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THE COMPETITION AND POLICY IMPLICATIONS OF REGULATORY DEPRECIATION AND THE ASSET BASE

Simon Carne David Currie Martin Siner
London Business School

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1. Introduction

After initial growing pains, the regulatory regime for UK utilities is now showing signs of maturity. The areas of debate about regulatory reform are narrowing, and there are increasing areas of consensus.[1] There is little pressure to overturn the distinctive UK system of RPI-X price-cap regulation; there is general agreement that within this system, regulated utilities should earn an appropriate rate of return; there is increasing acceptance that radical surgery on the institutional map of UK regulation is not required; and there is widespread agreement that the promotion of effective competition is key in allowing the shrinkage of regulatory boundaries.[2]

Despite this convergence, there remain important areas of continued debate. The question of the appropriate rate of return for regulated utilities remains contentious;[3] the boundaries for effective competition remain unclear, both across and within regulated industries; and the appropriate powers of regulators, and the mechanisms for appeal against regulatory decisions, remain disputed. But perhaps the largest domain of dispute is the definition of the Regulatory Asset Base (RAB), on which the regulated utility is expected to earn the appropriate rate of return on capital. Thus, for example, in BG's 1997 appeal to the MMC against the regulatory adjudication by Ofgas, argued differences between the two parties on the cost of capital were small (ranging from 7% to 8%, a difference of 14%), whereas the different positions on the appropriate RAB ranged from £10.3bn to £17bn, a difference of 65%. Before the appeal to the MMC these differences were even larger. In addition, there have been differences on associated issues, notably the question of the appropriate treatment of depreciation, in calculating the rolled-forward value of the RAB. These differences arise not just between the regulated companies and their respective regulators, but also between the regulators. Thus, for example, in June 1996, the press revealed the existence of a letter from Ian Byatt to Claire Spotiswoode, questioning her reopening of the 1994 MMC decision on the appropriate treatment of depreciation for British Gas. We examine below, and seek to illuminate, the reasons for these differences.

This paper focuses on the question of the determination of the RAB for the regulated utilities, and some associated issues. The RAB has been considered by five of the UK regulators (Offer, Ofgas, Oftel, Ofwat and ORR), as well as by the MMC, in arriving at price cap determinations since the UK privatisation programme began in 1984. A number of academics have also entered the debate with notable contributions being Whittington (1994) and Newbery (1997). But, as we have noted, the issues remain

[1] For an illustration of this, see the discussions in Currie (1997), Flemming (1996) and the Government's recent Green Paper, DTI (1998).

[2] For a discussion of competition policy in UK utilities, see Nuttall and Vickers (1996).

[3] For recent contributions, see Fama and French (1997), Clare and Priestley (1996) and Cooper and Currie (1999).

unresolved, with differences not confined merely to judgmental assessments of the valuation of assets; there remain differences of principle.

This paper seeks to examine the key issues underlying the determination of the RAB, with the aim of clarifying the reason for differences on this issue. We seek to set out from first principles the issues concerning the valuation of the RAB for a regulated utility. We highlight the possibility of two quite different policies, or models, for determining the RAB. At one extreme, there is a model relevant to a sector that is intrinsically monopolistic, where a key regulatory policy objective is to ensure that monopoly power is not used to extract monopoly profits through unduly high prices. At the other, there is a model relevant to a sector where the emergence of competition is feasible, so that a key regulatory objective is the promotion of effective competition. We demonstrate that, perhaps surprisingly, the mechanism by which the regulator can implement one model or the other is the level of depreciation of the RAB allowed for in prices which the utility is allowed to charge the consumer.

The structure of the paper is as follows. In the next section we note that two distinct rationales exist in the UK for regulating the privatised utility sector; one requiring the continuous regulation of companies and the other allowing regulation to be transitory. Section 3 draws on these two rationales in developing, in a stylised and therefore possibly over stark form, two alternative regulatory models with differing treatments of the RAB. Within the context of these rival models, the following two sections consider the implications of advances in technology (both anticipated and unanticipated) and changes in the cost of capital for regulatory policy. Section 6 contains our conclusions.

2. Utility Regulation in the UK

The need for regulation of a particular sector of industry arises because of the absence of effective competition.[4] This absence may arise for two distinct reasons. First, the sector in question may have intrinsically monopolistic elements, variously described as natural monopoly elements, increasing returns or essential facilities. Second, the sector may have inherited an industrial structure in which one or more companies have a dominant position, which they can exploit to extract monopoly profits. In the first case, the need for regulation is intrinsic and continuing, so long as technology changes do not eliminate the intrinsic monopoly elements. In the second, it can be transitional, disappearing if an industrial structure emerges that allows effective competition. In this case, a key objective of regulation may well be to facilitate the transition to this structure of the industry. In the first case, by contrast, the focus of regulation is limiting the exercise of monopoly power, and the need for regulation is ongoing.

[4] For a discussion of the meaning of effective competition, see Vickers (1995).

It is clear that, in practice, the UK privatised utility sectors exhibit both rationales for regulation. All have elements of natural monopoly; and all inherited on privatisation an industrial structure ill-designed to promote effective competition. All regulators have therefore had to grapple with the twin objectives of containing monopoly profits and promoting competition. But the relative importance of these objectives has varied, across sector but also across time within a specific sector.[5] Moreover, the boundaries of the intrinsically monopolistic elements within each sector inevitably remain unclear and therefore a source of dispute between regulator and regulated.

In regulating the monopoly aspect of the sector, it is often argued that the regulator should seek to simulate the operations of the competitive market, by replacing the absent "gale of competition" with the power of the regulator. Thus even in those sectors where effective competition is absent, faced with a fundamental innovation in the sector, the regulator may decide to adopt a rule of setting prices in the regulated sector in a such a way that mirrors how prices would move in a competitive sector experiencing such an innovation. There is clearly scope for disagreement as to how to implement such a rule in practice, but the principle makes considerable sense, and it is one that the UK regulators have generally adopted.[6]

A key practical issue for all the UK regulators arises from the fact that the market valuation of the assets of the regulated businesses at privatisation diverged appreciably from their replacement value. In the case of water, this under-valuation of assets was of the order of 90%; in other sectors, the degree of under-valuation was less severe, but still significant. For example, it was 59% in the case of British Gas. This under-valuation arose for a number of reasons. These include weaknesses in the procedures for privatising state assets, issues of regulatory uncertainty, the sale of assets in large, undifferentiated blocks, and the large scale of the offerings to the market in relation to total new issues. In addition, and perhaps crucially, was the postulate, implicit in privatisation, that there should be no consumer price shocks at privatisation. The extrapolation of pre-privatisation prices into the post-privatisation regime (with the prospect of RPI-X for the foreseeable future) meant that rational investors would not buy the company at the replacement value of its assets, because prices for the foreseeable future would not be sufficient to cover the costs of providing the service plus a reasonable return on capital. As we discuss in the rest of this paper, this

[5] Thus, in telecoms, in the early years after privatisation, limiting BT's profits through a price cap was key, whereas now the latest price cap covers only one quarter of BT's sales to consumers, and Oftel can envisage the total elimination of the price cap in the foreseeable future. At the same time, Oftel's emphasis on its role as a competition authority has grown. In contrast, Ofwat's emphasis on competition has remained necessarily limited; and its concern to limit monopoly profits correspondingly prominent.

[6] See, for example, Ian Byatt's letter of 11 February 1997 to all the water companies (MD 124): "In creating this dynamic pressure on prices, I act as proxy for a competitive market."

divergence poses regulators with difficult choices, wherever their balance lies between the objective of limiting monopoly profits and promoting effective competition.

3. Two Policy Regimes for Regulation

In this section, we develop two contrasting models or policy regimes for regulation: a competitive model; and a monopolistic model. The first focuses on moving the sector towards competition; the second on maintaining low pre-privatisation prices in a monopolistic utility sector. Through the use of these two models, we highlight the dilemmas facing regulators in determining their strategies for price cap regulation and clarify the theoretical issues underlying the treatment of the RAB.

The Competitive Model

In the competitive model, the regulator seeks market behaviour associated with competitive forces. This can be achieved in one of two ways: the first is by using the regulatee's licence to simulate (or mimic) the behaviour of the competitive market, without there actually being any real competitors; the second is by allowing and encouraging effective entry into the market. The decision to allow or not to allow entry into the regulated market would normally be one for government, at least so far as the UK is concerned, but it may well be left to the regulator to decide just how much encouragement to give to entry once it has been permitted by law.

If the regulator inherits a market in which competition is permitted, but is not presently achievable because the incumbent's prevailing prices are below the new entrant rate, the encouragement of effective competition requires the regulator to move the sector progressively towards the position where competitive forces can operate.

If the industry is such that effective competition is feasible (the prerequisite for applying this model), this requirement means bringing prices up to a level sufficient to cover long run replacement cost of the assets, together with operating expenditure and cost of capital, used in the industry.[7] Until this has been achieved, new entrants will not be able to compete.[8]

Unless technological progress is very rapid (as in telecoms), bringing prices and long run marginal cost into line through rapid cost reductions, this entails an increase in price to the consumer. This, in itself, may not be politically acceptable, particularly if

[7] In the presence of natural monopoly elements, long run marginal cost will normally be below replacement cost, making it hard to promote competition, except artificially.

[8] By contrast, the company privatised at a market valuation below the long run replacement value of its assets can earn a normal, or even an above average, rate of return on capital invested, even if prices are below long run marginal cost.

the required price increase is large. But even if political acceptability is not an obstacle, there is also the question of how prices can be raised without giving an (unacceptable) windfall return to shareholders of the regulated company.[9]

As we show below, the solution to this dilemma depends on the rules adopted by the regulator for the determination of the RAB and, in particular, the rules adopted for depreciation of the asset base. It will be clear that, in order to equate to long run marginal cost, the price must be sufficient to recover not only the operating costs of providing the utility service, but also be sufficient to provide an economic return on the current (replacement) cost of the assets[10] used in business, together with depreciation of that asset over its useful working lifetime. In practice, with most regulated utilities, the return to shareholders has been based only on the flotation price of the utility, or some figure close to that level, on the grounds (which we do not disagree with) that this is the amount which shareholders invested in the business, and depreciation has often (but not always) been based on this same amount of capital.

As we demonstrate in some detail in Appendix 1 of this paper, if depreciation is based on the flotation value of the utility (or *any* value less than the full depreciation of the replacement cost of the assets), the funds generated by the company from selling its services will not be sufficient to finance the replacement assets as and when they are needed. At that point, the company will need to raise more finance, whether by means of equity, loans or reinvesting past profits in the business. As and when a replacement asset is purchased, an increase in the RAB is justified since, by hypothesis, additional investment has been made in the business. Moreover, the depreciation charge for the replacement asset should properly be based on the replacement cost of the new asset.[11]

By the time that *all* the assets in the business have been replaced, the volume of additional investment will, by definition, have been equal to the difference between the amount of depreciation originally charged and the cost of the replacement assets. Accordingly, the RAB will have increased to the replacement cost of the new assets and the price charged to consumers will be equal to the long run marginal cost.

Once the industry has been moved to a position where pricing behaviour is not only compatible with a competitive market, but there is also real, and effective, competition, the role of the regulator begins to alter. Effective competition eliminates the need for price caps, and the regulator assumes the different but nevertheless important role of enforcing the rules for fair and effective competition.

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[9] Insofar as these prices are unanticipated, they are genuine windfall gains. If they were anticipated, they would have been, at least partially, incorporated into privatisation sales prices, thereby mitigating the problem.

[10] Usually defined as the Modern Equivalent Asset (MEA).

[11] This is true at the point of purchase. As new developments in technology occur, and the cost of replacing the replacement asset falls, further considerations are needed. We return to this below.

The Monopolistic Model

In the presence of natural monopoly elements, the incumbent's marginal cost will be below new entrant costs (by definition of natural monopoly), making attempts by the regulator to promote full-scale competition futile.

In this policy regime, the regulator's key objective is not securing prices at new entrant levels, i.e. long run marginal cost, but that the company earns enough money to finance its functions, including new and replacement investment, at the lowest possible price to consumers. This requires that the regulator allows shareholders to earn a return only on their investment at privatisation and not on the replacement cost of the utility's assets.

This pricing policy could, of course, be the same as new entrant pricing if the flotation price of the utility's shares was sufficiently high that a proper return on capital was equivalent to new entrant pricing of the utility's services. In practice, however, at least in the UK, the price of utility services of the nationalised industries was typically below the new entrant price (or, in the case of natural monopolies, where the "new entrant price" is not relevant, below long run marginal cost). As a direct consequence of this, as mentioned above, rational investors would only buy the floated utility at a share price below the replacement cost of the existing assets.

As we saw when considering the competitive model, the transition to long run marginal cost is an inevitable, and automatic, consequence of setting the depreciation charge below the level of depreciation of the replacement cost of the assets. However, if, as in the case of the water privatisation in the UK, the depreciation charge is set from the outset at the level equal to depreciation of the full replacement cost of the asset, even though the RAB on which shareholders are remunerated is set well below that level,[12] the consequence is very different.

It has been argued,[13] wrongly in our view,[14] that to allow the company to recover depreciation equal to the full Current Cost Accounting (CCA) value of the assets when shareholders paid only a fraction of that value for them is to give the shareholders a windfall gain. This would be true only if the shareholders were free to keep the extra depreciation for themselves, but the companies are *required* under the terms of their

[12] As noted above, the RAB of the water companies was based on their flotation value, i.e. around 10% of the replacement cost of the assets.

[13] For example, "Allowing the full depreciation of original assets to be paid to shareholders … overcompensates shareholders who are able to buy the original asset at a discount to replacement cost value." Pg. 6, Newbery (1997).

[14] And in the view of both Ofwat and the MMC (1995) when reviewing Ofwat's 1994 Periodic Review of South West Water.

licences to continue to supply water services and, therefore, they are required to replace the assets as and when necessary. Any diversion of the depreciation moneys away from the regulated business would lead inevitably to the shareholders having to finance the replacement assets themselves without any corresponding increase in the RAB.

So, the effect of the regulator making allowance within the price caps for depreciation based on the full replacement cost of the assets is to ensure that the assets can be replaced at the end of their useful lives without the need for any additional capital to be raised. If there were no changes in the cost of the replacement assets and no need for any additional (as opposed to replacement) assets to be acquired to provide the utility's services,[15] the policy of allowing recovery of the full replacement cost through depreciation would mean that the RAB remained (broadly) constant over time. On this depreciation policy, if the RAB is initially set below the CCA value of the assets, and the price charged to customers is, thereby, below long run marginal cost, the price will not move to long run marginal cost unless technological improvements bring the long run marginal cost down to the level of the price charged. Subject to this one exception, this depreciation policy will not, therefore, allow new entrants to the industry to compete with the incumbents. There may, however, be scope, as in the case of the England & Wales water industry, for the encouragement of competition between existing incumbents in a limited part of the market, such as the market for large users.[16]

The absence of any competitors, with the associated inevitability that the office of the regulator will need to continue indefinitely, may cause the management of the regulated utility to contemplate whether life would be more comfortable in another market, where perhaps the gale of competition is less difficult to handle than the pronouncements of the regulator. This potential incentive to exit the market must be countered by a legal obligation not to, i.e. an obligation to replace worn out assets and to install new assets where required. Without this legal obligation, the continued provision of an essential facility will turn on the quality of decision-making by the managers of a private sector company facing, possibly, the wrong incentives. The legal obligation is only the minimum requirement. The regulator must also monitor closely the company's investment in new and replacement assets to ensure that the capacity and quality of the service are not eroded.

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[15] In the case of the UK water industry, the companies were privatised at a time when new EU regulations required significant additional investment in new assets to provide additional environmental protection.

[16] With prices for water generally around three times the long run marginal cost, the scope for competition would only appear to arise where the circumstances of the customer are such that economies exist which would bring down the cost of supply below the level of long run marginal cost. At the time of writing, Ofwat has authorised three 'inset appointments', whereby a location is supplied with water services by a competitor company. A handful of additional applications are under consideration.

Whilst the policy regime of limiting competition fixes prices in such a way as to prevent shareholders earning returns greater than those anticipated at privatisation, thereby protecting consumers' interests, it results in allocative inefficiency. So long as prices are below long run marginal cost, demand will be greater than the efficient level and resources accordingly misallocated. The only way in which an efficient allocation of resources can be achieved, once the utility has been privatised at a discount to its CCA value, is by allowing prices to rise as in the competitive model.

Reflections on the concept of "depreciation" of the regulatory asset base

On the basis of the foregoing analysis, it can be seen that much of the difficulty stems from the determination of the appropriate level of depreciation. The use of the term "depreciation", which implies the *writing off* of an asset, invites the debate to centre around the appropriate accounting value to place on the asset being written off, e.g. current cost, replacement cost, or the price paid for the asset by shareholders at privatisation etc.

If, instead, the issue is looked at as one of financing the replacement assets, the problem can be seen to be a very different one. The issue now becomes: should customers be required to pay for the cost of replacing the assets they consume *or* should today's customers be allowed to pay less than the cost of replacing the assets, with the result that additional finance will need to be raised with the consequence that tomorrow's customers will have to pay a higher price consistent with the increased capital investment in the business?

It could be said that, in these last two paragraphs, we are viewing the depreciation of a utility in a different way from the view adopted for non-utility companies. In answer to such a challenge, we would point out that a price-regulated utility is different from other companies in one very important respect. Such utilities all have the benefit (or encumbrance) of a licence which not only permits the company to operate in a statutorily controlled industry, but also constrains the way in which it may operate. In particular, the utilities which are subject to price control are required to continue providing services in the price controlled market. Unlike other companies, which have no obligation to replace assets once they have been written off, the utility must replace them. If the result of such an obligation to renew its assets[17] leads to a different view being taken of the amount of (or even the nature of) the depreciation charge, it should not be a surprise, nor a reason for rejecting the alternative view.

Other regulatory issues arise in addition to the above. In particular, how does the regulator determine the price cap, either prior to the emergence of effective competition or in a naturally monopolistic market, when faced with various

[17] Or, if not to renew the assets, to maintain, by some other means, the regulated level of service.

unanticipated developments. In the next two sections we consider an innovation (by an incumbent or a new entrant) and a fall in the cost of capital.

4. Innovations (by incumbents and new entrants)

We turn now to the issues that arise in the competitive and monopolistic models when there are improvements in technology that bring the price of new plant down. We consider first technical progress which is anticipated and then we examine the outcome when unexpected technical progress occurs.

Anticipated technical progress in the Competitive Model

The knowledge that new entrants will be able to enter the market at a price below the incumbent's prevailing price threatens the possibility that the incumbent will suffer a windfall loss. This would deter the incumbent from investing (and, likewise, would deter investors from putting up the necessary funds), unless remedial action is taken. The solution to this problem is to adopt a depreciation profile which reduces in line with the expected reduction in replacement cost of the capital asset. [18]

Because the total amount of depreciation will need to equal the cost of the asset in order to encourage investment, the initial depreciation level will exceed the conventional straight line level, tapering off over time in line with technical progress to a level which is below the straight line figure at the end of the asset's lifetime, see figure 1. For a more detailed explanation see Appendix 1.

[18] This is a pricing decision only; it is not necessary for the accounts to adopt a tilting of the depreciation charge for our analysis to be valid.

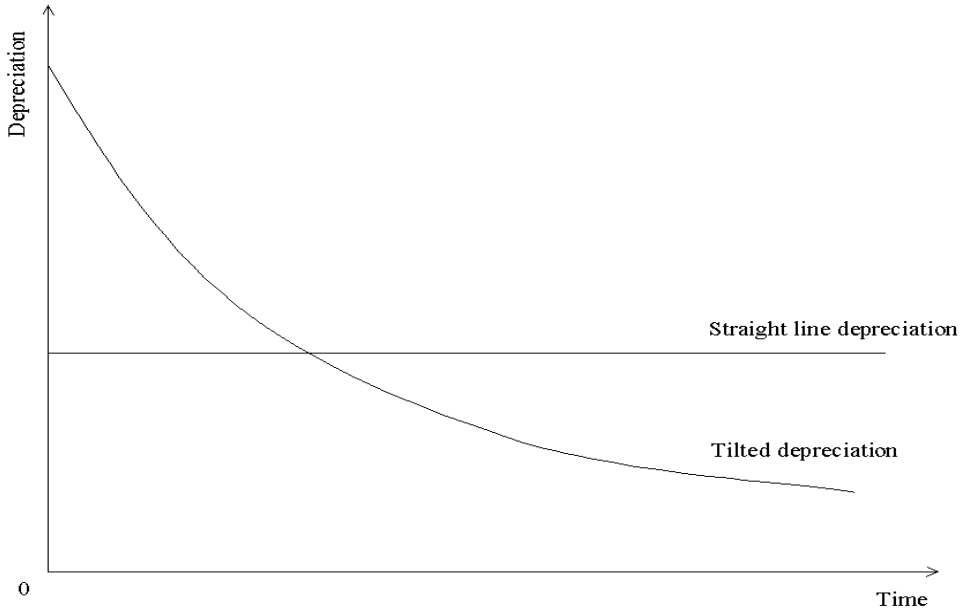

Figure 1: Straight line and 'tapered' depreciation with technological progress.

Anticipated technical progress in the Monopolistic Model

In the monopolistic model, there is, by definition, no threat of a new entrant, so depreciation does not need to be tilted. However, other, more complex issues arise when the flotation price is less than the CCA value of the assets. Full depreciation of the CCA value of the assets at the time of privatisation could lead to a permanently negative RAB, because the RAB is reset at the start of each cycle to:

flotation value *minus* depreciation of existing asset *plus* cost of replacement asset,

which will be negative if the floatation value was small enough and technical progress large enough.[19] In theory, the negative profits could become so great that the utility is required to charge a negative "price", but even if this extreme position is not reached, a scenario in which the RAB is permanently negative and the regulated business must therefore run at a loss gives rise to presentational difficulties.

To circumvent this difficulty, the depreciation charge can be based on the anticipated cost of the next (i.e. replacement) asset, rather than the cost of the existing asset or the current cost of a replacement in the year in question. This results in the RAB being reset to the flotation value at the start of each cycle.

[19] For example, in the water industry, where the floatation value was approximately 10% of the CCA value of the assets, the RAB will become negative if technical progress reduces the cost of the capital asset(s) by more than 10% over the asset lifetime (which is equivalent to only a relatively modest annual improvement).

If, however, technical progress is expected to drive the cost of the replacement asset below the flotation value, the price charged to customers under this regime would exceed the new entrant price. When this occurs it becomes appropriate to think of the industry as potentially competitive rather than inherently monopolistic. However if the regulator immediately switches to the competitive regime and permits entry the shareholders will suffer a windfall loss (unless the point at which the replacement cost falls below the floatation value is exactly at the start of a cycle). This can be avoided if, at the start of the cycle when replacement costs are projected to fall below the flotation value, the depreciation schedule is reduced such that only the flotation value is recovered. In this way, the price during the current cycle will not exceed the new entrant level and the RAB at the end of the current cycle will be reduced to zero and will start the next cycle at an amount equal to the replacement cost of the next asset, which (by hypothesis) is less than the RAB at the start of the previous cycle. From this point on, prices are set at the new entrant level and the model runs exactly as in the competitive scenario.

Unexpected technical progress

The foregoing analysis is based on the premise that the technical progress was anticipated, which enabled the incumbent to know exactly when and by how much to tilt the depreciation charge in the competitive model and when to switch the depreciation method from full CCA value to flotation value in the monopolistic model.

If there is unexpected technical progress in the competitive model, a new entrant will be able to undercut the incumbent(s), causing a windfall loss as the existing assets become stranded. This is a result that applies in any competitive market, not just the market for regulated utility services. There is nothing that the regulator can do, short of prohibiting entry into the market until the incumbent(s) have worn out their existing assets!

If the incumbent is a monopoly, unanticipated technical progress will have no impact until it reaches the level where a new entrant could undercut the incumbent's price. If new entrants are permitted by law and have simply been deterred hitherto by the incumbent's low prices (i.e. prices below long run marginal cost), they will now begin to enter and the incumbent will be forced to compete. This will mean suffering a windfall loss, just as in the competitive model above, unless first mover advantage and customer loyalty etc. outweigh the new entrant's lower prices.

If entry to the market is actually prohibited by law, the regulator has the option to ignore the unexpected technical progress and allow the incumbent monopolist to charge more than the economic cost of the service, thereby protecting the shareholders

from a windfall loss at the expense of the customers. Alternatively, the regulator can force the price down to economic cost with the resultant loss to shareholders.

In deciding between these two options, the regulator may take into consideration the possibility that the incumbent monopolist had been required by its licence to remain in a market in which its assets faced the threat of becoming stranded at the hands of an inventor with superior technology. Indeed, the incumbent may have been forced to make a capital investment that no "free" company would have entered into. In these circumstances, the regulator may decide that imposing the disciplines of the free market constitutes something of a double whammy.

5. Changes in the Cost of Capital

The Competitive Model

When there is a change in the cost of capital as a result of general changes in the economy, all other things being unchanged, the capital value of investments change. This is observably the case for fixed interest investments. The point may be obscured for equity investments because changes in general interest rates are usually associated with other changes in the macro-economy and "all other things" are not, therefore, usually unchanged.

Observable or not, however, it has been argued that any changes in the capital value of the utility resulting from a change in the cost of capital should be reflected in the RAB. The argument is put that[20] investors determine the market value of a company at flotation by evaluating the expected stream of earnings at the then prevailing cost of capital, so if the cost of capital subsequently rises, and the regulator applies the higher cost of capital at the next price control review, a higher stream of earnings will be realised than had been anticipated when the initial market value (and thereby the initial RAB) had been set. The converse applies for a fall in the cost of capital.

This argument has not been adopted generally, and was rejected by the MMC in the case of Scottish Hydro-Electric following the adoption of such a policy by the Director General of Electricity Services in his price proposals to Scottish Hydro. The MMC's argument was that, "in a competitive market, a general rise in unavoidable costs affecting all firms would lead to higher prices to cover the higher costs and a regulated company could reasonably expect to be treated in an analogous manner."[21]

[20] For example, see paragraph 11.9, Offer (1995).

[21] Paragraph 6.72, MMC (1995).

In one sentence, the MMC succinctly addressed an argument which we consider deserves amplification, so that its implications can be more widely appreciated.[22] If an increase in the cost of capital were reflected in the price cap not only by way of an allowance for an increased return, but also by lowering the RAB in line with the (assumed) reduction in the value of the regulated business, the two effects would tend to cancel each other out. The regulated company would, therefore, see no change in the allowed price on account of the higher cost of capital. A new entrant would, however, face the cost of acquiring the physical assets needed to provide the services, at the same price as immediately prevailed before the change in cost of capital (or higher) and would face the higher cost of capital. The new entrant could not, therefore, compete at the price implied by the policy of adjusting the RAB in line with changes in cost of capital.

Conversely, when there is a reduction in the cost of capital, a new entrant will be able to supply the service at a lower price than previously applied. So, even if the regulator were to allow an increase in the RAB in line with the lower cost of capital, thereby tending to cancel out the effect of the reduction due to the lower return, the existence (or threat) of new entrants should force the regulated utility to hold the price down. A regulator who was seeking to simulate a competitive market in the absence of effective competition would not, therefore, allow an increase in the RAB on account of the change in the cost of capital.

The foregoing analysis explains why adjusting the RAB in line with the cost of capital has an adverse effect on a regulator's competitive policy. However, not pursuing this policy leaves open the suggestion that investors in a regulated utility will be earning a return on a capital base that does not move in line with the capital base on which other investors earn a return. As we now show, such an inference is misconceived.

Consider the net cash flow of the regulated company. In any period of time, it is equal to depreciation plus return on capital less capital expenditure.[23] In the simplest case where depreciation equals capex in each period, the net cash flow is simply the return on capital. So if the regulator has set the price control so that the return on capital equals the cost of capital, the net present value of the net cash flow will equal the RAB.

An increase in the cost of capital will be reflected by a decrease in the share value only for so long as the market expects the company's return on capital to remain below the cost of capital. If prices in the market place are revised so that a company earns a profit equal to the cost of capital, then the share price should revert to its previous

[22] The analysis that follows is our own, not the MMC's. The MMC did not greatly expand upon the point.

[23] This follows from the fact that the regulated price cap is calculated from the equation: price = opex *plus* depreciation *plus* return on capital.

level. If, contrary to the conclusion reached above, the regulator were not only to make allowance for the higher cost of capital, but also to reduce the RAB, the two changes would (as noted above) cancel each other out. In this way, the regulator would have made no effective change to the price charged to customers following the change in cost of capital, thereby making *permanent* a fall in share value and imposing a windfall loss on shareholders of the regulated utility which would not be suffered by shareholders of unregulated companies. The converse applies to a decrease in the cost of capital.

In a more general case were capex does not equal depreciation in every year, there will be cash surpluses or deficits generated in individual years as a result of the excess or shortfall of depreciation over the level of capex. Over time, these surpluses and deficits will cancel out, but in any specific year the company may have either a net cash balance or an overdraft. There is no reason, however, why these balances or overdrafts should affect the conclusion reached in the previous paragraph (addressing the simplest case), since a change in the general level of interest rates does not alter the capital value of a cash balance or an overdraft. If the company decides to invest its cash balances in anything other than a risk-free instrument (which, by hypothesis, must be an investment in something other than the regulated business), any changes in the capital value of the company are a consequences of *that* decision and should be borne by the company rather than passed on to customers of the regulated business.

The Monopolistic Model

In the discussion of the competitive model above, we saw that changes in the cost of capital should be allowed for in the price control, but without any adjustment in the RAB. In the case of an increase in the cost of capital, this was because a reduction in the RAB would not allow new entrants to compete with the regulated utility. In the case of decreases in the cost of capital, new entrants would force the regulated utility to price at a level which was inconsistent with allowing for an increase in the RAB.

In the monopolistic model, it is not clear that the same conclusions follow. In the absence of a competitive threat, and in a regulatory regime which aims to hold down prices to the consumer, rather than mimic the competitive market place, considerations of actual or hypothetical competitors are not relevant.

The starting point for the analysis must be the price charged to customers at privatisation, because this is often an artificial price based on continuity with historical prices, rather than economic models of allocative efficiency. If the utility was privatised at a time when the cost of capital was at a relatively high level compared with other periods in history, it would seem that a subsequent reduction in the cost of capital can be passed on to customers, just as it would be in the competitive market, even though the price paid in the industry may not be sufficient to attract competitors.

But in the reverse case, i.e. an increase in the cost of capital following a privatisation at a time when the cost of capital is at a historically low level, it does not necessarily follow that the increase should be passed on to customers. This is because, in the monopolistic model, all replacement expenditure on assets is financed by customers through the depreciation charge, so there will be no difficulty in the company financing its existing functions if the lower cost of capital is retained in future price controls. The higher cost of capital is only needed to finance any *new* functions which the regulated business is called upon to enter into.

In theory, therefore, a regulator operating in the monopolistic model does not need to increase the return on capital following a period of historically low levels in order to enable the utility to continue to function, at least insofar as existing assets levels and existing functions are concerned. But any failure to pass such increases on will cause a windfall loss to shareholders as a result of the reduction in the capital value of their shareholdings (cf. the discussion above relating to net cash flows).

Once a regulator has adopted such a policy, all future privatisations will be affected by the knowledge of such a policy. Subsequent privatisations where the monopolistic model will apply will only be possible at much lower flotation values, as investors factor in the prospect of future windfall losses. Logically, there should be no such effect in the case of privatisations where the competitive model is to apply, but in practice, investors are unlikely to view the matter with strict logic or to rely on such a distinction.

The final case to consider is a privatisation in the monopolistic model where the cost of capital is neither high nor low compared with historical levels. Should the regulator reflect subsequent changes in the cost of capital in future price controls or leave the return on capital at its initial level? The first policy (reflecting changes in the cost of capital) will make the price charged to customers more variable over time. The second policy (ignoring changes in the cost of capital) will allow the price of the utility's service and the return on capital to remain more stable, but the capital value of the company's shares will be more volatile, reflecting the deviation between return on capital and cost of capital. These variations in the share price will, by definition, increase the company's ß and, with it, the cost of capital for the utility concerned. Failure to pass on this company-specific change in the cost of capital will lead to further windfall losses to shareholders with consequences for flotation price achievable at future privatisations.

6. Conclusions

Except for BT in 1984, UK utilities were consistently privatised at a value significantly below the level of replacement costs giving rise to a continuing dispute regarding the appropriate measure of capital on which regulated companies should be allowed to earn a return. Specifically, this has focused on whether the RAB should be rolled forward using either full CCA or MAR adjusted depreciation. In this paper, we have argued that either approach can be valid depending on the potential for effective competition in a given sector.

In the presence of a natural monopoly there is no scope for introducing effective competition and it can be appropriate to roll the asset base forward using full depreciation. This approach ensures that all existing assets are maintained or renewed and that customers experience no price shocks. In this scenario, price-cap and quality regulation remains a reality until such time as technological innovations undermine the natural monopoly. However, if natural monopoly elements can be ring-fenced, or are removed through innovations, the depreciation charge applied to the RAB can be adjusted by the MAR. Although this requires a gradual increase in price to consumers, subject to innovations, it enables the development of effective competition within a sector and ultimately could remove the requirement for a sector specific regulator.

Whether or not a sector has the potential to support effective competition has implications for other aspects of regulatory policy. For example, it is common regulatory practice in the UK to allow changes in the cost of capital to be reflected in the pricing equation, whilst holding the RAB constant. In potentially competitive markets we argue that this policy is appropriate, as it enables new entrants to compete. However, in markets with natural monopoly elements, the absence of any competitors requires this policy to be carefully considered.

APPENDIX 1: Modelling the Regulatory Asset Base from First Principles

In the main paper, we presented the dilemma facing regulators of industries which have been privatised at a discount to replacement costs. Either they encourage effective competition, by allowing prices to rise sufficiently to enable new entrants to compete effectively, or they hold them down to protect consumers' interests but at the expense of an inefficient allocation of resources and closer monitoring of the regulated company's quality and efficiency standards. The difference between these two regimes is manifested in the regulators' price-setting policy.

In this appendix we take a detailed look at the role that depreciation and the treatment of the Regulatory Asset Base (RAB) play in determining the price and policy regime. As we demonstrate, it is the level of allowed depreciation that is the key to the implementation of the two alternative policy options.

A1.1. Setting Price Controls

One of the most visible aspects of utility regulation in the UK is the setting of price controls by regulators who, in doing so, must make reference to their statutory duties[24]. For example, regulators are subject to a primary duty to ensure that suppliers are able to finance the provision of their services and a secondary duty to promote and protect consumer interests.[25] These two duties lead to the setting of the RPI-X price cap that is intended to create appropriate incentives for productive efficiency. The regulator also promotes allocative efficiency by trying to relate price to an appropriate level of costs. The price charged to the consumer should satisfy the following simple formula:

$$price = operating\ expenditure + capital\ expenditure + return\ on\ capital \qquad (A1.1)$$

This equation says that, if a company is to be able to finance the provision of its service, allowance must be made in the price for (a reasonable level of) operating expenditure, capital expenditure and a return on capital. Determining the appropriate level of operating and capital expenditure to make allowance for within the price cap is outside the scope of this paper, as is the determination of the appropriate rate of return on capital. It is the amount of capital to be included in the equation (which we have referred to in this paper as the regulatory asset base or RAB) and its movement over time which this paper is concerned with. In particular, it is the consumption (or wearing out) of the RAB which poses the more difficult problem. As we shall see

[24] See Fleming (1996) for a comparison of duties that different regulators face.

[25] The exact phrasing varies across different regulators but the principle remains the same.

below, increments to the RAB arise when expenditure on capital assets is incurred with the amount of the increment being equal to the purchase price of the asset.

This wearing out of the RAB is generally referred to in the literature as "depreciation", without necessarily intending any preference for traditional accounting methods. We adopt that term here, once again without any inference that accounting methods should be used.

A1.2. Single Asset Utility

To demonstrate the role of depreciation and the RAB in determining the price charged to customers for the utility's services, we begin with the simplest possible example: a utility with just one asset, which was newly acquired at privatisation at a cost of £100m, having a useful lifetime of ten years and no resale value. On flotation, the shareholders paid £100m for the company, i.e. an amount which is exactly equal to the replacement cost of the asset.[26] At this stage, we assume away both inflation and technological progress, thereby ensuring that the replacement cost of the asset is constant over time. We assume that demand for the utility's services exactly matches the supply capacity of the company and that the company's cost of capital is 10% pa.

The regulator can choose to allow for depreciation of the RAB in a variety of ways. The case we consider is that of straight-line depreciation. With this traditional accounting approach, the RAB is diminished from its initial value of £100m at a constant rate over its useful life of ten years, resulting in £10m pa being allowed for in the price formula, thus:

$$price\ (£m\ pa) = opex + 10 + return\ on\ capital \qquad \text{(A1.2)}$$

This price formula enables the company to cover the cost of its opex, earn an appropriate return on capital (which the company can pay away to shareholders or keep for reinvestment in the business) *and* have £10m pa, i.e. the amount of annual depreciation, left over. By the end of the ten year lifetime of the asset, the company will have accumulated £100m of available cash. Ignoring, for a moment, any interest that the company should have earned from investing this surplus cash, this is just enough to replace the company's capital asset when it is worn out at the end of its ten year useful lifetime.

By definition, the RAB is 'rolled forward' from year to year by subtracting the (£10m) depreciation charge in each year and adding capital expenditure as and when it is

[26] There is no significance attached to our use of an example in which the company is entirely equity financed. For the purposes of our exposition, we could equally well have allowed for some of the capital to be debt financed and referred to "investors" rather than "shareholders".

incurred, i.e. every tenth year. Over the life cycle of the asset, this results in the RAB declining by £10m pa from its initial £100m to zero after ten years, followed by an overnight increase back to £100m at the start of each ten-year cycle.

At first, this approach appears to suffer from two defects. Firstly, as the RAB is declining, it would appear that shareholders are not being rewarded on the basis of their full investment. Secondly, the £10m pa paid by consumers and invested by the company in a cash fund would earn interest and therefore the amount needed to replace the asset after 10 years appears to be less than £10m pa. However, on closer inspection, these two apparent defects cancel each other out. The interest earned on the cash fund is available to shareholders as an additional source of return and, since the sum of the RAB and cash fund remains constant at £100m in each year, shareholders will earn a return on a capital base of £100m in each year. The reduction in the RAB does not, therefore, cause shareholders to suffer a return on less than their full investment of £100m. Nor is the depreciation of £10m pa excessive on account of the fact that interest is earned on the cash fund.[27]

When, at the end of the tenth year, the utility uses the cash fund to purchase a new asset, the RAB increases overnight from zero to £100m. Under the regime described, this cycle repeats itself every ten years. Figure A1.1 illustrates the movement of the RAB over two cycles. As described, the cash fund will move in exactly the opposite way, i.e. from nil to £100m. It is important to note that, despite the fact that shareholders earn a return on capital of £100m in each year, the price charged to customers for the services of the utility is *not* constant. This is because the return on capital component of the price equation (A1.1 or A1.2) relates only to the return on the RAB.[28] Customers do not contribute to the shareholders return on the cash fund; the return is achieved by investing the fund.

[27] In this simple example of a company with just one physical asset, the capital base of the company is in a constant state of change from being wholly a physical asset (on day one) to purely a cash asset (at the end of the tenth year) and round this cycle again. Accordingly, the cost of capital will vary in each year as the company's ß varies from the asset ß to zero and back again. As we shall see, in the case of a multi-asset company, this scenario does not arise.

[28] It should perhaps be noted that the annual reduction in price is simply an artefact of a year being the conventional period for reporting results. The regulator could equally well level out the price and, therefore, the regulatory profit over the ten years, but the accounting profits would then increase each year as a result of the increasing interest on the cash fund.

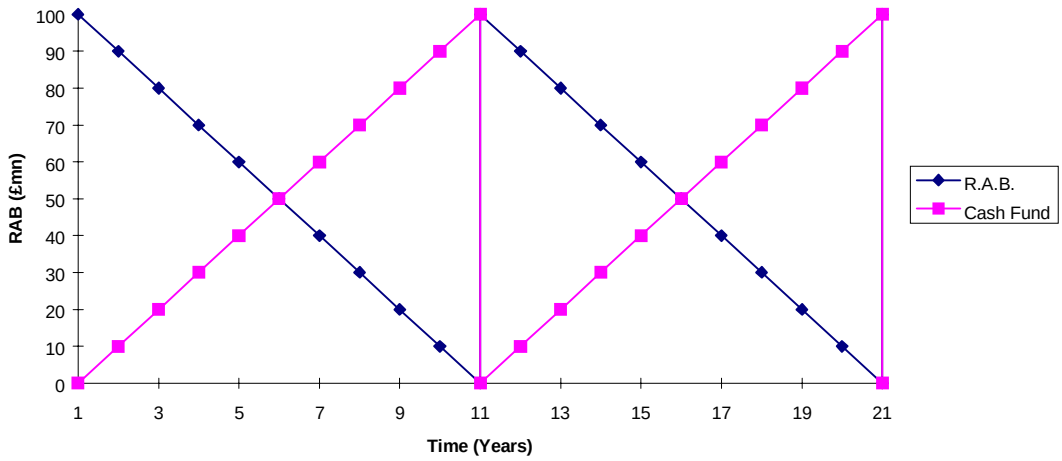

Figure A1.1: Profile of RAB in a single asset utility using straight line depreciation.

A1.3 The Multi-Asset, Steady-State Utility

The outcome of the model described in the preceding section, i.e. that the price charged to customers varies significantly over each ten-year cycle, is simply a feature of the single-asset model which we adopted for the purposes of exposition. In a scenario in which the utility has a multiplicity of assets, each with different replacement dates, the RAB would not fall to nil, the cash fund would never rise to 100% of the asset base and the price charged to customers would not be subject to the same extent of fluctuations as are inherent in the single asset case.

The most stable scenario, which we look at now, is the multi-asset, steady state model in which both the RAB and price charged to customers is constant from year to year. Consider a utility with ten capital assets, each with a CCA value of £10m, with a replacement profile requiring one new asset in each year. The consequences of such a model are that:

a) The cash fund built up during the course of each year would be needed to buy the replacement asset required at the end of that year. The only variation in the RAB would be between the year start value of £55m and the year-end value of £45m, immediately prior to the purchase of the replacement asset. (The derivation of this figure is shown in the algebraic notes included as Appendix 2.)

b) The investors' return on capital will, therefore, be based on the same asset base in each year. As a result, the profits will be constant in each year and so too will the regulatory price, which will be sufficient to remunerate the RAB, leaving the

company to invest the cash fund to make up the return on the full amount of its investment.

If the 10-asset utility was already in existence at privatisation, and is expected to continue indefinitely, it is only necessary to have a cash fund which increases from nil to £10m over each year, returning to zero once one of the assets is replaced.[29]

In this hypothetical steady state world, with the annual replacement of an equal part of the physical asset base, and with no change in the replacement cost over time, the price of the utility's service, and the utility's annual profits, will remain constant.

As we shall see below in Section A1.6, the introduction of efficiency improvements and/or technological improvements which reduce the replacement cost of the asset will enable the utility to reduce the price that can be charged to the consumer, which gives us the familiar RPI-X pricing rule adopted for British utilities.

A1.4 Introducing the capital value discount (or MAR)

In the above examples, shareholders receive a return on their initial investment. Part of the return comes from the regulated price of the utility service, which is sufficient to provide a return on the replacement cost of the assets, with the remainder earned by investing any cash fund built up in periods between asset replacements. Thus, this regime enables the regulator to encourage effective competition without compromising consumers' interests.

However, as discussed in the main paper, for the majority of utilities privatised in the UK, the sale price established by the government was less than the CCA value of the assets. With the sale price at a discount to the capital value,[30] the regulator must choose between a pricing policy in which customer prices equal the new entrant price (which we described as the "competitive" model in section 3) and a policy in which prices are sufficient to remunerate the shareholders' investment, but not sufficient to

[29] If the ten assets were acquired post-privatisation, the pricing and depreciation policy described here would, in fact, lead to the accumulation of a cash fund of £45m at the start of each year, rising to £55m by the end of the year, and falling back to £45m when the new asset was purchased for that year. If the steady state continues indefinitely, £45m of the cash fund is unnecessary. It is there simply to protect shareholders against the day when the company is wound down and the shareholders wish to re-coup their £100m investment. In practice, the utility would be privatised with its asset base already built up and no cash fund (other than the fund which builds up and is consumed within each year). This means that the value of the assets (physical assets plus cash) is only £55m at any given date and the logical arrangement at privatisation is for investors to pay only £55m for the company. We return to this scenario below when we consider the policy for companies privatised at less than the replacement cost of the assets.

[30] The ratio of floatation price to the CCA value is often referred to as the Market to Asset Ratio, or MAR. Thus, the MAR percentage is equal to (100% – the percentage capital value discount).

attract effective competition (described as the "monopolistic" model). We now explain why that policy option arises and how the choice is put into effect. The exposition which follows will also amplify our earlier discussion that it is the treatment of depreciation which determines the choice between the competitive and monopolistic models.

The first point to note is that the sale of a utility at less than the CCA value of its assets does not result in windfall gains for shareholders, despite the appearance that they are acquiring valuable assets at less than fair value. The crucial factor is that shareholders were not just buying assets to do with as they pleased; they were buying a company which also possessed a regulatory licence, with the associated permissions (to operate in the regulated market) and obligations (not to cease operating, without regulatory approval). By virtue of this obligation, shareholders (and the regulated companies which they bought) were prevented from selling these assets and capturing the CCA value.

The government established the sale price on the basis of the NPV of future profits which, at least for the foreseeable future, assumed customer prices would not (necessarily) be sufficient to provide a return on the CCA value of the companies' capital, but would instead be set at a lower level broadly in line with the pre-privatisation regime. The corollary to this method of setting the floatation share price was that customer prices were set on the basis of providing shareholders a return on their original investment, rather than the replacement cost of assets, which meant that new entrants would not have an incentive to enter the market because the return on their capital would not be sufficient.

This policy, adopted by the Government of the day, of having no price shocks at privatisation created the tension between holding prices down and promoting effective competition; and for those regulators who wanted to (or were charged with) promoting competition, the "no price shocks" policy also created the dilemma as to how to increase prices sufficiently to encourage competitors to enter without, at the same time, creating windfall gains to shareholders through higher prices and, thereby, higher profits. As we show in the next section, these windfall gains can be avoided, whilst still accommodating the introduction of effective competition, by pursuing a regulatory policy which requires additional injections of equity to be made, of an amount sufficient to justify the higher profits which are the inevitable consequence of higher, new entrant based, prices.

We now return to our example of the one asset utility to explain how the competitive and monopolistic policy choices are implemented. Now, instead of assuming that the company was sold for £100m, we assume that it was sold for £60m, i.e. 60% of the (undepreciated) CCA value.

It has been argued that, where the flotation price is less than the CCA value (i.e. the MAR is less than one), depreciation should be based on the MAR-adjusted figure. Any higher depreciation figure would (it is argued) reward the shareholders with more than they paid for the assets. Once again, however, this argument fails to take account of the utility's licence. The shareholders are not free to keep this extra amount of depreciation, because the utility licence effectively obliges the company to replace the existing assets when they are worn out, so there is no windfall gain.

Indeed, if only the MAR-adjusted depreciation figure is recovered from customers, there will not be enough cash accumulated in the depreciation fund to pay for the replacement of the flotation assets when they wear out. As we shall see in the description of the competitive model below, the cash shortfall does not rule out using the MAR-adjusted depreciation figure; it requires the cash shortfall to be made good through an injection of equity. The alternative, described in the monopolistic model, is to allow full depreciation, with no injection of capital needed to buy the replacement asset and no increase in consumer prices.

The Competitive Model

As indicated above, in the competitive model, we allow for depreciation of the MAR-adjusted RAB. The reasons for this will become apparent from the exposition that follows. This means depreciation at the rate of £6m pa, given our assumption of a flotation price of £60m and assets with a lifetime of ten years.

Consider, first, the single asset scenario. Over the first ten years from privatisation, the RAB declines from its initial value of £60m by the depreciation charge of £6m pa until it reaches zero by the end of the tenth year. Correspondingly, the cash fund increases from zero to £60m. In each year of the asset's ten year life, shareholders earn a return not only on the RAB, but also on the depreciation cash fund that is accumulating. The sum of these two is £60m in each year.

At the end of the asset's ten year life, the £60m that has built up in the cash fund is insufficient to buy the replacement asset which (by our assumptions) still costs £100m. Therefore, to replace the asset the company has to obtain an injection of a further £40m of equity. Once this injection is made and the new asset purchased for £100m, this justifies raising the RAB to £100m, so that both the new investment of £40m and the original investment of £60m can earn a full rate of return.

The increase in the RAB means that both the depreciation and the profit level will have to increase in line with the new asset base. In the single asset scenario, the price paid by consumers will have to increase by a multiple of 10/6 on that part in excess of the opex. This price increase to consumers makes it possible for new entrants to compete

in the market with the same technology, but without giving the original shareholders a windfall gain – which is exactly what the competitive model was seeking to achieve.

Once the equity injection has been made, and the replacement asset bought, the cycle is exactly the same as if the company had been privatised at its full CCA value. Figure A1.2 illustrates the movement of the RAB over the first 20 years following the privatisation of the single asset utility. As with figure A1.1, the cash fund moves in exactly the opposite direction to the RAB. Again, the reduction in the RAB over the cycle will lead to reductions in the consumer price, as the profit element allowed in each year's price falls in line with the falling RAB.[31, 32]

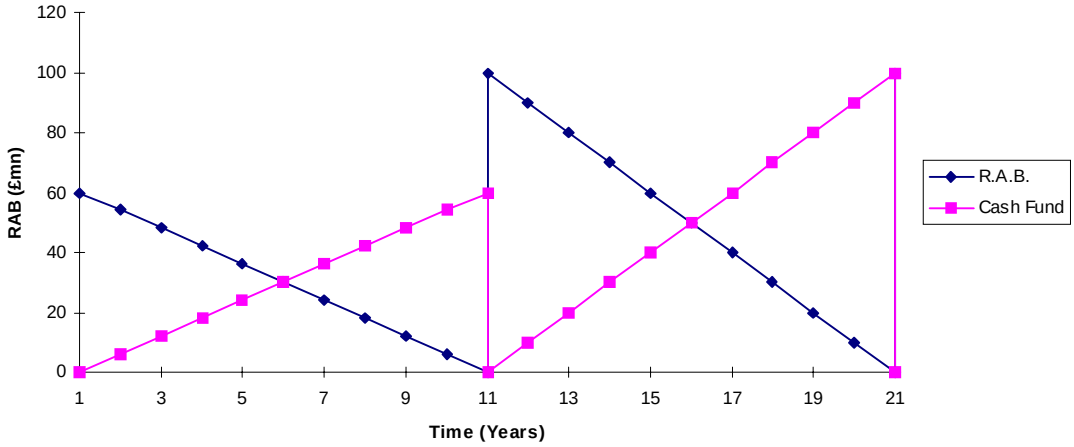

Figure A1.2: Profile of RAB in a single asset utility with straight line MAR-adjusted depreciation.

In the multiple asset scenario, the injection of additional capital, and therefore the price changes for the consumer, are progressive, not sudden. The first price change occurs after one year when the first asset wears out. The RAB of £54m (i.e. £60m less one year's depreciation of £6m) is increased to £64m as the first asset is replaced by a new one costing £10m and requiring a capital injection of £4m to top up the available cash of £6m. This process repeats each year for ten years, with the RAB increasing by £4m each year, until it reaches £100m and the depreciation charge increasing by £0.4m each year, until it reaches £10m, whereupon both amounts settle down. With all the pre-privatisation assets having been replaced, the MAR is now unity and the RAB will fall

[31] And, accordingly, the profit earned by shareholders from interest on the cash fund increases in inverse proportion to the profit element in the consumer price.

[32] As before, the annual reduction in price is simply an artefact of a year being the conventional period for reporting results. The regulator could equally well level out the price and, therefore, the regulatory profit over the ten years, subject to the accounting profits increasing each year as a result of increasing amounts of interest being earned on the cash fund.

thereafter from £100m to £90m in each year, as a result of depreciation, rising again to £100m when £10m from the cash fund is spent on the replacement asset for that year.

The Monopolistic Model

If, for the reasons discussed in the main paper, the regulator chooses (or is mandated) not to promote effective competition, prices to consumers can be maintained at their pre-privatisation level without the need for additional injections of debt or equity. This is true even when the utility is privatised at less than the replacement cost of its assets.

In order to achieve this result, the annual depreciation charge must be based on the full CCA value of the asset and not the MAR-adjusted value. This implies an annual depreciation charge of £10m.

In the single asset scenario, the RAB would decline by £10m pa (the depreciation charge) from £60m in year 1 to *minus* £40m by the end of year ten. The anomaly of a negative RAB need not be as disturbing as it first appears as it does not mean that the company has a negative capital employed. The aggregate of the RAB (whether positive or negative) plus the cash fund will always be £60m and shareholders will always be entitled to a positive return on their funds, albeit that the return on the *regulated* business will be negative in the last four years of each ten year cycle to offset the return on the cash fund which exceeds the shareholders £60m investment in those four years.

At the end of each ten year cycle the cash fund will have accumulated to £100m, which is sufficient to replace the worn out asset without the need for a further injection of debt or equity. Once the new asset is purchased and £100m added to the (negative) RAB to return it to £60m, the cycle repeats itself again, see figure A1.3. So, whereas in the competitive (single asset) model shareholders earn a return on only £60m until the asset is replaced, and earn a return on £100m thereafter (because an additional £40m of capital is injected), in the monopolistic model shareholders only ever earn a return on their initial investment of £60m. This means prices for consumers are held permanently below the level associated with allocative efficiency. There is a danger that companies will have the incentive to use the £100m cash fund to earn a full rate of return, rather than a MAR-adjusted rate of return, by investing in unregulated activities. Licence conditions are, however, in place to prevent companies doing this, by requiring maintenance of the regulated activity. Nevertheless, the existence of the incentive will require the regulator to monitor the utility's investment decisions.

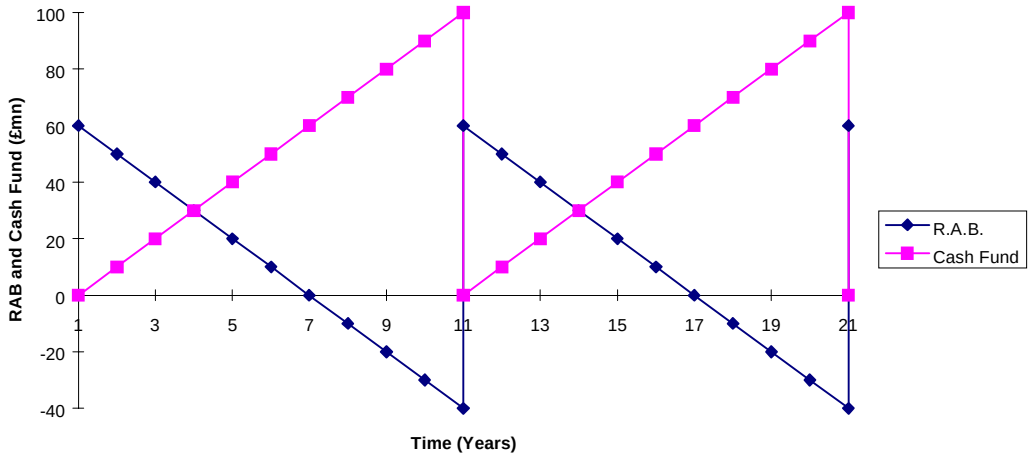

Figure A1.3: Profile of RAB and cash fund for single asset utility regulated under monopolistic model.

In the multi-asset, steady state scenario, the full depreciation of £10m pa exactly matches the capex in each year (just as it did when the company was floated at its full CCA value), the RAB falls by £10m during each year, but then returns to its initial value (£60m in our example) at each year end when a new asset is purchased for that amount. Since there is no need to inject any new capital (because the level of depreciation in each year is sufficient to replace assets which wear out in that year), there are no consumer price changes for so long as the steady state continues.

The monopolistic model we have described here is not an invention of the authors. It is, for example, the methodology underlying the treatment of the RAB, and depreciation thereof, adopted by Ofwat for the 1994 Periodic Review of water company price controls (and, based on Ofwat's recent Consultation Paper for the 1999 Periodic Review document, will be adopted by Ofwat again).[33]

A1.5. Switching Between Regulatory Models

Switching between the two regulatory models we have described raises a number of issues for the Regulator. As we shall see, much depends on the level of knowledge in the marketplace as to the Regulator's policy.

In order to see why, recall first that the flotation price (and hence the MAR) depends on the perception of investors as to the future depreciation policy to be adopted by the

[33] See, for example, section 8.5 of Ofwat's Consultation Paper on the 1999 Periodic Review of water company prices, which revises the policy adopted for the 1994 Periodic Review as well as indicating the policy for 1999. In the penultimate paragraph of this section, Ofwat specifically refers to the steady state scenario as part of its thinking.

regulator. Assuming a rate of return of 10% pa, a pre-privatisation price of opex plus £12m pa for customers would imply a MAR of 20% if full CCA depreciation is to be adopted (as in the monopolistic model), i.e. depreciation of £10m pa, leaving a profit of £2m pa on an investment of £20m, whereas MAR-adjusted depreciation (as applied in the competitive model) would imply a MAR of 60%, i.e. £6m pa of depreciation, leaving £6m pa of profit on a £60m investment. In the latter case, as and when replacement capital is purchased, new investment capital would need to be injected, increasing the RAB until it equalled £100m and increasing the price paid by customers to £20m pa, i.e. depreciation of £10m and profits of £10m on an initial investment of £60m plus a further £40m of injected capital.

In practice, the regulatory depreciation policy has not normally been announced at the time of privatisation of UK utilities. Where the first review of prices has been conducted by the MMC (as happened in the case of British Gas in the MMC's 1993 report), it would not have been possible for the MMC to announce its intention at the time of privatisation, five years earlier.

Reverting to the figures in our previous example, let us suppose that a utility with assets having a CCA value of £100m is to be privatised without any statement of policy on regulatory depreciation (or, equivalently, without any indication whether prices are to move towards economic cost). Customer prices are to continue at the pre-privatisation level of £12m pa (with no expectation of any expansion by the company and no technological improvements to drive prices down). On the basis of the analysis in this paper, the privatising government should choose between the alternative policies and set the flotation price accordingly. Specifically, using straight line depreciation, with and without the MAR adjustment, the two alternative flotation prices are £20m and £60m. Let us suppose that the government opts for £20m.

If the potential investors have sufficient information to know how the government arrived at this figure, they will anticipate full depreciation and be willing to pay £20m for the company. But now suppose that, after five years, the Regulator decides that his policy is to move to economic pricing, based on MAR-adjusted depreciation. When the Regulator draws up the utility's accounts (privately, for his own purposes) *using MAR-adjusted depreciation, rather than full CCA depreciation used by the government*, the regulator will deduct depreciation of £2m pa (because the MAR was 20%) from the revenue of £12m pa paid by customers and find that the utility has made profits of £10m pa, i.e. £8m in excess of the level appropriate to a flotation price of £20m.

From the perspective of a regulator who wishes to adopt MAR-adjusted depreciation, the flotation price of £20m suggests that post-privatisation prices need only have been opex plus £4 pa, i.e. allowing £2m for depreciation and £2m for profit. Alternatively, recognising that the only reason for the government privatising at a MAR less than one

was to avoid customer price shocks, the Regulator will conclude that the shares should have been sold at £60m.

In either event, the Regulator's policy decision requires the price to move, over time, to the economic level of opex plus £20m pa from their present level of opex plus £12m pa. In the hypothetical single asset scenario, the Regulator does not need to move prices upwards until the single asset needs to be replaced in five years time. In the meantime, he can reduce prices all the way down to opex plus £4m if he wants to (or even lower if he is minded to claw back the excess returns earned over the first five years), followed by a hike to opex plus £20m after a further five years. (In practice this strategy would be politically unacceptable but, in practice, utility's do not have single assets.)

In the multiple asset, steady-state scenario, the Regulator's view of prices is that they should be rising from opex plus £4m in the first year to opex plus £20m after ten years, in steps of £1.6m pa. This means that, after five years, the price should be at opex plus £12m, which is exactly where it has always been. The Regulator can, therefore, set prices on their upward trajectory towards opex plus £20m (subject to a reduction if he intends to claw back the excess profits earned in the early years).

In the real world, where neither the single asset scenario nor the steady state scenario holds, the necessary price trajectory will depend on when the assets actually need to be replaced.

A1.6. Technological Progress

In this section we explore the impact that technological progress has on the framework that we have developed. We shall assume that advances in technology result in the reduction of the cost of a modern equivalent asset by 3% per annum and this reduction is anticipated by all concerned. Therefore, the asset in place at privatisation, which had a replacement cost of £100m at that time, would cost £73.7m to replace ten years later.

Competitive model with technical progress anticipated

First, we consider the case of a company sold at its CCA value and which operates in a market which is open to competition. In this case, a new company can enter the market at any stage. If, as described in our previous analysis, the incumbent's depreciation charge is calculated on a straight line basis, a new entrant to the market one year later would be able to undercut the incumbent simply by virtue of the fact that the cost of the capital equipment is 3% lower.

Because, by hypothesis, the rate of technological progress is known (with certainty) to all players, the incumbent company will choose to 'tilt' the depreciation charge recovered in the price charged to consumers so that it starts out at a higher level than straight line depreciation would require, but declines at the same rate as technical progress is reducing the cost of the replacement asset. By adopting this strategy, the incumbent will be able to cut its price exactly in line with the new entrant's price, whilst still recovering the full amount of capital spent on the asset.

Figure A1.4 below shows how this pricing strategy works. To ensure that the shareholders earn an adequate return on their investment, the 'tilted' depreciation charge must be sufficient to build up a cash fund equal to the cost of the existing asset by the end of the asset's life (i.e. a cash fund of £100m built up during years 1 to 10 and a fund of £73.7m built up during years 11 to 20 and so on).

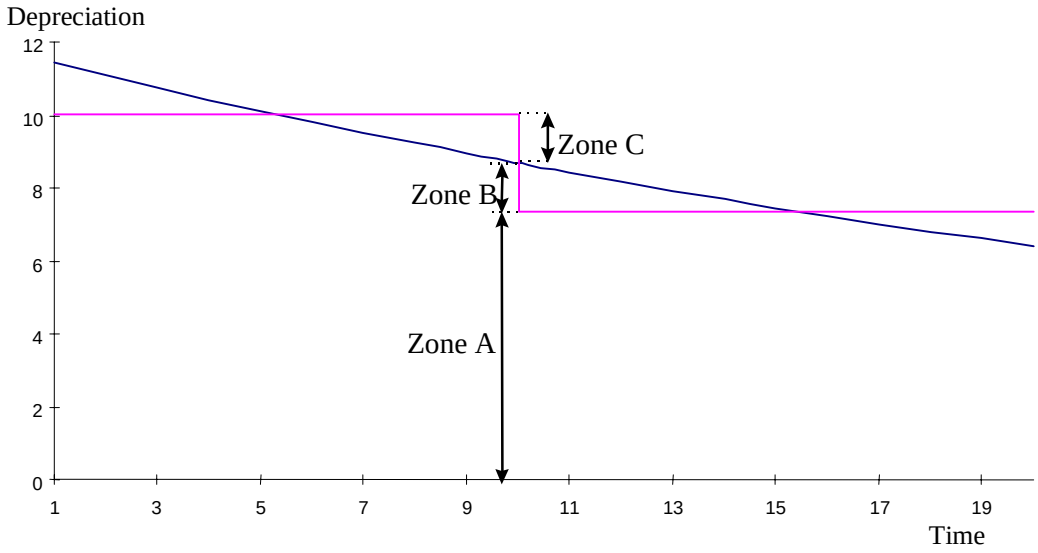

Figure A1.4: Depreciation profile with technological progress.

A consequence of this regime is that the cash fund built up over the lifetime of an asset is more than sufficient to replace it, so funds are released to the company which can be invested elsewhere or returned to the shareholders.[34] If the surpluses released in this way continue to be held as cash, the fund will asymptote towards the initial (privatisation) CCA value, just as the RAB asymptotes towards zero. Figure A1.5 below shows the movement over time of the price, the RAB and the cash fund in this scenario.

[34] If this surplus cash were not generated, e.g. as a result of charging consumers a lower price, the shareholders would suffer an inadequate return on their funds, because the price in each successive cycle remunerates a progressively smaller RAB.

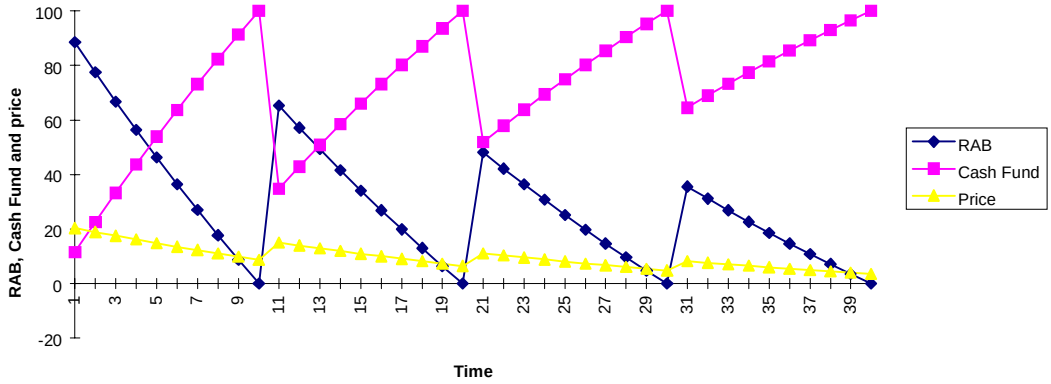

Figure A1.5: Price, RAB and cash fund profiles for a company privatised at its CCA value and operating in a competitive market with technological progress.

In the case where the company is privatised at less than its CCA value, the outcome of the strategy needs to be modified according to the size of the MAR in relation to the rate of technical progress, as we now show. Consider the position if, for the reasons explained above, the regulator adjusts the depreciation charge by the MAR. This results in a cash fund equal to 100*MAR having been accumulated by the time the original asset has expired. Provided that this sum is less than the replacement cost of the asset (£73.7m in year 10), marked as Zone A in Figure A1.4, a cash injection is required, as before, of sufficient size as to increase the available funds (and thereby the RAB) to the prevailing replacement cost.

There are two points worth noting in this "Zone A" scenario. Firstly, as a cash injection is required to bring the RAB up to the replacement cost of the asset, prices will increase to the new entrant level despite the existence of technological progress. Secondly, given that (by hypothesis) the low MAR caused the price during the first life cycle of the asset to be well below the new entrant price, the depreciation can be set on a straight line basis without new entrants being able to undercut the incumbent. Figure A1.6 shows some of the relevant profiles for this scenario when the MAR = 20% and the original asset is depreciated on a straight-line basis. After the original asset is replaced and the cash injection made, depreciation will once again need to be reduced at the rate of technological progress.

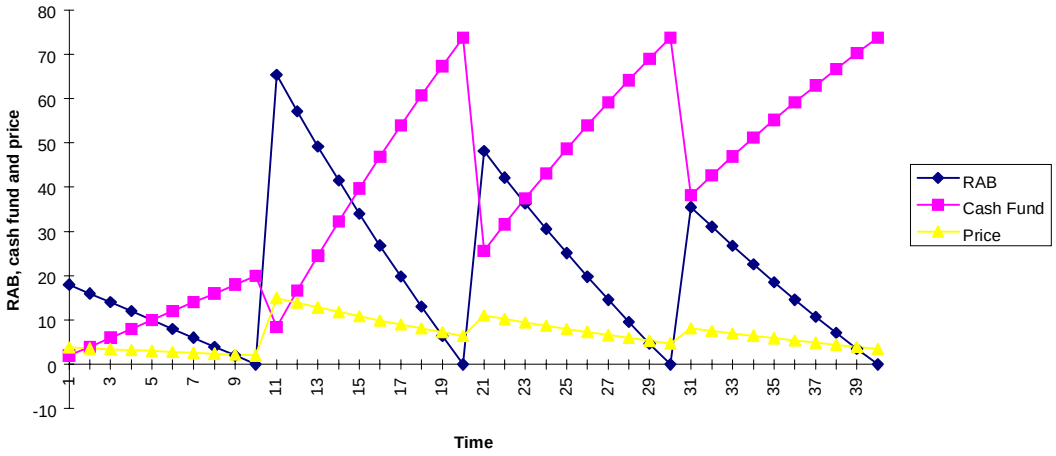

Figure A1.6: Price, RAB and cash fund profiles for a company privatised at 20% of its CCA value and operating in a competitive market with technological progress.

The requirement for a cash injection in the above example is a result of the size of the MAR. A larger MAR, and consequently a larger depreciation charge corresponding to Zones B or C in figure A1.4, would result in the accumulation of a cash fund that is greater than the replacement cost of the asset. When this occurs, competition is possible without any need to increase prices to consumers; in these scenarios, technological progress has done the work for the regulator.

The difference between Zones B and C relates to the choice of depreciation method. In Zone B, as in Zone A above, straight line depreciation can be charged without any new entrants being able to undercut the incumbent's price prior to the intended date, i.e. the inception of the second asset life cycle. However, in the case of Zone C, if the regulator sets depreciation on a straight-line basis, the incumbent's price will exceed the new entrant price from the point in time where the tilted depreciation shown in figure A1.4 falls below the incumbent's MAR-adjusted straight line depreciation. To avoid this, the regulator will have to tilt the depreciation charge as previously described to ensure that the regulated price does not exceed the new entrant price during the first cycle.

Monopolistic model with technical progress anticipated

In the monopolistic model, there is, by definition, no threat of a new entrant, so depreciation does not need to be tilted. However, other, more complex issues arise when the flotation price is less than the CCA value of the assets (i.e. the MAR is less than 100%).

The approach which bases depreciation on the CCA value of the assets at the time of privatisation could lead to a permanently negative RAB. This is because the RAB is reset at the start of each cycle to:

flotation value *minus* cost of existing asset *plus* cost of replacement asset.

If the MAR is small enough and technical progress large enough, this figure for the RAB at the start of a new cycle can become negative and, once that happens, the RAB will never return to a positive value.[35] Having a multiplicity of assets does not resolve this problem; it would simply mean that, one by one, the RAB for each asset will go negative.

In these circumstances, the company relies for its profits on the returns earned by the cash fund. In theory, the negative profits could become so great that the utility is required to charge a negative "price", i.e. the negative profits exceed the operating costs plus the cost of depreciation, but even if this extreme position is not reached, a scenario in which the RAB is permanently negative and the regulated business must therefore run at a loss gives rise to presentational difficulties.

To circumvent this difficulty, the depreciation charge can be based on the cost of the replacement asset, rather than the existing asset. This results in the RAB being reset to the flotation value at the start of each cycle. Figure A1.7 shows how the RAB, cash fund and price change under this scenario.

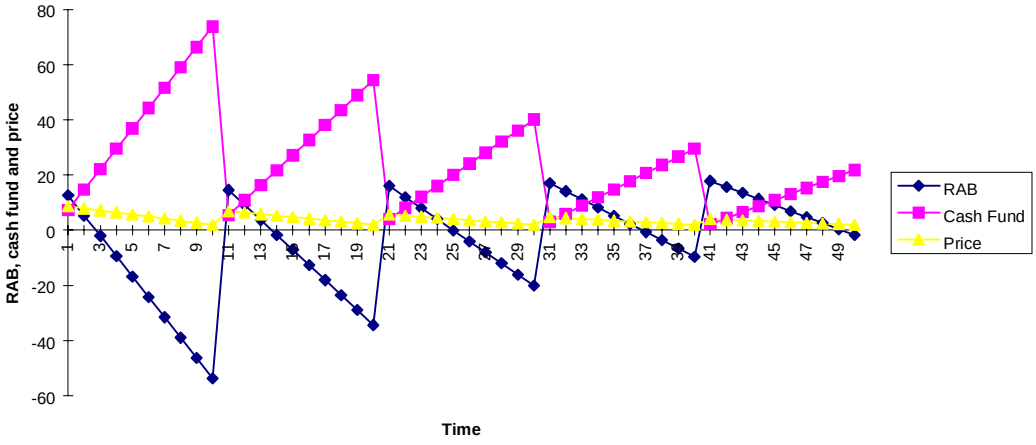

Figure A1.7: Price, RAB and cash fund profiles for a company regulated under the monopolistic model (MAR = 20%, technological progress = 3% pa).

A further difficulty arises, however, if technical progress drives the cost of the replacement asset below the flotation value. At this point, a RAB equal to the flotation

[35] For example, in the water industry, where the floatation value was approximately 10% of the CCA value of the assets, the RAB will become negative if technical progress reduces the cost of the capital assets) by more than 10% over the asset lifetime (which is equivalent to a relatively modest annual improvement).

value causes the profit element to exceed the profits earned in a competitive market and the price charged to customers could exceed the new entrant price. If entry to the market is permitted, the incumbent would suffer a windfall loss as prices are brought down to the new entrant level. On the other hand, if entry is prohibited, and the price to customers is maintained at a level that avoids a windfall loss to the incumbent, customers would necessarily be charged an economically inefficient price.

Both of these adverse results can be avoided if, at the start of the cycle when replacement costs are projected to fall below the flotation value, the depreciation schedule is reduced such that only the flotation value is recovered. In this way, the price during the current cycle will not exceed the new entrant level and the RAB at the end of the current cycle will be reduced to zero and will start the next cycle at an amount equal to the replacement cost of the next asset, which (by hypothesis) is less than the RAB at the start of the previous cycle. From this point on, prices are set at the new entrant level and the model runs exactly as in the competitive scenario. See figure A1.8.

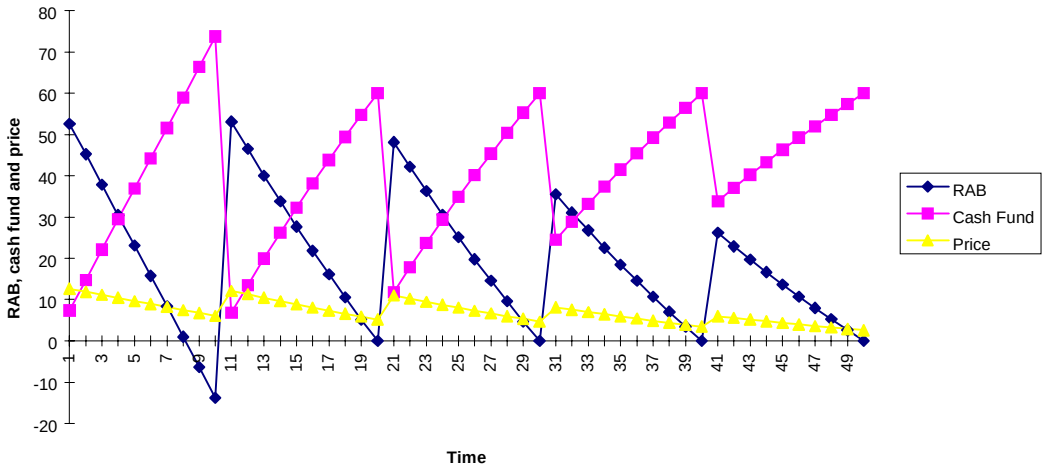

Figure A1.8: The effect on price, RAB and cash fund of switching methods (at start of period 11).

Unexpected technical progress

The foregoing analysis is based on the premise that the technical progress was anticipated, which enabled the incumbent to know exactly when and by how much to tilt the depreciation charge in the competitive model and when to switch the depreciation method from full CCA value to flotation value in the monopolistic model. The results of unanticipated technical progress are described fully in Section 4 of the body of the paper and do not require any amplification here.

Different rates of technological progress.

A final point worth raising is the effect of different rates of technological progress on prices. In particular, we observe that faster rates of cost reduction have the counter-intuitive outcome that prices are higher in the short run, as a result of the need for greater tilting of the depreciation schedule.

This point can be illustrated by reference to a single asset utility privatised at its CCA value and operating in a potentially competitive market. As already explained, if new entrants are to be prevented from undercutting the incumbent, the depreciation charge is required to decline at the same rate as technological progress. In addition, to reward shareholders appropriately, the sum of the charges must equal the price the company was sold for. This scenario is illustrated in figure A1.9 below for our single asset utility with costs declining at 3% and 6% p.a.

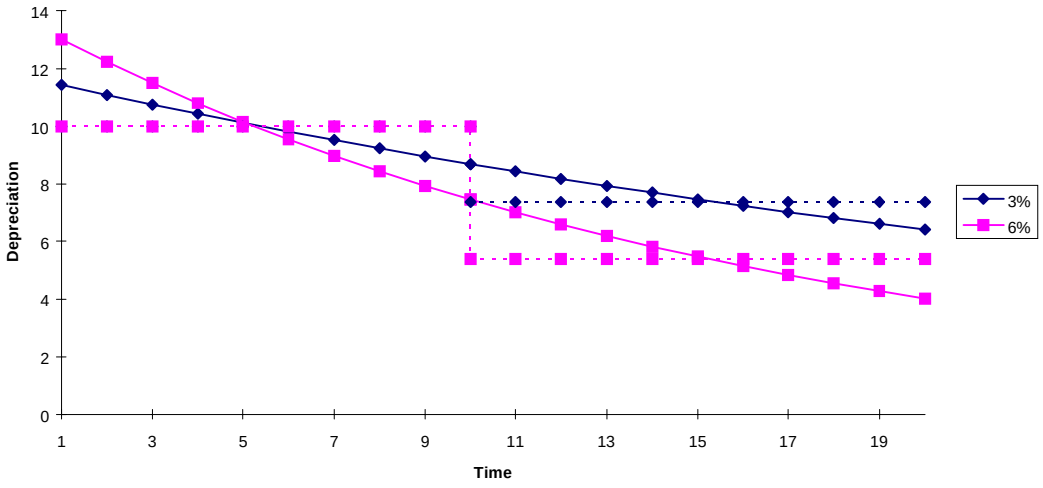

Figure A1.9: Comparing the effect of different rates of technological progress on depreciation charges.

APPENDIX 2: Algebraic notes

This appendix outlines a simple, discrete model of the Regulatory Asset Base (RAB) that informed the discussion in sections A1.2 and A1.3 regarding single asset and multi-asset utilities.

The assumptions of the model are as follows:

- All assets are identical, i.e. they cost the same and have the same life span.
- Assets expire evenly over time, i.e. if a company has ten assets each with a ten year life span then one asset is assumed to expire every year.
- There is no inflation or technological progress.
- There is no operating expenditure.

The model:

C = replacement cost of asset
r = interest rate
n = life span of asset
m = number of assets
t = time from start of cycle

In addition to the assumptions made above, we add the following:

$$1 \leq t \leq \frac{n}{m}; \quad n \geq m. \tag{A2.1}$$

This ensures that the variables of interest, e.g. price, RAB and cash balance, repeat in a cycle that lasts for (n/m) periods, i.e. two assets with ten year life spans will generate a cycle that repeats itself every five years. Alternatively, ten assets with ten year life spans will generate a 'cycle' that repeats every year, i.e. the multi-asset, steady state utility previously described. Although it might appear restrictive to assume that the number of assets cannot exceed their life span, we can define the life span using any period of time we wish (e.g. years, months, days etc), provided t is similarly treated.

As defined in equation A1.1, price is set to cover operating expenditure, capital expenditure and a return on capital. As we have assumed here that there is no operating expenditure, we can therefore define price as:

$$p_t = d + rA_t, \quad \text{where d = depreciation and } A_t = \text{regulatory asset base} \tag{A2.2}$$

Given that we have assumed all assets to be identical (i.e. $C_1 = C_2 = C_m$ and $n_1 = n_2 = n_m$) we can define the straight line depreciation charge as:

$$d = \frac{mC}{n} \tag{A2.3}$$

The regulatory asset base, A_t, on which shareholders earn their return, is equal to the cost of the assets less depreciation that has been accumulated (equal to the cash balance, B_t). Therefore, the RAB and cash balance can be defined as follows:

$$A_t = mC - B_t,$$

$$B_t = \frac{C(m-1)}{2} + \frac{mC(t-1)}{n}. \tag{A2.4}$$

The two expressions in B_t represent the depreciation accumulated up to the start of a new cycle and the depreciation accumulated during the current cycle. In the case outlined in section A1.3 of a utility with ten assets each having a ten year life span then (as $n = m$ and therefore $t = 1$) the 'cycle' only lasts one period and therefore represents something of a 'steady state'. As discussed in the main text, this multi-asset utility requires an opening cash balance to be in place at the time of privatisation. In this example, the cash balance is £45m representing the sum of 9 years depreciation on the oldest asset, 8 years on the next oldest all the way down to one years depreciation on the asset purchased at the start of the last period. This opening cash balance, which is a consequence of assuming that assets expire evenly over time, is consistent with a utility that started with one asset but, over time, built up to the assumed 10.

In this model, shareholders are assumed to earn a return on the asset base of the utility, through the price paid by consumers, and on the cash accumulated from the depreciation charge. Therefore,

$$\pi_t = r(A_t + B_t) = rmC. \tag{A2.5}$$

These equations can be used to calculate the profiles discussed in sections A1.2 and A1.3 and depicted in figure A1.1.

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