ACCESS REGIME DESIGN AND REQUIRED RATES OF RETURN:

PITFALLS IN ADJUSTING FOR INFLATION AND TAX EFFECTS*

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ABSTRACT

Some access pricing regimes derive allowable cash flows to provide investors with an expectation of receiving a required real pre – (company) tax rate of return, with compensation for inflation built in via the allowable return of capital (depreciation). The required real pre-tax return is derived from nominal (or real) post-tax required returns. Techniques commonly used to transform post tax into real pre tax returns are biased, because they fail to capture accurately the characteristics of tax depreciation allowances. There is no general solution to this "transformation problem", but alternative approaches can achieve the benefits prompting the use of a "real pre-tax" approach without suffering from this problem.

KEYWORDS: Access Pricing; Rate of Return; Depreciation; Tax; Inflation.

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This paper examines the calculation of real pre - (company) tax required rates of return[1] which is a contentious issue in incentive based price (or revenue) cap approaches to access pricing. Some Australian and UK regulators have adopted access pricing regimes which adjust the regulatory asset base for inflation. Several of these approaches require the use of a real pre-tax required rate of return to determine allowable cash flows and thus require such a calculation.

It is demonstrated in this paper that commonly used approaches which transform an available estimate of a nominal (or real) post-tax required rate of return into a real pre-tax magnitude are subject to significant biases (thus creating bias in access pricing determinations). A major contribution of the paper is to derive the nature (and indicative estimates) of those biases and show how they relate to differences between regulatory and tax depreciation schedules.

This has been an important issue for Australian access pricing regulation where discussion has focused on the merits of the alternative "real pre tax" and "nominal post tax" approaches, both of which have been used. In applying the "real pre tax" approach initially favoured by Australian legislators, the "transformation problem" (the method of deriving a "real pre tax required rate of return" from the more commonly estimated "nominal post tax required rate of return") has proved contentious. The so-called *market transformation* and *reverse transformation* methods give different (biased) results, and this has given rise to ad hoc, judgemental, solutions involving some averaging of the two

[1] The terms pre-tax and post-tax are used in this paper in reference to company tax. Personal tax is ignored, as are complications introduced by the existence of imputation tax systems such as exist in Australia.

results. Partly for this reason, some regulators have moved away from the real pre-tax approach to a nominal post-tax approach.

The same issue is relevant to UK access pricing.[2] There, the communications regulator (Ofcom), the Civil Aviation Authority (CAA) and the Competition Commission (CC) all use a real pre-tax approach. The CAA (2004), and the CC (2002a, 2002b) in dealing with airport cases, adopt an approach which relies on initial estimation of a real post-tax required rate of return. This is demonstrated below as being equivalent to the *reverse transformation* approach.[3] Ofcom (2004, p38), and the CC (2003) in dealing with mobile telephones, use a *market transformation* approach. The energy regulator (Ofgem) and water regulator (Ofwat) use (differing) real post-tax approaches.

Because the biases referred to arise from differences between tax and regulatory depreciation, there is no simple generic formula available to solve the transformation problem. This casts doubt on the merits of the real pre-tax approach which otherwise appears to possess advantages for access pricing in an inflationary environment. A second contribution of this paper is then to show that the perceived benefits of the real pre-tax approach, which have prompted its use by regulators, can be achieved by other means without introducing the transformation problem.

Section 1 of the paper briefly outlines a generic "building block" approach used in incentive based, price (revenue) cap, access pricing regulation, and explains the differences between the real pre tax and nominal post tax methods of applying this

[2] Crew and Kleindorfer (1996) provide an overview of the price (or revenue) cap approach used in the UK.
[3] PWC (2004) in a report for the CAA explicitly adjust a nominal post tax return for inflation first and then for tax which is the reverse transformation approach.

approach. Section 2 explains the transformation problem and outlines the details of the *market transformation* and *reverse transformation* approaches. Section 3 derives propositions regarding the nature of biases in the two transformation formulae and section 4 provides illustrative estimates of the scale of bias. Section 5 demonstrates that the UK approach of calculating a real pre tax rate of return from an estimated real post tax rate of return also suffers from the biases of the *reverse transformation* approach. Section 6 shows that the perceived benefits of the real pre tax approach (in the form of preferable real cash flow patterns) can be achieved by an appropriate choice of regulatory depreciation schedule within the nominal post tax approach, hence obviating the need to confront the transformation problem and the errors it may induce. Section 7 summarises and concludes.

1. ACCESS PRICING TECHNIQUES

The "building block" approach to the determination of access prices is based upon a relatively simple framework which identifies a target revenue stream for the regulated firm.[4] The target revenue model is illustrated in simplified form by equation 1, the right hand side of which shows the cost components (or building blocks) which, in the absence of taxation, revenue must cover.

$$\text{Total Revenue} = \text{Operating Costs} + \text{Return of Capital} + \text{Return on Capital} \qquad (1)$$

Equation 1 is based on the premise that in any year, total revenue from an investment should be sufficient to cover projected operating costs (based on demand projections), an appropriate return of capital (depreciation), and the required return on capital. To allow for payment of (company) tax as an additional cost, two approaches are possible. One is to add an estimate of tax payable as an explicit cost to the right hand side of equation 1, such that the return on capital is interpreted as an after-(company) tax return. The other possibility is to interpret the return on capital as a pre-(company) tax return and have no explicit tax term present.

Once a revenue target is determined by estimating the component costs, a price schedule to achieve that target can be set based on projected demand.[5] Note that equation (1) can be applied in either nominal or real terms. The latter approach appears to have the advantage that specifying a time path for the real return of capital (real depreciation) may be more conducive to generating a time path for real prices which will not be distorted by inflation. This is equivalent to deriving target revenue in nominal terms using a current cost accounting depreciation (return of capital) schedule and a real rate of return on capital (since inflation compensation is built into the return of capital).

If applied over the life of the asset in question, such that the cumulated return of capital just equals the original (nominal or real) cost, and the (corresponding nominal or real) rate of return on capital is that required by investors, equation 1 is equivalent to a zero NPV (or "fair pricing") condition.[6] Incentives for improved efficiency are provided by (for example) allowing the regulated firm to profit (for some period) from reductions in operating costs below those projected.

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[4] ACCC (1999) provides an overview of the approach.

1.1 Approaches to Inflation and Taxation

Implementation of this model involves a number of choices. For example, the schedule for the return of capital (regulatory depreciation) could be based on (straight line, sum of digits, or other allocation of) historical cost, inflation adjusted cost (or "trended original cost"),[7] economic depreciation, or depreciated optimised replacement cost.

Where the return of capital schedule provides compensation for inflation (to ensure a return of the original outlay in real terms) the "fair pricing" condition means that it is necessary that the return on capital be expressed using a real rate of return.[8]

As indicated above, if a "post-tax" rate of return is used, then tax payments are included explicitly as an additional term on the right hand side of equation 1.[9] If a "pre-tax" rate is used, allowance for company tax payments is implicitly included in that rate of return.

Table 1 illustrates some of these choices. In Australia, approach 2 has become know as the "real pre-tax WACC" approach,[10] and is mandated by legislation for several regulated industries[11] and preferred by IPART (2002). It is also applied by Ofcom, CAA, and the CC in the UK. Approach 3, (or the equivalent Approach 5) referred to as the "nominal

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[5] Typically projections of the composition of demand will be needed for multi output activities and the pricing structure may not a simple per unit price.
[6] See, for example Schmalansee (1989) for further discussion of this point.
[7] "Trended original cost" is a term introduced by Myers, Kolbe, and Tye (1985) which refers to the case of the regulatory asset base (rate base) being adjusted by an index to reflect the effect of inflation, and a real rate of return applied to that adjusted base. This approach is often referred to as current cost accounting (CCA) depreciation.
[8] See Davis (2004) for more detail.
[9] Alternatively the total revenue stream on the left hand side of equation 1 can be expressed as an after-company tax one.
[10] WACC refers to the weighted average cost of capital. Further choices must be made by regulators between alternative WACC formula which differ in the precise treatment of taxation. (Davis, 2002 provides a discussion in the Australian context).

post-tax WACC" approach has been adopted in Australia by the ACCC and some other State based regulators (such as QCA), following initial use of the "real pre-tax WACC approach". Ofwat and Ofgem use real post-tax approaches related to approach 4.[12]

Table 1: Some Alternative Building Block Methodologies

	Nominal Cash Flow	*Return of Capital*	*Return on Capital*	*Tax Cash Flows**	*Regulatory Examples*
1	Pre-Tax	Original Cost	Nominal Pre-Tax	n.a.	
2	Pre-Tax	Inflation Adjusted Cost	Real Pre-Tax	n.a.	IPART, Ofcom, CAA, CC
3	Pre-Tax	Original Cost	Nominal Post-Tax	Expected Tax Payments	ACCC, QCA
4	Pre-Tax	Inflation Adjusted Cost	Real Post Tax	Expected Tax Payments	Ofgem, Ofwat
5	Post-Tax = Pre-Tax – Expected Tax Payments	Original Cost	Nominal Post-Tax	n.a.	

* This column indicates whether explicit inclusion of tax cash flows is required on the rhs of equation 1 for the approach being considered.

In principle, all approaches listed in table 1 are equivalent (since each can be derived as an algebraic transformation of any other)[13]. In practice, estimating key parameters such as the real pre tax rate of return for use in some approaches can be problematic.

2 THE TRANSFORMATION PROBLEM

In Australia, debate has revolved around the so called "transformation problem" involving the derivation of the correct value of a real pre tax rate of return from an

[11] The Essential Services Commission of South Australia is required by the legislative pricing order for electricity to use a real pre tax WACC (unless otherwise agreed to by the regulated utilities. (Owens, 2002).
[12] Ofgem prefers a "vanilla WACC" approach in which interest tax shields are reflected in tax cash flows (and a pre-company tax cost of debt is used in the WACC calculation) while Ofwat prefers the more traditional WACC formulation in which an after company tax cost of debt is used in the WACC calculation and tax cash flows do not allow for interest tax shields.

assumed nominal post tax rate of return. This problem arises because the WACC has been estimated using required rates of return derived in nominal post tax terms. Typically this has involved applying risk premiums (using the Capital Asset Pricing Model for equity returns and a credit risk margin for debt) to the nominal risk free rate to estimate the WACC. It is thus necessary to adjust that estimate of the WACC for company tax and for inflation if the real pre tax approach is to be used.

The *market transformation approach* recommended in early Australian access cases involves the following steps.

(a) Estimate the nominal post tax WACC, denoted by i.

(b) Divide i by $(1-t)$ where t is the company tax rate to get the nominal pre tax WACC, denoted by $i_{pt} = i/(1-t)$.

(c) Use the Fisher relationship to estimate the real pre tax WACC (r^*_{pt}) from $(1+ r^*_{pt}) = (1+i_{pt})/(1+\pi)$, where π is the expected inflation rate, to give

$$r^*_{pt} = \frac{i_{pt} - \pi}{1+\pi} = \frac{\frac{i}{1-t} - \pi}{1+\pi} \qquad (2)$$

In the process of the 1998 Victorian Gas Industry Access decision, it was recognised that such an approach was not necessarily correct and an alternative *reverse transformation approach* recommended[14] in which the transformation steps are reversed,

(a) Estimate the nominal post tax WACC (i)

[13] See Davis (2004) for a demonstration

(b) Apply the Fisher relationship to *i* to obtain a real after tax WACC,

$(1+r_{at}) = (1+i)/(1+\pi)$

so that:

$r_{at} = (i-\pi)/(1+\pi)$

(c) Divide r_{at} by (1-t) to obtain a *real pre tax WACC* ($r_p^{\#}$) given by:

$$r_{pt}^{\#} = \frac{r_{at}}{1-t} = \frac{i-\pi}{(1+\pi)(1-t)} \qquad (3)$$

The UK approach for calculating the real pre tax rate equivalent to an estimated real post tax rate is a version of the reverse transformation approach in which the first step is replaced by direct estimation of a real post tax rate of return for debt and equity by applying risk premiums to the real risk free rate of return.

The market transformation approach formula (equation 2) can be justified in a single period framework where nominal income is subject to taxation. Consider a one period investment of \$1 which generates \$*C* cash flow, so that tax paid is \$*t(C-1)* and the after tax nominal rate of return is $i = (C-1)(1-t)$. The real pre-tax rate of return (r_{pt}*) is defined by $1+r_{pt}^* = C/(1+\pi)$, and substituting for C (in terms of i) generates equation (2). Thus the market transformation approach is appropriate in a one period case where nominal income is taxed and, implicitly, *nominal* depreciation (return of capital) is allowed for tax purposes.

[14] The market transformation approach was suggested by CS First Boston and the reverse transformation by Macquarie Risk Advisory Services in the 1998 Victorian Gas Industry Access Decision. (ORG, 1998, p 205). See also Davis (1998)

Similarly, the reverse transformation approach formula (equation 3) can be justified in a single period framework where only real income is taxed. If \$1 generates cash flow of \$$C$ and tax paid is \$$t(C-(1+\pi))$, then $(1+i) = C(1-t) + t(1+\pi)$. Noting that $1+r_{pt}^{\#} = C/(1+\pi)$ and substituting for C (in terms of i) generates equation (3). Thus the reverse transformation approach is appropriate in a one period case where real income is taxed and, implicitly, *real* depreciation (return of capital) is allowed for tax purposes.

These approaches give quite different results when inflation exists as shown in table 2 for illustrative values of i, t, and π. Some Australian regulators have resorted to taking a weighted average of the two approaches (with weights determined judgementally). This is unsatisfactory as it introduces unknown potential biases and uncertainty into the rate of return decision. Some UK regulators follow (implicitly) the reverse transformation approach while others (Ofcom) adopt the market transformation approach. This is also unsatisfactory, since even if the implicit assumption made in the transformation process about taxation of real versus nominal income is appropriate, the resulting (single period based) formulas only apply in multi-period cases (with which regulators deal) in very special circumstances. The following sections thus consider the transformation issue in more detail and provide new evidence on the causes, extent, and scale of bias.

Table 2:
Transforming a Nominal Post Tax to a Real Pre Tax Rate of Return

nominal post tax discount rate	7.50%
tax rate	0.3
inflation rate	4.00%
Market Transformation Approach	
$i_{pt} = i/(1-t)$	10.71%
$r^*_{pt} = (1+i_{pt})/(1+\pi)-1$	**6.46%**
Reverse Transformation Approach	
$r_{at} = (i-\pi)/(1+\pi)$	3.37%
$r^{\#}_{pt} = r_{at}/(1-t) = (i-\pi)/[(1+\pi)(1-t)]$	**4.81%**

3. BIASES IN THE TRANSFORMATION FORMULAE

In this section, it is assumed that the nominal post tax rate of return (i) required by investors in a particular asset with date 0 value of K_0 and life of N years has been calculated using standard techniques. A set of nominal pre tax cash flows (C_n, $n=1\ldots N$) giving a zero NPV over the life of the asset, based on that rate of return (i) and regulatory depreciation schedule (D_n, $n=1\ldots N$), are derived as would be done by an access regulator using a "post tax nominal" approach illustrated in equation (4).

$$C_n = D_n + i.K_{n-1} + T_n \qquad n = 1\ldots.N \tag{4}$$

In applying equation (4) the regulatory asset base evolves over time according to $K_n=K_{n-1} - D_n$. Cash flows[15] generated from equation (4) allow for return of capital (D_n), a

[15] For ease of exposition, operating costs have been subtracted from total revenue in the definition of C_n and thus do not appear on the right hand side of equation 2.

post tax nominal return on capital ($i.K_{n-1}$) and tax payments ($T_n = t(C_n - Z_n)$), where t is the corporate tax rate and (Z_n, $n=1 \ldots N$) is the tax depreciation schedule.[16]

Provided the regulatory depreciation schedule allows for full nominal return of the original investment, this cash flow series will ensure that the project has a zero NPV.[17] These cash flows can be converted into a set of real pre tax cash flows, by subtracting tax payments and adjusting for inflation. The real pre tax rate of return required by investors is, by definition, the discount rate which makes the present value of these real pre tax cash flows (net of initial asset cost, K_0) also equal to zero. Note that these pre tax cash flows are "shielded" from tax by depreciation. It is the difference between tax and regulatory depreciation schedules which makes simple transformation formula inappropriate.

Table 3 illustrates some possible combinations of regulatory and tax depreciation schedules which could occur and, for convenience, summarizes the results to be derived in the following sections. The most relevant cell involves regulatory depreciation based on current cost accounting (as used in the real pre tax approach) and tax depreciation based on historical cost (as generally applies). To demonstrate the biases in the estimated real pre tax rate of return arising in both transformation approaches the following procedure is adopted. First, the nature of biases arising when regulatory and tax depreciation are based on different historical cost schedules are derived. Second, the equivalence of cash flows generated using CCA regulatory depreciation to those from

[16] Depreciation is assumed to be the only tax shield. In the case of a levered company where interest is tax deductible, the interest tax shield is reflected in the use of an after tax cost of debt in calculating the WACC.

using a particular form of historical cost depreciation is demonstrated. Third, the biases inherent in using that particular form of historical cost depreciation are derived. Because of the equivalence demonstrated in step two, these also measure the biases from the transformation approaches when CCA regulatory depreciation is used.

Table 3 Regulatory and Tax Depreciation Combinations

		Regulatory Depreciation	
		Current Cost Accounting	Historical Cost
Tax Depreciation	Current Cost Accounting	Depreciation Schedules Equal – reverse transformation correct	*Not relevant*
	Historical Cost	Regulatory CCA depreciation equivalent to some "back end loaded" historical cost depreciation -market transformation overestimates - reverse transformation underestimates	Depreciation Schedules *Equal* - market transformation correct *Unequal with Regulatory depreciation:* (a) Front end loaded – market transformation underestimates (b) Back end loaded – market transformation overestimates

3.1 Historical Cost Regulatory Depreciation and Sources of Bias

Nominal pre tax revenue C_n (n = 1….N), from equation (4) can be rewritten as:

$$C_n = D_n + (t/(1-t))(D_n - Z_n) + (i/(1-t))K_{n-1} \quad (5)$$

and the resulting real pre tax revenue C_n^r (n = 1……N) as:

$$C_n^r = D_n /(1+\pi)^n + (t/(1-t))(D_n - Z_n)/ (1+\pi)^n + (i/(1-t))K_{t-1}/(1+\pi)^n \quad (6)$$

[17] See Schmalensee (1989) or Davis (2002) for illustrations. In this case, the proof involves calculating the NPV of the after-tax cash flow series $(C_n - T_n) = D_n + i.K_{n-1}$, using the after-tax discount rate (i)

By construction the real pre tax revenue stream C_n^r (n=1…N) has a zero NPV after subtracting the initial outlay K_0. The discount rate which makes the NPV of this revenue stream equal to zero is thus the "real pre tax" discount rate (r) consistent with (i).

Case 1

If regulatory and tax depreciation schedules are equal, the second term in equation (6) is zero. In this special case, the *market transformation* approach generates the correct value of r. Appendix 1 contains the proof of Proposition 1.

Proposition 1: If (a) tax and regulatory depreciation schedules are equal, (b) "full" nominal depreciation is allowed, then the real pre tax discount rate and the nominal post tax discount rate are related by $r = \dfrac{\frac{i}{1-t} - \pi}{1+\pi}$ which is derived using the *market transformation* approach.

Case 2

In general, the regulatory depreciation schedule (D_n) will not replicate the tax depreciation schedule (Z_n) and the second term in equation (6), $\dfrac{t}{(1-t)} \dfrac{D_n - Z_n}{(1+r)^n (1+\pi)^n}$, is non-zero. If r is calculated as in Proposition 1 (the *market transformation* method), the NPV of the investment will not be zero but will be:

$$V = \frac{t}{(1-t)} \sum_{n=1}^{N} \frac{D_n - Z_n}{(1+r)^n (1+\pi)^n} .$$

Although $\sum_{n=1}^{N} (D_n - Z_n) = 0$ (if both regulatory and tax depreciation schedules provide for full depreciation), the weighted sum (V) will not equal zero and its sign will depend on the relative time profile of D and Z.

V>0 corresponds to regulatory depreciation being "front end loaded" relative to tax depreciation. Thus the real pre tax discount rate (r) calculated by applying the *market transformation* approach of proposition 1 will generate a positive NPV. The correct value of r is thus higher than the value from the market transformation approach if regulatory depreciation is front end loaded. Conversely, if the regulatory depreciation schedule is "back end loaded", the correct value of r will be lower than the value derived from the market transformation approach. This demonstrates Proposition 2.

Proposition 2. If regulatory depreciation differs from depreciation for tax purposes, the *market transformation* approach to calculation of the real pre tax discount rate from the nominal post tax discount rate will give a biased result. If regulatory depreciation is front (back) end loaded relative to tax depreciation, the *market transformation* approach will provide an under (over) estimate of the correct value.

3.2 Current Cost Accounting Regulatory Depreciation and Bias

Use of a real discount rate approach arises because of the adoption of CCA regulatory depreciation, in which the return of capital schedule provides for full real return of capital. For an assumed historical cost depreciation schedule (D_n), regulatory depreciation will be $D_n^* = D_n(1+\pi)^n$. This section demonstrates that the resulting cash flow series can be replicated by the nominal post tax approach with an implied historical cost depreciation schedule D^a_n (different to D_n).

For a real post tax required rate of return (r_{at}), nominal after tax cash flows would be derived as:

$$C^{at}_n = r_{at}\,(1+\pi)A_{n-1} + D_n^* \tag{7}$$

where A_n is the regulatory asset base and evolves according to

$$A_n = (1+\pi)A_{n-1} - D_n^* \tag{8}$$

Given the series for C^{at}_n and A_{n-1} it is possible to derive an implied historical cost depreciation schedule D^a_n (different to D_n), such that:

$$C^{at}_n = iA_{n-1} + D^a_n$$

Since $A_n = (1+\pi)^n K_n$, where K_n is the asset value under the depreciation schedule (D_n), the implied replicating historical cost depreciation schedule is

$$D^a_n = A_{n-1} - A_n = (1+\pi)^{n-1}K_{n-1} - (1+\pi)^n K^n = (1+\pi)^{n-1}(K_n+D_n) - (1+\pi)^n K_n$$

$$= (1+\pi)^{n-1}.D_n - (1+\pi)^{n-1}\pi K_n.$$

Comparing D^a_n and D_n,

$$D_n^a > D_n \ as\ K_n < \frac{(1+\pi)^{n-1} - 1}{(1+\pi)^{n-1}\pi} D_n$$

so that for small n and large K (i.e. the earlier years of the asset life) the implied replicating historical depreciation is less than actual historical cost depreciation, and back end loading is implied.

The use of CCA depreciation is equivalent to using a "back end loaded" historical depreciation schedule. Since tax depreciation schedules are typically of the historical straight line or accelerated depreciation variety (and regulatory schedules derived by inflation adjustment of historical cost straight line), it seems appropriate to conjecture that the real pre tax approach involves back end loading of depreciation relative to tax depreciation. Consequently, drawing on proposition 2, the following conjecture is advanced.

Conjecture 1. Use of the *market transformation* approach to calculating the real pre tax discount rate in a regulatory framework using current cost depreciation is likely to lead to an estimate which is upwardly biased.

The intuition for this result is as follows. The market transformation implicitly equates tax depreciation with regulatory depreciation and thus assumes that the amount of the allowable cash flow shielded from tax by depreciation is less (more) in the earlier (later) years of the asset's life than is actually the case. Because the calculation of the present value of the depreciation tax shield is biased downwards, the estimate of the pre tax rate of return on capital to generate a cash flow series giving a zero NPV investment will be biased upwards.

3.3 The Reverse Transformation Approach and Sources of Bias

Consider first the case where a CCA depreciation schedule (D^*_n) is used for both tax depreciation and regulatory depreciation and tax is calculated as $T_n = t(C_n - D^*_n)$.[18]

The nominal pre tax revenue stream C_n ($n = 1 \ldots N$) can be written as:

$$C_n = D^*_n + r(1+\pi)A_{n-1} + T_n = D^*_n + (i-\pi)A_{n-1} + T_n$$

where $(i - \pi)A_{n-1} = r(1+\pi)A_{n-1}$ is a real rate of return on an inflation adjusted capital base.

Substituting for T_n and using $D^*_n = A_{n-1}(1+\pi) - A_n$ gives

$$C_n = A_{n-1}(1+\pi+(i-\pi)/(1-t)) - A_n$$

so that the real pre tax cash flows c_n^r are:

$$c_n^r = C_n / (1+\pi)^n = A_{n-1} [(1+\pi)^{-(n-1)} + (i-\pi)(1+\pi)^{-n}/(1-t)] - A_n(1+\pi)^{-n}$$

Using the same approach as used to prove Proposition 1, it is possible to derive Proposition 3.

Proposition 3 If tax and regulatory depreciation are equal and correspond to current cost accounting depreciation, the real pre tax rate of return which is consistent with a nominal after tax rate of return of i is given by: $r_{pt} = (i-\pi)/(1-t)(1+\pi)$ which is given by the *reverse transformation* approach.

Since taxation systems rarely, if ever, allow for current cost depreciation, the reverse transformation approach will result in a biased estimate of the real pre tax required rate of

[18] Depreciation is assumed to be the only tax shield. In the case of a levered company where interest is tax deductible, the interest tax shield is reflected in the use of an after tax cost of debt in calculating the WACC.

return. Tax depreciation which allows only for the nominal return of capital involves a smaller tax shield than assumed by the reverse transformation approach, and thus a larger after tax cash flow for a given pre tax cash flow than is appropriate. Consequently, the upward adjustment used to obtain the pre tax real rate from a post tax real rate is smaller than it should be given the actual nature of the tax treatment of depreciation. This demonstrates Proposition 4.

Proposition 4 The *reverse transformation* approach will underestimate the real pre tax discount rate when regulatory depreciation is based on current cost accounting and tax depreciation based on historical cost.

4. ESTIMATING THE BIAS

The extent of bias in the *market* and *reverse transformation* calculations can only be determined on a case by case basis, since it will depend upon factors such as the inflation rate, level of market interest rates, corporate tax rate, and features of the regulatory and tax depreciation schedules. Propositions 1 – 4 indicate that the market transformation will tend to overestimate and the reverse transformation will tend to underestimate the correct real pre-tax discount rate.

Table 4 provides estimates of the bias for different regulatory depreciation schedules and other parameters. Straight line depreciation is assumed for tax purposes and the difference between it and the regulatory depreciation schedule is summarized in the "back end load" parameter value. Two types of calculation were performed to derive the table 4 estimates. First, a nominal post tax model (equation 5) was used with alternative assumptions about regulatory depreciation (rows 1-4) to estimate the nominal post tax cash flows from which corresponding real pre tax cash flows were estimated. The implied real pre tax discount rate was calculated as that which resulted in a zero NPV for those latter cash flows. Second, a real pre tax model was used with CCA depreciation based on tax depreciation adjusted for inflation (i.e. $Dn = Z_n(1+\pi)^n$). Cash flows were calculated using equation (7) at the real pre tax discount rate consistent with the nominal post tax cash flows having a zero net present value.

Table 4 shows that even modest amounts of back-end loading of regulatory depreciation induce significant biases of the expected signs. The bias increases for higher tax rates (column 2 versus column 1) and for higher inflation (column 3 versus column 2). The bias also increases for higher real interest rates (column 3 versus column 4).[19]

Note that this bias is not a result of the effective company tax rate differing from the statutory rate, and will not be resolved by using an effective company tax rate in the transformation process. The bias arises because the formula used in the transformation process assumes a particular relationship between cash flows and tax payments which does not occur in reality.

[19] Note that accelerated depreciation for tax purposes would increase BEL for a given regulatory depreciation schedule relative to the values given in Table 4 and thus increase the upward bias of the market transformation.

Table 4: Back End Loading and Bias in the Transformation Formulae

This table demonstrates the upward bias in the market (M) and downward bias in the reverse (R) transformation estimates of the real pre tax discount rate for various depreciation schedules for a specific example of an asset with a life (N) of 5 years and straight line depreciation for tax purposes. The "Back End Load" statistic (BEL) provides a summary statistic of the difference between the regulatory and tax depreciation schedules. It is calculated as:

$$\text{BEL} = \sum_{n=1}^{N-1}(K_n^r - K_n^t)\,/\text{NK}_0$$

where K_n^r is the regulatory capital base at date n and K_n^t is the capital base for tax purposes. (If $K_n^r > K_n^t$, then accumulated regulatory depreciation up to that date n is less than accumulated tax depreciation. Higher BEL values correspond to greater back end loading of regulatory depreciation).

Assumptions		(1)		(2)		(3)		(4)	
nominal post tax discount rate (%) *(i)*		7.50		7.50		10.0		7.50	
tax rate *(t)*		0.3		0.4		0.4		0.4	
inflation rate (%) *(π)*		4.00		4.00		6.00		6.00	
	BEL	**Bias in real pre-tax rate of return estimates (basis points)**							
Regulatory Depreciation		M	R	M	R	M	R	M	R
1. Zero prior to year 5: all at end*	0.5	1.39	-0.26	2.34	-0.23	2.97	-0.80	2.29	-1.48
2. inverse sum of digits	0.17	0.68	-0.97	1.18	-1.38	1.50	-2.27	1.16	-2.61
3. Sequence of (15,15,20,25,25)**	0.075	0.35	-1.30	0.61	-1.95	0.77	-3.00	0.60	-3.17
4. Sequence of (15,20,20,20,25)**	0.05	0.25	-1.41	0.43	-2.14	0.54	-3.24	0.42	-3.36
5. CCA (*π = 4%*)	0.041	0.15	-1.50	0.23	-2.33	n.a.	n.a.	n.a.	n.a.
6. CCA (*π = 6%*)	0.063	n.a.	n.a.	n.a.	n.a.	0.44	-3.34	0.34	-3.34

*The calculation in this case assumes that tax losses in initial years can be used.

** Percentage of original cost.

5 DIRECT ESTIMATION OF THE REAL POST TAX RATE OF RETURN

The transformation problem appears to arise because of the need to convert a nominal post tax rate of return into a real pre tax rate of return. One approach, commonly used by UK regulators is to avoid the use of nominal rates of return completely.[20] In this approach, the real pre tax cost of debt and the real post tax cost of equity are estimated directly by applying risk premiums to the real risk free rate of interest. The pre tax real cost of equity is derived by multiplying by (1/(1-t)). The real pre-tax WACC is then derived as a weighted average based on the company's capital structure.

This approach does not avoid the transformation problem as can be seen by considering the case of a regulated asset which is financed entirely by equity and for which the real post tax cost of equity has been derived. First, derive the zero NPV nominal cash flow series consistent with the real post-tax required return, convert those to a real pre tax cash flow series and find the internal rate of return - which is the real pre tax cost of capital consistent with the known real post tax figure.

The nominal pre tax net cash flow series obtained using the real post tax rate of return (r_{at}) and the regulatory inflation adjusted depreciation schedule (D_n^*) is:

$$C_n = D_n^* + r_{at}K_{n-1}\,(1+\pi) + T_n$$

Noting that $T_n = t(C_n - Z_n)$

$$C_n = D_n^* + [r_{at}\,K(1+\pi)]/(1\text{-}t) + [t/(1\text{-}t)](D_n^* - Z_n) \qquad (8)$$

[20] This approach is used by the CAA and the Competition Commission (and by Ofgem (2004) in providing an illustrative estimate of the real pre tax rate).

Equation (8) indicates that only if $D_n^* = Z_n$ will it be appropriate to use $r_{pt} = r_{at} / (1-t)$ as the real pre tax rate of return. This approach leads to an underestimate of the real pre tax rate because it is implicitly equivalent to the reverse transformation approach outlined above. While it avoids the first step (converting a nominal post tax into a real post tax return) it follows the second step of the transformation into a real pre tax rate.

6. ACCESS PRICING DESIGN

The transformation problem arises because of the quite appropriate objective of smoothing the real price of access services through time. Applying a real rate of return to a "trended cost" asset base is one way of achieving this. However, as demonstrated in the previous sections, taxation creates severe complications in applying such an approach. Calculation of a real pre tax required rate of return cannot be done by application of a simple general formula. Regulatory methods used to date create the potential for significant biases or errors of judgement.

This problem is further complicated by the possibility of divergence between effective and statutory corporate tax rates. In previous sections it has been assumed that there is no accelerated tax depreciation or other factors which would cause a discrepancy between the effective and statutory rates. Often, that is not the case and the additional problem is raised of which tax rate should be used in the transformation process.

Fortunately, the benefits of a smooth time path for real prices of access services can be achieved in other ways which avoid the transformation problem completely. Any depreciation schedule (providing for 100 per cent return of nominal capital) can be used for regulatory purposes and will result in "fair" pricing provided that the correct (nominal post tax) rate of return is used in the derivation of allowable cash flows. Thus, for example, use of a "real annuity" depreciation schedule (D^a_n) which generates a constant real post tax cash flow series

$$(C_n - T_n)/(1+\pi)^n = [\ iK_{n-1} + D^a_n]/(1+\pi)^n = \text{const}$$

could be adopted.

Actual company tax payments and the implied pre tax cash flow stream can be modelled based on the characteristics of the tax system and a service price path derived based on demand projections. To the extent that the service price path derived is not optimal it is possible to iterate towards an alternative (perhaps implicit) regulatory depreciation schedule which achieves that outcome, and which has the same present value of cash flows. One such process (used by the ACCC in Australia) involves solving for the nominal price path which grows at a constant rate from the same initial price, and where the associated post-tax nominal cash flow series has the same present value as the series derived from the first depreciation schedule.[21]

Such an approach has two advantages over the alternative "transformation" based approaches. First, tax payments can be explicitly modelled and debate about whether the statutory or effective tax rate should be used in the transformation process largely avoided. Second, even though the (unknown) nominal post tax required rate of return must still be estimated (and could be incorrect), the potential biases arising from the

[21] This approach, described in ACCC (1999, 2001) leads to a "CPI-X" type outcome. However, the resulting "X" factor is not a productivity adjustment of the form associated with "RPI-X" in UK price-cap regulation. Rather, the X factor is determined by the shape of the regulatory depreciation schedule initially used (and arises from the impact this has on the starting value for the price path). Davis (2004) provides a fuller explanation.

transformation process are avoided. Since the desirable characteristic of a smooth path for real access prices can also be achieved, the grounds for an approach using a real pre tax rate of return appear extremely weak.

7. CONCLUSION

This paper has demonstrated that some commonly advocated and used techniques in access pricing regulation are inherently flawed. Specifically, procedures used for converting required post tax rates of return into a required real pre tax rate of return are subject to bias. Because the size and direction of bias depends upon the characteristics of the tax system treatment of the asset in question, there is no general formula which can be applied in all cases to effect the correct "transformation". Fortunately, however, it is possible to replicate the desirable features of the "real pre tax return" approach using a "nominal post tax return" approach which does not face these difficulties. Those access regulators currently using a "real pre tax return" approach, and those considering such an approach in the design of new access pricing arrangements should thus consider carefully whether dealing with the inherent biases is justified by the perceived benefits of this approach.

Appendix 1: Proof of Proposition 1

Note that $D_n = K_{n-1} - K_n$ and apply this substitution to equation 6. The present value of the real pre tax cash flow in period $n = 1....N$ discounted at the unknown rate (r) is given by

$$PV_n = \frac{K_{n-1}[(1-t)+i]}{(1+\pi)^n(1-t)(1+r)^n} - \frac{K_n}{(1+r)^n(1+\pi)^n},\ n = 1,......,N$$

Consider the net present value of the investment:

$NPV = -K_0 + PV_1 + ...PV_N$.

NPV = 0 if two conditions are met. First, if $K_N = 0$ (full depreciation is allowed)[22] the second present value term in PV_N is zero. Second, if $(1-t)+i = (1+\pi)(1-t)(1+r)$ the first term in PV_n equals the negative of the second term in PV_{n-1} for n=2,…N. These terms thus cancel while the first term in PV_1 is K_0. Hence, NPV =0. Since

$(1-t)+i = (1+\pi)(1-t)(1+r)$ is equivalent to $r = \dfrac{\frac{i}{1-t} - \pi}{1+\pi}$

which is the real-pre tax discount rate consistent with NPV = 0, this demonstrates Proposition 1.

[22] Since $D_n = K_{n-1} - K_n$, $\sum_{n=1}^{N} D_n = K_0 - K_N = K_0$ if $K_N = 0$.

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