and DHC where CPI–X incentive regulation uses productivity analysis, including proposing appropriate principles and criteria for evaluating the relative merits of the different asset valuation methods, in light of the principle of financial capital maintenance.

To adequately address this topic it has been necessary to revisit the theory of regulation and fill in some important gaps which have existed until now. In particular, two major limitations of the theory underlying productivity–based regulation to date has been that it has not recognised the sunk cost nature of network assets nor adequately allowed for the principle of real financial capital maintenance (FCM). Real FCM means that a controlled business is compensated for efficient expenditure and efficient investments such that, on an ex–ante basis, its financial capital is at least maintained in present value terms. A general measure of inflation (such as the CPI) is used as it maintains the purchasing power of investors' funds. The sunk cost characteristic of network assets and the desirability of ensuring real FCM both have important implications for how productivity analysis is used in network regulation. Similarly, the theory of network regulation has evolved in a relatively piecemeal way that has not adequately addressed key economic welfare issues.

A large part of this project has, therefore, involved developing a unified theory of network regulation using productivity analysis. The detailed analysis is, by necessity, relatively technical in nature and is presented in an accompanying technical report (Economic Insights 2009). This report presents the main findings and discusses implementation issues.

The following section of the report reviews the use of asset valuation in traditional productivity analysis. Section 3 then discusses CPI–X incentive regulation using both productivity analysis and the building blocks approach. The section draws on the accompanying technical report where we develop the theory of network regulation in the presence of sunk costs and appendix A which reviews the history and evolution of the building blocks method. In section 4 we exposit evaluation criteria for the alternative asset valuation methods before assessing the methods against these criteria in the context of productivity–based regulation.

2 THE USE OF ASSET VALUATION IN TRADITIONAL PRODUCTIVITY ANALYSIS

Productivity indexes are formed by aggregating output quantities into a measure of total output quantity and aggregating input quantities into a measure of total input quantity. The productivity index is then the ratio of total outputs to total inputs or, if forming a measure of productivity growth, the change in the ratio of total outputs to total inputs. To form the total output and total input measures we need a price and quantity for each output and each input, respectively. The quantities enter the calculation directly as it is changes in output and input quantities that we are aggregating. The prices are used to weight together changes in all output quantities and all input quantities into measures of total output quantity and total input quantity using revenue and cost measures, respectively.

Like other inputs and outputs, we thus need a cost and quantity for capital inputs.

2.1 The quantity of capital input

There are a number of different approaches to measuring both the quantity and cost of capital inputs. How the quantity of annual capital input to the production process should be measured depends on the relevant physical depreciation profile for the asset. Hotelling (1925) described the pattern of annual capital input quantities to the production process as the ‘service potential’ of the asset. An asset’s service potential relates to its physical deterioration or decline in its effective capacity (and/or service quality) over time. If the physical depreciation profile is thought to be best proxied by so–called ‘one hoss shay’ depreciation (ie the amount of annual input quantity the asset can provide remains relatively constant over its lifetime), then the quantity of capital inputs can be measured directly in quantity terms (eg using a measure of line or transformer capacity). If the physical depreciation profile is thought to be best proxied by so–called ‘geometric’ depreciation (ie the amount of annual input quantity the asset can provide falls by a given percentage each year of its lifetime), then the quantity of capital inputs can be measured indirectly using a constant dollar measure of the depreciated value of assets. Using this approach the proxied quantity of annual capital input for an asset falls relatively quickly from the first year leading to higher estimated productivity growth than under the assumption of one hoss shay physical depreciation.

For long–lived network assets such as poles, wires and transformers the physical depreciation profile is likely to be closer to ‘one hoss shay’ than it is to either declining balance (geometric) or straight line. In this case using a measure of physical asset quantity is likely to be the best proxy. If this approach is adopted then the input quantity (which is the primary driver of productivity results) will be unaffected by which asset valuation method is used. Rather, the asset value will only affect the secondary driver of what weight is allocated to the capital quantity change in forming the productivity measure.

Most productivity studies do not have access to adequate physical data to implement this approach and so tend to use the deflated, depreciated asset value as the capital input quantity proxy. Obviously, in this case the choice of asset valuation method will have a much larger impact on the end productivity result.

2.2 The annual user cost of capital inputs

The annual cost of using capital inputs can be measured either directly by forming a user cost measure based on an estimated depreciation rate, a rate of return reflecting the opportunity cost of capital, a deduction for the estimated rate of capital gains (or addition for capital losses) and the asset value or indirectly as the residual of revenue less operating costs. The user cost measure used in the direct approach recognises that there has to be a return of capital over the asset's lifetime (ie the firm has to recoup its original investment) and a return on capital to compensate for holding the asset over its lifetime as opposed to using the funds for an alternative investment. Following Hotelling (1925) it is important to recognise that an asset's value will reflect both the remaining service potential of the asset and the remaining life of the asset. That is, if the asset's service potential declines over time then its value will also fall reflecting its physical deterioration. However, even for so–called 'one hoss shay' assets whose service potential remains constant over their lifetime, their asset value will progressively fall over time reflecting the fact that as each year passes they have one less year of productive life left.

The direct user cost approach to measuring the annual cost of capital inputs is also described as an ex ante approach as it specifies what producers expect to happen when making decisions at the start of the period. The indirect approach, on the other hand, is often referred to as an ex post approach as it uses the results of what actually happened during the production period. If the indirect approach is adopted then the firm's realised profitability (excluding capital gains/losses) can be determined by forming the ratio of the residual return to capital (net of estimated depreciation) to the asset value.

The traditional direct approach to measuring the annual user cost of capital in productivity studies uses the Jorgenson (1963) user cost method. This approach multiplies the value of the capital stock by the sum of the depreciation rate plus the opportunity cost rate minus the rate of capital gains (ie annual change in the asset price index). The before tax user cost, u, can be represented as follows (Diewert 1993):

$$u = \underset{\text{interest cost}}{rP} + \underset{\text{depreciation cost}}{\delta(1+\rho)P} - \underset{\text{capital gains}}{\rho P} \tag{2.1}$$

where:
- r is the nominal interest rate;
- δ is the depreciation rate;
- ρ is the inflation rate of capital items; and
- P is the purchase price of capital.

That is, capital gains resulting from an increase in the price of the asset reduce the cost of holding (and using) the asset over the year. Thus, if revenue is being set equal to total costs then it will be reduced by the extent of capital gains between two years, all else equal. In this sense, the productivity approach is somewhat analogous to the building blocks approach where 'revaluation gains' resulting from asset revaluation exercises (the equivalent of capital gains in the productivity context) are treated as income and thus reduce the return to the business from its allowable service charges.

The practical problem with this approach, however, is that if we use ex post capital gains then the user cost becomes quite volatile and, in periods of rapid asset inflation, user costs can become negative, particularly for long–lived assets which have low depreciation rates. This has led to productivity analysts smoothing the pattern of ex post capital gains in an effort to proxy ex ante expectations of capital gains which are what actually drive producers' decision making.

A further step down this path is to use a relatively constant 'real' interest rate to cover both the nominal opportunity cost rate and the expected rate of capital gains. This approach effectively credits the producer with less ability to anticipate differing rates of capital gains through time. It is this approach that was used in the Lawrence (2003) electricity lines business study where an opportunity cost rate of 8 per cent was used to cover these two terms. It should be noted that this rate effectively assumes a significant rate of capital gains as 8 per cent is the net result of the sum of the standard 10 year bond risk free rate plus the market risk premium less the rate of capital gains.

The difference between the Jorgenson (1963) user cost method and the periodic adjustment for accumulated revaluation gains, that is sometimes seen in building block regulation using periodic recalculation of the ODV, is that the productivity approach allows for capital gains annually rather than in periodic lumps that then have to be either digested all at once or else spread forward and/or back over a number of years. However, the standard productivity approach would not typically allow for 'found' assets or more detailed differentiation of operating environment conditions (eg rocky ground in gas pipeline laying) that is often seen in periodic ODV recalculations.

Having formed a quantity of capital series (by either the deflated asset value approach or the physical measure approach) and a corresponding price of annual capital input using the direct approach, it is possible to form an estimate of the firm's total costs if it was not earning excess profits. By comparing this series with the firm's actual revenue, we can see whether the firm is earning positive excess profits or, using the terminology of productivity analysis, a positive monopolistic markup (ie over and above efficient costs). To form this estimate of excess profits, however, we have to make a judgement on what the firm's true opportunity cost of capital is after allowing for risk. This would normally involve some benchmarking of realised rates of return across the industry, often across countries. In this sense the decision–making process is somewhat analogous to forming a judgement on the weighted average cost of capital (WACC) in the building block process.

2.3 The value of the capital stock

From the preceding sections it can be seen that asset values typically enter at two places in the traditional productivity framework. Firstly, when using the ex ante framework for forming input cost measures, they are used to form the user cost of capital which becomes the weight applying to the change in capital quantity when aggregating input changes to form the change in total input quantity. Secondly, in some studies the deflated, depreciated asset value is used as a proxy for the capital input quantity.

In forming the asset value for a traditional productivity study, a number of approaches can be adopted. If a sufficiently long time series of investment data is available (at least as long as the assumed asset lifetime), the perpetual inventory approach can be applied whereby investment for each 'vintage' year is taken and progressively depreciated over its lifetime. After allowing for depreciation, the remaining capital stocks from each vintage year are then aggregated to form a measure of the total capital stock in each year. This process is conducted in constant price terms where the asset price index is then typically used to bring values into current dollars. The capital stock can be in either gross or net terms. The gross capital stock does not deduct annual depreciation but removes the asset from the stock at the end of the asset's life. The net capital stock deducts depreciation annually.

If the length of investment data available is less than the assumed maximum asset lifetime then the normal practice in forming a net capital stock series is to take a point estimate of the asset value and then roll this forwards (and backwards if necessary) using constant price investment (relative to the investment price index) and an assumed (geometric) depreciation rate as follows:

(2.2)
$$S_{t+1} = (1-\delta)S_t + I_{t+1} \quad \text{for } t > t_0 \text{; and}$$
$$S_t = S_{t+1}/(1-\delta) - I_{t+1} \quad \text{for } t < t_0 \text{,}$$

where: S_{t+1} is the end of period real capital stock in period t+1;

S_t is the end of period real capital stock in the period t;

δ is the declining balance rate of economic depreciation;

I_t is constant price investment in period t; and

t_0 is the date of the asset value point estimate.

The current price asset value is then formed by multiplying the constant price series by the relevant capital goods price index.

For traditional productivity studies with a limited history of investment data available, the asset value point estimate would typically reflect the market value of assets at that point in time. It would be standard practice to take the earliest point estimate of the capital stock available, provided there was reasonable confidence in the quality of the valuation process. Existing or, in the case of energy distribution, sunk assets and new investment have traditionally been treated symmetrically. The appropriateness of this treatment in the regulatory context where there are major network sunk costs is examined in the following section.

3 CPI–X INCENTIVE REGULATION

3.1 Price cap incentive regulation

Incentive regulation has been developed over the last 30 years in response to concerns over the performance of rate of return or cost of service regulation which had previously been the norm. Vogelsang (2002, pp.5–6) observes:

> '… the leading practice of rate–of–return regulation had been severely criticized at least since the early 1960s, when the discovery of the Averch–Johnson effect (Averch and Johnson 1962) and the empirical work of Stigler and Friedland (1962) had suggested a lack of improvement over unregulated monopoly outcomes. … The resulting incentive regulation has breathed new life into the stale public utility regulation.
>
> 'What do we mean by incentive regulation? In particular, it means that the regulator delegates certain pricing decisions to the firm and that the firm can reap profit increases from cost reductions. Incentive regulation makes use of the firm's information advantage and profit motive. The regulator thus controls less behavior but rather rewards outcomes.'

Although there are a few US precursors (eg railroads in the early 1980s), CPI–X price cap regulation was developed in the UK and has become the most common form of incentive regulation. Littlechild (1983) authored an influential report proposing a CPI–X approach for British Telecom where the approach was concerned with avoiding the pitfalls of US style rate–of–return regulation.

The principal rationale advanced for CPI–X regulation is that it mimics, as much as reasonably possible, the outcomes that would be achieved in a competitive market. Competitive markets normally have a number of desirable properties. The process of competition leads to industry output prices reflecting industry unit costs, including a normal rate of return on the value of assets after allowing for risk. Because no individual firm can influence industry unit costs, each firm has a strong incentive to maximise its productivity performance to achieve lower unit costs than the rest of the industry. This will allow it to keep the benefit of new, more efficient processes that it may develop until such times as they are generally adopted by the industry. This process leads to the industry operating as efficiently as possible at any point in time and the benefits of productivity improvements being passed on to consumers relatively quickly.

Because infrastructure industries such as the provision of energy transmission and distribution networks are often subject to decreasing costs in present value terms, competition is normally limited and incentives to minimise costs and provide the cheapest and best possible quality service to users are not strong. The use of CPI–X regulation in such industries attempts to strengthen the incentive to operate efficiently by imposing similar pressures on the network operator to the process of competition. It does this by constraining the operator's output price to track the level of estimated efficient unit costs for that industry. The change in output prices is 'capped' as follows:

(3.1) $$\Delta P = \Delta W - X \pm Z$$

where Δ represents the proportional change in a variable, P is the maximum allowed output price, W is a price index taken to approximate changes in the industry's input prices, X is the estimated total factor productivity (TFP) change for the industry and Z represents relevant changes in external circumstances beyond managers' control which the regulator may wish to allow for. Ideally the index W would be a specially constructed index which weights together the prices of inputs by their shares in industry costs. However, this price information is often not readily or objectively available, particularly in regulatory regimes that have yet to fully mature. A commonly used alternative is to choose a generally available price index such as the consumer price index or GDP deflator.

However, the theory of network regulation has evolved in a relatively piecemeal way that has not adequately addressed key economic welfare issues. In the accompanying technical report we develop a more unified theory of network incentive regulation.

There are two common alternative ways of implementing price cap regulation – the buildings blocks method (BBM) and productivity–based regulation. BBM relies on forecasts of the firm's own costs and draws on financial capital maintenance (FCM) concepts to set prices so that the net present values of forecast revenues and costs over the regulatory period are equal.

Productivity–based regulation, as it has been applied to date, argues that in choosing a productivity growth rate to base X on, it is desirable that the productivity growth rate be external to the individual firm being regulated and instead reflect industry trends at a national or even international level. This way the regulated firm is given an incentive to match (or better) this productivity growth rate while having minimal opportunity to 'game' the regulator by acting strategically. The latter can be a problem with the building blocks method for setting X which relies more heavily on information on the firm's own costs and likely best practice for that firm. The logic behind the productivity–based approach is, however, based on the assumption that starting prices are set a level which just recovers total costs and so full implementation of the productivity–based approach will need to be done in conjunction with an initial partial building blocks study which quantifies the first period's total costs including the risk–adjusted cost of capital.

However, major limitations of the theory underlying productivity–based regulation developed to date have been that it has not recognised the sunk cost nature of network assets nor adequately allowed for the principle of financial capital maintenance. The sunk cost characteristic of network assets and the desirability of ensuring FCM both have important implications for how productivity analysis is used in network regulation and will be explored further in section 3.4 and the accompanying technical report.

External factors beyond management control that the regulator may wish to allow for in the Z factor include changes in government policy such as community service obligations and tax treatment.

While the CPI–X framework can provide incentives to reduce costs, it may need to be accompanied by measures to stop firms from achieving those cost reductions by reducing quality. This may take the form of an 'S' factor introduced to provide incentives to maintain or improve quality (so that the formula becomes CPI–X+S) or the setting of minimum service standards.

3.2 The building blocks method

The BBM refers to an approach where prices or revenues are regulated by calculating forward looking, allowable cost components and summing those cost components to define allowable (or maximum) revenue. The cost components are described as cost building blocks and the allowable revenue is sometimes described as ‘building blocks allowable revenue’. Allowable revenue can then be defined as the target regulatory variable (after making additional adjustments based on other objectives) or allowable revenue can be converted to an average price as the target regulatory variable.

It is important to recognise that the methodology is forward looking and that normally costs are both forward looking and defined to reflect prudent expenditure and realistically achievable operational efficiencies for the utility in question. In addition, adjustments are normally made to offset asset revaluation gains and losses. The methodology is thus designed so that on an ex ante basis investors can expect that funds prudently invested in regulated assets will be fully recouped in net present value terms (based on a discount rate that reflects the opportunity cost of the investment taking risk into account) provided actual costs are expected to be comparable to allowable efficient costs. This latter condition is generally referred to as ex ante FCM which means that there is an expectation that the value of invested capital will be maintained in real terms over the life of the investment.

Ex ante FCM is intended to be achieved as opposed to ex post FCM and investors are allowed to retain realised returns in excess of those required to achieve ex ante FCM and required to bear the costs of realised returns lower than expected over a defined regulatory period. The rationale for adopting ex ante FCM as a regulatory principle is that it is consistent with ensuring efficient investment occurs.

In appendix A we review the history and development of both BBM and its key component, FCM. Stephen Littlechild, Michael Beesley and Geoff Horton developed the building blocks approach in the UK in the early 1990s for Offer’s first reset of the value of X in the electricity sector. Ian Byatt of Ofwat used a model similar to Offer’s building blocks approach almost at the same time as its application in the electricity sector.

Implementing a building blocks control regime is a very information intensive exercise and focuses on the firm’s own costs and estimates of what its efficient costs might be. It has the potential advantage of being able to focus on the specific circumstances facing each firm, to be more forward–looking and take account of FCM. However, the analysis of what the firm’s efficient costs might be is usually subjective and non–reproducible as it depends on the views of the relevant engineering consultant. The process then often appears to be a ‘black box’. The regulator invariably faces information asymmetry relative to the firm’s managers and there is a risk the regulator can be ‘gamed’ by being mislead about the true level of efficient costs and how quickly gaps can be bridged. To reduce this risk the regulator normally takes a relatively intrusive or ‘heavy handed’ approach to setting price caps. This is, in turn, a relatively resource–intensive process and one that may be subject to ‘spurious accuracy’ whereby estimated costs are specified with a degree of precision not justified by the nature of the analysis. Applying BBM to a large number of businesses in the one regulatory review may be infeasible if the regulator's resources are relatively constrained.

Many analysts have criticised the reliance of price cap methods that rely on the firm's own costs (as BBM does). For instance, King and Maddock (1996, p.63) note:

> 'Price cap regulation was initially hailed as a radical departure from regulatory processes based on observed profits. While there are important differences between ROR [rate of return] and price cap regulation, in practice the two regimes appear to have similar consequences. However, this similarity is due to inappropriate reliance on firm costs and profits in reviewing the value of X. A review process based on yardstick comparisons and other data that is not specific to the regulated firm may offer significant advantages. If implemented correctly, price caps represent a major advance compared to traditional 'cost–based' regulation. By sensibly addressing the problem of asymmetric information, price caps can lead to substantial community benefit without distorting production.'

Challenges in obtaining appropriate estimates of efficient costs in a cost effective way are an increasing issue in the application of BBM. For instance, one of the first regulators to apply BBM in Australia, Victoria's Essential Services Commission, noted the following problems arising from its last price determination for electricity distribution (ESC 2005, pp.12–13):

- tensions in a privatised industry with monopoly characteristics between the firms seeking to maximise returns and the expectations and objectives of customers
- the clear information asymmetry and reliance on the information provided by the utility with incentives to "talk up" costs and "talk down" future sales
- the regulator's underestimation, in hindsight, of the challenges involved in relying on costs reported by the regulated business
- restructuring of EDBs including arrangements with entities with common ownership, but which are not directly covered by the regulatory regime, and the possibility that such arrangements may not be at arm's length, with the potential to inflate or obscure reported costs
- the challenges generally of obtaining transparent cost data and unravelling complex and changing cost allocations making comparisons and forecasts difficult
- the considerable difficulty obtaining information per se, with delays in some cases and others where information was withheld entirely.

Regulators in both the UK and Australia are now considering other approaches to determining the value of X in price or revenue cap regulation and are trying to find a more light–handed approach that could better incorporate incentives for efficient investment. The Australian Energy Market Commission (AEMC) is currently conducting a review into whether TFP–based regulation should be allowed as an alternative to the building blocks approach. Part 4 of the Commerce Act now also generally requires a productivity–based approach to be used as part of the setting of default price–quality paths

3.3 Traditional productivity–based regulation

The framework that underlies the traditional productivity–based CPI–X approach can be illustrated as follows. We start with the index number definition of TFP growth:

$$\begin{aligned}(3.2)\qquad \Delta\,\mathrm{TFP} &\equiv [Y^1/Y^0]/[X^1/X^0] \\ &= \{[R^1/R^0]/[P^1/P^0]\}/\{[C^1/C^0]/[W^1/W^0]\} \\ &= \{[M^1/M^0][W^1/W^0]\}/[P^1/P^0]\end{aligned}$$

where the superscripts represent different time periods, R^t (C^t) is revenue (cost) in period t, M^t is the period t markup and $R^t = M^tC^t$. As a normal return on assets (after allowing for risk) is included in the definition of costs, a firm earning normal returns will have a markup factor of one while a firm earning excess returns will have a markup of greater than one. Rearranging the above equation gives:

$$(3.3)\qquad P^1/P^0 = \{[M^1/M^0][W^1/W^0]\}/\ \Delta\,\mathrm{TFP}$$

where W^1/W^0 is the firm's input price index (which includes labour, intermediate and capital inputs where the price of capital inputs is given by equation (2.1)). Equation (3.3) is approximately equal to:

$$(3.4)\qquad \Delta P = \Delta M + \Delta W - \Delta\,\mathrm{TFP}.$$

Thus, the admissible rate of output price increase ΔP is equal to the rate of increase of input prices ΔW less the rate of TFP growth $\Delta\,\mathrm{TFP}$ provided the regulator wants to keep the monopolistic markup constant (so that $\Delta M = 0$). Equation (3.3) or its approximation (3.4) is the key equation for setting up an incentive regulation framework: the term W^1/W^0 would be an input price index of the target firm's peers and the term $\Delta\,\mathrm{TFP}$ would be the average TFP growth rate for the target firm's peers. The markup growth term could be set equal to zero under normal circumstances but if the target firm was making an inadequate return on capital due to factors beyond its control, this term could be set equal to a positive number. On the other hand, if the target firm was making monopoly profits or excessive returns, then this term could be set negative. This effectively sets a 'glide path' to bring firms closer to earning a normal or average rate of return.

The next issue to be considered in operationalising (3.4) is the choice of the price index to reflect changes in the industry's input prices, W. The most common choice for this index is the consumer price index (CPI), even though this is actually an index of output prices for the economy rather than input prices. Regulators have tended to prefer the use of relatively robust and timely official price indexes (even though this typically introduces an additional layer of measurement problems related to economy–wide variables).

Normally we can expect the economy's input price growth to exceed its output price growth by the extent of economy–wide TFP growth (since labour and capital ultimately get the benefits from productivity growth). For convenience, we assume that the markup factors for the economy as a whole are one so that the counterpart to equation (3.2) applied to the entire economy becomes:

$$(3.5)\qquad P_E^{\,1}/P_E^{\,0} = [W_E^{\,1}/W_E^{\,0}]/\ \Delta\mathrm{TFP}_E.$$

Substituting the rate of change of the CPI for the economy–wide output price index on the left hand side of (3.5) and rearranging terms leads to the following identity:

(3.6) $1 = [CPI^1/CPI^0]\ \Delta TFP_E/[W_E{}^1/W_E{}^0]$.

Substituting the right hand side of (3.6) into (3.2) produces the following equation:

(3.7) $$P^1/P^0 = \{[CPI^1/CPI^0]\Delta TFP_E\ /[W_E{}^1/W_E{}^0]\}\{[M^1/M^0][W^1/W^0]\}/\ \Delta TFP$$
$$= [CPI^1/CPI^0][\Delta TFP_E\ /\Delta TFP]\{[W^1/W^0]/[\ W_E{}^1/W_E{}^0]\}[M^1/M^0].$$

Approximating the terms in (3.7) by finite percentage changes leads to the following:

(3.8) $\Delta P = \Delta CPI + \Delta M + [\Delta W - \Delta W_E] - [\Delta TFP - \Delta TFP_E]$

so that the X factor is defined as:

(3.9) $X \equiv [\Delta TFP - \Delta TFP_E] - [\Delta W - \Delta W_E] - \Delta M$.

This is often referred to as the 'differential of a differential' X factor formula. What equation (3.9) tells us is that the X factor can effectively be decomposed into three terms. The first differential term takes the difference between the industry's TFP growth and that for the economy as a whole while the second differential term takes the difference between the firm's input prices and those for the economy as whole. Thus, taking just the first two terms, if the regulated industry has the same TFP growth as the economy as a whole and the same rate of input price increase as the economy as a whole then the X factor in this case is zero. If the regulated industry has a higher TFP growth than the economy then X is positive, all else equal, and the rate of allowed price increase for the industry will be less than the CPI. Conversely, if the regulated industry has a higher rate of input price increase than the economy as a whole then X will be negative, all else equal, and the rate of allowed price increase will be higher than the CPI. However, the input price index used needs to allow for the presence of sunk costs. As noted above, the markup growth term could be set equal to zero under normal circumstances but if the target firm was making excessive returns, then this term could be set negative (leading to a higher X factor). Conversely, if the target firm was making less than normal returns, then this term could be set positive (leading to a lower X factor).

This general approach to setting the X factor was used in New Zealand's thresholds regime for electricity distribution regulation applying from 2004 (see Lawrence 2003).

The traditional productivity–based approach uses observable information on the performance of a number of firms to set regulatory parameters. It has the advantage of being objective and transparent as it relies on observable data and a clearly specified methodology which can be readily reproduced by other analysts. It can also be implemented relatively economically for a large number of firms. It has the practical advantage that the main driver for the price cap is the CPI which is a relatively robustly measured by statistical agencies. If the input prices changes for the industry are relatively close to those for the economy as a whole and TFP growth for the industry is relatively close to that for the economy as a whole, the last two difference terms in (3.8) will be small numbers and so the main driver of the price cap is change in the CPI. This contrasts with (3.4) where the main drivers for the price cap are the terms industry input price growth rate and the industry TFP growth rate alone, both of which may be difficult to measure with subsequently increased scope for argument. It has the potential disadvantage that it may not be able to take adequate account of firm–specific circumstances.

It can thus be seen that there are a number of broad similarities between the traditional productivity analysis approach and the building blocks approach to determining regulated firm costs and revenues. For instance, the building blocks approach treats revaluation gains as income while the productivity analysis also typically treats capital gains as income (although these may be smoothed to varying degrees). However, there are some important differences. The traditional productivity approach typically rolls the asset base forward using the asset price index rather than the general inflation rate. While the concept of financial capital maintenance (FCM) has received some consideration in productivity analysis, this has typically been in the context of the definition of income in macro level studies (see Diewert 2008). The concept of FCM needs to be integrated with productivity analysis at the firm level if we are to reconcile productivity analysis and building blocks regulation satisfactorily.

While the productivity–based approach to regulation incorporates allowance for adjustment for excess profits (in the form of the M or monopolistic markup factor), there is currently no accepted theoretical structure around this term or how it should be calculated. And existing productivity analysis has not addressed the issue of how to treat sunk costs. Sunk assets are assumed to be interchangeable with new investment and the framework is, in many ways, more consistent with perfect contestability than one where sunk costs are present. In particular, little work has been done to integrate the concept of FCM into productivity analysis at the regulated firm level and to assess the implications of this for the treatment of sunk costs and the calculation of excess returns.

One of the key articles addressing the link between productivity analysis and regulation and the role of non–marginal cost pricing – Denny, Fuss and Waverman (1981)[1] – was written before price cap regulation was introduced and concentrated on telecommunications where sunk costs are likely to be less of an issue than in energy networks. It is thus an opportune time to update and extend this analysis to address the issues currently confronting regulators.

3.4 Productivity–based regulation in the presence of sunk costs

The traditional analysis presented in section 3.3 assumed that capital inputs were not sunk cost inputs; ie capital inputs could be sold as second hand goods in the marketplace at the end of each period and hence the usual user cost of capital given by equation (2.1) could be used as the price for a capital input. However, in many regulated network industries, substantial components of the capital stock in use have the nature of sunk costs; ie once the investment is made, the firm is stuck with the associated bundle of capital services until the assets are completely worn out so that they have no resale value on second hand markets. The usual user cost methodology is thus not applicable in this context. The existence of sunk cost assets greatly complicates the regulator's responsibilities and changes the nature of some key regulatory theory findings.

[1] Denny, Fuss and Waverman (1981) show how the productivity index can be decomposed into effects due to departures from marginal cost pricing, nonconstant returns to scale, technical change, and effective rate–of–return regulation.

In the accompanying technical report we develop the theory of regulation in the presence of sunk costs. Most previous regulatory theory contributions have relied on partial equilibrium models that only model aspects of the industry in question and not the interactions between that industry, consumers and factors of production and have ignored the sunk cost nature of network investments. For example, in the seminal paper by Bernstein and Sappington (1999), their objective was to define a regulatory regime which would lead to the smallest possible rate of proportional growth in the prices of regulated products, while maintaining the solvency of the regulated firm. While this seems likely to be a welfare enhancing activity, we have no way of answering this question using their partial equilibrium methodology.

To provide rigorous guidance to regulators on the courses of action that will enhance economic welfare we need to move beyond partial equilibrium analysis to general equilibrium analysis. This approach inevitably involves the use of more demanding mathematical analysis but provides a much higher level of rigour. In the accompanying technical report we embed the regulated firm in a small general equilibrium model of an open economy where the role of the regulator in the model is to improve the welfare of households in the economy. In this section we will not attempt to summarise the extensive and complicated mathematical analysis presented in the appendix. Rather, we will concentrate on the key findings of the analysis.

Starting with a relatively simple general equilibrium model, we are able to verify some key regulatory theory findings including that to improve economic welfare regulators need to move regulated prices closer to their corresponding marginal costs and provide incentives for the regulated firm to improve its productivity performance.

Introducing sunk costs means that we can no longer use the standard user cost equation (2.1) and the total cost function in deriving parameters for optimal regulation. Rather, it is necessary to use operating expenditure (opex) cost functions for the regulated firm[2]. An opex cost function minimises the variable input costs associated with producing an output target, conditional on the availability of a fixed quantity of capital stock components. In other words, we need to recognise that the firm's relevant decision making options each period are to alter its level of opex given the quantity of sunk investments it has that period. It can opt to change the level of sunk investments gradually over time by undertaking additional investment or allowing the existing stock to run down but it cannot treat capital stocks as freely variable from period to period as has been the implication of past theory developed in this area.

Instead of the equation (2.1) user cost playing a key role, we now have a user benefit defined as the negative of the partial derivative of the opex cost function with respect to the sunk cost capital stock playing an analogous role. Put another way, the user benefit is the marginal saving in opex that could be obtained by increasing sunk capital by one unit while holding

[2] The term opex or variable cost is used here to refer to all non–capital costs. This includes operating expenditure whose benefits are confined to the current period and routine maintenance associated with original anticipated asset lifetimes. Items such as refurbishment and remedial action which extend asset lives should be treated as capital expenditure and not as opex, ie they should be capitalised and expensed over the subsequent periods they give a benefit for.

output constant. The (discounted) sum of these anticipated user benefit terms is set equal to the purchase price of the capital input. These partial derivatives of the opex cost functions are generally not directly observed and so must be estimated, either using econometric techniques or accounting cost allocation methods.

More generally, the full model of optimal regulation developed requires too much information for the regulator to be able to implement it in its entirety. In addition to information on the partial derivatives of the period by period opex cost functions with respect to sunk cost capital stock components, we would also require information on the partial derivatives of the period by period opex cost functions with respect to regulated outputs (ie marginal opex costs) and consumer intertemporal substitution matrices between regulated and unregulated products.

Since the information required to implement optimal regulation is difficult to obtain, simpler methods of regulation that are not fully optimal, like price cap regulation, will have to be used in practice. Fortunately, price cap regulation can be modified to accommodate both sunk costs and financial capital maintenance.

We now look at second best regulatory solutions which are less informationally demanding, starting with a simple method of price cap regulation for a single firm that relies on information on that firm only.

3.4.1 Price cap regulation of a single firm

The approach we take in the accompanying technical report involves obtaining an expression for the rate of change of the regulated firm's excess profits, $\Pi'(t)$, which has a term involving the rate of change of prices for regulated outputs[3], $p'(t)$. For simplicity, we initially move all of these prices in a proportional manner and determine this rate of proportional movement by setting $\Pi'(t)$ equal to a target rate of change which determines the price cap for the following period.

We derive a simple price cap formula which involves a price index and quantity for opex (or variable inputs), a price index for the amortisation amounts allowed by the regulator for sunk cost capital stock components and the quantity of sunk cost capital, a measure of the anticipated rate of opex technical progress in the regulated sector, another measure involving the deviations of regulated prices from their corresponding opex marginal costs and a final measure involving the deviations of the allowed amortisation amounts for sunk cost capital stock components from their corresponding marginal user benefits. The last two measures will be difficult for the regulator to estimate numerically.

The full formula for the price cap or allowable rate of increase in regulated prices, $\alpha'(t)$, is as follows:

$$(3.10)\ \alpha'(t) = \beta + \{w'(t)\cdot z(t) + P_k'(t)\cdot k(t) - \tau(t)C_z(t) - [p(t)-\mu(t)]\cdot y'(t) - [P_k(t)-\pi(t)]\cdot k'(t)\}/R(t).$$

where β is a scalar relating to the desired rate of change of excess profits, w is the opex price, z is the opex quantity, P_k is the per unit amortisation charge for sunk cost capital allowed by

[3] The notation adopted is f′(t) is the derivative of the function f with respect to time which is its rate of growth.

the regulator, k is the quantity of sunk cost capital, τ is the rate of technical progress for opex inputs, C_z is the cost of opex inputs, μ is marginal cost, y is the output quantity, π is the marginal user benefit of sunk cost capital, R is revenue and t refers to time.

We can simplify (3.10) by neglecting the last two terms[4] and assuming that excess profits are currently close to zero and the regulator wants to keep them close to zero (so that β=0). By using the Divisia index method we can further simplify the price cap formula to arrive at the following:

(3.11) $\alpha'(t) = [C_z(t)/R(t)]w_D'(t) + [C_k(t)/R(t)]P_{kD}'(t) - [C_z(t)/R(t)]\tau(t)$

where the subscript D refers to a Divisia index of the relevant variable.

Thus, if excess profits are close to zero, implementation of the price cap can be simplified to the sum of the rate of opex price change weighted by the share of opex costs in revenue and the change in approved amortisation charges weighted by the share of amortisation charges in revenue less the rate of technical progress for opex weighted by the opex share in revenue.

This is broadly equivalent to the output price cap being an index of input prices less the rate of technical change (or IPI–X). However, note that in this case we have to focus on technical change applying to opex inputs and weight this by the share of opex in total revenue in recognition of the sunk cost nature of capital inputs. The other major difference between the price cap in (3.11) and traditional price cap formulae is that allowed per unit amortisation charges replace the capital goods price index in the price cap formula when there are sunk costs. This is because the conventional user cost formula in (2.1) cannot be applied to sunk costs because there is no fluid second–hand market where these assets are freely traded.

The price cap formula (3.11) is simple enough to be implementable provided that the regulator can make forecasts for the overall rate of increase in variable input prices and for the anticipated rate of opex technical progress. Note that the regulator will be able to construct an index of allowable amortisation charges since the regulator determines these allowable charges. Typically, forecasts for opex technical progress would be made on the basis of past rates of opex technical progress in the industry. However, there is no guarantee that future rates of opex technical progress will mirror past rates. Note also that formula (3.11) requires estimates of future opex technical progress rather than either total or opex partial factor productivity.

While formula (3.11) is implementable, it needs to be borne in mind that it is only a rough approximation to the full price cap formula in (3.10) because it assumes excess profits are close to zero and it ignores the deviation of output prices from marginal costs and of allowed amortisation charges from marginal user benefits.

3.4.2 Price cap regulation of a single firm using productivity estimates and the CPI

As noted in section 3.3, most applications of price cap regulation use productivity estimates

[4] With increasing returns to scale in the regulated sector, we would expect the components of $p(t)-\mu(t)$ to be predominantly positive (ie prices exceed marginal costs) and with growth in the economy, we would also expect the components of $y'(t)$ to be positive and, thus, the term $-[p(t)-\mu(t)]\cdot y'(t)$ is likely to be negative. The last term is likely to be small since fixed capital stock components k(t) are likely to remain roughly constant and hence $k'(t)$ is likely to be small.

rather than estimates of the rate of technical change in determining the X factor and use the CPI rather than an index of the firm's input prices.

TFP growth of the regulated firm, $T'(t)$, is traditionally defined as an index of output growth minus an index of input growth. Input growth is defined to be a share weighted sum of the indexes of variable input and sunk cost capital services input indexes using (observable) amortisation prices as weights so that TFP growth is:

(3.12) $T'(t) \equiv y_D'(t) - s_z(t)z_D'(t) - s_k(t)k_D'(t)$

where y_D is an output index formed using revenue weights and the input cost share weights, $s_z(t)$ and $s_k(t)$, are the shares of opex and allowable amortisation charges in total cost, respectively.

In their seminal article on price cap regulation, Bernstein and Sappington (1999) showed that if excess profits were zero and the regulator wished to keep them at zero then the price cap for the regulated firm simplifies to:

(3.13) $\alpha'(t) = s_z(t)w_D'(t) + s_k(t)P_{kD}'(t) - T'(t)$.

This is the well known result that the price cap should equal an index of the growth in input prices less an index of the growth in TFP (broadly equivalent to equation 3.4 above and analogous to equation 3.11 which used technical change rather than TFP).

However, as we show in the accompanying technical report, where excess profits are not zero, the price cap formula using TFP becomes more complicated and is given by:

(3.14) $\alpha'(t) = [C(t)/R(t)]\{s_z(t)w_D'(t) + s_k(t)P_{kD}'(t) - T'(t)\} + [\Pi'(t)/R(t)] - [\Pi(t)/R(t)]y_D'(t)$.

Equation (3.14) recognises that if excess profits are non–zero then total revenue will not equal total cost and this has to be allowed for in setting the price cap.

Extrapolations of past TFP growth are often used as a proxy for future technical change but TFP growth in the context of a regulated firm is far from being identical to technical progress. In fact, conventional TFP growth depends not only on technical progress but also on variables that are controlled by the regulator including profits, the selling prices of regulated products and allowable amortisation charges.

More generally, where there are non–zero excess profits and sunk costs then TFP growth may not be a good proxy for technical change. The relationship between TFP and opex technical change – the measure required for price cap regulation in the presence of sunk costs – is as follows:

(3.15) $T'(t) = \tau(t)s_z(t) + [p(t)-\mu(t)]\cdot y'(t)/C(t) + [P_k(t)-\pi(t)]\cdot k'(t)/C(t) - [\Pi(t)/C(t)]y_D'(t)$

The first term on the right hand side of (3.15) shows that opex technical progress is definitely a contributor to the rate of TFP growth, $T'(t)$. But the remaining terms on the right hand side of (3.15) show that TFP growth encompasses more than just technical progress. The term $[p(t)-\mu(t)]\cdot y'(t)/C(t)$ depends on the deviations of the output prices $p(t)$ from the corresponding marginal costs $\mu(t)$ and these interact with output growth rates, $y'(t)$. Similarly, the term $[P_k(t)-\pi(t)]\cdot k'(t)/C(t)$ depends on the deviations of the allowed amortisation charges $P_k(t)$ from the corresponding marginal user benefits $\pi(t)$ and these interact with capital stock growth rates, $k'(t)$. It will be difficult to project past contributions to TFP growth that are due to these terms into the future. Thus, measured TFP growth is a rather complex concept in terms of its explanatory factors. Since the regulator controls p(t) (the vector of regulated prices), $P_k(t)$ (the vector of regulator approved amortisation charges for sunk capital stock components) and Π(t) (the profits of the regulated firm that are in excess of the regulated firm's cost of capital), measured TFP growth will not be a 'pure' measure of technical progress – it will be a blend of technical progress and improvements in managerial efficiency and other factors which are heavily influenced by the regulator.

In the case of a single firm, the regulator can look at past TFP growth for that firm and make a judgement about whether it can be sustained and the regulator can then set an appropriate price cap using formula (3.13) or the more accurate formula (3.14). The factors beyond the firm's control in equation (3.15) which relate TFP growth for a single firm to technical progress are likely to remain relatively constant for a single firm. These factors relate to differences between prices and marginal costs and differences between allowable amortisation charges and marginal user benefits of sunk cost capital. If they are not constant then, in the case of a single firm, the regulator can make adjustments to the price cap to take this into account. As will be seen in the following section, more problems arise with the use of the TFP proxy for technical change where multiple firms are being regulated.

As noted in section 3.3, regulators often use the CPI as the inflation measure in price cap setting rather than a direct estimate of the firm's input prices. Where CPI–X regulation is used and there are sunk costs, the X factor involves the difference between the firm's TFP growth weighted by its costs relative to its revenue and the economy–wide TFP growth rate plus the difference between economy–wide input price change and the sum of the firm's opex price growth and allowed amortisation charges growth each weighted by the respective shares of their cost in revenue plus a nonzero profits adjustment term less a rate of change in regulated profits term. As explained in detail in the accompanying technical report, the equivalent to the price cap formula (3.8) becomes the following:

$$\begin{aligned}(3.16)\ \alpha'(t) &= P_E'(t) + \{[C(t)/R(t)](s_z(t)w_D'(t) + s_k(t)P_{kD}'(t)) - W_E'(t)\} \\ &\quad - \{[C(t)/R(t)]T'(t) - T_E'(t)\} + [\Pi'(t)/R(t)] - [\Pi(t)/R(t)]y_D'(t) \\ &= P_E'(t) - X(t) \\ &= CPI(t) - X(t)\end{aligned}$$

where the subscript E denotes an economy–wide variable, $P_E'(t)$ is the change in economy–wide output prices (often approximated by the CPI), $W_E'(t)$ is the change in economy–wide input prices and $T_E'(t)$ is economy–wide TFP growth. Equation (3.16) is thus the sunk costs counterpart to the traditional 'CPI minus X Factor' regulatory price cap formula and the X factor equivalent to the 'differential of a differential' formula (3.9) becomes:

$$\begin{aligned}(3.17)\ X(t) &\equiv \{[C(t)/R(t)]T'(t) - T_E'(t)\} + \{W_D'(t) - [C(t)/R(t)](s_z(t)w_D'(t) + s_k(t)P_{kD}'(t))\} \\ &\quad + [\Pi(t)/R(t)]y_D'(t) - \Pi'(t)/R(t) \\ &= \text{TFP differential growth rate term} + \text{input price differential growth rate term} \\ &\quad + \text{nonzero profits adjustment term} - \text{rate of change of regulated profits term.}\end{aligned}$$

The first term in (3.17) is the differential rate of TFP growth between the regulated firm,

$T'(t)$, and the rest of the economy, $T_E'(t)$, at time t. However, the TFP growth rate of the regulated firm must be weighted by the ratio of the regulated firm's costs (including its cost of capital), $C(t)$, to its revenues, $R(t)$. The second term is the differential rate of growth of input prices in the rest of the economy, $W_D'(t)$, less $C(t)/R(t)$ times a share weighted rate of the growth of opex input prices for the regulated firm, $w_D'(t)$, and the rate of growth of allowable amortisation charges for sunk cost capital inputs, $P_{kD}'(t)$. Total cost for the regulated firm, $C(t)$, is defined as the sum of variable input costs, $C_z(t)$, plus allowable amortisation costs, $C_k(t)$, for sunk cost capital inputs. The regulated firm input cost shares which appear in the input price differential term, $s_z(t)$ and $s_k(t)$, are defined as the ratio of variable cost to total cost and the ratio of allowable amortisation costs to total cost, respectively.

The last two terms on the right hand side of (3.17) involve the level of excess profits of the regulated firm, $\Pi(t)$, and the rate of change of excess profits, $\Pi'(t)$. These two terms are also present in the simpler price cap formula (3.14) (which did not involve the rest of the economy). If the excess profits of the regulated firm are not close to zero, then if excess profits were markedly positive, the regulator will likely want to set $\Pi'(t)$ equal to a negative number in order to reduce these excess profits over time. On the other hand, if excess profits were substantially negative, then the regulator will likely want to set $\Pi'(t)$ equal to a positive number in order to maintain the financial viability of the regulated firm. Thus, when excess profits are substantially different from zero, the regulator will typically want to set a glide path for profitability so that either profits in excess of what is required to raise capital in the industry are eliminated or, in the case of negative profits, a glide path must be set to restore the long term solvency of the regulated firm. In the case where excess profits are positive, typically the regulator will set $\Pi'(t)$ in the price cap formula (3.16) equal to a negative number, which will cause the proportional change in regulated prices, $\alpha'(t)$, to become smaller, ie under these conditions, the price cap will become more stringent.

There are a number of differences between the traditional 'differential of a differential' X factor formula (3.9) which does not allow for sunk costs and the X factor formula (3.17) which allows for sunk costs. The main difference is the replacement of the Jorgenson user cost of capital (which incorporates the capital price index) by the regulator–allowed per unit capital amortisation charge when calculating input prices for the regulated firm. Other differences are adjusting the regulated firm's productivity and input prices by the ratio of costs to revenue and the inclusion of more structured change in 'monopolistic markup' terms in (3.17).

We turn now to look at the complications introduced by regulating several firms using a common X factor.

3.4.3 Price cap regulation of multiple firms using a common X factor

The approaches to the derivation of price cap formulae discussed in this section up till now have concentrated on the case where only a single firm is being regulated. In the case of a single firm it is less critical whether we use a price cap formula involving the rate of opex technical progress or the rate of TFP growth – as discussed above, the factors included in TFP other than opex technical change are likely to remain relatively constant for a single firm or else changes can relatively easily be adjusted for. However, when regulation involves several firms and past average rates of technical progress or of TFP growth are used in price caps going forward, then the measurement of these rates becomes critical. In particular, the use of average TFP growth rates across a number of regulated firms can create an uneven playing field since the ingredients which go into TFP growth as shown in formula (3.15) can contain terms which are beyond the control of the regulated firm.

As shown in equation (3.15) TFP growth for a single firm depends not only on the firm's rate of technological improvement (which is presumably an industry wide effect) but it also depends on the firm excess profits and factors which are largely beyond its control, namely the gaps between the regulated prices that the firm faces and its corresponding marginal costs and the gaps between the allowable amortisation costs for sunk cost capital stock components and the corresponding marginal user benefits of sunk capital. Thus, while basing a price cap on a forecast of future industry wide rates of technological progress (ie using equation (3.10) or the simplified (3.11)) seems appropriate, caution will be required in basing a price cap on a forecast of future industry wide rates of TFP growth for all of the regulated firms. This is because there will generally be substantial differences in the last three factors on the right hand side of (3.15) across the firms – namely, the extent to which prices exceed marginal costs, the extent to which allowed amortisation charges differ from user benefits for sunk capital and excess profits. If there are differences in these three factors across the individual firms then application of a 'one size fits all' rate of TFP growth may not be appropriate.

The single firm focus has also allowed us to abstract from operating environment factors beyond the control of the firm that may impact a group of regulated firms differently and affect their past and future productivity performances. Adverse operating environment conditions are likely to limit opportunities for future productivity growth as well as resulting in higher costs and lower productivity levels. For example, if the group being regulated are electricity distribution businesses and some distribution businesses are located in areas of high storm activity while others are not, the distribution businesses in the bad weather areas will generally face higher operating costs and fewer opportunities for productivity improvements than distribution businesses in good weather areas. Thus, when regulating groups of firms using a single TFP or technical progress target across firms in a price cap regime, the regulator should ideally either group the regulated firms into peer groups who face roughly similar operating environments or adjust the price caps for each firm (or groups of firms) according to differences in operating environments.

If a common rate of productivity growth is to be used in setting the price cap when regulating a group of firms using productivity–based regulation, then output specification becomes critical since different output concepts can lead to very different estimates of both technical progress and TFP growth. The output concept used is less critical when regulating a single firm – the price cap will by definition not discriminate against a single firm. But in the context of using TFP growth rates in a group setting, it is extremely important to have the right definition for the outputs of the regulated firms so that the price cap can be applied to the firms in the group in an even–handed way. In particular, it is necessary to move beyond the use of TFP measures based on revenue weighted outputs. Rather, it is necessary for the output measure to capture as fully as possible what regulated services are being provided by the firms in the group, independently of the institutional and historical factors that determine how the firms happen to charge consumers. As well as it being necessary to use comprehensive measures of output in this instance, it will also be necessary to use output cost share weights rather than revenue weights in forming the productivity measure.

In the accompanying technical report we illustrate how it is important in measuring TFP growth for the regulation of multiple network businesses to use an output measure that captures the system capacity provided as well as elements of peak demand and throughput. This is consistent with the approach to productivity measurement used in the New Zealand EDB thresholds regime (see Lawrence 2003).

3.4.4 Productivity–based regulation and financial capital maintenance

As noted in section 3.2, an important element of building blocks regulation has been the use of ex ante FCM in setting the price cap. The rationale for adopting ex ante FCM as a regulatory principle is that it is consistent with ensuring efficient investment occurs as there can be an expectation that the value of invested capital will be maintained in real terms over the life of the investment.

Most previous productivity studies have indexed the capital stock by the capital goods price index rather than the CPI and have used the Jorgenson user cost formula from equation (2.1) in calculating the annual cost of using capital inputs. As such, this approach has been more consistent with the criterion of operational capability maintenance (although it can be consistent with FCM if the right opportunity cost of capital is used and the depreciation allowances add up to the original investment value, as demonstrated in the accompanying technical report). Under operational capability maintenance the emphasis is on being able to maintain the capacity of the asset to contribute to the production process rather than on maintaining the value of invested capital in real terms.

In the accompanying technical report we demonstrate that in the presence of sunk costs the Jorgenson user cost no longer applies because sunk assets, by definition, cannot be freely traded in a second–hand market. Rather, the appropriate annual cost of capital inputs becomes the series of amortisation charges for the capital good approved by the regulator. These approved amortisation charges should ideally be the marginal user benefits from the sunk capital (ie the opex savings from an increase in sunk capital while holding output constant). They can be readily structured to achieve FCM.

A range of asset valuation methodologies can be consistent with financial capital maintenance, provided that the allowed cost of capital interest rates are equal to the firm's opportunity cost of financial capital. Each methodology will generate a time–series of asset values and the series of amortisation charges are used to ensure financial capital maintenance is achieved. The main difference between asset valuation methods is on the timing of revenue receipts rather than their net present value. The important requirements are that the amount actually invested is the opening asset value in the first period and the scrap value is the closing asset value in the last period. Efficiency considerations would further suggest the amount actually invested should have been an efficient amount.

4 ASSESSING THE ALTERNATIVE ASSET VALUATION METHODS FOR PRODUCTIVITY–BASED REGULATION

4.1 Introduction

As noted in sections 2 and 3, asset valuation plays an important role in productivity analysis and the implementation of productivity–based regulation. In productivity analysis the asset valuation method will affect the weighting of opex and capital in forming the total inputs index and, if the constant price depreciated asset value proxy for capital input quantity is used, the capital input quantity itself. In the implementation of productivity–based regulation the asset valuation method will affect the derived rate of industry productivity change, the input price differential and the identification of excess returns in setting the X factor (see equations 3.9 and 3.17).

It is worth noting that alternative approaches to asset valuation and capital measurement in the implementation of productivity–based regulation, and incentive regulation more generally, have long been under–researched as highlighted by Joskow (2005, pp. 81–2):

> ‘Price cap mechanisms are the most popular form of incentive regulation used around the world, in part because this mechanism has been heavily advertised as being a simple alternative to cost of service regulation. There is a lot of loose and misleading talk about the application of price caps in practice. … They are not so simple to implement because defining the relevant capital and operating costs and associated benchmarks is challenging. … Effective implementation of a good price cap mechanism with periodic ratchets requires many of the same types of accounting, auditing, capital service, and cost of capital measurement protocols as does cost of service regulation. *Capital cost accounting and investment issues have received embarrassingly little attention in both the theoretical literature and applied work on price caps and related incentive mechanisms*, especially the work related to benchmarking applied to the construction of price cap mechanisms. Proceeding with price caps without this regulatory information infrastructure and an understanding of benchmarking and the treatment of capital costs … can lead to serious performance problems.’ (emphasis added)

This section presents relevant criteria for assessing alternative asset valuation methodologies in the context of productivity–based regulation and then assesses the three main asset valuation methods we have been asked to review: optimised deprival value (ODV), depreciated historic cost (DHC) and indexed (for inflation) depreciated historic cost (IHC).

4.2 Criteria for assessing asset valuation methodologies used in productivity–based regulation

As highlighted in the project’s terms of reference, in this report we assume that ex ante financial capital maintenance (FCM) will be adopted as a key regulatory principle. This is an important part of ensuring there is dynamic efficiency and adequate incentives for efficient investment. One of our preferred principles for selecting asset valuation methods is, thus, that the method used should be effective in allowing NPV=0 to be implemented on an ex ante basis, which is equivalent to supporting the implementation of ex ante FCM.

As well as supporting the economic efficiency goals identified in Section 52A of the Commerce Amendment Act 2008, the use of FCM is also an important aspect of identifying excess returns and, hence, limiting producers' ability to extract excessive profits (as also identified in Section 52A of the Act). The asset valuation method used should, thus, be consistent with the setting of default productivity–based price paths that limit the ability to extract excessive profits.

There is also a range of economic efficiency considerations that are not captured by the simple FCM rule and which need to be considered along with other regulatory and practical considerations. For example, the implications of the different methods for the time profile of prices need to be considered. As formally demonstrated in the accompanying technical report, a range of asset valuation methodologies can be consistent with FCM, including the three methods reviewed here. Consistency with FCM requires an appropriate time profile of amortisation charges so the main difference between the asset valuation methods is likely to be on the timing of revenue receipts rather than their net present value. However, the time profile of amortisation charges impacts on the time profile of prices and will, hence, have intertemporal economic efficiency effects.

Although analytical separation of the valuation of assets and the time profile of charges is possible, in practice each method will imply different price profiles unless major adjustments are made to standard conventions for estimating regulatory depreciation (such as straight–line). So, in practice, the choice of asset valuation method will also depend on a range of intertemporal economic efficiency effects when the different methods are implemented using common regulatory depreciation profiles (such as straight–line) and practices. For this reason, the main intertemporal economic efficiency considerations implied by each asset valuation method when standard conventions with respect to allowable depreciation are adopted are also considered in the following assessments.

The relevant criteria for assessing asset valuation methodologies in the context of productivity analysis and productivity–based regulation are as follows:

1. **Supports economic efficiency.** The asset valuation methodology used in productivity analysis and productivity–based regulation should support outcomes that are dynamically, productively and allocatively efficient as required by Section 52A of the Commerce Amendment Act 2008.

2. **Facilitates FCM for prudent investment.** The asset valuation methodology should be effective in avoiding excess profits on an ex ante basis which is equivalent to allowing ex ante FCM.

3. **Cost effectiveness.** The asset valuation methodology used in productivity analysis should not be unduly costly and should draw on available information as much as possible.

4. **Consistency and accuracy.** The asset valuation methodology should be consistent and accurate to the maximum extent appropriate for the circumstances.

5. **Transparency.** The asset valuation methodology used in productivity analysis should be readily understood and be capable of being independently replicated with minimal need for judgemental assessments.

6. **Enables ready conversion of asset values from current to constant prices and vice–versa.** This principle is relevant for facilitating measurement of capital input prices and quantities in productivity analysis.

We turn now to assessments of the three specified asset valuation methods against these criteria in the context of productivity analysis and the implementation of productivity–based regulation.

4.3 Optimised deprival value

Optimised deprival value is a methodology that determines an asset value based on value–to–the owner rules. The origins of the concept as applied to publicly owned or regulated businesses can be traced to the Sandilands (1975) and Byatt (1986) reports in the United Kingdom (Hay and Morris 1993, pp.430–2).

As noted by the Commerce Commission (2004, p.12) ODV was designed to produce valuations for network assets consistent with contestable market outcomes and was first specified in a regulatory context in New Zealand for the valuation of the fixed assets of Transpower. However, it was first used as a regulatory valuation method for lines businesses on the basis that historical book values were considered to be unreliable or unavailable and there was a need for a common methodology for benchmarking purposes. Further, the Commerce Commission (2004, p.12) noted that ODV–based valuations were not required to be used for deriving line charges but they, in some cases, formed the basis for determining 'excess returns'.

Definition

ODV as applied by the Commerce Commission in relation to network assets in New Zealand is defined as the minimum of optimised depreciated replacement cost (ODRC) and economic value (EV):

(4.1) ODV = min [ODRC, EV].

The ODRC is defined as the depreciated cost of replicating the system using modern equivalent asset (MEA) values in the most efficient way possible from an engineering perspective, given the network's service capability, with depreciation based on the age of the existing assets (Commerce Commission 2004, p.13). As implemented in New Zealand, the optimal network is restricted to the existing network configuration (Commerce Commission 2008a, para.225).

The EV of any network segment is defined as the maximum of the net realisable value (NRV) of the segment and the present value of the notional after–tax cash flows that would be attributable to that segment (limited by the cost of alternatives, and net of any initial investment in working capital and fixed assets other than system fixed assets associated with the segment). Note that an issue in defining the EV is defining cash flows to determine the present value, as typically in a regulatory context these depend on regulated prices which in turn depend on allowable asset values and allowable returns thus entailing a fundamental circularity problem. However, this circularity problem was resolved for lines businesses by defining maximum prescribed tariff rates for calculating EV.

The optimised depreciated replacement cost (ODRC) method received considerable support in Australia and New Zealand as publicly owned business enterprises where being reformed through a process of corporatisation and, in some cases, privatisation in the late 1980s and through the 1990s. In Australia the approach is described as depreciated optimised replacement cost (DORC).

However, the approach is based on some strict theoretical assumptions and in practice allows considerable discretion in arriving at an asset value for regulated networks. The rationale for adopting ODRC from an economic efficiency perspective and problems in implementation are reviewed below before we assess ODV explicitly in terms of the relevant criteria for productivity analysis and productivity–based regulation.

The hypothetical efficient new entrant benchmark

The Commerce Commission (2004, p. 27) notes that the ODV method assumes a hypothetical operating environment where the relevant market is contestable and there are no material barriers to entry into that market by an alternative service provider or efficient new entrant. This assumption clearly applies to the ODRC part of ODV but does not strictly apply to the EV component where maximum prescribed tariffs are used to determine the EV and those tariffs are not directly reflective of the costs of an efficient new entrant. In practice, most New Zealand energy network ODVs rest on the ODRC rather than the EV component.

The hypothetical new entrant benchmark refers to a methodology for determining allowable costs for the purpose of regulating prices based on the costs a hypothetical efficient new entrant would face in providing the regulated service. Some regulatory authorities have argued that the approach is justified as it is a relevant application of the theory of contestable markets in the valuation of assets. The idea is that a valuation of assets based on an estimate of forward looking efficient capital costs to serve the regulated market will justify a price for the regulated services at which a new entrant would have the incentive to compete for the provision of the regulated services at the regulated price.

For example, the ACCC (1998) said:

> ‘A return on replacement cost is the maximum that a monopoly firm could earn in a perfectly contestable market.’

The ACCC (1999, p.39) also provided the following argument in the context of formulating principles to support the depreciated optimised replacement cost (DORC) methodology for the valuation of assets for electricity transmission:

> ‘One interpretation of DORC is that it is the valuation methodology that would be consistent with the price charged by an efficient new entrant into an industry, and so it is consistent with the price that would prevail in long run equilibrium.

> 'The second interpretation is that it is the price that a firm with a certain service requirement would pay for existing assets in preference to replicating the assets.'

The hypothetical efficient new entrant benchmark has also been used in New Zealand, in initially justifying the appropriate valuation methodology for Transpower and subsequently in the Commerce Commission's (2008a, para.219) ODV Handbook for electricity lines businesses.

The approach has also been advocated based on an appeal to the economic theory underlying Tobin's Q (Brainard and Tobin 1968 and Tobin 1969). Tobin's Q is simply the market value of a firm relative to minimum depreciated replacement cost and in long run equilibrium in a competitive market Q should have a value of one. Where Q was in excess of one the theory was that firms would have an incentive to enter or existing firms to expand until, in a long run competitive equilibrium, Q would be driven to one. The Office of the Regulator General in Victoria (1998, p.5) used the theory underlying Tobin's Q to justify the use of a DORC approach to asset valuation. However, the theory of Tobin's Q is not so much a precursor to the more formal contestability theory developed by Baumol et al (1988) but rather an approach used in macroeconomics and financial theory in identifying determinants of investment. In addition, Tobin's Q is a marginal concept relating to incremental decisions rather than a valuation methodology.

In the United Kingdom the 'Byatt report' (Byatt 1986, Vol II, pp.98–99) argued that the theory of contestable markets provided a unifying rationale for current cost accounting and what a new producer would have to pay to enter the market, including for assets that once invested are effectively sunk costs. However, as explained by Hay and Morris (1993, p.432), the relevance of the approach depends on the extent to which a contestable markets framework is relevant. When assets are effectively sunk so that their use is tied to a specific purpose in the regulated market and they are an important part of the cost structure then the 'hit and run' entry that is a defining characteristic of contestable market theory is not a valid assumption and the contestable markets theory is not a relevant theory for supporting asset valuation from an economic efficiency perspective.

The valuation of assets based on a hypothetical new entrant's efficient capital costs is also rationalised by interpreting such costs as relevant opportunity costs. However, where assets are sunk their opportunity cost (in another use) from the perspective of both the owner and society is zero.

The Hypothetical Efficient New Entrant Test and economic efficiency in network industries

The main economic efficiency rationale that is advanced to support the hypothetical new entrant test is the economic theory of contestable markets. In determining the relevance of the theory of contestable markets in establishing an approach to asset valuation in productivity analysis and productivity–based regulation it is important to assess the relevance of the underlying assumptions of contestability theory which are (Commerce Commission 2008a, footnote 114, based on Baumol et al 1988):

- entry is completely free and exit is costless, which requires that entry must not require the firm to make any 'sunk' investments;

- entrants and incumbents compete on completely ‘symmetric’ terms (ie on a ‘level playing field’), and
- entry is not impeded by fear of retaliatory price changes.

As explained by the Commerce Commission (2008a, para.D.49–D.73) the existence of sunk costs violates all the underlying assumptions of a perfectly contestable market. Entry is far from free because there are significant sunk costs and exit is not costless and so firms will have an incentive to recover all their investment costs if possible. Entrants and incumbents do not compete on symmetric terms because the existence of sunk costs means that, when considering whether to enter, the entrant does not have sunk costs prior to entry whereas the incumbent does. This creates a risk for the entrant that prices will fall as low as operating costs in the event of entry. The prospect that the incumbent can reduce prices to such a level because its costs are already sunk creates a barrier to entry.

Thus, the underlying theory of contestable markets is not applicable to network businesses because it assumes there are no sunk costs in a situation where the market or regulated service at issue involves substantial sunk costs. Furthermore, assuming the price adjustment implied by the theory of contestability is not relevant when there are significant sunk costs. This is because there needs to be a mechanism to ensure that sunk costs are recovered in an economically efficient manner and the theory of contestability does not specify such a mechanism when there are substantial sunk costs.

The second interpretation of the ACCC (1999, p. 39) set out above requires that the DORC estimate equals or approximates the amount that a new entrant would be prepared to pay for existing assets not to have to replicate the existing infrastructure. This assumes that the incumbent would be prepared to sell at that price. However, this assumption would be inappropriate in a situation where the incumbent had market power which is likely given the service is regulated.

As explained by Johnstone (2003, p.16), a new entrant in, for example, the market for energy transmission services would have to pay the full undepreciated optimised replacement cost to duplicate existing infrastructure as there is no second hand market for such a network or its individual components. Johnstone develops a present value model specified by King (2001) that defines the exclusion condition on the regulatory asset base and highlights the relevance of *undepreciated* optimised replacement cost as the relevant asset value for defining the price when the remaining life of the asset base is large and the entrant could expect to capture the whole market.

However, if the entrant could not capture the whole market the prospective entrant would require a higher price than implied by undepreciated (or depreciated) optimised replacement cost, recognising the importance of economies of scale in infrastructure. But capturing the whole market is unrealistic and the entrant would have to consider the pricing outcome from sharing the market including the prospect that if the incumbent decided to compete for market share it could price as low as variable costs recognising its assets were sunk costs. These considerations are clearly likely to deter entry at a price for services consistent with a DORC asset value.

In addition, the hypothetical efficient new entrant cost benchmark does not take account of the full costs to society if an entirely new optimised network were to be built. This would include the full design, approval and development costs as well as the costs of disrupting existing neighbourhoods.

The contestability concept and the associated hypothetical efficient new entrant argument are thus not relevant from an efficiency perspective for determining which valuation concept is most appropriate for use in productivity analysis and productivity–based regulation of network industries with significant sunk costs.

More generally, long–time ACCC Commissioner, Professor Stephen King (2000, p.2), has stated that the theory of contestable markets and the hypothetical efficient new entrant benchmark have 'limited economic merit' in the context of determining asset values of sunk assets for regulated businesses.

Windfall gains and losses

The adoption of a depreciated optimised replacement cost approach will entail windfall gains and losses. This is because asset replacement costs will typically not move in line with general inflation. In practice, windfall gains are more likely to occur given the long lived nature of and relatively mature technology employed in regulated energy network infrastructure.

As noted above, Johnstone (2003, p.36) argues that in cases where service providers have dated but long–lived assets, DORC valuations are likely to imply similar tariffs as if the assets were brand new. The implication is that this is likely to imply windfall gains to the asset owners.

The ACCC (2003 and 2004b) has also identified a number of concerns with DORC. In its 2004 decision on the statement of principles for the regulation of electricity transmission revenues, it summarised its position on the valuation of sunk asset as follows (ACCC 2004b, p. vii):

> '*Valuation of sunk assets*
>
> With respect to valuation of sunk assets, in the DRP [draft regulatory principles] the ACCC advocated that the asset base should be periodically revalued on a depreciated optimised replacement cost (DORC) basis.
>
> However, periodic revaluation of sunk assets can lead to significant variations in the value of sunk assets due to differences between asset replacement costs and historic costs.
>
> Revaluations can lead to unpredictable revenues and prices, and the prospect of windfall gains or losses. Periodic revaluation can also create a risk that efficient expenditure may not be recoverable. This may deter efficient investment.
>
> For these reasons, the ACCC considers that the periodic revaluation of sunk assets should not be continued. The ACCC will now roll forward the value of sunk assets at their depreciated historic cost, taking account of inflation.'

The implementation of a methodology that, as a concept and in practice, is likely to entail windfall gains and losses not only runs counter to the concept of ex ante FCM but also runs counter to the regulatory purpose of limiting the ability to extract excessive profits and sharing efficiency gains with consumers through lower prices as set out in Section 52A of the Commerce Amendment Act 2008.

A final point is that the use of a methodology (such as DORC or ODV) that will lead to windfall gains and losses in contrast to a methodology that avoids such windfall gains and losses while also ensuring the ex ante recovery of prudent investment (as embodied in the concept of ex ante FCM) will entail a number of economic inefficiencies. If there is a bias so that on average windfall gains are realised there would be allocative inefficiency as price would exceed the actual average cost of production[5] and there would be dynamic inefficiency as there would be an incentive to over invest. However, there would also be allocative and dynamic inefficiencies that would occur in a situation where windfall losses were realised.

Assessment against criteria for productivity–based regulation

1. **Supports economic efficiency.** ODV performs poorly in terms of economic efficiency as required in Section 92A of the Act. The underlying argument for ODV requires strict assumptions to be met that do not apply when there are significant sunk assets as is the case for network infrastructure. Significant sunk costs mean that the market is not contestable and the benchmark of the hypothetical efficient new entrant that ODV is based on is not relevant. Furthermore, given that the ODRC component of ODV is not based on unambiguous ‘black and white' information on actual past expenditure, there is both uncertainty as to the actual estimate that will be allowed and the risk of windfall gains or losses being realised. Although uncertainty would discourage investment, in practice the tendency is for ODV to lead to windfall gains given the long lifetime of infrastructure assets and slow real depreciation. The prospect of windfall gains being realised that were not recognised in regulated income would encourage over–investment with adverse impacts on dynamic, productive and allocative efficiencies over time.
2. **Facilitates FCM for prudent investment.** ODV performs poorly in terms of facilitating the NPV=0 principle unless appropriate adjustments are made to regulated income which may be difficult to reach agreement on and implement in practice. This will make it difficult to limit the ability to extract excessive profits and ensure that efficiency gains are shared with consumers.
3. **Cost effectiveness.** ODV performs poorly in terms of cost effectiveness because it requires complex and expensive calculation of the optimised depreciated replacement cost. While starting ODV estimates are currently available, subsequent periodic ODV updates would be costly.
4. **Consistency and accuracy.** ODV performs poorly in terms of consistency and accuracy given the wide scope for the use of judgement in determining asset values.

[5] The full economic inefficiency requires a comparison with marginal cost but some allocative inefficiency must occur to ensure the recovery of sunk costs. However, allocative inefficiency is worsened when prices also exceed average cost.

5. **Transparency.** ODV performs poorly with respect to transparency because of the considerable scope for judgemental assessments in the estimation of ODRC and associated difficulties in replicability.
6. **Enables ready conversion of asset values from current to constant prices and vice–versa.** ODRC does enable ready conversion of asset values from current to constant prices and is superior to DHC but not IHC on this principle.

Based on the above assessment, while ODV is useable for productivity–based regulation, it is unlikely to be the preferred asset valuation method. There may be little difference in practice in resulting industry productivity growth estimates between ODV and historic cost methods given that both would, in practice, have to use an early replacement cost–based valuation as a starting point given the unavailability of original cost information. This would particularly be the case where productivity estimates use direct or physical measure based capital quantity proxies (as opposed to constant price depreciated asset value quantity proxies). While the methodology developed in the accompanying technical report is capable of allowing ex ante FCM to be implemented via the calculation of a stream of amortisation charges which would then be used for productivity, input price differential and excess profit calculations, the implementation of this framework in practice would be considerably more difficult under ODV than historic cost methods. As the ACCC (2004b) has noted, periodic replacement coat–based revaluations can lead to unpredictable revenues and prices, and the prospect of windfall gains or losses. Unless appropriate adjustments are made to regulated income, which may be difficult to reach agreement on and implement in practice, this will make it difficult to limit the ability to extract excessive profits and ensure that efficiency gains are shared with consumers.

4.4 Depreciated historic cost

Under a depreciated historic cost method of asset valuation, the actual written down book value of the assets, defined under standard historic cost accounting conventions, ie the standard accounting book value of the assets adjusted for accumulated depreciation, is used as a basis for determining the regulatory asset base – hence the term depreciated historic cost (DHC). In some jurisdictions the terminology depreciated actual cost (DAC) is used[6]. DHC has tended to be used in the United States to value regulated assets.

Taking account of inflation

It is important to recognise the need to adjust for inflation and the relationship between the asset base and the allowed rate of return in the context of inflation. An adjustment for inflation is necessary to ensure that the regulated entity is able to recover the opportunity cost of its investment. Investors need to receive a return on their investment in the regulated asset that compensates for inflation otherwise they will invest in assets with similar risk where they are compensated for inflation. In well functioning markets such adjustments are made continuously and reflected in observable returns and market values of assets.

[6] It should be noted that DAC is sometimes used to refer to a historic cost approach where accumulated depreciation is based on actual past pricing practices rather than the reported book value accumulated depreciation (which does not necessarily reflect past pricing practices).

Adjustment for inflation can be achieved by either using a nominal rate of return and asset values in historic cost terms unadjusted for inflation or using a real rate of return and asset values adjusted for inflation. However, the equivalence of these two approaches depends on the equivalence of actual and expected inflation. This can be explained as follows.

The present value of the income stream obtained by applying the nominal required return to the historic asset base discounted by the nominal required return will be the historic cost of the asset. Note that this approach does not require an estimate of the real rate of return, just an estimate of the nominal rate of return which can be obtained from observable data. However, the present value of the income stream obtained by applying an estimate of a real rate of return to the historic cost base, adjusted by inflation and discounted by the nominal required return, will only equal the historic cost of the asset if the expected inflation figure implicit in the required real rate of return is equal to the actual inflation figure used to adjust the asset base.

This can be shown as follows (Patterson 1995, pp.274–6). In mathematical terms, the present value (PV) of an historic cost asset, using the nominal required return is:

(4.2) $$PV_H = \sum_{t=1}^{\infty} H \times n/(1+n)^t = H \times n/n$$

The PV of historic cost adjusted for inflation using actual inflation, and applying a real rate of return based on expected inflation is:

(4.3) $$PV_I = \sum_{t=1}^{\infty} H \times (1+i)^t[(n-i^e)]/(1+n)^t = H \times (n-i^e)/(n-i)$$

These two present values are equivalent if:

(4.4) $$i^e = i$$

If expected inflation is less (more) than actual inflation the present value of the asset base will be higher (lower) with the latter method than the former method. This is because the real rate of return is commensurately higher (lower) when expected inflation is less (more) than actual inflation for a given nominal rate of return. The two approaches are more likely to be equivalent in net present value terms when inflation is low and stable as it is then more likely to be predictable.

It is also important to recognise that even where the two approaches mean that investors earn identical returns, the price profiles of the two approaches will differ. In particular an historic cost base combined with a nominal return will imply a constant nominal price but a declining real price while a revalued asset base with a real return will imply a constant real price but a rising nominal price with positive inflation.

Thus, as recognised by the Commerce Commission (2008a, para.261–3), where DHC is used to value regulated assets, the use of a nominal allowable rate of return (as incorporated into a nominal WACC) provides compensation for expected inflation. If the DHC asset base was also indexed for inflation investors would be doubly compensated for inflation. When a DHC asset base is indexed directly for inflation it is defined as indexed (depreciated) historic cost (IHC) which is reviewed below. When IHC is used the allowable rate of return must be expressed in real terms (as incorporated into a real WACC) as indexing of the asset base will ensure compensation for inflation.

Assessment against criteria for productivity–based regulation

Assuming that an appropriate adjustment for inflation is made, the main advantage of an historic cost approach to valuation in productivity–based regulation is the certainty that it creates for the regulated entity and customers. The historic cost approach creates considerable certainty for investors because it is based on readily observable accounting information and it treats each new investment analogously to an ex ante long–term contract between the regulated entity and its customers, requiring customers to pay the original cost of the asset plus a reasonable rate of return, irrespective of changes in circumstances that could affect the value of the asset. This means that the approach does very well in terms of facilitating the NPV=0 rule, ie ex ante FCM. It thus performs well on encouraging dynamic efficiency and allowing the identification of excess returns.

However, the price of achieving this greater certainty for investors is greater risk for customers of the regulated services if capital expenditure is not prudent or efficient. This is because strict application of the historic cost approach would mean that customers bear the risk that investments will not be prudent, that some assets are included that are not being used or some assets are less useful because of technological developments. These problems can be addressed to some extent by developing prudency and 'used and useful' asset tests as in the United States. Note that such tests are a form of asset valuation based on optimising the asset base which, although beneficial to users of the assets at a point in time, may impact adversely on investment incentives. Normally the prudency tests are applied on a forward looking basis to forecast capital expenditure while the used and useful tests are applied to the existing asset base. The ODV methodology takes the latter approach by applying an ex post optimisation test to the entire asset base but ideally all approaches need to assess the efficiency of forecast capital expenditure over the regulatory period, unless ODV is applied every year.

The historic cost approach also has the advantage that it is based on actual accounting information which greatly reduces the need for the application of judgement in asset valuation. However, the use of prudency and utilisation tests re–introduces the need for some judgement and the potential for variation in asset values. But the scope for judgement to be applied to determine if capital expenditure is prudent and efficient is not likely to be anywhere near as extensive as the range of views that can arise when ODV is applied to the whole existing asset base.

1. **Supports economic efficiency.** DHC provides greater certainty than ODV which helps ensure appropriate investment incentives and an appropriate balancing of allocative and dynamic efficiency in the determination of a price that takes account of the interests of both consumers and firms. It provides similar certainty to IHC.

   Another intertemporal economic efficiency consideration is that unless offsetting adjustments are made to depreciation provisions (so that the time profile of depreciation differs considerably from standard straight–line depreciation provisions while still preserving FCM), DHC will imply more front loading of capital charges over the lifetime of assets compared to ODV and IHC (for the same dollar value asset base). This will mean higher real prices in the early stages than in the later stages of an asset's life. Such a price profile would be preferred by investors where they considered there was some probability that regulatory arrangements could change or there was some other perceived threat to the ex ante FCM price path.

However, a higher real price in the early years of an asset's life could contribute to under–utilisation of the asset which would be inconsistent with allocative efficiency. Furthermore, network assets are typically characterised by economies of scale in construction so that it is optimal to have some excess capacity until demand increases to make better use of that capacity. Thus, intertemporal economic efficiency considerations might imply smaller real charges in the early periods of the lifetime of network assets reflecting the low marginal cost of usage and to encourage use of the asset but progressively increasing as demand and utilisation of the network increased (see the accompanying technical report, section 10.4). Front loading of prices would also imply a greater burden on consumers who make greater use of the asset in the early stages of the asset's lifetime compared to consumers who make greater use of the asset later in the asset's lifetime. Assuming similar real incomes, this is likely to be considered inequitable and the effect would be exacerbated when real incomes rise over time, particularly where higher real incomes are associated with diminishing marginal utility of income.

Given the commitment of the Commerce Commission to FCM, the likelihood of network assets having some scope to accommodate considerable demand growth and the prospect of rising real incomes over time, it is suggested that a more even time profile of real prices over time would be preferred than one implied by DHC. Thus, based on these considerations DHC would be seen as inferior to ODV and IHC, for the same dollar asset value acquisition cost, where the CPI–X price path is set using productivity–based methods.

2. **Facilitates FCM for prudent investment.** DHC will help facilitate the NPV=0 principle more readily than ODV, including in circumstances where revaluation gains and losses are reflected in income estimates for the purposes of FCM. However, revaluations generally do not occur with DHC and FCM can still be achieved with DHC, provided an appropriate nominal return on capital is allowed for the regulated firm. As noted, ODV has a high risk that windfall gains and losses will be realised and not properly reflected in income adjustments, thus violating the NPV=0 rule for prudent investment. The ranking on this principle would be similar to IHC except where actual inflation diverged significantly from expected inflation. DHC would be superior in this respect as it relies on nominal returns and does not require an estimate of expected inflation (which is incorporated into the estimate of nominal returns which is based on observable data). However, this difference is not considered to be material in most situations in practice.

3. **Cost effectiveness.** DHC is considered to be more cost effective than ODV because it does not require an extensive and expensive calculation of the optimised replacement cost. But DHC would be significantly less cost effective than IHC, where ready conversion from nominal to real values is required (as per principle 6).

4. **Consistency and accuracy.** DHC is considered to be likely to be more consistent and accurate than ODV as there is less requirement for the use of judgement in determining asset values. The main scope for judgement relates to determining prudent and efficient future capital expenditure which is required under all three methods. Consistency and accuracy would be similar for DHC and IHC except where there was a significant divergence between actual and expected inflation.
5. **Transparency.** DHC is much easier to understand and document and is more capable of being independently replicated with minimal judgemental assessments than ODV. It would be more difficult to implement and replicate than IHC because of the need to satisfy principle 6.
6. **Enables ready conversion of asset values from current to constant prices and vice–versa.** DHC does not enable ready conversion of asset values from current to constant prices because at each point in time the accounting book value of the asset base is a mix of capital expenditure incurred at different points in time. To convert DHC from a nominal magnitude to a real magnitude would require the conversion of each of the capital expenditure components over the lifetime of an asset to a real component and then aggregation of those components to form an aggregate real capital measure for each year. This is not seen as practical and would increase the cost of implementing DHC were a constant price asset value series to be used as a proxy for the capital input quantity in productivity measurement.

Based on the above assessment, DHC would be a suitable asset valuation method for productivity analysis and productivity–based regulation. Its use would promote dynamic efficiency and facilitate the application of ex ante FCM. It would also facilitate ready identification of excess returns and would accordingly allow more accurate determination of the X factor components associated with excess returns. Its main disadvantage is that it does not allow ready conversion between current and constant price asset values and hence reduces the range of productivity specifications that can easily be used.

4.5 Indexed historic cost

Assessment against criteria for productivity–based regulation

The indexed historic cost (IHC) methodology for valuing assets requires the estimation of the asset base in real (inflation adjusted) terms and then the indexing of that asset base by a suitable deflator. In practice, this requires the selection or estimation of an initial asset base and then the estimation of the time profile of that asset base over time by incorporating annual capital expenditure and depreciation. The indexing of the asset base converts it to nominal terms which provides compensation for inflation. An allowable real rate of return and allowable depreciation are then defined to determine allowable capital charges. Note that in order to achieve ex ante FCM the asset base would need to be indexed by the same deflator as used in measuring the allowed expected real return from the investor's perspective. This would normally be a general deflator such as the consumer price index as this would be most relevant in ensuring capital was maintained in real general purchasing power terms.

This approach has similar 'certainty' characteristics to DHC and, like DHC, entails less need for judgemental assessments than ODV. However, as noted, in practice all three methods require similar judgemental assessments to be made about prudent and efficient future capital expenditure.

1. **Supports economic efficiency.** IHC provides greater certainty than ODV which helps ensure appropriate investment incentives and an appropriate balancing of allocative and dynamic efficiency in the determination of a price that takes account of the interests of both consumers and firms. It provides similar certainty to DHC.

   As noted above, IHC is considered to be superior to DHC in terms of intertemporal economic efficiency considerations that relate to the time profile of prices. It effectively 'back–end loads' the profile of receipts which encourages utilisation of the asset in the early stages of its life while serving to ration use once the asset becomes fully utilised towards the end of its life. This reflects the likelihood of network assets having scope to accommodate considerable demand growth. This pattern of pricing also comes closest to user pays while recognising the prospect of rising real incomes over time. However, it requires a high degree of regulatory credibility for investors to be confident that the regulatory rules will remain unchanged for a sufficiently long period for them to recover their costs.

2. **Facilitates FCM for prudent investment.** IHC will help facilitate the NPV=0 principle more readily then ODV, including in circumstances where revaluation gains and losses are reflected in income estimates for the purposes of FCM. This is because, as with DHC, revaluation gains and losses do not need to be recognised in order to achieve FCM with IHC, provided an appropriate real return on capital is allowed for the regulated firm. If a nominal rate of return is used with IHC then revaluation gains do need to be recognised to ensure FCM. As noted, ODV has a high risk that windfall gains and losses will be realised and not properly reflected in income adjustments, thus violating the NPV=0 rule for prudent investment. The ranking on this principle would be similar to DHC except where actual inflation diverged significantly from expected inflation. As noted, DHC would be superior in this respect as it relies on nominal returns and does not require an estimate of expected inflation (which is incorporated into the estimate of nominal returns which is based on observable data). However, this difference is not considered to be material in most situations in practice.

3. **Cost effectiveness.** IHC is considered to be more cost effective than ODV because it does not require an extensive and expensive calculation of the optimised replacement cost. As noted, IHC would be less cost effective than DHC, except where ready conversion from nominal to real values is required. As this principle (6 below) is important for some productivity specifications, IHC would be significantly more cost effective than DHC.

4. **Consistency and accuracy.** IHC is considered to be more consistent and accurate then ODV as there is less need for the use of judgement in determining asset values. The main scope for judgement relates to determining prudent and efficient future capital expenditure which ideally is required under all three methods. Consistency and accuracy

would be similar for DHC and IHC except where there was a significant divergence between actual and expected inflation which would tend to favour DHC.

5. **Transparency.** IHC is much easier to understand and document and is more capable of being independently replicated with minimal judgemental assessments than ODV. It would be far less difficult to implement and replicate than DHC because of its ready ability to satisfy principle 6.

6. **Enables ready conversion of asset values from current to constant prices and vice–versa.** IHC enables ready conversion of asset values from current to constant prices and is similar to ODRC in this respect.

Based on the above assessment, IHC would be a suitable asset valuation method for productivity analysis and productivity–based regulation. Its use would promote dynamic efficiency and facilitate the application of ex ante FCM. The implied time profile of prices is also consistent with that required by economic efficiency with 'back loading' of prices which is close to that required by the user pays principle. It would also facilitate ready identification of excess returns and would accordingly allow more accurate determination of the X factor components associated with excess returns. It also allows ready conversion between current and constant price asset values and hence increases the range of productivity specifications that can easily be used.

4.6 Conclusions

A summary comparison of the performance of each of the three asset valuation methods against the criteria required for use in productivity–based regulation is presented in table 1. Both IHC and DHC are clearly preferred to ODV and of particular importance is that both these methods are seen as superior in terms of economic efficiency, ability to identify excess returns, cost effectiveness, consistency and accuracy, and transparency. IHC is clearly preferred to DHC in terms of the criterion for ready conversion of asset values from current to constant prices and vice–versa which increases the range of productivity specifications that can be readily used.

The assessment of the methods supports the use of historic cost rather than replacement cost–based valuations as the preferred valuation method for use in productivity–based regulation. IHC is the only one of the three methods which satisfies all 6 evaluation criteria and so is preferred over DHC. However, given the non–commercial nature of the origins of many utilities and the long–lived nature of their assets, in many cases historic cost information does not exist or cannot be recovered. In these cases, the use of the earliest available comprehensive asset valuation – which will usually be a replacement cost–based valuation – can be justified as the starting point. There is then a case for 'locking in' the starting valuation and rolling the asset value for use in productivity–based regulation forward from that point using data on investment and depreciation under the IHC framework.

Table 1: **Assessment of ODV, DHC and IHC for use in productivity–based regulation**

Principle	ODV	DHC	IHC	Comment
1. Supports economic efficiency	x	√	√ √	IHC is superior when constant real prices are required for intertemporal efficiency or when front loading of capital charges is considered to be economically inefficient and conventional depreciation is adopted, making it difficult to make offsetting adjustments in defining allowable capital income.
2. Facilitates NPV=0	x	√ √	√	DHC is superior if there is a significant divergence between actual and expected inflation. ODV is more likely to lead to windfalls gains and losses.
3. Cost effectiveness	x	√	√ √	IHC is clearly superior if ready conversion from nominal to real magnitudes is required (principle 6). ODV requires expensive periodic valuations.
4. Consistency and accuracy	x	√√	√	DHC is superior if there is a significant divergence between actual and expected inflation. The need for extensive judgements to be made makes ODV less likely to be consistent and accurate.
5. Transparency	x	√	√√	DHC would be more difficult to be replicated than IHC because of the difficulty in converting from nominal to real magnitudes (principle 6). The need for extensive judgements to be made makes ODV less transparent and less replicable.
6. Conversion of nominal to real	√	x	√	DHC performs poorly on this principle which would be important for total factor productivity measurement if a constant price asset value is used as a proxy for the capital input quantity.

Notes: x = performs poorly. √ = performs well. √ √ = performs very well.

APPENDIX A: THE RATIONALE FOR AND HISTORY OF THE 'BUILDING BLOCKS' METHODOLOGY

A1 BACKGROUND

This appendix provides an overview of the rationale and historic development of the 'building blocks' methodology for regulating prices in network industries. The 'building blocks' methodology reviewed here refers to an approach where prices or revenues are regulated by calculating forward looking, allowable cost components and summing those cost components to define allowable revenue. The cost components are described as cost building blocks and the allowable revenue is sometimes described as 'building blocks allowable revenue'. Allowable revenue can then be defined as the target regulatory variable (after making additional adjustments based on other objectives) or allowable revenue can be converted to an average price as the target regulatory variable.

It is important to recognise that the methodology is forward looking and that normally costs are both forward looking and defined to reflect prudent expenditure and realistically achievable operational efficiencies. In addition, adjustments are normally made to remove asset revaluation gains and losses (that are not related to efforts to achieve efficiency). The methodology is thus designed so that on an ex–ante basis investors can expect that funds prudently invested in regulated assets will be fully recouped in net present value terms (based on a discount rate that reflects the opportunity cost of the investment) provided actual costs are expected to be comparable to allowable efficient costs. This latter condition is generally referred to as ex–ante financial capital maintenance (FCM) which means that there is an expectation that the value of invested capital will be maintained in real terms over the life of the investment.

Note that ex–ante FCM is intended to be achieved as opposed to ex–post FCM and investors are allowed to retain realised returns in excess of those required to achieve ex–ante FCM and required to bear the costs of realised returns lower than expected over a defined regulatory period. The rationale for adopting ex–ante FCM as a regulatory principle is that it is consistent with ensuring efficient investment occurs.

Baumol (1971, section 4.1.5) was an early regulatory analyst who drew attention to the importance of the investor recovering the full 'opportunity cost' of their investment. Baumol noted that, "from the point of the investor, if no more than replacement cost is returned, the entire asset purchase can turn out to be a mistake. That is, the investment decision will have been worth his while only if at the end he receives back his initial purchasing power plus compensation for the use of funds". Baumol also noted that, from the point of view of society, if consumers of the services produced with the aid of that investment are unwilling to pay the opportunity cost (in real terms) of obtaining the asset in question, then construction of that asset represents a wasteful use of resources. Consequently, payments to capital should "return funds whose discounted value, after correction for changes of the price level, is equivalent to the cost of the investment. This may or may not be equal to the replacement cost of the asset". This is effectively an early exposition of the FCM concept.

The FCM concept is central to the application of the building blocks methodology as applied in Australia, New Zealand and the United Kingdom. However, there are differences in how each jurisdiction implements the FCM concept and the building blocks methodology, particularly with respect to the determination of allowable efficient costs.

Understanding the rationale and evolution of the building blocks methodology and the incorporation of the FCM criterion provides information relevant to determining the appropriate method of asset valuation and the design of methods to determine efficient costs. This appendix focuses on the regulatory approaches in Australia, New Zealand and the United Kingdom to identify when, why and how the building blocks methodology has been used in certain network industries to help ensure that the application of FCM in the New Zealand context will be as effective as possible.

Although there is a focus on these three countries some references are made to experience in other European countries and the United States as well. Selected academic articles were also surveyed to help confirm the theoretical foundations for the development of the building blocks methodology.

A2 THE ORIGINS OF FCM AND CPI–X AS REGULATORY CONCEPTS

A2.1 Rate–of–return regulation, FCM and CPI–X regulation

The origins of the FCM criterion in the regulation of prices for network industries really lie in the adoption of rate–of–return regulation, as this approach is intended to ensure that investors receive a "fair rate of return" on their capital invested after allowing for all costs incurred. Costs need to include appropriate allowances for depreciation so that investors receive a return **of** capital as well as a fair return **on** their capital and, to the extent that both are achieved, then financial capital will be maintained in real terms. However, the advantage of the FCM criterion is in how tightly it is defined so that there is no doubt that when applied on an ex–ante basis financial capital is expected to be maintained in real (inflation–adjusted and risk–adjusted) terms.

The essential differences between rate–of–return regulation and CPI–X price cap regulation are outlined below for context before focusing on the more specific methodology for determining price caps known as 'building blocks' incorporating FCM.

As rate–of–return regulation was the precursor to more explicit adoption of the FCM concept and CPI–X regulation, it is important to understand the weaknesses of rate–of–return regulation. The main flaws in rate of return regulation were that if actual costs were used there would be no incentive to achieve efficiencies and (with a cap to the rate of return) there would be an incentive to over invest in the capital base known as the Averch–Johnson (1962) effect. Rate–of–return regulation without indexing of costs also became problematic when inflation was significant.

Over time, rate–of–return regulation was modified so that estimates of efficient forward looking costs could be used rather than actual costs (Thompson 1991, p.201) and this together with lags between the setting of prices, with scope for excess profits to be retained in the interim period, improves incentives for efficiency. Although various adjustments can ameliorate the adverse efficiency incentives associated with rate–of–return regulation, this approach can still essentially be seen as providing a 'low powered' incentive mechanism (Baldwin and Cave 1999, p.225) to the extent that revenues are not decoupled from actual costs. The consensus view is that there is less scope for the decoupling of revenues from costs to occur under rate–of–return regulation compared to CPI–X regulation.

To the extent that price capping by a forward looking CPI–X mechanism makes it easier to decouple revenues from costs it can be described as a 'high powered' incentive mechanism to achieve efficiencies. The decoupling of revenues from costs arises in the CPI–X system because a forward looking price cap requires an ex ante assessment of efficient opex and capex (Beesley and Littlechild 1989, p.461 and Dassler, et al 2006, p.167) and the time period between price reviews is usually of several years' fixed duration. These characteristics constituted the main economic efficiency rationale for the CPI–X approach to setting prices. Other advantages included greater flexibility in practice for the regulated firm to set individual prices under a total price cap and greater discretion for the regulator in setting X than under the US tradition in determining cost components (Beesley and Littlechild 1989, p.461). The main disadvantage is that regulated costs may diverge too much from true efficient costs and compromise an objective of maintaining ex–ante financial capital maintenance.

Although there are a few US precursors, CPI–X regulation was first applied on a large scale in the UK to British Telecom in 1984 and then extended to other UK utilities as they were privatised (Baldwin and Cave 1999, p.226). Littlechild (1983) authored an influential report proposing a CPI–X approach for British Telecom. The approach was concerned to avoid the pitfalls of the US style rate–of–return regulation.

However, as subsequently explained by Littlechild, this simple formulation did not emerge elegantly from the draft version of his paper but was motivated more by considering the economic and political constraints on the privatisation of BT. The specific idea was based on the so–called "Buzby Bond" in the context of a privatisation option, where it referred to an RPI–2 per cent cap on BT's tariffs but the bond never transpired.

Littlechild highlights the role of Professor Alan Walters, the UK Prime Minister's economic advisor at the time of the introduction of CPI–X for British Telecom, and in particular the argument–clinching quote that Walters drew on from his earlier writing in a key ministerial meeting (Littlechild in Bartle 2003, p.37):

> "The imposition of a maximum rate of return has many of the characteristics of a tax rate which is fairly low until the maximum rate is achieved, then it becomes a hundred per cent. We all know the consequences of that sort of tax system on cost control and enterprise."

The initial formulation of the CPI–X approach did not incorporate the forward looking consideration of efficient costs that is a feature of the 'building blocks' approach. But in applying the CPI–X approach, attention naturally turns to estimating future efficient cost levels in order to determine an appropriate X factor.

However, it is emphasised that there is obvious convergence of the rate–of–return and CPI–X approaches when the time period between regulatory reviews is shortened and the methodology for estimating costs to determine starting point prices between the two approaches is similar. In the limiting case where there are annual reviews and the methodology for estimating costs is the same, both CPI–X and rate–of–return regulation based on efficient costs collapse to being simple cost–plus pricing. However, in practice rate–of–return regulation has been increasingly displaced by CPI–X regulation including in the United States (at least for telecommunications, although not for energy) (Littlechild in Bartle 2003, p.40).

A2.2 The capital maintenance concept

Capital maintenance is a longstanding financial accounting concept. It is closely related to the definition of capital that one seeks to explain and, hence, must be consistent with the valuation method in use. Financial capital refers to equity or net assets, while physical capital is the productive or operating capacity of the assets.

Financial capital maintenance (FCM) is the maintenance of the expected income earning power of the shareholders' investments (or investments' purchasing power). As long as the net present value (NPV) based on the appropriate opportunity cost discount rate is greater than or equal to zero, financial capital maintenance will be achieved.

Operational capability maintenance (OCM) treats physical assets, instead of the shareholders' funds, as its main interest. Profit is only recognised after the specific operating capacity of assets has been maintained or when the operating capacity of the enterprise at the end of the period exceeds the operating capacity at the beginning of the period, after excluding any distributions to and contributions from owners during the period. OCM essentially determines asset prices and depreciation charges based on the cost of replacing assets in order to maintain operational capability at a defined level.

For reference, note that for a defined level of operational capability FCM differs from OCM by recognising capital gains and losses as well as the standard OCM charge.

From the reports and other documents reviewed in this study, ex–ante FCM is much more commonly used than OCM in overseas jurisdictions particularly in the UK, Australia and in the member countries of the European Union. Ofgas and British Gas used OCM for a time but switched to FCM after the 1997 Price Control Review.

A2.3 Capital maintenance in the UK

Byatt et al (1986) in an influential two volume report discussed the appropriate choice of accounting rules in the measurement of economic costs including in the context of regulating state owned enterprises. The reports advocated FCM as a common standard for comparing returns and as the ex–ante standard relevant for defining an investor's expectation with respect to recovering the opportunity cost of capital for a specific investment (Byatt el 1986, Volume 1 paragraphs 18–19 and Volume II paragraph 3.54).

FCM appears to have been in use by UK regulators since the early 1990s. According to

Whittington (1998), the Regulatory Asset Base in the UK is considered to represent shareholder financial investments rather than the physical assets or operating capacity of the firm. This is reflected by the referencing of the initial financial capital base for the electricity and water sectors to the market value of equity in the immediate post–privatisation period.

The Regulatory Accounting Guidelines (RAG) issued by Ofwat (1992, 2003 and 2007) have been explicit in discussing the concept of capital maintenance as a measure of a company's profits. These guidelines were formulated to ensure that the accounting statements published by companies are consistent with the economic framework in which they are regulated. The following excerpt from the 1992 guidelines (pp. 3–4) explains the concepts and position of Ofwat (whose director was then Ian Byatt):

> "1.4 Profit measurement
>
> 1.4.1 The ASC Handbook on 'Accounting for the effects of changing prices' discusses two alternative measures of a company's profits which can be summarised as follows:
>
> Real Financial Capital Maintenance ('FCM') is concerned with maintaining the real financial capital of a company and with its ability to continue financing its functions. Under real FCM, profit is measured after provision has been made to maintain the purchasing power of opening financial capital. This involves the use of a general inflation index such as the RPI. Real FCM therefore addresses the principal concerns of the shareholders of a company. In the absence of general inflation real FCM is equivalent to conventional HCA, with the exception of the treatment of unrealized holding gains (paragraph 1.7.8).
>
> Operating Capability Maintenance ('OCM') is concerned with maintaining the physical output capability of the assets of a company. Under OCM, profit is measured after provision had been made for replacing the output capability of a company's physical assets which involves the use of specific inflation indices such as the Baxter index. This will typically be a major concern for the management of a company and was the approach used in Statement of Standard Accounting Practice ('SSAP') 16.
>
> 1.4.2 The Director has a duty to ensure that companies can finance the proper carrying out of their functions. In this regard he has a responsibility to customers to ensure that the return earned by the providers of capital to efficiently operated water companies is sufficient, but no more than sufficient, to induce them to hold shares and to make loans. The Director has therefore decided, following discussions with the Working Group on Accounting Issues for Regulation ('WGAR'), that the regulatory current cost accounts should be prepared on a real FCM basis since this will provide a measure of profit that is well suited to achieving a balance between the providers of capital and customers.
>
> 1.4.3 The Director also has a duty to ensure that the companies maintain the required level of physical operating capability. The July Returns to the Director, on the level of service and capital expenditure, are however specifically designed to monitor operating capability plans against required service standards, and the Director has concluded that there is no need to reflect OCM concepts in the current cost accounts."

Note that the UK water regulator considered using both concepts of capital maintenance at the outset following the duty placed on the Director to guarantee that companies can both finance the proper carrying out of their functions and, at the same time, maintain the required level of physical operating capability. In the end, Ofwat decided to apply real FCM only for the following reasons:

- The report on the level of service and capital expenditure contained in the July Returns to the Director was specifically designed to monitor operating capability plans against required service standards. Hence, there was no need to reflect OCM concepts in the current cost accounts anymore.
- Preparing the regulatory current cost accounts on a real FCM basis would provide a measure of profit that was well suited to achieving a balance between the providers of capital and customers. This would ensure that the return earned by the providers of capital to efficiently operated water companies was sufficient, but no more than sufficient, to induce them to hold shares and to make loans.
- It is usual for the accounts in a normal competitive environment to focus on the returns to shareholders.
- The use of RPI as a measure of the change in the purchasing power of the unit of account, the relevant index in measuring real financial performance, was already built into the price control formula as a measure of general inflation. Because of this, the value was readily available and the estimates were stable.

The earliest regulatory report that appeared to apply the contents of these Guidelines in the UK is the first volume of Ofwat's Cost of Capital Consultation Paper (1991). The report reiterated the duty of the regulator to ensure that regulated businesses can finance their functions. It also stated that maintaining the financial capability was something broadly mirrored by the legislation for other privatised utilities already. Their question at that point was how to incorporate the rather novel reference to "reasonable returns on capital" with the initial setting of the value of K, a parameter relevant to setting the price level over time.

According to Ian Byatt, the Director of Ofwat, the accounts prepared on a real FCM basis better reflect the impact of the financial performance of companies than accounts based on the calculation of profit using maintenance of operating capability accounting. However, Ofwat's Cost of Capital Consultation Paper (1991) also considered allowable rates of return in the initial price setting period following privatisation had been too generous and proposed a significant downward revision to the allowable return on capital. Although this is not necessarily inconsistent with achieving FCM, an important assumption used in the Ofwat 1994 periodic review is inconsistent with FCM as a principle. The Ofwat (1994a) paper that sets out the framework and approach to the 1994 periodic review contains an assumption that is inconsistent with ex–ante FCM when it says (p.5):

> "In the absence of persuasive arguments to the contrary, the Director will assume that companies can in future deliver at least current levels of service at prices which are, in real terms, no more than those charged at present. That is what would be expected from companies in competitive markets."

The problem with this principle, as stated above, is that it is not a universal theoretical principle but rather a principle based on average outcomes for the economy and it does not guarantee ex–ante FCM for a reasonable rate of return since it sets the standard for regulated prices as no increase in real prices. On average there is not a real increase in prices in an economy since the general price deflator is an average price deflator and by definition there will be no real increase when the same price deflator is used to convert a general price change to a real price change. However, if ex–ante FCM is to be maintained it is not logically possible to set a cap on prices so that there is no real increase in regulated prices. Forward looking real prices may or may not increase to achieve ex–ante FCM – it will depend on what is required to finance forward looking capital and operating expenditures which, among other things, depends on the movements in input prices the utility faces.

Prior to the 1997 Price Control Review British Gas used the OCM version of current cost accounting in which assets are revalued to current replacement cost and where any holding gains or losses are taken to reserves and not through the profit and loss account (Ofgas 1996).

OfGas subsequently recommended that assets be revalued for regulatory purposes in line with changes in the Retail Price Index, rather than in line with changes in the cost of asset replacement for two reasons. This was essentially a shift from OCM to FCM. The reasons for this move were:

> a) There is a need for consistency between the basis for estimating TransCo's cost of capital and the basis for estimating the regulatory value of its assets.
>
> b) Current cost revaluations involve an element of subjectivity which complicates the regulator's task. Linking revaluation to a general inflation index removes the problem of companies having an incentive to exaggerate or to understate changes in the cost of asset replacement.

The ACCC (2004, p.24) noted that British Telecom purportedly uses the FCM convention in accordance with the principles set out in the handbook "Accounting for the effects of changing prices" published in 1986 by the Accounting Standards Committee. Under this convention current cost profit is normally arrived at by adjusting the historical cost profit to take account of changes in asset values and the erosion in the purchasing power of shareholders' equity during the year due to general inflation. However, the Commission also noted that: the approach to FCM, as implemented in the UK context, can produce hybrid accounting systems, in which enterprises could combine a looser capital maintenance concept with one of a number of asset measurement bases (irrespective of the degree of conceptual and practical compatibility); and the ability to adopt such combinations allows greater flexibility in the process by which the profit of the enterprise is determined. Note, however, that an issue is whether greater flexibility in the measurement of profit also means that FCM is effectively compromised.

A2.4 Capital maintenance in the European Union

A detailed discussion of FCM and OCM can be found in a report on the implementation of cost accounting methodologies and accounting separation by telecommunication operators with significant market power prepared by Andersen Business Consulting (2002) on behalf of the European Commission DG Information Society. This study provided the backbone to the Commission's explicit rejection of OCM for application to telecommunications regulation.

The objective of this study was to assess the different practices and initiatives implemented in member states to ensure compliance with the Directives and Recommendations on cost accounting and accounting separation issued by the European Commission. The study also assessed the effectiveness of the Commission's recommendations on accounting separation and cost accounting.

The Andersen Business Consulting report (2002, p.15) argued that FCM is the superior capital maintenance concept as follows:

> "The use of the OCM concept may systematically incorporate insufficient or excess returns into the level of allowed revenue (depending, respectively, on whether asset–specific inflation was expected to be lower than or higher than general inflation). This is not a desirable feature of any regulatory regime, as it would not provide appropriate investment incentives. Under FCM, however, the returns to the providers of capital would equal the required return (as measured by the cost of capital) irrespective of whether replacement costs were rising or falling relative to general prices. Hence, if current cost accounting information is used as the basis to determine interconnection charges, FCM is the preferred capital maintenance concept."

A recent NERA (2008) report provides a useful review of the European Regulator's Group for Electricity and Gas (ERGEG) consultation paper on "Principles for Calculating Tariffs for Access to Gas Transmission Networks". NERA (2008, p. 12) note that with respect to asset valuation and accounting standards for regulation the most serious omission in the ERGEG consultation paper is the lack of any general regulatory principles to guide the choice of valuation method or the associated rate of return.

The NERA report (2008, p.15) also notes the following examples of regulatory systems that do not meet the standard of FCM in Europe:

- Germany's method of regulating energy sector assets still applies OCM standards, in which asset values are inflated by a different (asset–specific) price index without any offsetting compensation for rising/declining real values.
- A recent "draft method decision" from the Dutch energy regulator proposed a combination of real WACC and non–revalued RAB for gas distribution networks. That combination is also a mistake, since it deprives investors of any compensation for inflation, and so exposes them to a steady decline in the real value of their assets.
- The situation in Finland is hard for me to determine with precision (a description of the latest decisions is available only in Finnish), but I understand that some regulatory decisions apply an estimate of the nominal rate of return to a revalued asset base. The combination would offer compensation for inflation twice over – were it not for the fact that the estimated nominal rate of return seems to be extremely low.

A2.5 Capital maintenance in Australia

Documents in Australia discussing FCM and OCM largely draw from the Andersen Business Consulting report to the European Commission, the Network Economics Consulting Group

(NECG 2001a) report to the Productivity Commission and the Ergas (2003) summary of the 2002 decision on the case of Epic Energy filed before the Western Australia Supreme Court.

NECG, before the Telecommunications Act came into force, suggested that the Act require FCM for investments in regulated assets that were prudent at the time. It was one of the supplements to the legislated access pricing principles recommended by NECG, alongside compensation for regulatory risk and recognition of the impact of social obligations. NECG (2001b p. 3) noted:

> "Financial Capital Maintenance ("FCM") ensures that funds prudently invested in regulated assets will be recouped. No regulatory arrangement can be sustainable if investors in regulated assets cannot reasonably expect the regulatory contract to ensure FCM. NECG recommends that FCM be used as a guiding access pricing principle."

Ergas (2003) discussed ex–ante FCM in his commentary on the Western Australia Supreme Court's decision on Epic explaining it in the context of determining efficient costs or efficient investments. The case focused on the decision by the regulator, Offgar, to value the Dampier to Bunbury Natural Gas Pipeline at about half the cost paid for it in a competitive tender for a publicly owned asset. The Epic case involved judicial review of the regulator's decision. In granting relief to Epic, the Court required the regulator to reconsider its decision and that in effect the price paid by Epic for the pipeline was a matter which the regulator had to consider in the context of his decision about access charges for the use of the pipeline.

The Court did not explicitly recommend the FCM approach but noted that recovery of the cost of the investment, even if it reflected an expectation of monopoly prices, was not contrary to a legitimate business in accordance with requirements of the National Third Party Access Code for Natural Gas Pipeline Systems. The Court further noted that taking account of the actual investment cost was consistent with another Code objective of not distorting investment decisions but also noted that accepting any cost could also lead to a distortion of investment decisions.

The Court noted that the Code also required that access prices should seek to ensure that revenue is sufficient to recover efficient costs and there was support for the view that only forward looking costs should be considered. However, the Court did not attempt to resolve any inconsistency in these objectives under the Code and in effect left it to the regulator. Ergas (2003, p.11) argued that rather than widening the factors for consideration to non–economic matters, the Court could have taken a more economic perspective and in particular adopted the concept of ex–ante financial maintenance so long as prudent or efficient expenditures were made.

Offgar issued a revised decision that increased the regulatory asset base from $A1.234 billion to $A1.55 billion compared to the price of $A2.407 billion paid by Epic. Ergas (2003, p.13) noted that Offgar concluded that Epic did not undertake a prudent or objective assessment of a future regulator's position on the rate of return and that there was a need to take account of the interest of users and the public interest. Ergas argued the asset base was estimated to meet what was considered an expected tariff level which was also sufficient for Epic to fund its debt commitments. Ergas (p.15) also noted that although the regulator's approach provided very detailed calculations, it was weak in terms of setting out economic concepts to guide access charging.

It is clear from this decision that an ex–ante FCM concept for prudent expenditure was far from the guiding principle used by the regulator. Instead, in the end the criterion used was an asset value that avoided bankruptcy for Epic and, as noted by Ergas (p.15), highlighted weaknesses in the Gas Code.

A similar issue arose following the privatisation of the electricity distribution sector in Victoria where American investors paid $A 8.3 billion for assets for which the regulatory asset base was subsequently set at $A 3.8 billion (Fearon 2006, p.15).

Turning to telecommunications, in January 2004 the ACCC (2004) released a framework document outlining the current cost asset valuation and capital maintenance methodologies to apply in the longer term to Telstra in relation to accounting separation of its retail and wholesale operations. The document specified the use of modern equivalent asset (MEA) valuation (based on replacement cost) and the use of FCM as the basis of this reporting. It argued that the valuation of assets was a separate issue to the measurement of profit and capital maintenance within the current cost accounting framework. Furthermore, it noted that its approach to the valuation of assets was also adopted in the UK by Oftel and recommended by the EU (ACCC 2004a, p.15). However, it is important to recognise that if both the FCM and MEA concepts are concurrently adopted then it is inconsistent to use the FCM concept in recovering the asset value represented by MEA. In some cases, however, the historic cost of past investments may not be available, particularly for long–lived assets, and the earliest available depreciated replacement cost estimate may be used as the best available substitute for historic cost.

FCM is widely used and applied by Australian regulators in the measurement of profit, particularly in the regulation of the telecommunications industry. It is also used by all energy regulators in setting building block allowable revenues. In the latest Current Cost Accounting Report relating to the Accounting Separation of Telstra, ACCC (2008, s.2.1) explains:

> “**Approach to financial capital maintenance**
>
> In determining the level of profit in the current–cost profit and loss statements, the concept of financial capital maintenance (FCM) has been employed.
>
> FCM is concerned with maintaining the real financial capital of the company so that it can continue financing its functions. Capital is maintained if shareholders’ funds at the end of the period are maintained in real terms at the same level as at the beginning of the period. Under FCM, profit is therefore only measured after provision has been made to maintain the purchasing power of opening–period financial capital.
>
> The FCM basis of capital maintenance requires adjustments to be made to the current–cost profit and loss statement to reflect holding gains or losses arising from changes in the value of the assets over the relevant period, depreciation differences between historical cost and current cost accounting, and the effects of inflation on the resources invested in the enterprise.”

A3 THE DEVELOPMENT OF THE BUILDING BLOCKS METHODOLOGY

There has previously been little attention directed to the history, development and rationale for the building blocks methodology as applied to economic regulation in Australia, New Zealand and the United Kingdom. Related literature usually comprises descriptive accounts of this type of methodology or what its strengths and weaknesses are relative to other approaches. They are either especially prepared for or prepared by the regulators (see Farrier Swier Consulting 2002 and Productivity Commission 2001). A few articles made mention of building blocks analysis but descriptively only (eg a method used in Australia and the UK, a method of building up costs faced by regulated businesses) and did not go beyond that level of discussion (Carrington, Coelli and Groom 2002, Cowan 2006, Fearon 2006).

In the documents reviewed that relate to the UK experience, the process of cost build–up in the determination of a price cap or maximum allowable revenue was rarely referred to as a 'building blocks' approach. However, the most recent Electricity Distribution Price Control Review does use the term "building block framework", regarding the individual building blocks to be used by distribution network operators when presenting their forecasts for cost components for the price control review for the period 2010–2015 (Ofgem 2008, pp. 63–64 and Appendix 8). In addition Ofgem (2009, p.23) in a recent review of the History of Energy Network Regulation in the UK does describe the approach to setting price controls in the energy sector as based on a building block approach as the term is understood in Australia and New Zealand.

The key elements of the "building blocks" methodology, including the incorporation of ex–ante FCM and forward looking estimates of costs were adopted in the UK with the work of both Byatt (Byatt et al 1986 and Ofwat 1991) and Littlechild being highly influential (Littlechild 1986, Littlechild in Bartle 2003, Littlechild 2007).

A3.1 The first steps in the UK – electricity and water

CPI–X regulation (referred to as RPI–X in the UK) was adopted at the time various utilities in the UK were privatised. The UK government typically set the initial values of X at the time of flotation of each utility company for a period of 5 years but did not explain how the original decisions on the X values were reached (Littlechild 2007, p.5). However, in the water industry X factors known as K factors (as they determined the rate of increase of real prices) were derived in order to ensure the net present value of each firm's future cash flows was equal to the value implied from assuming the cash flows that firms might have been expected to earn on existing assets if the previous regulatory regime had continued (Armstrong, et al 1995, p.345). This is equivalent to ex–ante FCM for both existing and new investment at the time of privatisation.

Price paths were initially set for electricity transmission, supply and distribution from 31 March 1990 for three, four and five years, respectively (Armstrong, et al 1995, p.299). Price paths were initially set for water and sewerage companies in 1989 for a ten year period which was subsequently changed to five years in 1991 (Ofwat 1994, p.5).

However, the development of a more rational, systematic and transparent approach occurred when the water and electricity regulators came to reset the initial price controls. The resetting of prices occurred for both electricity distribution and water and sewerage companies in 1994.

According to Littlechild, at the time there was a need for a method that could explicitly show that no individual company had been favoured or disfavoured relative to its peers. Until then the emphasis had tended to be on regulators proposing the toughest value of X they could and investors had been applying substantial pressures on regulators to explain their calculations (Littlechild 2007, p.6 and Littlechild in Bartle 2003, p.47).

In developing the approach a key consideration of Littlechild was to ensure that “the level of X offered a rate of return at least comparable to what investors could get elsewhere (for a comparable risk and requirement to be efficient and innovate, etc)” (Littlechild in Bartle 2003, p.46). Littlechild considered numerous approaches but focused on two. One was developed by Michael Beesley and one by his regulation and business affairs director, Geoff Horton (Littlechild in Bartle 2003, p.46). Both Beesley’s and Horton’s methods involved assessing the efficient levels of operating costs, capital expenditure and cost of capital for the forthcoming period and beyond, and projecting cash flows (Littlechild 2007, p.7). This feature together with the concern to ensure an adequate rate of return on capital are key aspects of the ‘building blocks’ approach.

Beesley’s method was based on future cash flows, share prices and other financial indicators. The method entailed projecting the dividend streams and borrowing necessary to finance the sustained operation of the company, but implied an explicit role for the regulator in determining or influencing share prices that Littlechild found difficult to accept. Geoff Horton, on the other hand sought to reconcile the forward–looking thinking embodied in Beesley’s approach with the more conventional approach of incorporating a return on existing capital (Littlechild in Bartle 2003, p.47). Littlechild decided on the Horton approach as he considered it would be easier to explain, implement and defend (Littlechild 2007, p. 7). Over time this approach evolved into what became known as the ‘building blocks’ approach or methodology which has underpinned the explicit calculations that accompany the resetting of X in the utilities sector.

The approach was used in setting the Regional Electricity Companies’ (RECs) distribution price controls in the August 1994 proposals document and in all subsequent work. The model underlying it was circulated to RECs in 1994. It was more explicitly expounded in numerical detail in the Monopolies and Mergers Commission Report on Scottish Hydro in 1995. Details of the history of the approach and its current application in the energy sector in the UK are set out in Ofgem (2009).

Under the current regime Electricity Distribution Network Operators (DNOs) have to submit their cost forecasts in the defined building blocks, each with clearly identifiable assumptions, costs and outputs. They also have to provide information on other options considered, sensitivities to changes in assumptions and required outputs including the impact of any stakeholder engagement.

The objectives of this detailed methodology are:

1. To allow the regulator to assess DNOs' forecasts taking into account the baseline expenditure from the modelling.
2. To provide forecasts that the regulator can compare across DNOs without compromising flexibility on the part of DNOs in the submission of their cost forecasts.

The building block approach was also developed by Ian Byatt in his role as the water regulator at around the same time. However, he considered the K factors that were decided for the initial regulatory period were too generous (Ofwat 1991a, Ofwat 1991b and Armstrong, et al 1995, p.346) and proposed and decided on a lower rate of return for new investment. It is important to recognise that even if ex–ante FCM is adopted there will still be the issue of what is the appropriate cost of capital as well as what is appropriate for operating costs. However, as noted earlier it is notable that the Ofwat (1994a, p.5) paper that sets out the framework and approach to the 1994 periodic review contains an assumption that is inconsistent with ex–ante FCM.

Table A1: **Ofwat rationale for building blocks analysis**

Year	Rationale
1994	1. Consistency with the law: the Water Industry Act requires the regulator to exercise his powers in the manner that he considers is *best calculated* in order to ensure that companies are able to finance proper carrying out of their functions 2. Incentivise companies to reward shareholders from greater efficiency as well as to deliver better services to their customers 3. Ensure that profit is (just) sufficient to attract and retain capital in the business 4. Nature of the water industry (universality of the essential service, difficulty of differentiating quality, indefinite life of assets and the appropriate capital maintenance, low growth in demand and limited opportunities to enhance market share)
1999	1. Efficiency and incentives 2. Maintaining service to customers 3. Quality program 4. Maintaining the balance between supply and demand 5. Financial Issues
2004	1. Allow businesses to meet all existing obligations, and make sufficient revenue to finance their operating expenditure and capital investment programs 2. Maintain assets for current and future customers 3. Ensure a sufficient balance between supply and demand for the water and sewerage services 4. Future efficiency gains 5. Incentive allowance for outperformance 6. Efficient and transparent approach to the review and a framework that stimulates the pressures of a competitive market.

The building blocks approach was used in the 1994, 1999 and 2002 price reviews for water and sewerage companies (Ofwat 1994b, 1999 and 2002). Based on the price review documents covered, there seems to be no significant changes on the rationales behind the adoption of the Building Blocks approach in the water sector. Table A1 provides a summary of these rationales.

A3.2 Application by other regulators in the UK

Gas and telecommunications industries in the UK were not faced with the same pressure to present a formal model from regulated companies as Offer was. While there was only one telecommunications or gas company, there were more than a dozen electricity companies and over 40 water companies on a comparable basis. Detailed calculations underlying the resetting of the price formulae for British Telecommunications and British Gas have not been published. On a general note, the regulators of these two industries favoured a financial approach to regulation paying more attention to profit forecasts and other related information. It is understood that typically, in the early stages of regulation following privatisation, the FCM principle was effectively adopted in terms of a goal of ensuring prices were sufficient to cover the cost of capital.

In the regulated gas sector the initial price control period following privatisation operated from 1987 to 1992. In that period there was a three part formula for the setting of maximum allowable average revenue known as an RPI–X+Y cap where the Y denoted a cost pass through term (Armstrong, et al 1995, p.256). The formula allowed for the full pass through of the cost of gas, specified that the non–gas cost component was to grow by no more than RPI–X and also included a correction factor to allow for any under– or over–charging in one year to be corrected in the following year to recognise that outturn can never be precisely the same as forecast. The justification for full pass through of gas costs was that gas was supplied under long term contracts that could not be changed. The X factor was focused on providing discipline on non–gas costs including the cost of operating and maintaining transmission, distribution and storage facilities and the costs of marketing and metering gas sales.

Some deficiencies that have been noted about this approach are as follows. The formula allows the average cost of all gas purchases including those for the non–tariff (non–regulated) market to be passed through to tariff customers which can be higher if marginal costs exceed average costs and marginal expansion occurs in the non–tariff market. This could lead to underpricing of other cost components in selling to the non–tariff market in order to raise average costs that can be recovered in higher tariffs in the tariff market. Complete pass through of gas costs also removed the incentives to purchase efficiently. Finally, as the cap was a constraint on average revenue there was an incentive to set prices that were not close to Ramsey prices. See Armstrong et al (1995, pp.256–7).

A comprehensive accounting exercise, called the Cost Apportionment Program, provided OfGas with more detail about how BG apportions both gas and non–gas costs between its major market segments. It commenced in 1987 and was carried out on a confidential basis in an effort to find a more satisfactory basis for the price formula.

In the 1990–91 review a new formula was defined as RPI–X+GPI–Z+E (Armstrong, et al

1995, p.259). The X factor was increased from 2 to 5. The GPI–Z term refers to a gas price index less an efficiency factor which was defined to be 1 per cent. The E factor was an energy efficiency factor that allowed for reasonable expenditures that act to reduce demand to be passed on to consumers.

It was not until the 1997 Price Control Review that Ofgas explicitly used building blocks analysis to calculate allowed revenues of Transco (Ofgas 1996a). The approach was based on the methodology first formalised by MMC in the 1993 Gas and British Gas Reports under the Fair Trading Act (Monopolies and Mergers Commission 1993a, b, c and d). However, there was a difference in how pre–privatisation assets were valued compared to the approach used by the water and electricity regulators. This reflected differences in how to best incorporate into the valuation the reasonable expectations of shareholders at the time of privatisation. However, Ofgas (1997c, p.81) summarised the common thinking of the water, electricity and gas regulators as follows:

> "Rather the intention in setting price controls for those industries where companies were initially privatised at substantial discount to net book values has been to reconcile the need for new investment to be remunerated at the companies' respective cost of capital with the desire not to give shareholders windfall gains through allowing equivalent returns on the current cost net book values of pre–privatisation assets. The debate has, been about how to value pre–privatisation assets and how to incorporate into that valuation the reasonable expectations of shareholders at the time of privatization."

Oftel did not use the building blocks approach in either the first review of prices in 1988 or the second review in 1992, although it did use a RPI ± X approach (Oftel 1988 and 1992b and c). In 1992 X was reported to have been set at a level which provided BT with an expectation of covering the cost and risk of capital, while providing demanding targets for improvements in customer service and increased efficiency (Armstrong, et al 1995, p.227).

A3.3 Developments in the UK

Refinements to the building blocks approach used by gas and electricity regulators in the UK are as follows (Armstrong, et al 1995, Littlechild 2007, Ofgem 2006 and 2009):

- The form of the control and whether to set a price cap or a revenue cap. The initial controls typically set a price per unit cap which was subsequently replaced for electricity transmission by a total revenue cap because of concerns about risk for the company. However, this increased the risk to consumers as reflected in fluctuating prices if output fluctuated unexpectedly. A subsequent price control on distribution companies embodied a 50–50 weighting on actual and expected output thereby sharing output risk between the company and its customers.
- Adjusting the regulatory asset base to reflect actual rather than assumed capital expenditure, seeking greater agreement on future capital expenditure plans, providing incentives to forecast accurately and making capital expenditure more conditional on the growth of demand. In particular, a sliding scale mechanism was introduced to provide for a more flexible approach to capital expenditure, without disadvantaging those companies that have provided more reasonable forecasts.

- Incentive mechanisms to ensure specified levels of quality and to reduce loss factors in distribution companies. An information quality incentive mechanism was introduced to provide efficiency rewards to licensees who manage to deliver savings against the most demanding targets. The mechanism gives licensees a degree of choice over their target cost and reduces the risk that the level of available rewards is set too high or too low.
- Smoothing of allowable operating and investment expenditure to avoid gaming of the system.
- Adjustments of cost pass through terms to encourage cost efficiency.
- Use of correction mechanisms to adjust the price control for any previous over– or under–recovery against allowed revenues. The mechanisms could apply to revenue or cost parameters.
- Re–opener mechanisms to enable a price review for specific events or circumstances.
- Use of benchmarking to help determine allowable costs in implementing the building blocks approach.

A3.4 Application by Australian regulators

The building blocks approach has been the "dominant method" of determining the P_0 and X factors in Australia. The Productivity Commission (2001, p.341) claims that regulators have adopted the approach because it is seen to be objective, transparent, and results in prices which closely track individual facilities' costs. The ACCC (2004, p.21) described the approach in a Statement of Regulatory Principles for the Regulation of Electricity Transmission Revenues as follows:

> "The building block approach is used to ensure that the expenditure of each TNSP is appropriately amortised over time to ensure that each TNSP, given efficient expenditure practices and decisions, is adequately compensated for the cost of providing the transmission services to customers in the long run.
>
> The building block model consists of two equations which are known as the revenue equation and the asset base roll forward equation. These two equations are used to determine an allowed stream of revenues for each TNSP for as long as it remains regulated. Ignoring any incentive rewards or penalties, these equations together ensure that the present value of the allowed revenue stream is equal to the present value of the expenditure stream of the regulated firm."

Reports from Australian regulators, particularly from the Australian Competition and Consumer Commission (ACCC), Australian Energy Regulator (AER), the Independent Pricing and Regulatory Tribunal of NSW (IPART), Queensland Competition Authority (QCA) and Essential Services Commission of South Australia (ESCOSA) confirm that building block analysis continues to be widely used in Australia. Victoria has been at the forefront of advocating a shift from the building blocks approach to a TFP based approach to CPI–X price setting where the X factor relies more on external (to the regulated company) industry TFP benchmark trends and less on information specific to regulated firms (Fearon 2008). The Australian Energy Market Commission (AEMC) is currently conducting a review into whether TFP based regulation should be allowed as an alternative to the building blocks approach.

In general the building blocks approach adopted in each Australian jurisdiction consists of three components: efficient operating and maintenance costs, an allowance for the return on capital and an allowance for the return of capital (depreciation). However, there are some differences in cost components and the methods for their determination. These include: efficiency carry over mechanisms, unders and overs adjustments (to take account of any under or over recovery of allowable revenue), trigger mechanisms, asset valuation, the cost of capital and the time profile of X factor adjustments.

In New South Wales the approach is called the Cost Building Block Revenue Model and is designed to be used in conjunction with the Weighted Average Price Cap model. It provides the option of using the rolled forward Regulated Asset Value or entering a new Regulated Asset Base using straight line depreciation. A return on working capital is also allowed and an unders and overs adjustment has been allowed in the past.

In Victoria, an important feature incorporated in the 2001–05 price review for electricity distribution network service businesses was an efficiency carry over mechanism to reflect efficiency savings relative to forecasts, effectively allowing the full value of an efficiency gain to be retained by the regulated company for a 5 year period. However, following concerns about its operation, for the 2006–10 regulatory period, the mechanism only applies in relation to operating and maintenance expenditure.

In Queensland where a total revenue cap applies for electricity distribution network service businesses, there is a demand trigger mechanism based on maximum demand and customer numbers. An unders and overs account also exits.

It is worth noting that an issue of difference for Australian regulators and across sectors is the form of price control and in particular whether to use a weighted average change in prices (sometimes referred to as a pure price cap), a total revenue cap or a revenue yield (average revenue) price cap. A pure revenue cap reduces risk to the firm relative to a pure price cap and discourages innovations to achieve growth while an average revenue cap can lead to profits higher than allowed for in setting regulatory parameters. This contrasts with a pure price cap where revenue is allowed to move in line with the specific tariff applying to marginal consumption (Office of the Regulator General, Victoria 1998, pp. 46–47).

For electricity distribution New South Wales and Victoria adopted a weighted average price cap while Queensland adopted a total revenue cap and South Australia adopted an average revenue cap. In transmission New South Wales and Victoria adopted a total revenue cap. All these regulatory functions have either now passed or are in the process of passing to the AER.

A3.5 Developments in Australia

It is important to recognise that the application of the building blocks methodology in Australia to date has emphasised firm–specific costs with a regulatory lag of generally five years. The derivation of the X factor depends on a judgement of the extent to which reasonable efficiencies can be achieved based on the specific circumstances of the firm. This contrasts with an approach where the X factor is based more on industry trends in total factor productivity.

A report prepared by Farrier Swier Consulting (2002) for the Utility Regulators Forum (URF) undertook a comparison of the building blocks and indexed approaches". The report concluded that a TFP based approach to price regulation was likely to create superior economic efficiency incentives (p.84) provided the approach tended to operate (p.72) "mechanistically" without triggering excessive reviews; earnings sharing mechanisms are either not incorporated or have wide bands; and the approach was implemented within an appropriate and robust decision–making framework.

As noted above, the TFP based approach is currently the subject of a review by the Australian Energy Market Commission.

Other problems identities with the building blocks approach in Australia are as follows (most of these are summarised by Fearon 2006 and 2008):

- tensions in a privatised industry with monopoly characteristics between the firms seeking to maximise returns and the expectations and objectives of customers
- the clear information asymmetry exacerbated by reliance on the information provided by the utility with incentives to "talk up" costs and "talk down" future sales
- underestimation, in hindsight, of the challenges in relying on reported costs
- restructuring of EDBs including arrangement with entities with common ownership, but which are not directly covered by the regulatory regime, and the possibility that such arrangements may not be at arm's length, with the potential to inflate or obscure reported costs
- the challenges generally of obtaining transparent cost data and unravelling complex and changing cost allocations making comparisons and forecasts difficult
- the considerable difficulty obtaining information per se, with delays in some cases and others where information was withheld entirely
- asset valuation based on depreciated optimised replacement costs provides considerable scope for judgement and a wide divergence of views
- divergence in regulatory decisions about cost of capital parameters.

A4 CONCLUSIONS

The key findings with respect to the origins and evolution of FCM and the building blocks approach in the regulation of prices for utilities are as follows:

- The FCM concept has its origins in accounting literature but its relevance in providing incentives for efficient investment, as an ex–ante application, is well recognised by the regulatory authorities in Australia, New Zealand, the United States and the United Kingdom.
- The origin of the FCM concept in economic regulation lies in the adoption of rate–of–

return regulation to the extent that such an approach is concerned to ensure investors receive a "fair rate of return". However, its explicit use as an ex–ante concept in economic regulation followed the initial privatisation of utilities in the UK in the late 1980s.

- The ex–ante FCM concept has been applied by most utility regulators in the UK and continues to be widely used.
- Byatt, prior to becoming the first Director of Ofwat, was the joint author of an influential report in 1986 that advocated FCM for measuring returns and as the ex–ante standard for an investor.
- Ofwat's Regulatory Accounting Guidelines first issued in 1992 appeared to be the first document to discuss the concepts of FCM and OCM in relation to the regulation of a utility in the UK. Other regulators from the UK did not have the power to formulate similar accounting guidelines at the time.
- An important divergence from the application of the FCM concept was by Ofwat in its 1994 price review where it specified a principle it was adopting (based on a competitive markets analogy) was that prices for current service levels could not increase in real terms. However, this position seems to be related to a view that rates of return were too generous which is not an unreasonable position and can be addressed while still adopting FCM. However, the assumption as specified conflicts with FCM for future investment.
- Ofgas used OCM until the 1997 Price Control Review.
- FCM has tended to be preferred over OCM in the UK, Australia and member countries of the European Union.
- However, there are exceptions: Germany applies OCM rather than FCM in regulating the energy sector while the Netherlands and Finland also do not adopt the FCM criterion.
- In addition, a recent consultation paper by the European Regulator's Group for Electricity and Gas is notable for the lack of any general regulatory principles to guide the choice of valuation method or the associated rate of return.
- The ex–ante FCM concept is the dominant approach to calculating regulatory allowable revenue in the electricity sector in Australia although in many cases the historic cost of past investments has not been available and the earliest available depreciated replacement cost estimate has been used as the best available substitute for historic cost.
- However, in telecommunications the ACCC has drawn a distinction between the use of FCM for calculating profits (which it considers is appropriate) and its use in the valuation of assets where it prefers a modern equivalent asset (replacement) approach.
- Stephen Littlechild, Michael Beesley and Geoff Horton developed the building blocks approach in the UK in the early 1990s for Offer's first reset of the value of X in the electricity sector.
- Ian Byatt of Ofwat used a model similar to Offer's building blocks approach almost at the same time as its application in the electricity sector.
- There was relatively little material provided on the rationale for the building blocks

approach in the UK, however its origins relate to the adoption of CPI–X price regulation and the need to adopt a forward looking perspective on efficient costs in order to determine an appropriate X factor.

- The rationales and assumptions underlying the use of the approach have not changed much through time.
- However, various refinements have been made to encourage efficiencies and avoid gaming problems.
- Over time the approach has become more transparent.
- Challenges in obtaining appropriate estimates of efficient costs in a cost effective way are an increasing issue.
- Regulators from the UK and Australia are now considering other approaches to determining the value of X in price or revenue cap regulation. They are trying to find a more light–handed approach that could better incorporate incentives for efficient investment.

REFERENCES

Andersen Business Consulting (2002), *Study on the Implementation of Cost Accounting Methodologies and Accounting Separation by Telecommunication Operators with Significant Market Power.*

Armstrong, M., S. Cowan and J. Vickers (1995), *Regulatory Reform: Economic Analysis and British Experience,* The MIT Press, London.

Australian Competition and Consumer Commission (ACCC) (1998), *Victorian Gas Transmission Access Arrangements Final Decision,* October.

Australian Competition and Consumer Commission (ACCC) (1999), *Draft Statement of Principles for the Regulation of Transmission Revenues*, May.

Australian Competition and Consumer Commission (ACCC) (2003), *Review of the Draft Statement of Principles for the Regulation of Transmission Revenues,* Discussion Paper.

Australian Competition and Consumer Commission (ACCC) (2004a), Current *Cost Accounting Methodology for Telstra's Subsequent Reports under the Accounting Separation Regime Framework Document.*

Australian Competition and Consumer Commission (ACCC) (2004b), *Statement of Principles for the Regulation of Electricity Transmission Revenues*, Background Paper, Decision, 8 December.

Australian Competition and Consumer Commission (ACCC) (2008), *Current Cost Accounting Report Relating to the Accounting Separation of Telstra for July–December 2007.*

Australian Energy Regulator (AER) (2005), *Compendium of Electricity Transmission Regulatory Guidelines*, August.

Averch, M., and L. Johnson (1962), "Behaviour of the Firm Under Regulatory Constraint", *American Economic Review* 52, 1052–69.

Baldwin, R. and M. Cave (1999), *Understanding Regulation: Theory, Strategy and Practice,* Oxford University Press.

Baumol W.J. (1971), "Optimal depreciation policy: pricing the products of durable assets", *Bell Journal of Economics and Management Science* 2, 638–656.

Baumol, W., J. Panzar and R. Willig (1988), *Contestable Markets and the Theory of Industry Structure,* 2nd edition, Harcourt Brace Jovanovich, New York.

Beesley, M. and S. Littlechild (1989), "The Regulation of Privatized Monopolies in the United Kingdom." *The RAND Journal of Economics,* 20:3 454–472.

Bernstein, J.I. and D.E.M. Sappington (1999), "Setting the X Factor in Price Cap Regulation Plans", *Journal of Regulatory Economics* 16, 5–25.

Biggar, D. (2004), *Updating the Regulatory Asset Base: Roll–Forward, Re–valuation and*

Incentive Regulation, Australian Competition and Consumer Commission.

Bloom, R. and P. Elgers (1995), *Foundations of Accounting Theory and Policy A Reader*. USA, Dryden Press and Harcourt Brace College Publishers.

Bonbright, J.C., A.L. Danielson and D.R. Kamerschen (1988), *Principles of Public Utility Rates*, 2nd edition, Public Utilities Reports Inc., Arlington, Virginia.

Brainard, W.C. and J. Tobin (1969), 'Pitfalls in Financial Modelling', *American Economic Review* 58, 99–122.

Byatt, I.C.R. (1986), *Accounting for Economic Costs and Prices: A Report to HM Treasury by an Advisory Group,* the Byatt Report, Volumes I and II, London: HMSO.

Carrington, R., T. Coelli and E. Groom (2002), "International Benchmarking for Monopoly Price Regulation: The Case of Australian Gas Distribution", *Journal of Regulatory Economics* 21(2), 191–216.

Caves, D.W., L.R. Christensen and W.E. Diewert (1982), "The Economic Theory of Index Numbers and the Measurement of Input, Output, and Productivity', *Econometrica* 50, 1392–1414.

Commerce Commission (2004), *Regulation of Electricity Lines Businesses, A Companion Report to the Handbook for Optimised Deprival Valuation of System Fixed Assets of Electricity Lines Businesses*, 31 August, Wellington.

Commerce Commission (2008a), *Authorisation for the Control of Supply of Natural Gas Distribution Services by Powerco Ltd and Vector Ltd*, Decisions Paper, 30 October, Wellington.

Commerce Commission (2008b), *Regulatory Provisions of the Commerce Act 1986,* Discussion Paper, 19 December, Wellington.

Dassler, T., D. Parker and D. S. Saal (2006), "Methods and trends of performance benchmarking in UK utility regulation", *Utilities Policy*, 14, pp. 166–74.

Denny, M., M. Fuss and L. Waverman (1981), "The Measurement and Interpretation of Total Factor Productivity in Regulated Industries, with an Application to Canadian Telecommunications", pp. 179–218 in *Productivity Measurement in Regulated Industries*, T.G. Cowing and R.E. Stevenson (eds.), New York: Academic Press.

Diewert, W.E. (1993), *The Measurement of Productivity: A Survey*, Swan Consultants (Canberra) conference on *Measuring the Economic Performance of Government Enterprises*, Sydney.

Diewert, W.E. (2008), *The Measurement of Income and the Determinants of Income Growth*, University of British Columbia, http://www.econ.ubc.ca/diewert/594ch8.pdf.

Diewert, W.E. and D. Lawrence (2000), "Progress in Measuring the Price and Quantity of Capital", pp. 273–326 in *Econometrics Volume 2: Econometrics and the Cost of Capital: Essays in Honor of Dale W. Jorgenson*, Lawrence J. Lau (ed.), Cambridge: The MIT Press. http://www.econ.ubc.ca/diewert/progress.pdf

Ergas, H. (2003), *Epic in Retrospect and Prospect.* Accessed from:

http://www.greenwhiskers.com.au/papers_reports/epic_in_retrospect_and_prospect_HE_26–06–03.pdf

Essential Services Commission (ESC) (2007a), *2007 Review of Retail Electricity Price Path Issues Paper,* Melbourne.

Essential Services Commission (ESC) (2007b), *Review of Gas Standing Contract Prices 2008/09– 2010/11,* Melbourne.

Essential Services Commission of South Australia (ESCOSA) (2004), *Statement of Principles for the Regulation of Electricity Transmission Revenues*, Adelaide.

Farrier Swier Consulting (2002), *Comparison of Building Blocks and Indexed Base Approaches,* Report prepared for the Utility Regulator's Forum

Fearon, P. (2006), *Public Utility Regulation: A Practitioners Perspective,* Essential Services Commission, Melbourne.

Fearon, P. (2008), *Regulating Victoria's Electricity and Gas Distribution Networks: Finding the Right Balance,* Essential Services Commission, Melbourne.

Hay, D.A. And D.J. Morris (1993), *Industrial Economics and Organization – Theory and Evidence,* 2nd edition, Oxford University Press.

Hotelling, H. (1925), 'A general mathematical theory of depreciation', *Journal of the American Statistical Association* 20, 340–353.

Independent Pricing and Regulatory Tribunal (IPART) (2002), *A Users Guide to the Financial Model for the 2004 Electricity Network Pricing Review,* Sydney.

Independent Pricing and Regulatory Tribunal (IPART) (2004), *Cost Building Block Revenue Model for Electricity Distributors,* Sydney.

Johnstone, D. (2003), *Replacement Cost, Asset Valuation and the Regulation of Energy Infrastructure Tariffs: Theory and Practice in Australia*, CRI (Centre for the Study of Regulated Industries) International Series 8, School of Management, The University of Bath, UK.

Joskow, P. (2006), 'Incentive regulation in theory and practice: Electricity distribution and transmission networks', CWPE 0607 and EPRG 0511, mimeo.

King, S. (1996), 'Asset valuation and access to essential facilities under Part IIIA of the Trade Practices Act 1974 (Cth)', in M. Richardson (ed.), *Deregulation of Public Utilities: Current Issues and Perspectives*, Centre for Corporate Law and Securities Regulation, University of Melbourne.

King, S.P. (2000), *Report on Agility's approach to DORC valuation*, Report prepared for the Independent Competition and Regulatory Commission, Canberra, 21 November.

King, S. and R. Maddock (1996), *Unlocking the Infrastructure: The Reform of Public Utilities in Australia*, Allen and Unwin, Sydney.

Lally, M. (2003), *The Weighted Average Cost of Capital for Electricity Lines Businesses*, School of Economics and Finance, Victoria University of Wellington, 4 August.

Lawrence, D. (2003), *Regulation of Electricity Lines Businesses, Analysis of Lines Business Performance – 1996–2003*, Report prepared by Meyrick and Associates for the New Zealand Commerce Commission, Canberra, 19 December.

Lawrence, D. (2007), *Electricity Distribution Business Productivity and Profitability Update*, Report prepared by Meyrick and Associates for the New Zealand Commerce Commission, Canberra, 7 December.

Lawrence, D.A. and W.E. Diewert (2006), "Regulating Electricity Networks: The ABC of Setting X in New Zealand", pp. 207–241 in *Performance Measurement and Regulation of Network Utilities*, T. Coelli and D. Lawrence (eds.), Cheltenham, UK: Edward Elgar.

Lawrence, D.A., W.E. Diewert and K.J. Fox (2006), "The Contribution of Productivity, Price Changes and Firm Size to Profitability", *Journal of Productivity Analysis* 26, 1–13.

Lawrence, D., P. Swan and J. Zeitsch (1991), "The Comparative Efficiency of State Electricity Authorities", in P. Kriesler, A. Owen and M.R. Johnson (eds.), *Contemporary Issues in Australian Economics*, MacMillan.

Littlechild, S.C. (1983), *Regulation of British Telecommunications' Profitability*, Report to the Secretary of State, Department of Industry, London.

Littlechild, S. (1986), *Economic Regulation of Privatised Water Authorities,* London: HMSO.

Littlechild, S. (2003) in Bartle, I., ed "The UK Model of Utility Regulation: A 20th Anniversary Collection to Mark the Littlechild Report Retrospect and Prospect."

Littlechild, S. (2007), "Key input decisions, a merits review and the role of the firm in proposing regulatory control terms: A contribution to the MED Review of Regulatory Control Provisions." Accessed from: http://www.med.govt.nz/upload/48550/stephenlittlechild.pdf

Ministry of Economic Development (MED) (2000), *Inquiry into the Electricity Industry*, Report to the Minister of Energy, June, Wellington.

Monopolies and Merger Commission (1993a), *Gas, Volume 1 of Reports under the Fair Trading Act 1972*, Cm 2314, London: HMSO.

Monopolies and Merger Commission (1993b), British Gas plc, *Volume 1 of Reports Under the Gas Act 1973*, Cm 2315, London: HMSO.

Monopolies and Merger Commission (1993c), Gas and British Gas plc, Volume 2 of Reports Under the Gas and Fair Trading Acts, Cm 2316, London: HMSO.

Monopolies and Merger Commission (1993d), Gas and British Gas plc, Volume 3 of Reports Under the Gas and Fair Trading Acts, Cm 2317, London: HMSO.

NERA Economic Consulting (2008), *ERGEG Paper on Tariff Principles: A Comment*, Prepared for Gas Transport Services.

Network Economics Consulting Group (NECG) (2001a), *Presentation to the Productivity Commission's Public Hearings into Telecommunications Competition Regulation,* Canberra.

Network Economics Consulting Group (NECG) (2001b), *Submission to the Productivity Commission Draft Report: Telecommunications Competition Regulation,* Canberra.

Offer (1991), *Connection Charges Discussion Paper.* London, Office of Gas and Electricity Markets.

Offer (1993), *Electricity Distribution: Price Control, Reliability and Customer Service.* London, Office of Gas and Electricity Markets.

Offer (1994), *The Distribution Price Control: Proposals.* London, Office of Gas and Electricity Markets.

Offer (1995), *The Distribution Price Control: Revised Proposals.* London, Office of Gas and Electricity Markets.

Offer (1996), *The Competitive Electricity Market from 1998: Price Restraints.* London, Office of Gas and Electricity Markets.

Offer (1998), *Reviews of Public Electricity Suppliers 1998 to 2000: Price Controls and Competition Consultation Paper.* London, Office of Gas and Electricity Markets.

Offer (1998), *Reviews of Public Electricity Suppliers 1998 to 2000: Regulatory Accounts Consultation Paper.* London, Office of Gas and Electricity Markets.

Office of the Regulator General, Victoria (ORG) (1998), *Weighted Average Cost of Capital for Revenue Determination: Gas Distribution,* Staff Paper, Number 1, May.

Office of the Regulator General, Victoria (ORG) (2001a), *2001 Electricity Distribution Price Review: Framework and Approach.*

Office of the Regulator General, Victoria (ORG) (2001b), *Submission to the Productivity Commission: Review of the National Access Regime: Position Paper,* Melbourne.

Ofgas (1986), *The Tariff Price Formula.* London, Office of Gas and Electricity Markets.

Ofgas (1991), *New Gas Tariff Formula Economic Aspects.* London, Office of Gas and Electricity Markets.

Ofgas (1991), *New Gas Tariff Formula Proposed Modifications of the Conditions of British Gas Authorization.* London, Office of Gas and Electricity Markets.

Ofgas (1991), *New Gas Tariff Formula Tariff Structures.* London, Office of Gas and Electricity Markets.

Ofgas (1994), *Price Controls on Gas Transportation and Storage The Director–General's Decision.* London, Office of Gas and Electricity Markets.

Ofgas (1994), *Pricing Methodology for Gas Transportation and Storage.* London, Office of Gas and Electricity Markets.

Ofgas (1994), *Proposed Changes to the Gas Tariff Formula A Consultation Document.* London, Office of Gas and Electricity Markets.

Ofgas (1994), *Proposed Price Controls on Gas Transportation and Storage A Consultation*

Document. London, Office of Gas and Electricity Markets.

Ofgas (1996a), *1997 Price Control Review British Gas' Transportation and Storage The Director–General's initial proposals.* Volume 1: Consultation Document, London, Office of Gas and Electricity Markets.

Ofgas (1996b), *1997 Price Control Review: British Gas' Transportation and Storage: The Director General's Initial Proposals*, Volume 2, Appendices, London, Office of Gas Supply.

Ofgas (1996c), *Price Control review Supply at or below 2,500 therms a year– British Gas Trading The Director General's initial proposals.* London, Office of Gas and Electricity Markets.

Ofgas (1997), *Notice of tariff changes by British Gas Trading: License Modification A Consultation Document.* London, Office of Gas and Electricity Markets.

Ofgem (2004), *Electricity Distribution Price Control Review Final Proposals.* London, Office of Gas and Electricity Markets.

Ofgem (2006), *Transmission Price Control Review2007–2012: Third Consultation.* London, Office of Gas and Electricity Markets.

Ofgem (2007), *Gas Distribution Price Control Review Updated Proposals Document.* London, Office of Gas and Electricity Markets.

Ofgem (2008), *Electricity Distribution Price Control Review Initial Consultation Document and Supplementary Appendices.* London, Office of Gas and Electricity Markets.

Ofgem (2009), *Regulating Energy Networks for the Future: RPI–X@20: History of Energy Network Regulation*.

Oftel (1988), *The Control of British Telecom's Prices,* London.

Oftel (1992a), *BT's Cost of Capital,* London.

Oftel (1992b), *BFuture Controls on British Telecom's Prices,* London.

Ofwat (1991), *Cost of Capital: A Consultation Paper,* Vol. 1, London.

Ofwat (1992), *Regulatory Accounting Guideline 1.02 License Condition F: Accounts and Accounting Information Section 8 Guideline for Accounting for Current Costs Financial Year 1991–1992.*

Ofwat (1994a, 1999 and 2004), *Setting Price Limits for Water and Sewerage Services: The Framework and Approach to Periodic Reviews*, London.

Ofwat (2003), *Regulatory Accounting Guideline 1.03 Guideline for Accounting for Current Costs and Regulatory Capital Values Financial Year 2002–2003*, London.

Ofwat (2007), *Regulatory Accounting Guideline 1.04 Guideline for Accounting for Capital Maintenance Charges and Current Costs; and the Analysis of Regulatory Capital Values Financial Year 2006–2007*, London.

Peasnell, K.V. (1981), 'On capital budgeting and income measurement', *Abacus* 17(1), 52–67.

Productivity Commission (PC) (2001), *Review of the National Access Regime,* Canberra.

Queensland Competition Authority (QCA) (2003), *Form of Regulation of Electricity Distribution to Commence from 1 July 2005,* Brisbane.

Sandilands, F. (1975), *Inflation accounting*, Report of the Inflation Accounting Committee, the Sandilands Report, London, HMSO, September.

Schmalensee, R. (1989), 'An expository note on depreciation and profitability under rate of return regulation', *Journal of Regulatory Economics* 1(3), 293–298.

Stigler, G. and C. Friedland (1962), 'What can regulators regulate? The case of electricity', *Journal of Law and Economics* 5, 1–16.

Thompson, H.E. (1991), *Regulatory Finance: Financial Foundations of Rate of Return Regulation*, Kluwer, Boston.

Tobin, J. (1969), 'A General Equilibrium Approach to Monetary Theory', *Journal of Money Credit and Banking* 1, 15–29.

Vogelsang, I. (2002), 'Incentive regulation and competition in public utility markets: a 20–year perspective', *Journal of Regulatory Economics* 22(1), 5–27.

Whittington, G. (1998), "Regulatory Asset Value and the Cost of Capital", in *Regulating Utilities: Understanding the Issues*, London, Institute of Economic Affairs.