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The Design of Regulatory Pricing Models for Access Arrangements: Inflation, Tax and Depreciation Considerations*

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1. Introduction

The objective of this paper is to clarify a number of issues associated with the structure of regulatory pricing models for access arrangements. Such models, as implemented in Australia, involve the determination of a CPI-X revenue cap, or price cap, path over the regulatory horizon based on a "building block" approach. Critical components of that building block approach are the forecast operating and maintenance expenses (dependent upon demand forecasts); return of capital (depreciation); and return on capital[1].

Alternative approaches to implementing such a model arise, *inter alia*, from different possible treatments of depreciation, inflation, and taxation. In the Victorian Gas Industry access determination, the approach was based on use of "current cost" depreciation, a real pre tax WACC, and an estimate of an effective tax rate equal to the statutory tax rate. In this approach, the "real pre tax" WACC needs to be derived from the more commonly estimated "nominal post tax" WACC by some adjustment to allow for inflation and tax liabilities. The "target revenue" stream derived by use of the equation:

Target Revenue = Operating Costs + Return of Capital + Return on Capital

has several important features:
- Taxes to be paid by the entity are allowed for implicitly through the estimated (real pre tax) return on capital rather than as an explicit item
- The need for the return on capital to incorporate an allowance for inflation is achieved through the use of a "current cost accounting" depreciation schedule rather than through use of a "nominal" return on capital.

In implementing this approach, significant complications arose through:
- the need to model the impact of the dividend imputation tax system on the cost of capital
- the existence of tax depreciation allowances which were quite different to (both) regulatory and "economic" depreciation schedules
- the need to develop a "conversion formula" to convert a "nominal post tax" WACC to a "real pre tax" WACC.

The approach recommended in the *Draft Statement of Principles for the Regulation of Transmission Networks* (DRP) (ACCC, 1999) embodies a number of significant changes in approach – reflecting concerns with the previously used method. These changes include:
- Use of a nominal post tax return on capital concept
- Use of a "competition depreciation" approach
- Explicit modeling of the expected annual tax payments of the entity for explicit inclusion in the target revenue model.

[1] In the analysis which follows certain aspects of the regulatory approach are not considered. In particular, in several places in the argument, it is assumed that the periodic regulatory horizon is equivalent to the life of the assets involved. To the extent that the regulatory approach is applied consistently across future periods this should not cause any major complications. The possibility that the newly proposed regulatory approach for the electricity industry involves a change in approach from that currently in existence does raise some potential transitional issues which are not pursued here.

- Use of an "equity" rather than "entity" framework

These changes are not uncontroversial – although it can be shown that the different approaches are all mutually consistent and should give rise to the same outcomes, provided the correct input parameters are used in the modeling process. If incorrect parameters are used, the model can give rise to significant undesirable wealth redistribution effects affecting regulated entities, their customers, and taxpayers. In that sense, the reasons for preferring one approach over another arise from concerns over:

- Accuracy of estimation of key parameters in each approach
- Transparency of the process
- Ease of interpretation

Since the "true" values of the key parameters in the approaches are not observable, a concern for all participants in the process is whether particular approaches are more likely to generate better estimates of the true values or be more subject to "gaming" behavior and spread of misinformation.

It is worth noting at this stage that the process of determining a CPI-X price (or revenue) path over the regulatory horizon, can significantly moderate the effects of the approach taken to determining the "target revenue". Once a set of target revenues (c_1, …. c_5) for years 1 to 5 of the current regulatory period have been derived, allowable cash flows of C_1, …. C_5 are obtained as $C_t = C_{t-1}(1+\pi)(1-x)$ where π is the assumed inflation rate and x is a "productivity / efficiency" adjustment factor. The allowable cash flows are calculated by determining the x factor such that the PV of the series c_1 ….. c_5 equals that of C_1 …. C_5, where $c_1 = C_1$. Even if different approaches give rise to a different time path for c_1…. c_5, the CPI-X smoothing largely offsets this. There may be differences between the initial year cash flow, but these will be offset by differences in the calculated x factor such that the present value of the allowable revenue streams are equal – provided the correct parameter values are used. However, if incorrect parameter values are used, the extent of wealth redistribution may very well be significantly affected by approach used.

In the remainder of the paper three issues are addressed. The first concerns the choice of a regulatory depreciation schedule. The second relates to the choice between a "nominal post tax" and a "real pre tax" approach and the related "conversion problem". The third relates to the merits of alternative ("entity" versus "equity") approaches to the determination of target revenues with regard to the treatment of the imputation tax system and appropriate modeling of tax liabilities.

2. Regulatory Depreciation Schedules: Do They Matter?

Much debate has arisen over the choice of a regulatory depreciation schedule for the "return of capital" component of revenues to regulated industries. It is worth asking the question: does the particular form of depreciation schedule matter? If so why?

Answer 1: No. Consider an initial investment of K_0 for which the required rate of return is r. Suppose per period cash flows are set equal to $C_t = r.K_{t-1} + D_t$ where D_t is depreciation in period t, and K_{t-1} is the written down book value of the investment at the end of year t-1 (so that $K_t = K_{t-1} - D_t$). For any depreciation schedule ($D_1, \ldots\ldots D_N$) where $D_1 + \ldots. + D_N = K_0$, the investment will have an NPV=0.

Demonstration:

The following table sets out net cash flows which are based on a return of capital D and a return on capital rK, and the NPV of each of those cash flows

Year	**0**	**1**	**2**	**……..**	**N**
Cash Flow	$-K_0$	rK_0+D_1	rK_1+D_2	…….	$rK_{N-1} + D_N$
NPV	$-K_0$	$(rK_0+D_1)/(1+r)$	$(rK_1+D_2)/(1+r)^2$	…….	$(rK_{N-1} + D_N)/(1+r)^N$

Substitute $D_t = K_{t-1} - K_t$

Year	**0**	**1**	**2**	**……..**	**N**
NPV	$-K_0$	$K_0-K_1/(1+r)$	$K_1/(1+r) - K_2/(1+r)^2$	…….	$K_{N-1}/(1+r)^{N-1} - K_N/(1+r)^N$

Adding the NPV's of each cash flow to get the overall NPV we can see that provided that $K_N = 0$, the overall NPV = 0.

Answer 2: Yes. The pattern of the cash flows over time differs for different depreciation schedules, and this might be of concern – even though the NPV is zero in all cases. In particular, if the time path of potential output and demand for the product does not match the time pattern of allowable cash flows implied by the chosen depreciation schedule, unwanted price fluctuations may eventuate and /or the allowable revenue may not be achievable.

Demonstration: Consider two extreme cases
(a) $D_1 = K_0$, so that $K_1 = \ldots. = K_N = 0 = D_2 \ldots.. D_N$. In this case, the only cash flow is in year 1.
(b) $D_1 = \ldots D_{N-1} = 0$, so that $D_N = K_0$. In this case, the cash flows are the constant amount rK_0 for years 1….N-1, and $rK_0 + K_0$ in year N.

The "competition depreciation" approach suggested by the ACCC attempts to match the regulatory depreciation schedule over the life of the asset with something thought more likely to match up with underlying "economic depreciation". It is thus hoped to generate a pattern of target cash flows more like what might be seen in a competitive industry. Under this approach the anticipated DORC value at the end of the regulatory horizon (including allowing for the effect of anticipated inflation over the period on the replacement cost estimate) is used to derive the depreciation allowance. Since, at the end of the life of the asset the depreciated value is zero, this approach allocates the historical cost of the asset as a return of capital over its life, but in a pattern thought more consistent with the technology and inflation outlook. It is thus consistent with use of a nominal return on capital concept.

Answer 3: No. The regulatory model uses a CPI-X mechanism which achieves a smoothing of the cash flows over time, and thus reduces the impact of the chosen depreciation schedule.

Demonstration: Let the initial cash flows generated by the depreciation schedule be c_1, $c_2,\ldots c_N$. The regulatory model derives the allowable cash flows as $C_1, \ldots C_N$ where $C_t = C_{t-1}(1+\pi)(1-x)$ where π is the assumed inflation rate and x is a "productivity / efficiency" adjustment factor. The allowable cash flows are calculated by determining the x factor such that the PV of the series $c_1 \ldots c_N$ equals that of $C_1 \ldots C_N$.

$$PV = \sum_1^N \frac{c_t}{(1+r)^t} = \sum_1^N \frac{C_1(1+\pi)^{t-1}(1-x)^{t-1}}{(1+r)^t} = C_1 \sum_1^N \frac{(1+\pi)^{t-1}(1-x)^{t-1}}{(1+r)^t} = C_1 Z$$

where $C_1 = c_1$ (ie the first allowable cash flow is that implied from the chosen depreciation schedule) and where x is chosen such that $C_1 Z = K_0$.

Answer 4: Maybe. Since the depreciation schedule chosen determines the first cash flow the smoothed path of cash flows will be affected by the depreciation schedule. If the depreciation schedule implies a low first cash flow (relative to some other depreciation schedule) the x factor derived will be relatively low. This could occur for a depreciation schedule which weights depreciation towards the end of the life of the asset. In this case, the initial cash flow would be lower than under straight line depreciation, but the cash flows would grow at a faster rate over time since the x adjustment would be less. However, the regulator may choose to set the initial year cash flow for the regulatory period using some other criteria, such as to avoid any jumps in the revenue stream or price level relative to prior years.

Answer 5: Yes. The demonstration of a zero NPV assumes that the regulatory model uses the correct cost of capital estimate. The NPV will only be zero if the determination of cash flows and the discounting process both use the same value of r. If the regulatory model uses a higher value of r than is appropriate (and higher than that used by investors in discounting the cash flows) investors should prefer a depreciation schedule which is "back end" loaded. The reason is that the size of "excess" returns will depend upon the size of the asset base upon which they are calculated. Deferring the write down of the asset value increases the amount of excess returns.

Answer 6: Yes. The demonstration of a zero NPV assumes that the entire original cost of the asset is returned over its life. If the asset is suddenly made redundant (stranded) and no return of capital provided for its immediate loss in value, the NPV will be negative. Thus some way of providing for an appropriate return of capital on such assets is important. One possibility is that, within the context of a portfolio of assets, the total revenue stream from all assets can absorb the gradual writing down of the stranded asset. The return of the full initial investment (despite its having been *ex post* a poor investment) may be possible via this process. However, this means that other customers bear the burden of the poor investment after it has been so demonstrated. Under the DRP approach, an attempt is made to identify likely redundancies and provide an accelerated return of capital prior to the eventual redundancy.

"Real" versus "Nominal" Depreciation Schedules – Does it matter?

To date, the regulatory model adopted in Australia has used a "current cost accounting" basis for the depreciation schedule in conjunction with a real cost of capital. In this formulation, the impact of inflation on the allowed cash flows is reflected in the return of capital (the depreciation allowance) which is adjusted each year by the inflation rate. The return of capital component is a real return concept. Over the life of the asset, the cumulative dollar value of the return of capital exceeds the initial outlay by an amount sufficient to ensure that the return of capital is equal in real terms to the initial outlay.

The DRP framework involves a nominal framework in which the return on capital is a nominal return which implicitly incorporates an allowance for inflation. The appropriate depreciation schedule is thus implicitly a nominal one such as an historical cost accounting based schedule. In such an approach, the cumulative dollar value of the return of capital over the life of the asset equals the initial outlay. In the DRP a “competitive depreciation” schedule is adopted which applies this approach and involves a particular time pattern of the return of capital which is more “back end loaded”.

It is easy to demonstrate that the use of a “real” depreciation schedule (return of capital) is equivalent to use of a “nominal” depreciation schedule in the sense of generating the same NPV of the cash flow series. Note that the cash flow series is the sum of the return on capital and the return of capital. Suppose that a series of cash flows has been generated using a real depreciation schedule and a real rate of return. It is a simple matter to decompose the given cash flow each year into a nominal rate of return on the start of year nominal asset value and a residual amount which is the implied nominal depreciation amount. Appendix 2 demonstrates.

If the appropriate parameters for the cost of capital etc are used in the model, the choice between the nominal and real depreciation approaches do not matter. However, if the incorrect cost of capital is utilised, the magnitude of the NPV effect will depend upon the depreciation schedule used. If the cost of capital is too high, “back end loading” of depreciation will increase the NPV of the cash flow stream (since the excess return is achieved on a larger average capital base over the life of the asset).

3. The Conversion Issue: Nominal Post Tax to Real Pre Tax Returns

Generally, market participants calculate required rates of returns in nominal post tax terms using the Capital Asset Pricing Model or some alternative. If a real pre tax rate of return is to be used it must then be derived from a nominal post tax estimate. There is no simple formula which can be used to do this – although several simple approaches have been suggested.

Define i_{at} to be the nominal post tax rate of return and r_{bt} to be the real before tax rate of return. The simple approaches involve conversion from post tax into pre tax terms by dividing by one minus the tax rate, and converting from nominal into real terms by using the Fisher equation which links nominal (i) and real (r) rates to the rate of inflation (π) by:

$$(1+i) = (1+r)(1+\pi).$$

The two simple approaches suggested involve different orderings of these steps and have been as follows.

Approach 1:
Step 1 – convert i_{at} into a nominal pre tax rate by dividing by the tax rate t to get

$$i_{bt} = i_{at} / (1-t)$$

Step 2 – convert i_{bt} into a real pre tax rate by using the Fisher equation to get:

$$(1+i_{bt})/(1+\pi) = (1+r_{bt})$$

Approach 2:
Step 1 – convert i_{at} into a real post tax rate by using the Fisher equation to get:

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

Step 2 – convert r_{at} into a real pre tax rate by dividing by the tax rate t to get

$$r_{bt} = r_{at} / (1-t)$$

Unfortunately, neither of these simple approaches work, because tax depreciation allowances make the relationship between pre tax and post tax cash flows a complex one. This can be shown analytically, and the simple arithmetic example shown in Table 1 demonstrates the issue. In this example, an asset with a five year life and straight line depreciation for tax purposes is used. The example has been constructed so that the NPV of the nominal cash flows after tax is zero at the assumed nominal post tax discount rate of i_{at} = 10.03%. (Note that the decomposition of the after tax cash flows into a return on capital and a return of capital involves identifying a sequence of “book values” for the asset which differ from the values for tax purposes. Those “book values” are constructed by identifying the return of capital (implied depreciation) as the difference between after tax cash flows and the return on capital.)

In this example, the correct real pre tax rate of return is calculated as the internal rate of return implied by the real pre tax cash flows and is 10.81% p.a.. Also shown are the estimates for the two suggested simple approaches. Approach 1 leads to an overestimate (11.22% p.a.) and approach 2 leads to an underestimate (9.06%). Even in this very simple case with annuity cash flows and a straight-line depreciation schedule for tax purposes, both approaches give biased answers.

It is important to note that the example used here assumes a non-accelerated, straight-line tax depreciation schedule over the true life of the asset. There should be no misconception that the relative size of the errors from the two approaches for this example will apply more generally. If accelerated depreciation provisions apply, the true relationship between the nominal post tax and real pre tax rates of returns becomes even less clear[2].

[2] Appendix 1 provides an illustration using accelerated depreciation, where the nominal post tax return is 10.54% p.a. and the true real pre tax return is also 10.81% p.a.. (Since the assumed pre tax cash flows are unchanged – ie it is assumed that competition is inadequate to ensure that the tax benefits flow through to customers - the preferential tax treatment leads to a higher post tax return). It can be seen that for that particular case, the average of the two approaches is closer to the true value than in the first case.

Table 1

The Nominal post tax – Real pre tax Conversion Problem: An Illustration

Nominal post tax discount rate (i_{at})	10.03%					
tax rate (t)	0.36					
Inflation rate (π)	4.00%					
Year	**0**	**1**	**2**	**3**	**4**	**5**
Asset Taxable Value	100	80	60	40	20	0
EBDIT		30	30	30	30	30
Tax Depreciation		*20*	*20*	*20*	*20*	*20*
Tax		3.6	3.6	3.6	3.6	3.6
After Tax Cash Flow	-100	26.4	26.4	26.4	26.4	26.4
PV of after tax cash flow	100	23.99	21.81	19.82	18.01	16.37
NPV	0					
Return on Capital ($i_{at}.BV_{t-1}$)		10.03	8.39	6.58	4.59	2.41
Return of Capital (BV_{t-1} - BV_t)		16.37	18.01	19.82	21.81	23.99
Asset "Book" Value (BV)	100	83.63	65.618	45.800	23.993	0.000
Real Pre Tax Cash Flow	-100	28.85	27.74	26.67	25.64	24.66
Correct Internal Rate of Return (r_{bt})	10.81%					
Approach 1						
$i_{bt} = i_{at} / (1-t)$	15.67%					
$r_{bt} = (1+i_{bt}) / (1+\pi)-1$	11.22%					
Approach 2						
$r_{at} = (1+i_{at}) / (1+\pi) -1$	5.80%					
$r_{bt} = r_{at} / (1-t)$	9.06%					

4. Alternative Models

The WACC model used for the gas industry was based on *real, pre tax, cash flow to entity* principles. Each of these three characteristics is an important component of the approach. Considering the three principles, each has particular significance.

The *real* specification was adopted to allow for a particular time path of target revenue cash flows which recognised the impact of inflation on the return of capital. As noted above, the CPI-X calculation of allowable cash flows removes much of the relevance of this issue.

The *pre tax* specification is a major source of concern, since it requires somewhat *ad hoc* adjustments to the required post tax rate of return to be made. Available models of the WACC are not well suited to indicating the nature of the appropriate adjustment.

The *entity* approach enables the issue of capital structure (financing choice) to be ignored in the specification of cash flows, with the impact of this variable entering via the calculation of the WACC. Given the impact of financing choice on the tax position of the businesses, this creates some problems in the modeling of the WACC. It is, however, possible to adopt an "unconventional" definition of the WACC (using the pre tax cost of debt) and include tax effects of debt financing in the cash flow specification. An alternative approach is to specify the cash flows to *equity* (ie after interest payments) to ensure that an appropriate return to equity holders is provided. This approach requires that the discount rate utilised is the cost of equity rather than a WACC.

In the Gas Industry case, the starting point for the WACC was:

$$r_o^i = r_e \frac{E}{V} . \frac{(1-T)}{(1-T(1-\gamma))} + r_d . \frac{D}{V} .(1-T) \qquad \textbf{Equation 1}$$

which is a (nominal) WACC formula for valuing the cash flows after tax (calculated as if it were an unlevered entity), where r_e is a "partially grossed up" cost of equity capital estimate obtainable from the CAPM, and γ is the fractional value ascribed to franking credits. The formula implicitly assumes that the entity is in a tax paying position, and the effect of imputation is reflected in the adjustment to r_e.

An alternative approach is to include the value of franking credits generated in the cash flow figures and use a WACC estimate which is not adjusted in this way.

To examine alternative approaches, the following definitions are used:

TR_t = target revenue in year t

OC_t = operating costs in year t

D_t = depreciation in year t

K_{t-1} = capital at start of year t

B_{t-1} = debt at start of year t

E_{t-1} = equity at start of year t

r_b = cost of debt

r_e = cost of equity (partially grossed up measure)

T_t = tax paid in year t

FC_t = value of franking credits distributed in year t

(Note that FC_t equals γ times the dollar value of franking credits distributed and, if there is a 100 per cent distribution of franking credits generated each year, $FC_t = \gamma.T_t$).

It is assumed that capital structure is maintained such that $B_t = bK_t$, i.e. that debt is a constant proportion of the value of capital, and $E_t = (1-b)K_t$. Under these assumptions, and ignoring working capital and additions to capital, a target revenue specification for returns to the entity, which is after tax but which incorporates the value of franking credits would be:

$$\mathbf{TR_t = OC_t + D_t + r_e (1-b) K_t + r_b\, b\, K_{t-1} + T_t - FC_t} \qquad \textbf{Equation 2}$$

Denoting $r_o = r_e(1\text{-}b) + r_b.b$ as a (non standard)WACC, this permits a return on funds employed (r_oK_{t-1}) plus return of capital D_t, plus coverage of operating costs OC_t, plus payment of company taxes (T_t) less the value of any franking credits distributed. Denoting operating cash flows (C) as

C = TR-OC
and noting that

$$K_t = K_{t-1} - D_t$$

it is possible to rewrite equation 2 as:

$$C_t = K_{t-1} - K_t + r_e(1-b)K_{t-1} + r_b b K_{t-1} + T_t - FC_t \qquad \textbf{Equation 3}$$

so that:

$$C_t + K_t - T_t + FC_t = (1-b)K_{t-1}(1+r_e) + b K_{t-1}(1+r_b) \qquad \textbf{Equation 4}$$

Noting that E=(1-b)K and B=bK (so that E+B=K) gives

$$\begin{aligned} C_t + K_t - T_t + FC_t &= E_{t-1}(1+r_e) + B_{t-1}(1+r_b) \\ &= E_{t-1}+B_{t-1} + E_{t-1}r_e + B_{t-1}r_b \\ &= K_{t-1}[1+r_o] \qquad \textbf{Equation 5} \end{aligned}$$

where $r_o = r_e(E/K)+r_b(B/K)$ is a version of the WACC.

Equation 5 is a one period present value relationship which relates operating cash flow plus end of period capital value minus taxes paid plus value of franking credits paid to the starting asset value. Note that

- The cost of debt is before tax
- The tax is calculated to include the interest tax shield (i.e. actual tax paid is used)

An alternative specification which could be used is to calculate tax cash flows *as if* the company were unlevered, so that T_t on the LHS of equation 5 can be written as:

$$T_t = t\,EBDIT - OTS - ITS$$

where OTS is other tax shields (depreciation) and ITS is the interest tax shield). Noting that ITS = tr_bB_{t-1}, and writing

$$T(unlevered)_t = tEBDIT - OTS$$

Gives

$$C_t + K_t - T(unlevered)_t + FC_t = (1-b)K_{t-1}(1+r_e) + b K_{t-1}(1+r_b) - tr_b bK_{t-1}$$

$$C_t + K_t - T(unlevered)_t + FC_t = K_{t-1}[1 + (E/K)r_e + (B/K)r_b(1-t)]$$

Or

$$C_t + K_t - T(unlevered)_t + FC_t = K_{t-1}[1 + wacc]$$

Note that this approach

- Uses the after tax cost of debt in the calculation of the wacc
- Calculates taxes *as if* the company were unlevered
- Uses the "partially grossed up" cost of equity measure
- Assumes that the value of franking credits created and distributed is unaffected by the debt position and size of the interest tax shield.

Particularly because of the last requirement, this approach is not recommended.

Returns to Equity Approach

The target revenue model could alternatively be specified using the "returns to equity" approach, by calculating a target revenue net of interest costs which generated the required return to equity. The complication which arises here is that the "return of capital" in the form of depreciation is partially a return of capital to providers of debt finance, and thus needs to be recognised. Commencing with equation (2) which depicted returns to all providers of credit

$$\mathbf{TR_t = OC_t + D_t + r_e (1\text{-}b) K_{t-1} + r_b\, b\, K_{t-1} + T_t - FC_t} \qquad \textbf{Equation 2}$$

note that of these returns some part will go to debt holders. Since debt outstanding is linked to capital by B = b K, cash flows to debt holders in period t (C_t^b) will comprise:

$$\mathbf{C_t^b = r_b\, b\, K_{t-1} + bK_t - bK_{t-1}}$$

Denoting cash flows to equity by C_t^e and noting that:

$$\mathbf{C_t^e = C_t - C_t^b}$$

rearranging equation (2) gives:

$$\mathbf{C_t^e = K_{t-1} - K_t + r_e (1\text{-}b) K_{t-1} + T_t - FC_t + bK_t - bK_{t-1}} \qquad \textbf{Equation 6}$$

or

$$\mathbf{TR_t = OC_t + D_t + r_e (1\text{-}b) K_{t-1} + T_t - FC_t + b(K_t - K_{t-1})} \qquad \textbf{Equation 7}$$

so that

$$\begin{aligned} \mathbf{C_t^e + K_t(1\text{-}b) - T_t + FC_t} &\mathbf{= K_{t-1}\, [1\text{-}b + r_e(1\text{-}b)]} \\ \mathbf{C_t^e + E_t - T_t + FC_t} &\mathbf{= (1\text{-}b)K_{t-1}\, (1+r_e)} \\ &\mathbf{= E_{t-1}(1+r_e)} \qquad \textbf{Equation 8} \end{aligned}$$

It can be seen that equation 8 is a present value relationship which links cash flows to equity holders after all tax (with value of franking credits added back) plus end of period equity value (as a proportion of capital stock) to the start of period equity value. The discount rate required is the nominal cost of equity capital (partially grossed up). Equation 7 provides the "target revenue" model for the equity based approach. Target revenue to equity holders must cover operating costs plus depreciation plus the "partially grossed up" return on equity (from the CAPM) plus total tax paid net of the value of franking credits distributed. In addition, the target revenue needs to be adjusted for the net flow of debt capital required to maintain capital structure unchanged.

The cost of equity and tax calculations

The benefit of the preceding approach is that the effective tax rate does not need to be calculated nor included in the analysis. Instead it is necessary to determine the amount of tax per period and the value of franking credits generated per period for inclusion in the cash flows.

The partially grossed up cost of equity can be derived directly from a CAPM once the risk free rate, market risk premium, and beta are estimated. The difficult unknown parameter is the "γ" factor which determines the valuation of franking credits included in the cash flow. Note that if it is assumed that γ=1, so that franking credits are fully valued, $FC_t = T_t$ and the target revenue model does not include any tax terms. The reason is that under that assumption, company tax is "washed out" by the operation of the imputation tax system. Alternatively, if γ=0 is assumed, company tax liabilities are fully included in the target revenue, with no offset from the valuation of franking credits.

5. Conclusion

There are many alternative specifications for models for regulatory price determination which can be shown to be equivalent, provided that consistent information is used in each of them. However, some specifications are better than others, in that the information required may be more reliable or less subject to manipulation and distortion.

One characteristic of such models is that they are based on a zero NPV formulation, which implies that the market value of the assets (business) involved should be equal to the replacement value of the assets used in determining the allowable cash flows. The experience of the Victorian Gas Industry, where significant multiples of DORC asset value were paid by winning bidders in the privatisation process is indicative of problems in setting appropriate access prices using the "real pre tax" approach. It is difficult to escape the conclusion that the cost of capital allowed by the regulators was, with hindsight, too high. A target revenue model based on a "nominal post tax" approach, in which tax issues are clearly identified and the "conversion problem" avoided, is likely to lead to better social outcomes.

Appendix 1

The Nominal post tax – Real pre tax Conversion Problem:

Accelerated Depreciation

nominal post tax discount rate (i_{at})	10.54%
tax rate (t)	0.36
inflation rate (π)	4.00%

Year	0	1	2	3	4	5
Asset Taxable Value	100	75	50	25	0	0
EBDIT		30	30	30	30	30
Tax Depreciation		*25*	*25*	*25*	*25*	*0*
Tax		1.8	1.8	1.8	1.8	10.8
After Tax Cash Flow	-100	28.2	28.2	28.2	28.2	19.2
Present Value	100	25.51	23.08	20.88	18.89	11.64
NPV	0					
Return on Capital		10.54	8.67	6.62	4.34	1.83
Return of Capital	100	17.66	19.53	21.58	23.86	17.37
Asset "Book" Value	100	82.335	62.810	41.227	17.370	0.000
Real Pre Tax Cash Flow	-100	28.846	27.737	26.670	25.644	24.658
Correct Internal Rate of Return (r_{bt})	10.81%					
Approach 1						
$i_{bt} = i_{at} / (1-t)$	16.46%					
$r_{bt} = (1+i_{bt})/(1+\pi)-1$	11.98%					
Approach 2						
$r_{at} = (1+i_{at})/(1+\pi)-1$	6.28%					
$r_{bt} = r_{at} / (1-t)$	9.82%					
average	10.90%					

Appendix 2

Real versus Nominal Depreciation Schedules Compared

The example below considers a five year asset initially purchased at \$100 and with straight line depreciation. The nominal cost of capital is 15.5% p.a. and the inflation rate 10% p.a. Under the nominal depreciation approach, the allowable cash flow is:
$C_t = i.K_{t-1} + D_t$.
This comprises two parts – a return on capital (iK_{t-1}) and a return of capital (D_t). It is simple to check that the date zero present value of the future cash flow stream is 100.

Under the real depreciation approach, the cash flow allowed for return of capital involves maintaining the real value of depreciation constant. Thus:
$D_t{}^* = Dt\ (1+\pi_1)(1+\pi_2)\ldots..(1+\pi_t)$.
The capital base is adjusted according to $K_t{}^*=K_{t-1}{}^*(1+\pi_t) - D_t{}^*$ where:
$K_0{}^* = K_0$.
The allowable cash flow stream is:
$C_t{}^* = rK_{t-1}{}^*\ (1+\pi) + D_t{}^*$
This comprises two parts – a real return on capital ($rK_{t-1}(1+\pi)$) and an inflation adjusted return of capital ($D_t{}^*$). It is simple to check that the future cash flow stream has a present value at date zero of 100.

As shown, given the cash flow stream from the real depreciation approach, it is a simple matter to construct the implied nominal depreciation schedule which applied in conjunction with a nominal return on capital gives the same cash flow. It involves a "rear end loading" of depreciation which becomes more significant as the inflation rate increases.

			End of Year			
	0	**1**	**2**	**3**	**4**	**5**
Nominal Depreciation Approach – straight line depreciation						
Capital – Kt	100	80	60	40	20	0
Depreciation - Dt		20	20	20	20	20
Cash Flow – Ct		35.5	32.4	29.3	26.2	23.1
Corresponding Real Depreciation Approach						
K_{t-1}*(1+π)		110.0	96.8	79.9	58.6	32.2
Dt*		22.0	24.2	26.6	29.3	32.2
Kt*	100.0	88.0	72.6	53.2	29.3	0.0
Ct*		27.5	29.0	30.6	32.2	33.8

Implied Nominal Depreciation Equivalent					
iK_{t-1}	15.5	13.6	11.3	8.3	4.5
D (implied)	12.0	15.4	19.4	24.0	29.3
C_t	27.5	29.0	30.6	32.2	33.8
K (implied)	88.0	72.6	53.2	29.3	0.0

Assumptions

i	15.5%
π	10%
r	5%

References

ACCC (1999) "Draft Statement of Principles for the Regulation of Electricity Transmission Revenues" http://www.accc.gov.au/electric/sridiisseme/sridissemi.htm