Excessive Profits and Overcharging

Multiple errors in the UK's model for setting utility prices

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Summary by the Reid Foundation

Electricity, gas, water, transport; these services are central to modern life and none of us can survive without them. But all of these services are now privatised and because of their necessity this makes them either monopolies or virtual monopolies. The only thing stopping them from unrestricted exploitation of their market position is regulation. Which is to say that the only protection the consumer has in many instances is the action of the regulator.

And yet many of these services are more expensive in Britain even than the privatised equivalents in other countries. This implies that some part of the regulatory system is failing. It is: the mechanism through which regulators allow privatised utilities to charge customers for investment in capital infrastructure. The result is that Britain allows utilities to make profit from financial speculation in a way other countries don't. The result is that customers pay more for their utilities than they should and the extra goes straight into investors' pockets. And since this financial speculation is based on how much the companies spend on infrastructure, it gives them an incentive to make infrastructure investment as expensive as they possibly can, all to be paid by the customer.

The problem is straightforward: the formula used by regulators to allocate the cost of investing in infrastructure to customers greatly overestimates the cost to the utility company of financing that infrastructure. This has led to windfall profits for the utility operators on the capital investment they undertake: it also means that utilities are under an incentive to manage infrastructure investment to maximise their benefit from the unfairness faced by the customer.

This means that equity investors in the utilities companies are making an grotesquely high return on their investment. In the case of the English water companies it is estimated that returns on equity invested are running at over 20 per cent per annum. This is coming straight out of the pockets of the customers and straight into the pockets of financing consortiums etc.

The process works as follows:

- The regulator calculates the cost of delivering services to customers and of investing in infrastructure for the future. It then restricts how much profit beyond these costs utilities are allowed to make from their customers. The regulator does a reasonable job of restricting profiteering in service delivery.

- The regulator estimates the finance costs of infrastructure investment on the basis of assumptions on the real rates of interest the company will have to pay for its debt and equity finance, and an assumption about the proportions of the overall finance package coming from debt and equity.

- The assumptions are then fed into a model, the output of which then determines the maximum amount the utilities companies can charge customers to cover the costs of infrastructure investment borne by the companies.

- But the regulator has consistently overestimated the cost of infrastructure investment and allowed the companies to pass this cost on to consumers. The companies then pocket the difference between the inflated costs they pass on to consumers and the real costs they actually pay.

- This is because a number of key errors have been made in this process. These occur in the way the regulatory model has been conceived, in the assumptions made in its application, and in the way the effects have been presented. The paper uses OFWAT's record of setting water prices in England and Wales as a case study to illustrate these points.

To give some specific examples:

- There is a mismatch between the timescales under which costs are passed on to the customer and the timescales and ways utilities actually pay financing costs in reality (this is known as the 'profile' of repayments). Section 4.4 demonstrates this and Section 3 explains the consequences. One of the implications is that the indicator the regulator uses to work out how the utility company funds investment is no longer reliable. Using this indicator, the "gearing ratio", Ofwat has significantly overestimated the percentage of capital investment financed by equity. Since companies are allowed to charge the customer a higher rate for equity finance than for debt finance, this contributes to a significant overestimation of the true cost of capital.

- Ofwat has consistently overestimated the cost of debt finance to the utility companies (see Section 4, paragraph 2). Again, this contributes to a significant overestimate of the true cost of capital.

- To make matters worse, the regulator fails accurately to report the actual returns on capital invested made by the companies (what it rescribes as "the overall return on capital that investors and lenders received"). Because its reporting methods are flawed, the excess profits the utility companies make are concealed - profits arising from Ofwat's inaccurate assessment of the true cost of financing capital investment. (More detail on the flaws in the mechanism is available in Section 4, paragraphs 11 and 12 and in Annex 5.)

- As the report shows, it is not merely the specific mistakes in applying the model which result in customers being overcharged. The underlying philosophy of the regulatory model applied in the UK means that customers are charged for the use of utility infrastructure assets as if they were paying a rent for the asset, a rent which is continually uprated in line with inflation. This in itself results in customers being overcharged in the long term.

- If in doubt, one report points out: "Profit margins in the UK [water industry] are typically three or even four times as great as the margins of water companies, private and public, in France, Spain, Sweden or Hungary. The profit margins of the greatest water multinationals – Suez-Lyonnaise and Vivendi – worldwide, also show a much lower return than enjoyed by the UK companies." Water is expensive in England and Wales because it is a front for financial speculation not permitted in other countries.

That all almost all these regulators use the same formula is bad enough; that the one that uses a variation (the rail regulator) uses one that is even worse is an even greater scandal. It helps to explain why investment in UK rail infrastructure appears to be so expensive. This in turn helps to explain why train travel in Britain is so prohibitively expensive – because the customer is paying through the nose to fund what amounts to a financial scam which is not improving infrastructure in the right way.

For many years people have asked the question 'why are UK privatised utilities so expensive for customers?' and 'why is it so expensive to upgrade infrastructure in the UK?' This report reveals the answers for the first time.

This is a national scandal that must be addressed; reform must become a priority. The first thing to be done in sorting out this mess is to involve customers in rethinking the philosophy of the basic charging model: and then to make sure that the resulting charging model is indeed applied correctly.

Excessive Profits and Overcharging

Multiple Errors in the UK's Model for Setting Utility Prices

Jim Cuthbert, July 2012

1. Introduction

1. When the major utility companies in the UK were privatised, as part of the Thatcherite revolution, one of the problems was how customer charges should be set. The approach to price setting used in the first privatisation, that of British Telecom in 1984, was devised by a Treasury economist, Stephen Littlechild, in a report he published in 1983: (Littlechild, 1983, discussed in Stern, 2003): this was the so-called RPI-X approach, where the regulator would specify the maximum price increase that could take place as X percentage points less than the increase in RPI.

2. The Littlechild report, however, which was produced at great speed, and which did not envisage that regulation of prices for BT would extend much beyond a five year period, did not provide an adequate basis for setting prices in the utilities that were privatised next. In particular, in an industry like water (privatised in England and Wales in 1989) which is a natural monopoly, regulatory price control would be a long term feature: and there was also the problem of how to compensate the utility owner appropriately for the very large scale capital investment which the industry would require. So while RPI-X was the price setting technique which came to be applied to all UK utilities, it had to be supplemented by the development of appropriate methods for handling the costs associated with capital expenditure. These methods were articulated in particular by OFWAT, the regulator of the newly privatised water industry in England and Wales, and have come to be applied as the price setting orthodoxy in all UK utilities: (with the exception that a slightly modified method is applied in the rail industry.)

3. The purpose of this paper is to examine in detail the operation of the capital element of the UK utility pricing approach. As will be demonstrated, there are fundamental flaws, in the way the model has been conceived, in the assumptions made in its application, and in the way in which the effects of the model have been presented. The overall results have been grossly excessive windfall profits for the utility equity owners: and significant over-charging of customers. While the findings of this paper are illustrated with particular reference to the water and sewerage industry in England and Wales, similar effects will apply more generally: (and, as will be seen, the variant of the model applied to the rail industry has particularly pernicious effects).

4. It is appropriate to say a little at this stage about the approach adopted in this paper. The basic concepts involved are not difficult: nevertheless, there are dangers in attempting to handle the discussion at too superficial a level. This is, indeed, a trap into which the regulators have fallen: they tend to justify their approach in terms of statements like "we are assuming a z% return on capital" – whereas, as will be demonstrated, it is not just the percentage return which plays a crucial role, but also the way in which the payments of interest and repayments of capital are scheduled through time. So to understand fully what is going on, and how the current regulatory approach has gone wrong, a certain level of technical detail is unavoidable. The approach adopted here is to confine such detail to technical annexes. The main text is self-standing, and can be read on its own by those who are not technically minded.

5. The structure of the report is as follows:

- Section 2 describes the basic pricing model as it relates to capital expenditure.
- Section 3 deals with the important implications of the way payment profiles are scheduled through time.
- Section 4 discusses how current cost charging has performed in the E. and W. water industry.
- Section 5 considers the implications of the particular variant of the charging model used by the Office of Rail Regulation.
- Section 6 considers implications: and what should be done.

2. The Basic Pricing Model as it Relates to Capital Expenditure

1. In many utilities – like water, electricity, gas, and rail – the delivery of the product depends on a highly capital intensive distribution system. The owner of this system (for example, the water supply and distribution network, the system of rail track and signalling, etc.) is therefore placed, almost inescapably, in a quasi-monopolistic situation. This means that there is no competitive market to determine what price customers should pay for the use of the distribution network. A standard solution to this problem is for a state appointed regulator to be given responsibility for determining the maximum price which the utility operator can charge.

2. The utility regulator therefore has the problem of how to set prices so as to cover both the day to day costs of running the network, and also the cost of the capital expenditure necessary to replace and enhance the network. The problem of setting prices to cover operating expenses is relatively straightforward: the regulator will typically set prices (or the maximum allowable increase in prices) so as to make what it judges is a reasonable allowance to cover operating expenses including some level of profit on operating activities, but probably with some degree of abatement to encourage operational efficiencies.

3. The problem of setting price to cover capital expenditure is much more difficult. The approach adopted for the privatised water and sewerage industry in England and Wales (and which as has been noted is now applied in all UK regulated utilities, including the publicly owned water industry in Scotland) is as follows:

a. First of all, the regulator determines how much capital investment is required – this is the amount of capital investment which will be reimbursed by the pricing system.

b. The regulator also determines a target real rate of return, at which capital investment will be reimbursed.

[See OFWAT's regular Final Determinations on setting prices for further details (OFWAT 1994, 1999, 2004): plus technical details on the OFWAT model can be found in OFWAT's financial model rule book: (OFWAT 2006)].

When a utility operator invests in a capital asset which has been approved at stage (a) above, then this results in customers being charged each year, through the life of the asset, an amount which in real terms is equal to

i. a depreciation charge, equal to the capital cost of the asset, divided by the life (in years) of the asset: plus

ii. an interest charge, equal to the target rate of return at (b) above, applied to that portion of the original capital value which has not yet been paid off through the annual payments at (i).

Note that this series of customer charges relating to the asset terminates at the end of the assumed asset life, since by then the original capital asset has been completely depreciated. The depreciation and interest charges at (i) and (ii) are in real terms: what is actually included in customer prices are these amounts after being uprated to current prices by cumulative inflation since the original investment was made. Since depreciation and interest, when they are included in customer charges, are calculated at current prices, this method of setting charges is known as current cost pricing.

4. It is a standard result of investment theory that, if inflation is running at a constant rate per annum, then the series of charges determined by the current cost pricing rules yields, over the lifetime of the asset, a nominal annual return on the original investment equal to the real target rate of return plus the rate of inflation. This result is proved in Annex 1. (Strictly, if the target rate of return is r, expressed as a fraction: and the annual rate of inflation is i, again expressed as a fraction, then the nominal annual rate of return is $r + i + ir$. So if the target real rate of return is 3% (that is, $r = 0.03$) and the rate of inflation is 2.5% ($i = 0.025$) then the nominal rate of return is (0.03 + 0.025 +0.025*0.03) = 0.05575, or 5.575% per annum.)

5. The principle OFWAT adopted when adopting this pricing model was that it should set its target real rate of return to reflect the cost to the utility of raising capital. However, OFWAT had to recognise that a privatised utility could fund its investment from two sources. One would be conventional debt or loan finance: the other would be equity. In setting its rate of return on equity, OFWAT stated that it believed "***that the returns allowed should provide shareholders with sufficient incentives to commit additional funds, either in the form of retained earnings, or new equity injections where this is appropriate, to enable companies to make new investment***" (OFWAT 2004, p 41). Since greater risk typically attaches to equity investment, the target rate of return on equity will be somewhat higher than the return on debt financed capital.

6. So in arriving at an assumption about the overall target real rate of return it would allow, OFWAT had in fact to make three underlying assumptions:

- About the real rate of return it should allow on debt financed capital, reflecting the cost to the utility of borrowing in the debt market.
- About the real return it should allow on equity financed capital.
- About what proportion of capital investment would be financed by debt, and what by equity.

7. Clearly, if the regulator pitches the cost of debt too high, or assumes that a higher proportion of capital is financed by the more expensive equity route than turns out to be the case, then this opens up the possibility of more revenue coming in to the utility operator by way of reimbursement than it actually needs. In these circumstances, the utility would be making a windfall profit (over and above the level of profit the regulator had intended) on the capital investment.

8. It is obvious, therefore, that the three assumptions in paragraph 6 are critical assumptions. But in fact, there is another assumption implicit in the OFWAT model, which is much less obvious, but no less critical. This relates to the way in which payments are scheduled through time. Even if the regulator makes the correct assumption about, say, the interest rate on loan finance, windfall gains or losses for the utility can still occur if the phasing of the payments which the utility makes on its loan finance differs from the phasing of the payments which the utility will receive from customers through the operation of the pricing model. Since this is not an obvious point, it is one that will be examined in detail in the next section.

9. Before considering the effect of different payment profiles, it is appropriate to conclude this section by introducing some relevant definitions. An equivalent way at looking at the rules of current cost pricing is to regard the utility's customers as paying, each year, a depreciation charge equal to current cost depreciation on the value of allowable capital assets, plus an interest charge equal to the target real rate of interest applied to the current cost value of the allowable capital stock. The current value of the capital stock on which this return is earned is known as the Regulatory Capital Value (RCV) or Regulatory Asset Base (RAB): and the pricing method is also known as RCV or RAB pricing. The RCV in any given year is obtained from the RCV of the previous year by uprating the previous year's RCV for inflation, adding on allowable investment, and subtracting off current cost depreciation. An important statistic related to RCV is that of the gearing of a utility company. Using the same definition as employed by OFWAT, the gearing of a utility is defined as the ratio of net debt to RCV, and is usually expressed as a percentage.

3. Why Payment Profiles Matter

1. The easiest way to demonstrate the critically important role which the actual profile of payments plays is to consider the simplified example of an imaginary utility where capital expenditure is entirely funded through debt. (That is, it is assumed that there is no equity finance.) In deciding how prices should be set to reimburse the utility for capital expenditure, the regulator has only one decision to make – namely, the real cost of debt for the utility. Let's assume the regulator gets this decision absolutely right: so that the real rate of return (*r*) which the regulator assumes in determining prices by the RCV model is the real rate at which the utility can borrow in the market. And again for the sake of simplicity, it is assumed that inflation is running at the same, constant rate (*i*) per annum. (So the nominal rate at which the utility can borrow is (***r***+***i***+***ir***).)

2. Then if this utility invests in an approved asset, what it will receive by way of reimbursement via the charging mechanism is a stream of payments over the lifetime of the asset, as determined by the current cost RCV pricing rules. More precisely, if it invests in year zero in a capital asset of worth K, which it is assumed has an asset life of ***n*** years, then in year ***j*** (***j*** =1 to ***n***) it will receive through the pricing mechanism an amount

$$\frac{K}{n}[1+r(n-j+1)](1+i)^{j} \qquad (1)$$

This will equate to a nominal rate of return of (***r***+***i***+***ir***) on the original investment (as proved in Annex 1.)

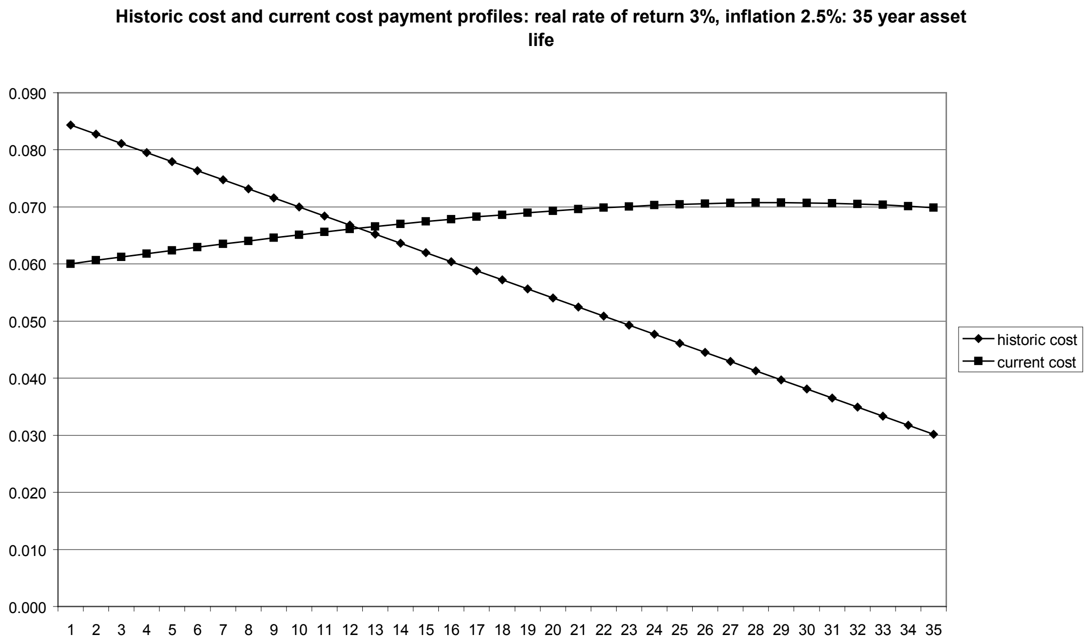
Suppose, however, that the utility has funded the investment by borrowing from the market, at the same nominal rate of interest (***r***+***i***+***ir***) but by means of a conventional fixed interest (also known as historic cost) loan, where the borrower pays back each year 1/***n*** of the original loan, plus interest on the outstanding debt.

Then the payment the utility will make in year ***j*** will be

$$\frac{K}{n}\,[1+(r+i+ir)(n-j+1)] \qquad (2)$$

3. While the interest rates associated with the current cost stream of reimbursements (1) and the historic cost stream of loan charges (2) are exactly the same – namely (***i*** + ***r*** + ***ir***) – the actual profiles of payments are quite different. This is illustrated in the following chart, in the case of ***r*** = 0.03, and ***i*** = 0.025, and assuming an asset life of 35 years. (For the purposes of this chart, ***K*** = 1).

Note how the payments are much more weighted towards the later years of the asset's life for the current cost as opposed to the historic cost profile. This is in fact a feature which gets much more marked, the higher the rate of inflation.



4. If there is a difference in payment profiles between the reimbursement stream, and the funding costs stream, then this potentially has a number of profound implications.

5. Consider first of all the question of gearing. Let's continue with the simple example in the above chart, of a utility which makes a single investment of ***K*** in year 0, reimbursed by current cost charging at real rate of return ***r***, and with inflation at ***i*** per annum: and which funds the investment by a historic cost loan, at interest rate (***i***+***r***+***ir***).

Then in year ***j*** the RCV of the utility will be

$$K\frac{(n-j+1)}{n}\,(1+i)^{j} \qquad , \quad j = 1,\ldots,n.$$

But the outstanding debt of the utility in year ***j*** will be

$$K\frac{(n-j+1)}{n} \quad .$$

So the gearing of the utility in year j , which, it will be recalled, is defined as the ratio of debt to RCV, will be $(1+i)^{-j}$.

In other words, the gearing of the utility will decrease exponentially over the life of the asset: and the higher the rate of inflation, the more rapid the decline in gearing.

6. This example, of a utility with just a single investment, is perhaps a little artificial. So let's consider the case of a utility which actually makes the same amount of real investment every year. (This, for example, is quite like a large utility such as Scottish Water, which has an annual investment programme of £500 million in real terms). If such a utility was funding its entire investment programme by historic cost borrowing, then the gearing of the utility would eventually settle down to a steady state, depending only on asset life and the rate of inflation. The steady state gearing ratios for such a utility are shown in the following table: (the formula used in calculating the values in the Table is derived in Annex 2.)

Steady State Gearing for Utility Financed by Historic Cost Debt

Percent

Inflation (as fraction)	Asset life (years)			
	10	**20**	**30**	**40**
0	100	100	100	100
0.005	98	96	95	93
0.01	96	93	90	87
0.015	94	90	86	82
0.02	92	87	82	77
0.025	91	84	78	73
0.03	89	81	75	69
0.035	87	79	71	65
0.04	86	76	68	62
0.045	84	74	66	59
0.05	83	72	63	56
0.055	81	70	60	53
0.06	80	68	58	51
0.065	79	66	56	49
0.07	77	64	54	46
0.075	76	62	52	45

7. What are the implications of this? Well, this depends on what use is being made of gearing as an indicator. If you were to use the gearing ratio of this utility as an indicator of how much of its capital investment was being funded by debt, and how much by equity, then you would be going badly wrong. In this example, all of the capital expenditure of the utility is actually funded by debt. But if inflation was running at 5%, and if asset life was thirty years, an observer who used the observed gearing ratio of the company (63%) as a guide would mistakenly conclude that more than a third of the investment of the company was actually funded from equity. In other words, such an observer would be grossly overstating the contribution made by equity to funding the capital investment of the company.

8. The crucially important point is that, if the profile of payments by which a utility funds its capital stock differs from the profile on which it is reimbursed through the current cost charging mechanism, then the observed gearing of that utility cannot be used as an indicator of what percentage of its capital investment is funded by equity. Unfortunately, as will be seen later, this is precisely a trap into which OFWAT, and the other UK regulators, have fallen.

9. Now let's look at another impact of differing payment profiles between reimbursement and funding streams. Let's go back to the simple example of a utility making a single investment of

K in year 0, as considered in paragraph 2. If we take the specific example illustrated in the chart in paragraph 3 (***r*** = 0.03, ***i*** = 0.025, and an asset life of 35 years) then it turns out that, over the lifetime of the asset, the utility will actually receive, under current cost pricing, a total reimbursement of 2.357**K* : but it will pay out, in loan charges, a total of 2.004**K*. So the customer will be paying out, by way of charges, 0.353**K* more over the lifetime of the asset than the utility pays out by way of funding costs. It must be stressed that this overall difference between what the customer pays, and what the utility pays, is not in itself evidence that the customer is being overcharged. Funding streams which take place over a number of years cannot just be added up and compared: the correct approach is to compare the Net Present Values (NPV) of the two payment streams, where the NPVs are calculated using an appropriate discount rate to encapsulate the time preference for money of the person or other agent who is making the valuation. (For a definition of NPV and related concepts, see Annex 1). If the current cost reimbursement stream, and the historic cost funding stream, are discounted at the discount rate (*i+r+ir*) then they both have the same NPV, namely *K*: (which is just another way of saying that the interest rate implicit in both streams is (*i+r+ir*)). So for an agent for whom the appropriate discount rate to express their time preference for money is (*i+r+ir*) the value of the current cost reimbursement equals the value of the funding cost: and such an agent would not regard there as being either over or under charging.

10. A discount rate of (*i+r+ir*) is an appropriate way of expressing the time preference of money for the utility operator, since that is the interest rate at which they can borrow money in the market. However, another key agent in the process is the customer – that is, the general public. From the customer's perspective, what is appropriate when it comes to comparing the values of the reimbursement and funding cost payment streams is to calculate NPVs using a discount rate which would represent the time preference of an individual member of the public for money. And since an individual, nowadays, cannot invest his or her money in a way which yields any significant real return, it is quite inappropriate to regard a nominal discount rate of (*i+r+ir*) which is equivalent to a real return of ***r***, as expressing the time preference for money of the general customer. It would be much more appropriate to take, from the view point of a rational customer, a nominal discount rate of ***i***, corresponding to a zero real return on savings. (In fact, given the effect of tax, a negative real return would probably be more accurate: but a zero rate is considered here in order to be conservative.)

11. Calculating NPVs at a discount rate of ***i***, the NPV of what the customer pays by way of current cost charges is significantly greater than the NPV of what the utility pays out, by way of funding costs. The following table illustrates this, for ***r*** = 0.03, and different combinations of ***n*** and ***i***.

Ratios of NPVs of Current Cost to Historic Cost Charges.

NPVs calculated at discount rate equal to rate of inflation.

Real rate of return 3%

	Asset life (years)			
Inflation(as fraction)	10	20	30	40
0.01	1.00	1.01	1.03	1.05
0.02	1.01	1.03	1.06	1.09
0.03	1.01	1.04	1.08	1.13
0.04	1.02	1.05	1.1	1.16
0.05	1.02	1.06	1.12	1.19
0.06	1.02	1.07	1.14	1.21
0.07	1.03	1.08	1.15	1.24
0.08	1.03	1.09	1.17	1.26
0.09	1.03	1.1	1.18	1.28
0.1	1.03	1.11	1.19	1.29

In other words, from the point of view of a rational customer, if a utility is being reimbursed by current cost charging, but funding its investment by historic cost borrowing at the same interest rate, then the customer would regard what he or she has to pay to the utility as being more expensive than what the utility pays out by way of funding costs. Such a customer could reasonably regard themselves as being overcharged: note how, when asset lives are long, the degree of such overcharging, as perceived by the customer, increases rapidly as inflation increases.

12. In fact, there is a neat relationship between the above table, and the steady state model of a utility which undertakes a constant real amount of investment, K, each year. Under the same assumptions as paragraph 6 above, where such a utility is operating in a steady state, then the ratio of how much money the utility will receive as reimbursement for capital expenditure each year, to how much it will pay out in funding costs, will settle down to precisely the figures in the above table: (a proof of this is given in Annex 3.) So in the long run, if, for example, inflation was 5% per annum, if the target real rate of return set by the regulator was 3%, and if the length of asset life was 40 years, then customers would pay the utility each year 19% more than the utility needed to pay out in funding costs.

13. What this section has demonstrated is the crucial importance of the actual profile of payments a utility is making when it funds its capital investment. In particular, when the profile of payments differs from the profile of reimbursements under the current cost pricing model, then:

- the gearing of the utility cannot be used as an indicator of what proportion of new capital investment is funded by debt or equity.
- customers may regard themselves as being significantly over-charged, if the appropriate real discount rate for assessing the time preference for a rational customer is less than the target real rate of return set by the regulator.

[Just to avoid any doubt: it is not being argued in this last point that the regulator should reduce its target real rate of return to equal the time preference rate of the customer: if the regulator did this, the utility would not be able to fund its investment. What is being argued is that, when there are profiling differences, what the customer pays under current cost pricing may well cost more (in terms of the customer's NPV) than what the utility itself pays out by way of funding costs.]

14. In the previous section, three key assumptions were identified, which underlie the current cost charging method: namely, the cost of debt, the cost of equity, and the proportion of capital formation funded by equity. In the light of the analysis in this section, a fourth critical factor must now be added to this list: namely, how well the profile of payments made by the utility in funding its capital investment corresponds to the profile of reimbursements implied by current cost pricing. The next section will consider the extensive experience of the application of current cost pricing in the water industry in England and Wales, to see how well the pricing model has performed in relation to these four critical factors.

4. How Current Cost Charging has Performed in the E. and W. Water Industry.

1. The regulator, OFWAT, has applied current cost charging to the privatised water industry in England and Wales since 1994. OFWAT has published regular reports (OFWAT, 1994, 1999, 2004) on the assumptions it has made in setting price caps for the industry. OFWAT has also published regular, and detailed, reports on the financial performance of the water industry: (OFWAT, annual). These reports provide a good deal of factual information, which enables the performance of the pricing model to be assessed. (Incidentally, and regrettably, the 2010 financial performance report is the last which OFWAT proposes to publish.)

2. The financial performance reports publish information on the net debt of the industry in each year, and also on the interest payments made on that debt. From this information, it is possible to calculate the average rate of interest being paid by the industry for its debt finance – both in nominal and real terms. (Annex 4 sets out the approach taken on the relevant calculations.) On the basis of these calculations, it is estimated that, over the period 1990 to 2009, the water and sewerage companies in England and Wales have been paying a real rate of interest of between 2.45% and 3.41% per annum for the loan finance they have raised. In contrast, the assumptions on the real, post-tax cost of debt in OFWAT's periodic pricing reviews are as follows:-

- 1994 review (covering years 1995 to 2000): 4% to 5%.
- 1999 review (covering years 2000 to 2005): 2.8% to 3.5% (plus a premium for debt acquired before 2000).
- 2004 review (covering period 2005 to 2010): 3.3% to 4.4%.

In other words, on the first critical assumption, the cost of debt, OFWAT consistently, and significantly, overstated what utility companies would be paying for loan finance: commonly by one percentage point or more in real terms.

3. The fact that water companies expect to be able to borrow in the debt market at real interest rates significantly lower than those assumed by OFWAT is confirmed by the following quotation from United Utilities 2011 Report and Financial Statement:-

> *"The aim is to raise future financing, as required, at interest rates that will deliver further outperformance when compared with OFWAT's allowed cost of debt of 3.6 per cent real. UUW has recently agreed a new £200 million index-linked loan with the European Investment Bank at an average real interest rate of 1.2 per cent, ..."*

4. Next, what about payment profiles. Information relevant to this question is contained in the annual reports and accounts published by each of the privatised water and sewerage companies. These accounts give information on whether the debt finance of the company is in the form of a fixed interest or index linked loan. What the accounts show is that a substantial proportion of debt is indeed fixed interest debt. For example, the accounts of Anglian Water for 2011 indicate that almost half of their debt is fixed interest: 74% of Northumbrian water debt is fixed interest (2011 Accounts): as is 56% of Severn Trent debt (2010 Accounts): 58% of Thames water debt (2011 Accounts): 34% for Southern Water (2011 accounts): and 41% for Yorkshire Water (2010 Accounts). Moreover, the accounts indicate that a substantial proportion of the fixed interest debt is typically of a fairly long maturity. Most utilities, therefore, raise a substantial proportion of their debt on a fixed interest basis. But, as has been seen in the previous section, fixed interest debt will have a quite different payment profile from the profile of reimbursements companies will receive under current cost charging. So the problems identified in the previous section are indeed likely to arise: that is, the companies' observed gearing ratios will be a misleading indicator of the proportion of funding actually raised by equity: and (relative to the time preference for money of a rational customer) current cost charging is likely to involve overcharging the customer for the capital actually raised.

5. Next, let's look at the question of gearing. The following table, calculated from the figures on net debt and RCV in OFWAT's reports on the financial performance of the industry, shows the industry gearing (defined as the ratio of net debt to RCV) from 1990 to 2009, and also the reverse percentage, based on the ratio (RCV – net debt)/RCV.

Gearing for Water and Sewerage Companies

Year	Gearing	percent 100-gearing
1990	4.0	96.0
1991	18.0	82.0
1992	25.8	74.2
1993	26.4	73.6
1994	23.4	76.6
1995	28.0	72.0
1996	29.1	70.9
1997	37.1	62.9
1998	42.6	57.4
1999	44.8	55.2
2000	47.3	52.7
2001	51.4	48.6
2002	58.6	41.4
2003	60.9	39.1
2004	62.0	38.0
2005	60.0	40.0
2006	64.7	35.3
2007	68.1	31.9
2008	71.2	28.8
2009	71.3	28.7

As can be seen, gearing ratios start very low (since the companies were essentially debt free on privatisation, as a result of the debt commutation that took place before privatisation) but gearing ratios then increase steadily throughout the period, to over 70%. It is not clear what gearing ratio OFWAT assumed when they were working out their assumed overall cost of capital in their 1994 review. But in their 1999 review, they assumed a gearing ratio of 50%, and they assumed 55% in their 2004 review. That is, when setting the assumed cost of capital in 1999, they were effectively assuming that 50% of new investment would be funded by equity, and that 45% would be funded by equity in the 2004 review period. It is immediately apparent that OFWAT's assumed equity percentages are high, relative to the figures in the final column of the table. But the implication of the preceding section, together with the information in the preceding paragraph on the amount of capital which utilities funded through fixed interest debt, is that the figures in the final column of the table are in any event likely to substantially overstate the amount of new capital investment actually funded by equity. The combined effect is that OFWAT will have very substantially overstated the percentage of new investment actually funded by equity.

6. That this is indeed the case can be seen directly, by looking at another set of figures drawn from OFWAT's financial performance reports: namely, figures for the aggregate of called up share capital plus share premium. These figures represent the cumulative amount of capital which has actually been made available from shareholders to the companies (and which might then be used for investing in capital assets or other purposes). These figures are shown in the following table:

Called up Share Capital plus Share Premium
for Water and Sewerage Companies.

£million

Year	
1995	5153.7
1996	5189.9
1997	6159.0
1998	6284.0
1999	6387.0
2000	6229.0
2001	6229.0
2002	6226.0
2003	6587.0
2004	6596.0
2005	6557.0
2006	6557.0
2007	6536.0
2008	5510.0
2009	5473.0

What is relevant in interpreting these figures are the changes from year to year- representing the amount of capital raised from shareholders. It is clear that, after the initial purchase of shares on the privatisation of the companies, only relatively small amounts of new capital have been raised from shareholders by the issue of shares– in fact, fairly trivial amounts compared with the aggregate of around £52 billion of gross investment the companies have undertaken over the period. Of course, a portion of new investment each year will also have been financed from retained profits – which could also be regarded as a form of equity contribution. But given that, over the period 1991 to 2009, the increase in net debt each year has averaged 66% of gross investment each year, the OFWAT assumption that 50% (or 45%) of new investment would be financed from equity represents a gross overestimate of the true percentage. OFWAT has well and truly fallen into the trap identified in the previous section, of using gearing as an indicator of the amount of capital raised from equity, when this indicator has been rendered valueless for this purpose because of profiling effects.

7. Given that OFWAT has typically assumed a 2% to 3% real, post tax premium on the cost of equity capital relative to debt finance, the gross overestimation of the true contribution of equity to the funding of capital will have been a further contributor to very significant overestimation of the overall cost of raising new capital. But that is not the end of the story. As the OFWAT 1999 price review states,

> "***Returns have been modelled on a post-tax basis, and the companies' projected tax costs added to the revenue required to allow them to earn an adequate pre-tax return to enable them to finance their functions***."

In other words, as regards the assumed equity element of capital finance (the costs of which are paid out of company profits after tax) customer charges have been further increased to recoup the tax element of these costs. So if the equity element of capital finance is overestimated, this tax compensation element of customer charges will be overestimated too.

8. What the evidence points to, therefore, amounts to a shocking position. OFWAT has consistently overestimated the cost of debt: has greatly overestimated the contribution of equity (so further overestimating the post-tax cost of capital): and there will be a further overestimation of the tax element of charges, because the equity element is overestimated. All of these effects mean that customers will have over-paid, hugely, for the capital element of water charges. The resulting excess profits will have been available to take as dividend returns for the equity owners.

And indeed, and not surprisingly, confirmation of this can be seen in the rate of return earned on the equity capital invested in the industry. Annex 5 outlines the approach adopted here in estimating this figure, based on the figures published in OFWAT's reports on financial performance. The bottom line is that, relative to the equity capital actually invested in the industry, the dividends paid represent an annual nominal return of 20.0%: an eye watering return, and surely much more than even the most rabid free market proponents of privatisation envisaged.

9. Another, independent, source on the returns received in the water industry in England and Wales was a report produced by the Public Services Research Unit in 2001: (Lobina and Hall, 2001). Lobina and Hall identify what they describe as excessive profit margins for UK water companies by international standards. To quote from their report:-

> "*Profit margins in the UK are typically three or even four times as great as the margins of water companies, private and public, in France, Spain, Sweden or Hungary. The profit margins of the greatest water multinationals – Suez-Lyonnaise and Vivendi – worldwide, also show a much lower return than enjoyed by the UK companies.*"

10. The conclusion is clear: the water and sewerage companies in England and Wales have proved to be extremely, indeed excessively, profitable.

11. It might be objected that a very different picture of the returns on equity would be obtained if dividend returns were related to equity as defined by (RCV-net debt). In fact, over the period, the estimated return on equity measured in this sense was 10.1% per annum in nominal terms, and 6.6% in real terms: much lower than the 20.0% nominal return earned on the equity capital actually raised from shareholders. However, there are two very good reasons why measuring dividend returns relative to (RCV-net debt) is a misleading approach:-

- because, as noted in the previous section, when a substantial proportion of capital funding is raised on the basis of fixed interest debt, then (RCV-net debt) is likely to substantially overstate the true contribution towards funding capital investment made by share capital raised plus retained profits.
- and also because, insofar as part of the growth of (RCV-net debt) is due to the investment of retained profits, then to give a fair assessment of the true return on equity, an adjustment should be made for such retained profits. See Annex 5 for an example illustrating this point: as this example shows, without such an adjustment the ratio of reported dividends to the size of the asset base can seriously underestimate the scale of return actually being earned.

For both of these reasons, the figure of 20.0% is a much better indicator of the return earned relative to the equity invested, as against estimates derived from relating reported dividend returns to (RCV-net debt).

12. The technical points raised in the previous paragraph are important in another context as well. In its regular reports on the financial performance of the water industry, OFWAT provides information on what it describes as "***the overall return on capital that investors and lenders received***:" this is defined as dividends plus interest as a percent of RCV. But the technical points identified in the preceding paragraph also apply to this measure: and mean that it will give a misleadingly low indication of the actual return being earned on capital invested. It is yet another criticism of OFWAT that it publishes this faulty measure, without any recognition of the potential pitfalls surrounding its interpretation. The effect has been to camouflage the excessive returns actually being made in the industry.

5. A Short Trip into a Siding: the Office of Rail Regulation Model for Utility Pricing.

1. This section represents a brief diversion from the main thrust of the report: but one that is very important nevertheless, particularly in the context of current plans for massive capital investment in the rail network. In the introduction, it was mentioned that the rail regulator, the Office of Rail Regulation (ORR) uses a variant of the standard current cost RCV charging model, in working out how much customers should pay, via their rail tickets, or via state subsidy, for rail capital investment. As an indicator of just how significant rail capital investment is, it is worth remembering that a single project, the upgrade of the West Coast mainline, cost some £8-10 billion.

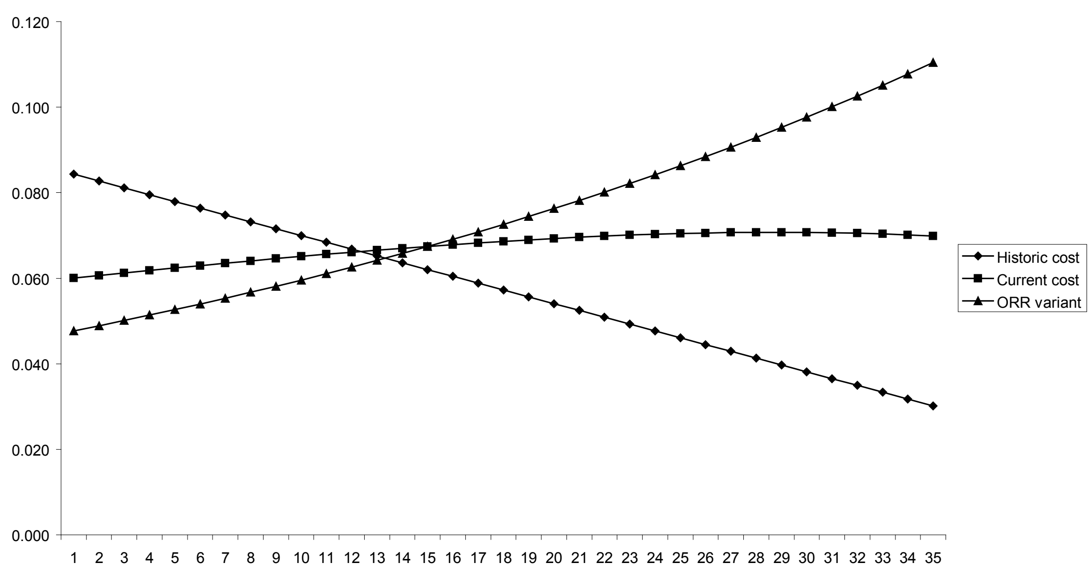
2. The way the ORR variant of the charging model works is as follows. The regulator adopts the same initial approach as the other utility regulators – setting an approved level of capital investment and a target real rate of return (*r*) and making an assumption about the length of asset life (typically 25 years in the case of rail investment). The regulator then works out what constant annual payment over the life of the asset would repay the initial capital investment, and give the rate of return ***r***. That is, the regulator does the appropriate calculation for a mortgage style repayment at interest rate ***r*** – rather than an equal repayment of principal loan like the standard RCV model. What is included in customer charges each year is this annual mortgage payment, uprated to the current prices of that year by the rate of inflation: (ORR, 2010). Technically, in terms of the notation used previously, if the utility company makes a capital investment of *K* in year 0, then in year ***j*** it will receive a reimbursement of

$$Kr\ (1+i)^{j} / [1 - \ (1+r)^{-n}]\ , \qquad j = 1, \ldots \ n.$$

(A proof of this is given in Annex 6.) In fact, the investor, typically Network Rail, has the choice of whether they are reimbursed by the standard RCV method of charging, or the ORR mortgage variant. In practice, for reasons which will now become apparent, the investor always chooses the ORR variant.

3. The seemingly innocuous variation implicit in the ORR method in fact has a very significant effect. If the previous chart (see section 3) is repeated, but now with the ORR variant added, then the picture is as follows:

Historic cost, current cost and ORR variant payment profiles: real rate of return 3%, inflation 2.5%: 35 year asset life



(Here r = 0.03, and i = 0.025, so all three profiles imply the same rate of return of 5.575%).

4. What is immediately apparent is that the ORR variant implies a further significant rightward shift in the profile of payments. This means that the ORR approach will be even less attractive to a rational customer, whose time preference is expressed by a real discount rate less than r. Similarly, the ORR approach will involve a higher level of charges each year in the long run, for an industry operating in a steady state of a constant real amount of investment each year. Both effects are illustrated in the following table, which shows the long run ratio of ORR charges to conventional RCV charging, and to historic cost loan finance, for a variety of combinations of target real rate of return and inflation, and for an asset life of 25 years.

Ratio of ORR variant Steady State Charges, to Historic Cost and Current Cost Charges

***r* = 0.03**

inflation	HC	CC
2.50%	1.085	1.033
5%	1.126	1.033
7.50%	1.159	1.033

***r* = 0.05**

inflation	HC	CC
2.50%	1.152	1.075
5%	1.217	1.075
7.50%	1.27	1.075

Using the result already proved in Annex 3, the table also shows the relative costs as perceived by a rational customer with time preference expressed by the nominal discount rate i.

5. The results are revealing. In the long run, the ORR variant is significantly more expensive than conventional current cost charging: by some 3.3% if the regulator sets a 3% real target rate of return, and by some 7.5% at a 5% real target rate of return. Note also how the excess over current cost charging does not vary with inflation. The ORR variant is, of course, even more expensive relative to historic cost charging: and in this case, the excess cost of the ORR variant increases markedly as inflation rises.

6. Given this, it is no surprise that the ORR variant is the method of choice for virtually all rail capital expenditure. Nor is it surprising how, when each round of rail fare increases is announced, there is general bewilderment how rail fares in the UK are so much more expensive than international comparators.

6. Implications: and What Should Be Done

1. What has been demonstrated so far, therefore, is that there have been a number of gross errors in the approach to price setting adopted post-privatisation by UK utility regulators – errors which, in the case of the water industry in England and Wales, have demonstrably resulted in overcharging, and in grotesquely high returns for the equity investors. Nor are the effects confined to water: the same techniques are applied in all other UK utilities (including airports) – with the exception of rail, where the variant approach which has been adopted is even worse.

2. The effects, however, go beyond overcharging and excess profits. The charging mechanism for capital expenditure means that it is by undertaking capital investment that utilities make a large part, and indeed probably most, of their profits. Regulators are, presumably, good at controlling

the reimbursement which utilities receive for their ongoing operations, and hence ensuring that they only earn reasonable profit on this aspect of their activities. The road to profit for a utility is to undertake capital expenditure reimbursed through the current cost pricing mechanism. In other words, there is an incentive for the utility to seek out projects for which it can get regulatory approval – and then to get the most expensive and capital intensive versions of these projects past the regulator's scrutiny. Hence the pricing mechanism has almost certainly thoroughly distorted the whole thrust and nature of the capital investment undertaken on our utility infrastructure.

3. This was a complaint which was indeed made by Michael O'Leary, the boss of Ryanair, when in 2006/2007 he complained about the "gold plated Taj Mahal" airport investment projects undertaken by BAA "at excessive cost". O'Leary, in that quotation, accurately put his finger on the symptom of the disease. What this paper explains is the cause.

4. So what should be done? It is not the purpose of this paper to put forward alternative pricing mechanisms: the appropriate way to develop alternatives is by an informed process of democratic consent, where the final decisions are made by the body of customers, who, after all, end up paying for all of this.

5. Before the process of democratic consent can begin, however, it is necessary to be absolutely clear as to why the present system has gone so badly wrong. What will be argued here is that mistakes have been made at three fundamental levels – and that the mistakes made at each of these levels have been disastrous. The three levels relate to accuracy of assumptions: appropriateness of model: and basic philosophical concept. Each of these levels is now examined in more detail.

Accuracy of assumptions

6. This is the most basic level. Clearly, if you are using a model to work out customer prices, a fundamental requirement is to estimate the parameters in that model correctly. But as has been seen, regulators have failed badly even at this most basic level. OFWAT, for example, overestimated the cost of debt by one percentage point or more in real terms: and it has also grotesquely overestimated the actual contribution of equity to funding investment in the water industry.

Appropriateness of model

7. It is not enough, however, just to get the basic parameter estimates right, if the underlying model does not describe the real world accurately enough. As has been seen above, if the profile of payments made by the utility operator when it is funding its capital expenditure differs from the reimbursement profile in the charging model, then all sorts of problems arise. First of all, the statistic which the regulator uses to estimate the proportion of new capital investment funded from equity (based upon the gearing of the company) ceases to be an accurate estimator. Secondly, there is the potential for a long term excess between what the utility operator gets in by way of reimbursement, and what goes out by way of funding costs. Thirdly, it can no longer be assumed that there is an equivalence between the way a rational customer would value what he or she is being charged for the service of a capital asset, compared with the way the same customer would value what the utility is paying by way of funding costs for the asset: so the charging system may no longer be fair from the customers' viewpoint.

Basic philosophical concept

8. So let's suppose that the real world does correspond to the regulator's model: (for the sake of simplicity, let's assume that all utilities have moved over to funding their debt through index linked borrowing). And let's also suppose that the regulator has correctly estimated the basic parameters (cost of debt and equity, and proportion of new capital expenditure financed

from equity). Would that be all right, then? Well, actually, the answer is no. The reason is that, implicit in the current cost pricing approach, is a basic view about the relationship between the customer, and the infrastructure capital assets on whose services he or she depends. And the customer may well not be happy with the underlying philosophy involved in this relationship.

9. To see why this is the case, it is useful to think of housing as an analogy. If we buy a house on a mortgage, we may pay more initially than if we rented, but in the long run we can expect the real value of our mortgage payments to be eroded by inflation – and we will end up paying less than someone who rents, and whose rental values will continually be uprated in line with inflation. In the case of utility pricing, the decision to implement current cost pricing was equivalent to the decision to convert the customer from someone who paid for the capital element of their utility service as if they were owner occupiers, to someone who paid as if they were a renter. This imposes a significant long term cost penalty on the unfortunate customer: (the scale of this penalty has already been illustrated: see the table in para 3.11 above.)

10. Nobody consulted the customer about this change in any meaningful sense, at the time when Thatcher was privatising the utilities: indeed, they couldn't – because the detail of the current cost pricing mechanism had not been worked out at the time of the major privatisations. This is an important point: because it means that the excess profits implicit in current cost pricing (and also in the particular way it has been implemented) were not part of the original privatisation prospectus, but were an additional bonus for the utility operators, which they received after the event because of regulatory slackness. And if customers had been properly consulted about what was in store for them, it seems inconceivable that they would have agreed.

11. In outline terms, it is now clear what needs to be done. What is required is to work back through the three different levels identified above, and put things right. First of all, we need to be clear about philosophy: are we, as customers, content to be placed in the position of quasi-renters of the nation's infrastructure assets, where the utility companies gain continuing windfall benefits from the effects of inflation: or do we want to secure these benefits for ourselves? It is important to remember that we can change the present system if we want: there is nothing in privatisation in itself which dictates that we have to pay for infrastructure assets as if we were renting them. (And in the case of Scottish Water, which we still own, the present system is even more ludicrous, and easy to change.) Having agreed on the correct philosophy, we then need to sort out a pricing model which delivers this: and then we need to estimate the relevant parameters accurately.

12. This is all fairly simple: but not with the current regulatory system. We have been cursed, since privatisation, with a group of regulators who have conducted a masterclass in how not to deliver a price setting model. They have been unclear (whether deliberately, or through genuine ignorance) about philosophy: they have set up inappropriate models: there have been gross errors in the estimation of key model parameters: and the way the results have been presented has obscured the resulting excessive returns being earned by equity investors. We have all suffered as a result. One paradox of privatisation is that we need regulators to protect us from being exploited by the natural monopolies which occur in network utilities. In setting up the regulatory system we have, in fact, established another monopoly – the monopoly of the regulator. And we have been defenceless in the face of this new monopoly, which we created ourselves.

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Annex 1: Definition of NPV and IRR: derivation of IRR of current cost payment scheme.

Definition of NPV and IRR.

1. Let **a** = ($a_0, a_1, ... a_n$) be a sequence of payments, where the individual terms may be positive or negative.

Then the Net Present Value, (NPV), of the payment stream, calculated at discount rate $\sigma, (\sigma > -1)$, and with year zero reference date, is defined as

$$\text{NPV}(\mathbf{a}, \sigma) = \sum_{j=0}^{n} a_j (1+\sigma)^{-j} \qquad (1)$$

The NPV can be taken as representing the value at time zero of the payment stream **a**, to an agent whose time preference for money is expressed by the discount rate σ.

2. An important special case occurs where **a** represents the stream of payments associated with an investment, (or a loan). Here negative terms represent investment of capital, (or lending of money), and positive terms represent returns to the investor, (or to the lender). For such a payment stream **a**, which will contain both positive and negative terms, an Internal Rate of Return, (IRR), of **a** is defined to be any discount rate, μ, for which

$$\text{NPV}(\mathbf{a}, \mu) = 0 \qquad (2)$$

IRRs are not necessarily unique: but there is an important special case, when the negative terms in the payment stream precede the positive terms: in this case, every payment stream has an IRR, and it is unique.

Historic Cost Borrowing Formula

Suppose that there is an initial loan of 1 in year 0, ($a_0 = -1$), and for the next *n* years there is a repayment of $1/n$ of the original principal, plus interest calculated at rate *r* on outstanding debt:

then $a_j = \frac{1}{n}[1 + r(n - j + 1)]$, for *j* = 1,.. *n*.

This is the historic cost, equal repayment of principal, borrowing formula.

The IRR of this payment stream, in terms of the definition at (2) above, is *r*, as would be expected: this is a standard result, but nevertheless it is worth giving a proof here, for completeness. To prove this, it is necessary to establish that

$$\sum_{j=0}^{n} a_j (1+r)^{-j} = 0 \ ;$$

In other words, it is necessary to prove that

$$\sum_{j=1}^{n} \frac{1}{n}[1 + r(n - j + 1)](1+r)^{-j} = 1 \ .$$

This can be established by the following iterative argument.

Let d_j = outstanding debt at beginning of period *j*:

So $d_j = \frac{(n - j + 1)}{n}$:

Then the following relationship holds: namely

$$d_{j+1} = (1+r)d_j - a_j \ , \text{ for } j = 1, \ldots n, \qquad (3)$$

since the right hand side of this expression

$$= (1+r)\frac{(n-j+1)}{n} - \frac{1}{n}[1+r(n-j+1)]$$
$$= \frac{(n-j+1)}{n} + r\frac{(n-j+1)}{n} - \frac{1}{n} - r\frac{(n-j+1)}{n}$$
$$= \frac{(n-j)}{n} = d_{j+1} .$$

So, applying (3) recursively, it follows that

$$0 = d_{n+1} = (1+r)d_n - a_n$$
$$= (1+r)[(1+r)d_{n-1} - a_{n-1}] - a_n$$
$$\ldots..$$
$$= (1+r)^n d_1 - \sum_{j=1}^{n}(1+r)^{n-j} a_j$$
$$= (1+r)^n - \sum_{j=1}^{n}(1+r)^{n-j} a_j .$$

Dividing through by $(1+r)^n$, it follows that

$$\sum_{j=1}^{n} a_j (1+r)^{-j} = 1,$$

Thus establishing that the IRR of the historic cost loan scheme is indeed *r*.

IRR of Current Cost Formula.

Under the current cost charging formula, $a_0 = -1$, and

$$a_j = \frac{1}{n}[1+r(n-j+1)](1+i)^j \quad , \; j = 1,\ldots n.$$

In the previous section of this annex, it was proved that

$$\sum_{j=1}^{n}\frac{1}{n}[1+r(n-j+1)](1+r)^{-j} = 1 \; :$$

it therefore follows that

$$\sum_{j=1}^{n}\frac{1}{n}[1+r(n-j+1)]\frac{(1+i)^j}{(1+i)^j(1+r)^j} = 1:$$

that is

$$\sum_{j=1}^{n} a_j [(1+i)(1+r)]^{-j} = 1 \; ,$$

that is

$$\sum_{j=1}^{n} a_j [(1+i+r+ir)]^{-j} = 1 \; ,$$

Hence establishing that the IRR of **a** is $(r+i+ir)$.

Annex 2:Formula for Gearing in Steady State Model..

It is assumed that inflation = i, and asset life =n: it is also assumed that the utility makes a constant real amount of investment each year. Specifically,

investment in year t = $(1+i)^t$.

And it is assumed that the utility funds this investment entirely by historic cost borrowing.

In deriving the formula for the gearing of this utility when operating in a steady state, (that is, when $t > n$), the following fact will be used:-

$$\sum_{j=1}^{n} jx^{j-1} = \frac{(n+1)x^n}{(x-1)} - \frac{(x^{n+1}-1)}{(x-1)^2} \quad . \qquad (1)$$

The RCV of the utility in year t is the sum of contributions made by the investments in each of the preceding n years, and is equal to

$$\sum_{j=1}^{n}(1+i)^{t-j}\frac{(n-j+1)}{n}(1+i)^j$$

$$= \frac{(1+i)^t}{n}\sum_{j=1}^{n}(n-j+1)$$

$$= \frac{(n+1)}{2}(1+i)^t \quad .$$

Historic cost debt in year t is, similarly, the sum of contributions from investments made in each of the preceding n years, and is equal to

$$\sum_{j=1}^{n}(1+i)^{t-j}\frac{(n-j+1)}{n} \quad .$$

Therefore,

$$\text{gearing} = \frac{\text{debt}}{\text{RCV}}$$

$$= \frac{2}{n(n+1)}\sum_{j=1}^{n}(n-j+1)(1+i)^{-j}$$

$$= \frac{2}{n}\sum_{j=1}^{n}(1+i)^{-j} - \frac{2}{n(n+1)(1+i)}\sum_{j=1}^{n} j(1+i)^{-j+1}$$

$$= \frac{2}{n}\frac{1}{(1+i)}\frac{[1-(1+i)^{-n}]}{[1-(1+i)^{-1}]} - \frac{2}{n(n+1)(1+i)}\left[\frac{(n+1)(1+i)^{-n}}{[(1+i)^{-1}-1]} - \frac{[(1+i)^{-n-1}-1]}{[(1+i)^{-1}-1]^2}\right]$$, on using the formula at (1) above in the second summation,

$$= \frac{2}{ni}[1-(1+i)^{-n}] + \frac{2}{ni}(1+i)^{-n} + \frac{2(1+i)}{n(n+1)i^2}[(1+i)^{-n-1}-1]$$

$$= \frac{2}{ni}\left[1 - \frac{(1+i)}{(n+1)i}(1-(1+i)^{-n-1})\right] \quad .$$

Annex 3: For a Utility Operating in a Steady State, the Real Value of Steady State Charges is Equal to the NPV of the Payment Stream Relating to the Initial Investment, at a Discount Rate Equal to the Rate of Inflation.

Suppose that a utility is operating in a steady state: so that, if investment is 1 in year 0, and the rate if inflation is *i*, then investment in year *j* will be $(1+i)^j$.
Suppose also that, for an investment of *K* in a given year, the resulting stream of payments relating to that investment, in each of the succeeding *n* years, will be $Ka_1, Ka_2, ..., Ka_n$: (this covers both cases, where the payments are customer charges paid to the utility, or funding costs paid out by the utility.)

Then, when the utility is operating in the steady state, (that is, for $t > n$), the total payment in year *t* will be the sum of contributions from the investments made in each of the preceding *n* years.

Therefore,

$$\text{Nominal payment in year } t = \sum_{j=1}^{n} (1+i)^{t-j} a_j$$

$$= (1+i)^t \sum_{j=1}^{n} a_j (1+i)^{-j}$$

$$= (1+i)^t \,\text{NPV}(\mathbf{a}, i), \text{ where } \mathbf{a} = (a_1, a_2, ..., a_n).$$

Hence,

Real payment in year = NPV(**a**,*i*).

Annex 4: Estimating IRR from Truncated Series of Debt and Interest Payments.

1. The problem is to estimate the IRR of loan finance from series of debt and interest payments: the approach adopted is to work back from the figures for debt and interest to the stream of payments, (**a** in the notation used in this paper), and then estimate the IRR by solving equation (2) in Annex 1 above. To obtain an estimate of real IRR, the appropriate approach is to derive the nominal stream of payments, **a**, then to deflate this to constant prices, and then to estimate the real IRR by again applying formula (2) in Annex 1.

3. There is a further difficulty, because the figures for net debt and interest published in OFWAT's Financial Reports on the water industry are truncated: figures for net debt and interest are available from 1990 to 2009: but obviously, the loans in existence at 2009 will continue, in many cases, for many years thereafter.
This problem of truncation can be handled as follows.
Let **a** be a payment stream with IRR μ:
let d_j denote the outstanding debt at the beginning of period j:
so $d_1 = -a_0$, and $d_{j+1} = (1+\mu)d_j - a_j$, j = 1, … n.
(that is, outstanding debt at beginning of period j+1 = outstanding debt at beginning of period j, increased at rate μ, less payment made in period j.)

By the definition of IRR, the IRR μ of **a** satisfies

$$0 = \sum_{j=0}^{n} a_j (1+\mu)^{-j}$$

$$= \sum_{j=0}^{n-1} a_j (1+\mu)^{-j} + d_n (1+\mu)^{-n+1} \text{ , since } a_n = (1+\mu)d_n \text{ ,}$$

$$= \sum_{j=0}^{n-2} a_j (1+\mu)^{-j} + [(1+\mu)^{-1}(a_{n-1} + d_n)](1+\mu)^{-n+2}$$

$$= \sum_{j=0}^{n-2} a_j (1+\mu)^{-j} + d_{n-1}(1+\mu)^{-n+2}$$

……….

$$= \sum_{j=0}^{M} a_j (1+\mu)^{-j} + d_{M+1}(1+\mu)^{-M} \text{ , for any } M < n.$$

So, for any $M < n$, if ($a_0,...,a_M$) are known, and also d_{M+1}, then the IRR of **a** is equal to the IRR of the payment stream ($a_0,...,a_{M-1}, a_M + d_{M+1}$)

4. Let b_j denote the interest payment in period j: so $b_j = \mu d_j$:
then, since $d_{j+1} = (1+\mu)d_j - a_j$, it follows that $a_j = d_j - d_{j+1} + b_j$, and $d_{j+1} + a_j = d_j + b_j$.
So, if what is known are $(d_1,...,d_M)$ and $(b_1,...,b_M)$, what is required is to find the IRR of the payment stream

$$(-d_1, d_1 - d_2 + b_1, d_2 - d_3 + b_2, ..., d_{M-1} - d_M + b_{M-1}, d_M + b_M). \quad (1)$$

5. The estimates quoted in Section 4, para 2, for the real cost of debt were obtained as follows. Annual figures for net debt and interest payments were taken from the appropriate volumes of OFWAT's annual Financial Performance reports for the industry, to give current cost figures for each year in question, with the exception of six initial years, where figures at current prices were not available, and the constant price figures in the Financial Performance reports were converted to current prices using the RPI. These nominal series for debt and interest were then substituted into expression (1) in the preceding paragraph, to give a nominal payment stream. This payment stream was then deflated to constant prices, using RPI as deflator. The real return on debt was then estimated, as the IRR for this real payment stream, by solving equation (2) in section (1). This procedure was, in fact, repeated, first under the assumption that the reported debt figures were close to debt at beginning year, and then under the assumption that the reported debt figures were close to debt at end year: this gives the range of values for real IRR quoted in the paper.

Annex 5: Notes on Calculation of Nominal IRR on Equity.

1. The estimate of the nominal IRR on the equity invested in the industry was calculated by applying formula (2) in Annex 1 to a payment vector, **a**, representing the net financial flow to/(from) equity investors and the utility. This payment vector **a** was calculated as the sum of equity drawdowns plus dividends.
In the first year, (1999), the initial equity drawdown was taken as the initial share capitalisation of the utility at offer prices, (£-5239 million). For each succeeding year, the equity drawdown was taken as the change from the previous year in the aggregate of share capital plus share premium, (increases counted as negative.) These figures were taken from the appropriate volumes of OFWAT's annual Financial Performance reports for the industry, to give current cost figures for each year in question. Dividends were also taken from the appropriate volumes of OFWAT's annual Financial Performance reports for the industry, to give current cost figures for each year in question, with the exception of six initial years, where figures at current prices were not available, and constant price figures were converted to current prices using the RPI.
In the final year, (2009), a figure of £13975 million was added to the final term in the payment stream. This is the value of (RCV-net debt) in that year, and represents equity investors continuing stake in the industry. (In fact, the estimated IRR is not at all sensitive to the value of this final year adjustment.)

Why retained profits mean that it is not possible to calculate an equity IRR from (RCV – debt).

2. In Section 4, paragraph 11, it was stated that it is inappropriate to measure the return on equity by relating dividends to (RCV – net debt), where an element of the company's capital investment has been funded by retained profits.

To see why this is so, consider the following example. (This example is simplified by assuming there is no inflation: no tax effects: and that the companies involved are investing in a long lived asset, for example, land, on which there is no depreciation.) Consider two companies, A and B, which are essentially identical. In both companies, there is an initial investment of 10 units of equity in year zero. This capital is invested in assets which yield 15% per annum. Each year, 10% of this return on capital is reinvested, while 5% is taken as profit by the equity holders. At the end of year 10, the companies are sold, for an amount equal to the cumulative total of the capital which has been invested: and the equity owners take the sale value as profit.

The only difference between the two companies is the way they fund their annual reinvestments: in company A, the total of the 15% return on capital is taken as dividend, and then the equity holders reinvest two thirds of this in the company through the issue of share capital. In company B, the annual dividend is 5%, and the 10% reinvestment is achieved by retention of profits.

The following table shows the relevant details for company A.

Company A

year	Asset base	Payments between equity owners and company. Equity in	Dividends	Sale	a	ratio div/asset
0		-10			-10.00	
1	10	-1.00	1.50		0.50	0.15
2	11.0	-1.10	1.65		0.55	0.15
3	12.1	-1.21	1.82		0.60	0.15
4	13.3	-1.33	2.00		0.67	0.15
5	14.6	-1.46	2.20		0.73	0.15
6	16.1	-1.61	2.42		0.81	0.15
7	17.7	-1.77	2.66		0.89	0.15
8	19.5	-1.95	2.92		0.97	0.15
9	21.4	-2.14	3.22		1.07	0.15
10	23.6		3.54	23.6	27.14	0.15

The column headed **a** shows the net flow of payments between the equity holders and the company: and the IRR of this payment stream, (on solving equation (2) in Annex 1), is, indeed, 15%. The final column shows the ratio of dividend payments each year to the value of the company's asset base: again, this is 15%.

The next table shows the corresponding details for company B.

Company B

year	Asset base	Payments between equity owners and company. Equity in	Dividends	Sale	a	ratio div/asset
0		-10			-10.00	
1	10		0.50		0.50	0.05
2	11.0		0.55		0.55	0.05
3	12.1		0.60		0.60	0.05
4	13.3		0.67		0.67	0.05
5	14.6		0.73		0.73	0.05
6	16.1		0.81		0.81	0.05
7	17.7		0.89		0.89	0.05
8	19.5		0.97		0.97	0.05
9	21.4		1.07		1.07	0.05
10	23.6		3.54	23.6	27.14	0.15

The growth in the asset base of company B, and the payment stream **a** showing net payments between the equity owners and the company, are identical to company A. Calculation of the IRR of equity based on this payment stream therefore correctly shows the return on the capital invested in the company as 15%. However, for all but the final year of operation, the ratio of dividend to asset base for the company is only 5%. If this figure was used as a means of estimating the actual return being earned on capital it would thus give a completely misleading underestimate of the true return. This illustrates the point made in the text of the paper: that where investment is being funded in part from retained profits, the relationship between reported dividends and asset base cannot be used to estimate the true return on capital.

Annex 6: The IRR of the Office of Rail regulation Variant.

Under the ORR variant, $a_0 = -1$, $a_j = \frac{r}{[1-(1+r)^{-n}]}(1+i)^j$.

Therefore,

$$\sum_{j=1}^{n} a_j (1+r+i+ir)^{-j}$$

$$= \frac{r}{[1-(1+r)^{-n}]} \sum_{j=1}^{n} (1+r)^{-j}$$

$$= \frac{r}{[1-(1+r)^{-n}]} \frac{1}{(1+r)} \sum_{j=0}^{n-1} (1+r)^{-j}$$

$$= \frac{r}{[1-(1+r)^{-n}]} \frac{1}{(1+r)} \frac{[1-(1+r)^{-n}]}{[1-(1+r)^{-1}]}$$

$$= 1,$$

which establishes that the IRR of **a** is indeed $(r+i+ir)$.