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Privatisation of Utilities and the Asset Value Problem

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Abstract
Privatised utilities are typically characterised by both undervaluation and underpricing. When faced with this problem, regulators have tended to employ a market value approach to determine the regulatory asset base. This paper analyses this approach and shows that any error at privatisation is magnified and that relative errors remain entrenched forever. We suggest an alternative, i.e., the regulatory agency's own estimate of the company's value and show that errors made at the time of privatisation do not have the same impact on future prices and hence far less effect on the potential sale price.

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1. Introduction

Perceptions of the appropriate size of the traditional public sector, and the natural boundary between the public and private sectors, have moved dramatically in the last two decades. The scale of this change is abundantly clear from the accelerating international trend to privatise state assets. Europe has been at the vanguard of this movement, particularly linked with the creation of private regulated utilities. For example, Dewenter and Malatesta (1997) in their recent international comparison of public offerings of state owned and privately owned enterprises report that the UK alone accounted for 33 of the 55 privatisations of firms in regulated industries within their sample. Even within well developed European economies regulated privatised companies (mostly telecommunications) account for a significant fraction of the stock market (e.g., at least 13.1% in Germany, 11.7% in Italy and 7.7% in France (see Megginson and Netter (2001)).

Privatisation of utilities has typically been characterised by both undervaluation and underpricing.[1] Undervaluation occurs when the market-value of the company (equity plus debt) at privatisation is less than the replacement cost of the assets. Underpricing occurs when the shareholders pay less than the market value for these assets, i.e., shares are sold at a discount to the post privatisation market price. To promote efficient investment it is standard to allow assets to earn a risk-adjusted cost of capital on the replacement cost of the assets. This is generally accepted policy for investments that are made post privatisation and indeed essential in the long run if regulated companies are to have the correct incentive structure. However, it is often argued that shareholders may derive a windfall gain if assets that are transferred at privatisation are undervalued at privatisation but valued at replacement cost for future regulatory purposes. Generally, when faced with this problem, shareholders have been remunerated on the basis of the market value of the company at or around the time of privatisation. This is usually referred to as the market value approach to the valuation of privatised assets for regulatory purposes. This paper assesses this market value approach and shows that it has inherent problems. We then address the question whether there is an alternative mechanism that can accommodate the

[1] Telecommunications tend to be an exception to undervaluation.

undervaluation problem but does not fall foul of the difficulties inherent in the market value approach. We outline an alternative and show that it is practical and superior to the market-value approach.

Final utility prices are determined by the product of the cost of capital and the approved asset base so it is not surprising that they have received a great deal of attention both in the regulatory and the academic arena. Kahn (1989), referring to the regulated return on invested capital, points out that 'since it is this element in the cost of service that determines the size of the company's profit it is not surprising that its determination has been by far the most hotly contested aspect of regulation, consuming by far the greatest amount of time'. In the US context, both cost of capital and asset base issues have received considerable academic attention. Interestingly, Kahn notes that in the US it is the asset base that has been the focus of most litigation. In contrast, in the context of privatised utilities the cost of capital has been the subject of considerable theoretical and econometric analysis, but there is almost none as to the choice of asset base despite the fact that it is the transfer of assets that is particularly troublesome. Armstrong, Cowan and Vickers (1994) provide some analysis of the appropriate asset base in the face of undervaluation but conclude, when referring to price cap regulation of privatised utilities, that 'capital valuation is a crucial input into setting prices, as it is with rate of return regulation, but there is a heavy burden on the regulator and there are few operational principles'. We believe that this paper is the first to provide a rigorous consideration of the problem and provide a viable solution.

Differences in the choice of asset base have major impact on economies because of its importance in the determination of output prices of regulated utilities, because such companies are frequently critical components of the economy (both as final goods and intermediate inputs into most industries) and because of the sheer scale of the industries in this position.[2] Therefore, it is important to understand the consequences of particular approaches and to establish operational principles where possible. This is likely to become a central problem for Europe in the coming decade. With the exception of the UK, the biggest privatisations of regulated utilities in Europe have been in the

[2] By 1999 the proceeds raised by privatising governments exceed $1trillion dollars although, of course, many of these, probably the majority, are not consequently regulated.

telecommunications sector. This sector has not suffered greatly from the undervaluation problem in the past although this may be less so in the future. As countries begin to broaden the utilities that are privatised, it is difficult to see how the same problems that the UK has faced will not emerge throughout the continent. Clearly, it is important to get to grips with the problems before rather than after the event.

As background and motivation, Section 2 of the paper provides a brief summary of the experience of asset valuation in the US and the UK. In the US, with no history of privatisation, the discussion of asset base (after some initial confusion) has focussed on the choice between historical and replacement cost. However, in the UK, with the exception of the telecommunications sector, all privatisations of regulated utilities have faced significant undervaluation. Shareholders have frequently paid less than 50% of the replacement cost of the assets at privatisation. Indeed, in the water sector this figure is as low as 3.6%. We show that the treatment of the undervaluation problem has converged on the market value approach to determine the regulatory asset base. That is, assets transferred at privatisation are entered into the regulatory accounts at the market value at or near to privatisation. This may be greater than the price shareholders paid if there is underpricing as well as undervaluation.

Section 3 of the paper provides a simple analysis of the privatisation and regulatory problem. At the centre of the problem is a tension between two forces. On the one hand, regulators do not wish to provide shareholders with an abnormal return. That is, if there is undervaluation they wish to see this reflected in returns. On the other hand, if the market value is used to fix future prices, any temporary 'blip' in value, say arising from short-lived 'low' output prices at privatisation, can be exaggerated. It is shown that an error at privatisation causes prices to be lower or higher than optimal prices in perpetuity and that relative errors remain entrenched forever. Furthermore, and critically, because of the feedback mechanism (i.e., short lived changes enter the market value which then affect all future prices) small changes can have big impacts on the market price of the utility at privatisation. This is really the core problem. Given the political sensitivity that tends to surround privatisation programmes, it is not ideal to adopt a model that magnifies the impact that small changes in expectations have on the potential sale price. Valuation procedures become far more difficult. It leaves the government with far more uncertainty

about the potential revenues that can be achieved from a privatisation and generally exacerbates undervaluation, reducing general proceeds.

Section 4 presents an alternative mechanism. The approach we suggest is to use the regulatory agency's own estimate of the company's value at privatisation as the asset base for future regulatory purposes. We call this the model-based approach to distinguish it from the market-value approach. A purely practical attraction of requiring the regulatory agency to estimate the value, and present this prior to privatisation as the base for future reviews, is that it gives full transparency and hence fairness in the process. However, we show that there is a more important benefit. This is that errors made at the time of privatisation do not have anything like the same impact on future prices and hence far less effect on the potential sale price.

At first this may seem counterintuitive. Given that the regulatory agency is estimating the value of the business at privatisation and allowing within the modelling process for the fact that this value will be used as the basis for future regulatory reviews, the process may seem prone to the same errors and volatility as the market base alternative. There is, however, an inherent correction mechanism built into the model-based approach. It is true that if the regulatory agency makes an error and underestimates the cost of capital the error will lead the regulatory agency to set output prices for the first price cap that are too low whether the regulatory process uses a market based or model based approach. However, in the model-based approach the regulatory agency uses this incorrect cost of capital both to set prices and to conduct the discounted present value. If the cost of capital is too low then the present value will be overestimated. That is, the tendency to set low prices is offset by a similar tendency to overvalue the cash flow. This is symmetric since any tendency to set prices too high will be offset by a tendency to undervalue the consequent cash flow. In contrast, with a market based approach it is the market's cost of capital that dictates the present value and hence the share price at privatisation. In this case, there is no offsetting effect hence the initial error becomes magnified. We therefore suggest that the model-based approach is both fairer and more practical than the approach currently in use.

Finally, we introduce the distinction between undervaluation and underpricing. Our main results (Proposition 2) relate to the use of the market value or regulatory agency's

indication of market value. However, it is theoretically possible for the regulatory agency to incorporate underpricing as well as undervaluation in the regulatory asset base. The situation is then more complex but we show in this case (Proposition 3 and numerical examples) that the market-based approach is still inferior. [3]

2. Treatment of the Asset Base

2.1 The United States

In the United States, the method of selecting the appropriate asset base for regulated utilities was debated in a series of important Supreme Court cases taking place between the 1890s and the 1940s. The seminal case was *Smyth v. Ames* (1898), which concerned a dispute about railroad rates in Nebraska. The verdict in this case had a powerful and damaging influence on regulation for the following fifty years. The Supreme Court's judgement in the case stated that a regulated company was entitled to a 'fair return on fair value'.[4]

This judgement gave six different criteria for assessing the value of capital:

- the original cost of construction and the amount spent on permanent improvements;
- the amount of bonds and stock;
- the market value of bonds and stock;
- the present as compared with the original cost of construction;
- the probable earning capacity of the property; and
- operating expenses.

These criteria are both confusing and somewhat circular, and most of these were rejected as inappropriate in subsequent cases.[5]

[3] The paper is concerned with valuations set in stock markets but in principle, since the model is driven by the present value of cash flows, the general results should carry over to many common value auction markets but not to the broad category of auctions (e.g., Klemperer (1998, 2002).
[4] Smyth v. Ames 169 U.S. 466 (1898).
[5] See Grout and Zalewska (2001) for a discussion of the problems of circularity in asset valuation.

With the price level tending to fall in the late nineteenth century, companies in the *Smyth v. Ames* case had preferred a historic cost asset base. However, around the turn of the century the general price level began to rise and companies involved in subsequent rate base cases came to favour the use of replacement cost to determine the asset base. In *Willcox v. Consolidated Gas Co.* (1909), the Supreme Court endorsed the view that the value of the property was to be determined at the time of the inquiry, not when it had first been acquired. This was often to be cited as a precedent in later cases, and in a number of other cases decided before the First World War, most notably the Minnesota rate cases, the Supreme Court delivered verdicts in support of a replacement cost asset base. [6]

During the First World War the price level rose much further and the arguments by companies for reproduction cost became more vehement, while the regulatory commissions consistently preferred a historic cost rate base. In 1923 the Supreme Court created confusion when, in three cases within a few weeks of each other, the Court decided that a reproduction cost rate base should be chosen in two cases while in the third case it found in favour of historic cost.[7]

Alongside the changing case law in the first half of the twentieth century there was considerable debate in law journals and economics journals about the appropriate method of valuing the asset base. While historic cost versus reproduction cost was the main battleground in public utility economics in the inter-war period, other valuation models were also analysed. For example, academic economists were consistently critical of the use of elements of market value in the Supreme Court judgements. The market value of the utility's stocks and bonds, despite its appearance in *Smyth v. Ames*, had been ruled out at an early stage in the development of case law. Market value was rejected in 1923 in *Southwestern Bell Telephone Co. v. Missouri Public Service* Commission on the grounds that utilities were not commonly bought and sold. But an element of market value had continued to be incorporated in legal cases by the inclusion of allowances for various intangibles, such as good will and going concern, in the asset base valuation.

[6] Willcox v. Consolidated Gas Co, 212 US 19 (1909); Minnesota rate cases (Simpson v Shepard), 230 US 352 (1913).

[7] The Supreme Court upheld replacement cost in Southwestern Bell Telephone Co v Public Service Commission, 262 US 276 (1923), and in Bluefield Waterworks v. Public Service Commission, 262 US 679

The late 1920s were the high water mark of cases determined in favour of reproduction cost. For example, in McCardle v. Indianapolis Water Co. (1926), the Supreme Court found against a regulatory commission that had estimated the asset base using replacement cost averaged over the previous ten years, asserting that the commission should have used current values only.[8] Similarly, in the O'Fallon case of 1929 the Supreme Court rejected the valuation methods of the Interstate Commerce Commission, which were based predominantly on historic cost because they gave insufficient weight to replacement cost.[9]

Thereafter, the tide began to turn. During the 1930s the Supreme Court gradually swung towards allowing the use of historic cost by commissions. In *Los Angeles Gas & Electric Corp. v. Railroad Commission* (1933) it found that the company's use of replacement cost based on average prices between 1926 and 1929 was not valid in the 1930s when the prevailing price level was much lower.[10] And in *California Railroad Commission v. Pacific Gas & Electric Co.* (1938) it rejected the company's estimates of reproduction cost on the grounds that they were 'plainly erroneous'.[11]

It was the *Hope* case of 1944 that finally put an end to the confusion begun by *Smyth v Ames*.[12] Bonbright described the case as 'one of the most important economic pronouncements in the history of American law'. This case brought to a close the involvement of the Supreme Court in settling disputes between regulated and regulators, by its emphasis on pragmatism and a presumption in favour of the Commissions:

> Under the statutory standard of "just and reasonable" it is the result reached not the method employed which is controlling... It is not theory but the impact of the rate order which counts. If the total effect of the rate order cannot be said to be unjust and unreasonable, judicial enquiry under the Act is at an end. The fact that the method employed to reach that result may contain infirmities is not then important. Moreover, the Commission's order does not become suspect by reason of the fact that it is challenged. It is the product of expert judgement which carries a presumption of validity. And he who would upset the rate order

(1923); it supported historic cost in Georgia Railway and Power Co v. Railway Commission, 262 US 625 (1923).

[8] McCardle v. Indianapolis Water Co, 272 US 400 (1926).

[9] St Louis & O'Fallon Railway Co. v. United States, 279 US 461 (1929).

[10] Los Angeles Gas & Electric Corp v. Railroad Commission, 289 US 287 (1933).

[11] Railroad Commission v. Pacific Gas & Electric Co., 302 US 388 (1938).

[12] Federal Power Commission v. Hope Natural Gas Co. 320 U.S. 591 (1944).

> under the Act carries the heavy burden of making a convincing showing that it is invalid because it is unjust and unreasonable in its consequences.

The Hope judgement did not specify a uniquely valid approach to the asset base, but left the matter in the hands of regulatory commissions. It laid the ground for the movement to historic cost since most commissions chose to use historic cost valuation of the asset base.[13] A survey of 43 states in 1954 found that 19 had explicitly switched to historic cost as a result of Hope; a further 8 had adopted historic cost in practice, though they had not formally disavowed fair value; 4 had used historic cost prior to Hope and continued to do so; while 9 were still using fair value, leaving 3 states in the survey as indeterminate. A 1991 study of 53 regulatory commissions revealed that 44 were using historic cost, while 7 still adhered to fair value, and two commissions considered all the evidence, without a predetermined choice of rate base.[14]

The interesting feature is that the US experience rejected market-based approaches and focused after 1944 on the historical cost approach. This is in marked contrast to the UK experience.

2.2 Privatisation and the Asset Base in the UK

As indicated, a common feature of public sector utilities is that when privatised they tend to have market values below the replacement cost of the assets. In the UK all primary utilities had market valuations at the end of the first trading day that were below the CCA replacement cost of their assets. This difference between replacement cost and market value, however, varies significantly from industry to industry. In the case of the water industry, market value was less than 4% of CCA book value at the time of privatisation; for the gas industry the figure was around 42%; 60% for regional electricity companies; while the discrepancy was very small in the case of telecommunications with British Telecom's market value at privatisation some 97% of the CCA valuation. (Carey *et al*, 1994).

[13] See Grout and Jenkins (2001) for evidence of opportunism on the part of regulators in the US at this time.
[14] See Phillips (1993).

Despite the historical experience on this topic in the US, there was almost no discussion of the problem before or at the time when the industries were first privatised. Under the system of regulation practised in the UK, the privatised companies have price caps set for a period of four to five years. It was generally in the period leading up to the setting of a new price cap, some three to four years after the transfer of ownership, that the issue of the appropriate regulatory asset base was tackled.

The first major privatised utility in the UK was British Telecommunications in 1984. The debate concerning the future price in telecoms followed the US tradition and focused on historic cost versus current cost asset valuation, with the former being chosen in the first two regulatory price reviews (1988, 1992) and a switch to a current cost approach since the third review (1996).

In the run-up to the first price review in the gas industry, British Gas and the industry regulator, Ofgas, were unable to reach agreement on the rate of return which British Gas should be allowed to earn, and the matter was referred to the Monopolies and Mergers Commission (MMC). In its deliberations on the question of the appropriate asset base, the MMC suggested that the rate of return for British Gas should be set at just over 60% of a risk adjusted cost of capital. The reduction was to reflect the difference between the market value (debt plus equity) and CCA book values at the end of 1991, a time chosen on the assumption that it was just before the uncertainty of the MMC case may have impacted on share values. The reduction was justified as a compromise which in part reflected what shareholders had paid for the assets at the time of privatisation (Monopolies and Mergers Commission (1993)). Thus the MMC chose what was essentially an implicit market value approach to the asset base.

In the water industry an explicit market value approach was chosen. When the industry was privatised, in 1989, the government made an assessment of the value of the existing assets which it termed ‘indicative value’. Prior to privatisation, the water and sewerage companies had been earning about 2% on the replacement cost of their assets. It was assumed that they would continue to do so after privatisation, and these hypothetical cash

flows were discounted by the cost of capital to determine the initial value of the assets, i.e., the indicative value.[15]

However, the water regulator, Ofwat, rejected these indicative values on the grounds that they 'involved a number of important assumptions, and the resulting value was subject to a wide degree of uncertainty'. CCA valuations, which were very large relative to market value, were also rejected and the water regulator selected instead an explicit market value asset valuation based on share prices averaged over the first 200 trading days from the date of privatisation. To this figure the value of debt less cash balances was added to determine the total initial valuation of the asset base, which has been used since then for all regulatory reviews.

Explicit market values have also been used by the Office of Electricity Regulation, Offer. When the regulatory asset base for the Regional Electricity Companies (RECs) was considered, Offer rejected the CCA approach in favour of a market value asset base. Offer decided to scale up the value at flotation and so an uplift of 50% was added to the flotation value. The resulting valuations varied from company to company but, on average, were equivalent to about 90% of CCA asset value. However, before these values could be implemented, a contested bid for one of the RECs indicated that the outcome of the periodic review may have been overly generous and so this particular asset valuation was never used. Offer concluded that an uprate of 50% was too large, and settled instead on a figure of 15 per cent, i.e., an increase of 15% on the flotation value of the RECs at the close of the first day of trading. The market value approach has also subsequently been adhered to by Offer in assessing the regulatory asset base in other parts of the electricity industry (such as the National Grid Company and Northern Ireland Electricity).

As the most recent of the major privatisations, the railways were also the last to consider the question of valuing the regulatory asset base. The Rail Regulator followed precedents set in the other regulated industries quite closely, and chose a market valuation. For

[15] See, for example, Armstrong *et al (*1994).

example, for the price review in December 1998, the value of Railtrack's assets were set at their value at the close of the first day of share trading.[16]

In summary, with the exception of telecommunications where a CCA asset value is now in use, it is clear that the regulatory framework for major UK privatised utilities has converged on a market value approach to determine the regulatory asset base. Regulators have tended to conclude that investors should be remunerated on the basis of what was actually paid at or around the time of privatisation, rather than on the generally larger CCA valuations. The details are summarised in Table 1.

Table 1.
The Asset Base in Major Privatised UK Utility Industries

Companies and Regulatory Bodies	***Outcome of Periodic Reviews/MMC Enquiries***
British Telecom/Oftel	Historic cost at the first two regulatory reviews (1988 and 1992), CCA from third regulatory review (1996)
British Gas/Ofgas	Implicit Market Value at the end of 1991 adopted after MMC enquiry
Water Companies/Ofwat	Market Value averaged over first 200 days
RECs/Offer	Market Value at close first day trading plus 15%
NGC/Offer	Market value at close first day trading
Northern Ireland Electricity/ Offer	Market Value at close of first day's trading plus 7.5%
Railtrack/Office of Rail Regulator	Market Value at close of first day's trading

3. Market Value

The previous section has shown that regulators faced with the problem of underpricing and undervaluation in privatised industries have chosen to adopt a market value approach to asset valuation. In this section we formalise this approach and discuss its weaknesses.

The company has in place, at privatisation, a set of assets with replacement cost k. We assume there is no growth in demand, no inflation and that the regulatory regime requires

[16] Railtrack has recently gone into administration as a result of financial failure.

the company to replace assets. Therefore, physical capital and its replacement cost are constant. Let S denote the market value of the company at privatisation, i.e., S is the present value of the cash flow of the privatised company at the time of privatisation. At privatisation the regulatory agency values assets for regulatory purposes at their replacement cost and initial prices for the company are based on the asset base k. However, if S differs from k then at the first review and for all subsequent reviews the regulatory agency places a market-based value on the assets transferred at privatisation.[17] This may be less or greater than k.[18] Assets replaced after privatisation are always valued in the regulatory asset base at purchase/replacement cost.

The regulatory agency reviews the company's prices every T periods. To determine prices the regulatory agency must make an estimate of the appropriate risk adjusted cost of capital for the utility. We assume that the agency makes an independent assessment at each review. At review the agency allows the company to set prices to cover the agency's estimate at that time of the cost of capital and to cover the depreciation charge for the coming T periods. Assets depreciate at an instantaneous rate of γ. For the first and all subsequent reviews, the allowed depreciation charge is based on regulatory asset value for assets acquired at privatisation and the allowed depreciation charge for new assets is based on their true value.

The true cost of capital is $r > 0$. This does not change over time. The regulatory agency's estimate of the cost of capital at time t is equal to $r + \varphi(t)$. The error generating process has a symmetric distribution function with zero mean and a support contained in an interval $(-r, r)$. $\varphi(0)$ is known and announced before privatisation. Note, it is not the cost of capital itself that is random but the regulatory agency's estimate of it.

It is important to draw the distinction between undervaluation and underpricing. Undervaluation occurs when S is less than k. This arises when the present value of expected future cash flows is less than the replacement cost of the assets. In addition the

[17] Note that the market value is used to determine prices from the first review onwards, not from the moment of privatisation.
[18] In practice a regulator is unlikely to approve an asset value greater than k simply because the shareholders paid more than k at the time of privatisation. However, we include the possibility for completeness.

price that shareholders pay may not be the equilibrium market price, i.e., shareholders may pay $(1-\mu)S$, at privatisation. Underpricing occurs when $\mu > 0$.

The privatisation of utilities has been characterised by both undervaluation and underpricing. Underpricing has been well-documented (see, e.g., Dewenter and Malatesta (1997), Jenkinson and Mayer (1988) and Perotti (1995)) but undervaluation rather less. In practice the market-based regulatory asset approach has ignored the offer price, $(1-\mu)S$, and focused on market price, S, i.e., undervaluation but not underpricing has entered the asset base. However, it is useful to look at what might happen if underpricing is allowed to enter the asset base and so we allow for the possibility that regulation is affected by underpricing. We denote the regulatory value of assets acquired at privatisation by αS where α is equal to $(1-\mu)$ if the regulatory asset base reflects underpricing and unity if it does not.

Finally, we define a relationship between the privatised utility's price and the asset base. Clearly, the utility's 'aggregate' output price is determined by input cost other than capital and the regulatory rule that enables the company to cover the allowable cost of capital and depreciation of the asset base. Since inputs other than capital play no role in this analysis, they are set equal to zero for convenience. For all $t > T$ we denote the expected (output) price that exactly covers the expected cost of capital plus depreciation rate times the replacement cost of capital by p^*, i.e.,

$$p^* = (r + \gamma)\, k.$$

*G*iven that replacement cost is, under reasonable regulatory rules, the deprival value of the assets, we refer to p^* as the 'optimal price', i.e., optimal in the sense that it is a reflection of opportunity cost.[19]

For any t from T onwards, the exact price charged by the utility will depend on two separate errors by the regulatory agency, $\varphi(0)$ and $\varphi(T_i)$, where T_i is the time of the most

[19] Note, in addition to being a reflection of opportunity cost, there is an additional element of optimality in p^* since if the regulatory agency never makes an error then $p_t = p^*$ for all t. However, we cannot say if p^* is or is not optimal in any broader sense since we provide no analysis of how this aggregate price maps onto price per unit, etc.

resent review before t. $\varphi(0)$ appears since it determines the regulatory asset base. $\varphi(T_i)$ appears because, at t, $r+\varphi(T_i)$, is the agency's estimate of the relevant risk adjusted cost of capital. We can therefore talk of the expected price at time t where the expectation is taken over $\varphi(T_i)$. This expected price, derived using the market value (or underpriced equivalent) in the calculation of the regulatory asset base is denoted p_t^m. Indeed, throughout the paper, all prices in the paper, save for p^*, will be expected prices taken over $\varphi(T_i)$.

We can now investigate the consequences of using a market value as the regulatory asset base.

Proposition 1 *For $\alpha = 1$ and $\varphi(0) \neq 0$ $\left(p_{t_2}^m - p^*\right) / \left(p_{t_1}^m - p^*\right)$ is independent of $\varphi(0)$ for any $t_1, t_2 > T$.*

Proof

The prices set by the regulatory agency during the first period after privatisation are chosen to cover:

$$(1) \qquad \int_0^T (r + \varphi(0) + \gamma)\, k e^{-rt} dt$$

where $\varphi(0)$ is known. At time T there will be a new review and prices will be set to cover:

$$(2) \qquad \int_T^{2T} (r + \varphi(1) + \gamma) \left(\alpha S e^{-\gamma t} + \left(1 - e^{-\gamma t}\right) k\right) e^{-rt} dt\,.$$

The difference between (1) and (2) is that the regulatory asset base from T onwards reflects αS whereas prices from 0 to T are based on k. The impact of S diminishes as time passes, i.e., depreciation runs down the original assets as new assets replace them. Note also that when viewed from time zero, $\varphi(1)$ is not known. The expected present value of the company from T onwards is the expectation of:

$$(3) \qquad \sum_{n=1}^{\infty} \left[\int_{nT}^{(n+1)T} (r + \varphi(n) + \gamma) \left(\alpha S e^{-\gamma t} + \left(1 - e^{-\gamma t}\right) k\right) e^{-rt} dt \right]$$

Thus the value of the company is (1) plus (3) minus investment. The company has to make good all depreciation so the present value of investment is:

$$(4) \qquad -\int_0^{\infty} \gamma k e^{-rt} dt .$$

Therefore the total expected present value of the company is

$$S = \int_0^T \left(r + \varphi(0) + \gamma \right) k e^{-rt} \, dt$$

$$(5) \qquad + E\left(\sum_{n=1}^{\infty} \int_{nT}^{(n+1)T} \left(r + \varphi(n) + \gamma \right) \left(\alpha S e^{-\gamma t} + \left(1 - e^{-\gamma t} \right) k \right) e^{-rt} dt \right)$$

$$- \int_0^{\infty} \gamma k e^{-rt} \, dt.$$

(5) reduces to

$$(6) \qquad S = k + \frac{\varphi(0)}{r} k \left(1 - e^{-rT} \right) + \left(\alpha S - k \right) e^{-(r+\gamma)T}$$

or

$$(7) \qquad S = \frac{k \left(1 - e^{-(r+\gamma)T} \right) + \frac{\varphi(0)}{r} k \left(1 - e^{-rT} \right)}{\left(1 - \alpha e^{-(r+\gamma)T} \right)}$$

This gives:

$$(8) \qquad S = k \left(1 + \frac{\varphi(0) \left(1 - e^{-rT} \right)}{r \left(1 - e^{-(r+\gamma)T} \right)} \right) \qquad \text{if } \alpha = 1 .$$

For $\alpha = 1$, given non-zero $\varphi(0)$ and any $t > T$ we find:

$$p_t^m = (r+\gamma)\left[e^{-\gamma t}\ k\left(1+\frac{\varphi(0)\left(1-e^{-rT}\right)}{r\left(1-e^{-(r+\gamma)T}\right)} \right)+\left(1-e^{-\gamma t}\right)k \right]$$

$$= (r+\gamma)k\left[1+e^{-\gamma t}\ \frac{\varphi(0)\left(1-e^{-rT}\right)}{r\left(1-e^{-(r+\gamma)T}\right)} \right].$$

Therefore,

$$p_t^m - p^* = (r+\gamma)\, e^{-\gamma t}\, \frac{\varphi(0)\left(1-e^{-rT}\right)}{r\left(1-e^{-(r+\gamma)T}\right)}\, k$$

which is non zero for all non zero $\varphi(0)$.

For all $t_2 > t_1 > T$ and non zero $\varphi(0)$ we have

$$\left(p_{t_2}^m - p^* \right) \Big/ \left(p_{t_1}^m - p^* \right) = e^{-\gamma(t_2 - t_1)}$$

which gives the required result.

■

Proposition 1 says that an error at privatisation causes prices to be lower or higher than optimal prices forever and similarly that the relative price consequences of alternative errors are also infinitely lived. That is, comparing the price consequences of two possible errors, if we find at one point in time that one price is *n* times as far from the optimal price as the other then it will always remain *n* times as far from the optimal price as the other.

Equation (6) also shows that if the regulatory asset base is equal to the market value at the time of sale, i.e., $\alpha = 1$, then the elasticity of *S-k* with respect to $\varphi(0)/r$ is unity. This indicates that the small changes in the initial error can have large changes in the market value even though the initial lower prices induced by the error are in place for a very short period. For example, if the true cost of capital is 5% and the regulatory agency believes

for the first review only that the cost of capital is 4% then the market value is 20% lower than replacement cost regardless of how rapidly the situation is reviewed.

The latter is the major problem of the market-based approach. Valuation procedures become far more difficult, leaving the government with far more uncertainty about the potential revenues that can be achieved from a privatisation. This is particularly important given the political sensitivity and inherent uncertainties that tend to surround privatisation programmes. It makes little sense to adopt a model that magnifies the impact that small changes in expectations have on the potential sale price.

The relevant question is whether there is an alternative mechanism that can accommodate the undervaluation problem and does not fall foul of the difficulties inherent in the market value approach? In the next section we suggest an alternative approach that meets this objective.

4. A model-based asset valuation

Section 3 has quantified the problems that arise with using UK-style market based valuations to determine the regulatory asset base. In contrast, not surprisingly, companies have argued for the use of replacement cost of capital as the relevant asset base. However, there may be a problem with using replacement cost if the shareholders receive a windfall gain as a result of its implementation. There has been a debate as to whether there is a windfall gain or not. It is difficult to answer this question without knowledge of why there is undervaluation and what shareholders expectations were at the time of privatisation as to the precise regulatory regime that they thought would be in place.

As indicated, we seek to find an alternative mechanism that can accommodate the undervaluation problem and does not fall foul of the difficulties inherent in the market value approach. It is clear that if there is a strong possibility of undervaluation then an obvious need is to identify a common, agreed valuation that is common knowledge at the time of privatisation. If all participants know this value and know that it will be employed in future regulatory reviews then one can have some confidence that shareholders are

aware of what they are buying. This process rules out market value since it cannot be known before privatisation.

The approach we suggest here is to use the regulatory agency's own estimate of the company's value. This is found by adopting a present value process similar to that identified in Section 3. We denote this value as *I*, to denote the regulator's 'indication' of value. There will be two main differences between this approach and the present value equation that underlies the market value. One is that the regulatory asset base used on the right hand side of the present value calculation from T onwards will be I rather than the market price. The other is that the regulatory agency will use their best estimate of the cost of capital to conduct the exercise. The latter must obviously be the case since if the agency believed that their estimate of the cost of capital was systematically incorrect in some way they would not have been using it. We call the consequent valuation a model-based value since by definition it will be calculated using a present value model of the estimated cash flows of the company.

An attraction of requiring the regulatory agency to estimate the value and present this prior to privatisation as the chosen base for future reviews is that there is full transparency and hence fairness in the process. However, we show in Propositions 2 and 3 that there are more significant benefits.

Proposition 2

If $\alpha = 1$ *and* $\varphi(0) \neq 0$ *then for any* $t > T$: $| p^* - p^m | > p^* - p^I = 0$.

Proof

Following the proof to Proposition 1 the value of I is given by:

$$I = \int_0^T (r + \varphi(0) + \gamma) k\, e^{-(r+\varphi(0))t}\, dt$$

$$(9) \quad + \left(\sum_{n=1}^{\infty} \left[\int_{nT}^{(n+1)T} (r + \varphi(0) + \gamma) \left(\alpha I e^{-\gamma t} + \left(1 - e^{-\gamma t}\right) k \right) e^{-(r+\varphi(n))t}\, dt \right] \right)$$

$$- \int_0^{\infty} \gamma k\, e^{-(r+\varphi(0))t}\, dt.$$

This reduces to

$$(10) \quad I = k + (\alpha I - k)\, e^{-(r+\gamma+\varphi(0))T}$$

or

$$(11) \quad I = \frac{k\left(1 - e^{-(r+\gamma+\varphi(0)T}\right)}{\left(1 - \alpha e^{-(r+\gamma+\varphi(0)T}\right)}$$

This gives:

$$(12) \quad I = k \quad \text{if} \quad \alpha = 1.$$

$I = k$ gives the right hand equality and Proposition 1 gives the left-hand inequality. ■

Proposition 2 shows that from T onwards the expected price under the model-based approach is optimal regardless of $\varphi(0)$ whereas the expected price under the market-based approach is optimal iff $\varphi(0)$ is zero. The intuition for this result is the following. If the regulatory agency at privatisation makes an error and underestimates the cost of capital then the regulatory prices are set too low both for the market value and the model-based approach. However, in the model-based approach the regulatory agency is using their own view of the cost of capital to conduct the discounted present value in the model as well as to set prices. Therefore, the tendency to set low prices is offset within the model by a similar tendency to overvalue the future returns. Indeed Proposition 2 shows that these two effects exactly offset each other, therefore the expected price from T onwards is efficient.

Note, this is a symmetric argument and any tendency to set prices too high will be offset by a tendency to undervalue the consequent cash flow. Of course, unless $\varphi(0)$ is zero, the regulatory agency will still set incorrect prices during the first period, i.e., up to the first review, but expected prices will be optimal for all future reviews.

The situation becomes more complex if the regulatory model incorporates the undervalued prices rather than the market prices, that is, α is equal to (1-μ) in both the market and the model-based model. We should emphasise that we believe this is an implausible approach for two reasons. One is that in practice regulators have not attempted to apply this approach to the market model. Second, even if applied to the market model, it is not clear that it makes any sense to implement the same price reduction, i.e., use (1-μ)I in future reviews rather than I, in the model-based approach. Indeed, we know of no regulatory regime that incorporates α = (1-μ), as opposed to α = 1. However, even in this case we are able to show that there are benefits, albeit somewhat less, to the model-based approach.

We can prove the following proposition where the expectations operator is across all $\varphi(0)$.

Proposition 3 *If* $\alpha = (1-\mu)$ *then for any t>T,*

1) $p^* \geq p_t^I$ *for any* $\varphi(0)$

2) $p^* > p_t^m$ *when* $\varphi(0) < \frac{r}{1-e^{-rT}}\left(\frac{1}{\alpha}-1\right)$ *and* $p^* < p_t^m$ *when* $\varphi(0) > \frac{r}{1-e^{-rT}}\left(\frac{1}{\alpha}-1\right)$.

3) $E\left(\left| p^* - p_t^m \right|\right) > E\left(p^* - p_t^I\right)$ *when* α *is sufficiently close to 1 (i.e., for small values of* μ*).*

Proof

To prove part 1 of the proposition is sufficient to notice that

$$\begin{aligned} p^* - p_t^I &= (r+\gamma)k - (r+\gamma)(\alpha I e^{-\gamma t} + k(1-e^{-\gamma t})) \\ &= (r+\gamma)ke^{-\gamma t}\,\frac{1-\alpha}{1-\alpha e^{-(r+\gamma+\varphi(0))T}} \end{aligned} \tag{13}$$

is always non-negative as $0 \le \alpha \le 1$ and $|\varphi\ (0)| < r$.

The proof of part 2 follows from analogous calculations. That is,

$$p^* - p_t^{\ m} = (r+\gamma)k - (r+\gamma)(\alpha S e^{-\gamma t} + k(1-e^{-\gamma t})) \tag{14}$$

$$= (r+\gamma)ke^{-\gamma t}\ \frac{1-\alpha(1+\frac{\varphi(0)}{r}(1-e^{-rT}))}{1-\alpha e^{-(r+\gamma)T}}$$

is positive if the nominator is positive.

The proof of Part 3 is an immediate consequence of Proposition 2 and continuity of $p^* - p_t^{\ m}$ and $p^* - p_t^{\ I}$ as functions of α.

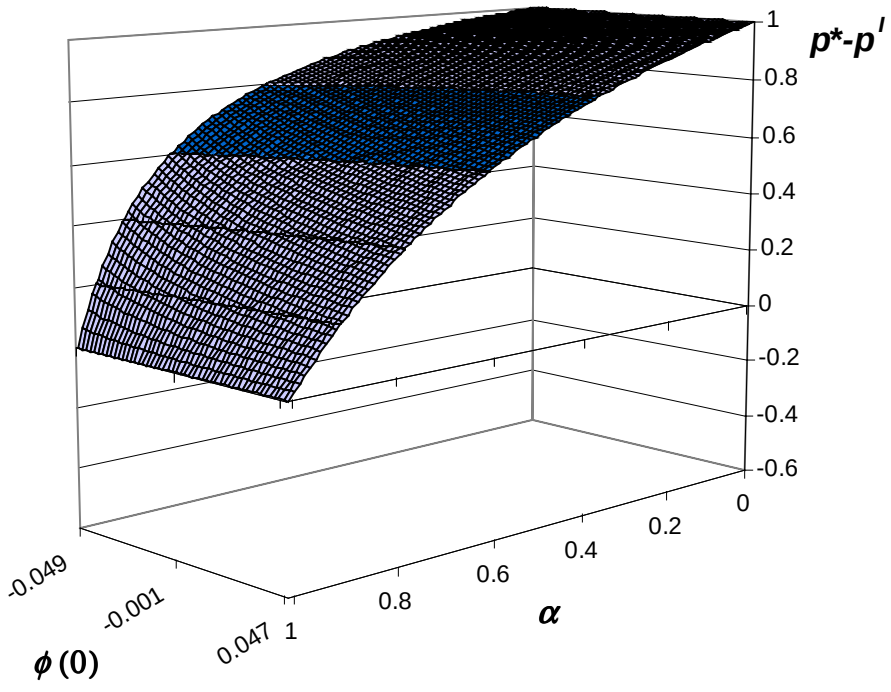
■

Proposition 3 proves that for any error generating process at time 0 the expected absolute difference between p^* and price under the model-based valuation approach at any t greater than T, is smaller than the expected absolute difference between p^* and price under the market-based valuation approach providing α is in some interval $(1, \alpha_0)$. That is, providing underpricing is not too large, then the model-based approach gives prices that are closer to p^* than the market-based approach. This raises the question as to how large these differences are both within and outside the interval. To consider this we provide numerical examples that throw some light on the relationship.

Figures 1 and 2 illustrate the differences between p^* and model-based price p_t^I, and between p^* and market price p_t^m respectively.[20] Both graphs are plotted under the assumption that the review takes place every four years (T = 4), the depreciation rate γ is 4% and the cost of capital r is 5%. Given the bounds on the error term, the latter assumption immediately implies that $|\phi(0)|<0.05$. It is clear from the figures that when the regulator's error is negative (i.e., she underestimates the true value of the cost of capital), $p^*-p_t^I$ is always smaller than $p^*-p_t^m$ for any $\alpha \in [0,1]$. Hence, for all $-0.5<\phi(0)<0$ the inequality in Proposition 3(3) holds all α and for any distribution of the regulator's error.

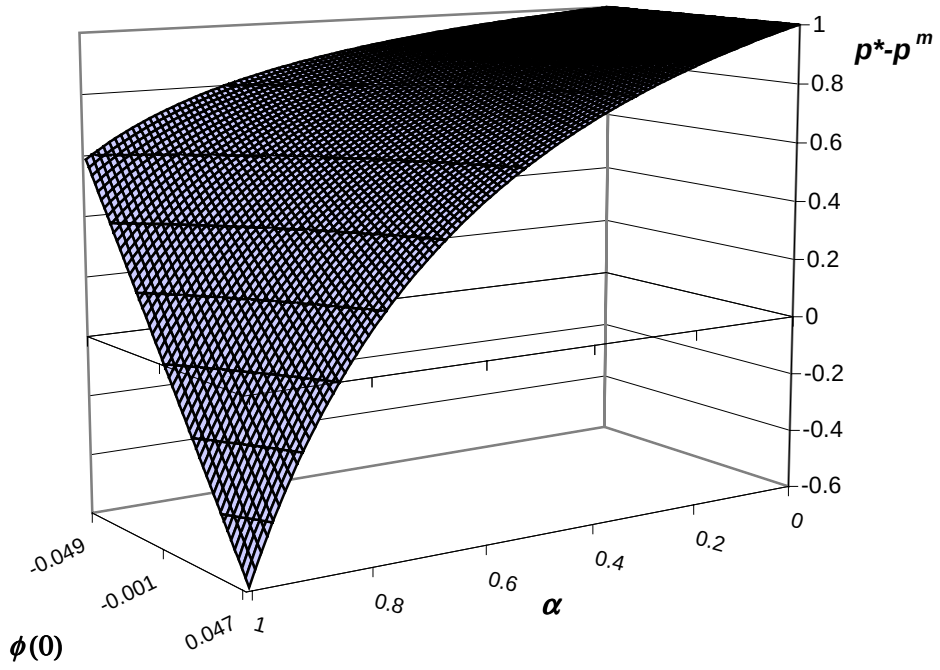
The situation reverses when the regulator overestimates the true value of the cost of capital (i.e.$0<\phi(0)<0.5$). In this case, if $\alpha \in [\alpha_0, 0]$, the price obtained from the market-based valuation can be closer to p^*, than the price found based on the model-based valuation.

Figure 1. p^* minus price under model-based valuation for r=5%, γ=4% and T=4



[20] In fact we only plot the differentiating parts of formulas 13 and 14, that is we drop off $(r+\gamma)ke^{-\gamma t}$ from both expressions.

Figure 2. p^* minus price under market model valuation for r =5%, γ=4% and T =4



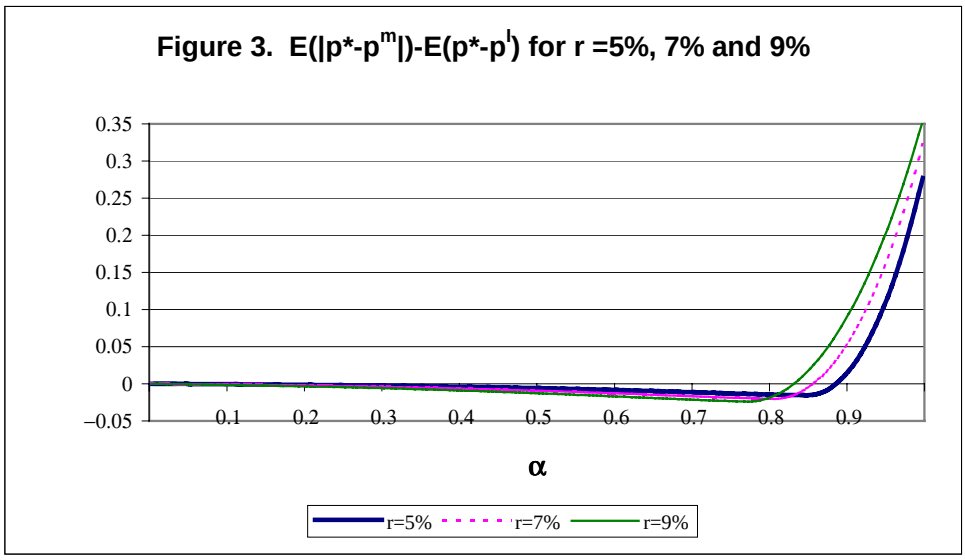
If we assume that $\varphi(0)$ is uniformly distributed on interval $(-r, r)$ (i.e., (-0.5, 0.5) in our example), then for any given α

$$E(|\, p^* - p_t^{\,m}\,|) = \begin{cases} (r+\gamma)ke^{-\gamma t}\,\dfrac{1-\alpha}{1-\alpha e^{-(r+\gamma)T}} & \text{if} \quad \alpha \in [0, \dfrac{1}{2-e^{-rT}}] \\ (r+\gamma)ke^{-\gamma t}\,\dfrac{\alpha^2(1-e^{-rT})^2 + (1-\alpha)^2}{2\alpha(1-\alpha e^{-(r+\gamma)T})(1-e^{-rT})} & \text{if} \quad \alpha \in (\dfrac{1}{2-e^{-rT}}; 1] \end{cases}$$

and

$$E(p^* - p_t^{\,I}) = (r+\gamma)ke^{-\gamma t}\,\frac{1-\alpha}{2r}(2r + \frac{1}{T}\ln\frac{1-\alpha e^{-(2r+\gamma)T}}{1-\alpha e^{-\gamma T}}).$$

Figure 3 shows the results of the comparison of $E\left(\left|\, p^* - p_t^{\,m}\,\right|\right) - E\left(p^* - p_t^{\,I}\right)$ for three values of r (i.e., r = 5%, 7% and 9%), under the assumption that γ= 4% and T = 4.



All three have a similar feature. For most cases where prices under the model based valuation are closer to p* than prices under the market-based approach the difference in proximity is marked. That is, when the figures are in the positive domain they are strongly positive. In contrast, when prices under the model based valuation are less near to p* than prices under the market-based approach the differences between them (and from p*) are small. Therefore, although once we allow for any possible level of underpricing we cannot say for sure than the model-based valuation provides prices that are always closer to p*, these figures still lend further evidence in favour of the model based approach since the scale of error is very one-sided. In the examples here, large deviations can occur from p* if one adopts the market-value approach but not if one adopts the model-based approach.

5. Conclusions

The paper has addressed the question of how to deal with the regulatory asset base problem caused by undervaluation of privatised utilities. We show that the standard solution to this problem is flawed. Errors made at privatisation as to the appropriate risk adjusted rate of return cause output prices to be lower or higher than optimal prices forever. Furthermore, the relative price consequences of alternative errors are also infinitely lived. That is, comparing the price consequences of two possible errors, if we find at one point in time that one price is *n* times as far from the optimal price as the other

then it will always remain *n* times as far from the optimal price as the other. Given the political sensitivity that tends to surround privatisation programmes, it is inappropriate that the standard approach to resolve the undervaluation problem magnifies the impact that small changes in expectations have on the potential sale price. This can exacerbate undervaluation reducing government proceeds. Furthermore, valuation procedures become far more difficult, leaving the government more uncertainty than necessary about the potential revenues that can be achieved from a privatisation.

We then address the question whether there is an alternative mechanism that can accommodate the undervaluation problem but does not fall foul of the difficulties inherent in the market value approach. We outline the alternative of using the regulatory agency's own estimate of the company's value at privatisation as the asset base for future regulatory purposes; called the model based approach. We show that for a given error generating mechanism the privatisation raises more money and there are smaller deviations from optimal prices with this approach than with the market value approach. Finally we consider the merits of the model based approach when the regulator corrects the asset base for underpricing as well as undervaluation and show that the model based approach is superior, albeit less than when the regulatory agency deals with undervaluation alone.

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