ABACUS, Vol. 39, No. 1, 2003

D. J. JOHNSTONE

Replacement Cost Asset Valuation and Regulation of Energy Infrastructure Tariffs

In Australia, access tariffs (rental charges) paid by third party users to the owners of energy transmission assets (e.g., gas pipelines) are determined by regulators on the basis of their depreciated optimized replacement cost (known as DORC). Reliance on the replacement cost, rather than actual cost, of existing assets inflates tariffs and incites the criticism that asset owners earn a return on investments of a scale never made. The economic rationale of the regulators' model is that it emulates the workings of a contestable market, by setting tariffs at a level just short of that required to motivate a new entrant (system duplication). Properly reconstructed, this model constitutes a dynamic and internally consistent theory of replacement cost valuation and depreciation. Its mathematical consequences, however, especially with regard to the valuation of sunk assets with long times to expiry, are shown to be practically and politically unpalatable. In particular, the implied tariff levels for such assets are very close to those that would apply to new infrastructure assets built today at today's prices. Regulators unwilling to accept this implication of a new-entrant-exclusion pricing logic are left with no alternative framework for DORC.

Key words: Asset valuations; Infrastructure; Replacement costs; Tariffs.

INTRODUCTION

The owners in Australia of energy transmission infrastructure assets (gas pipelines and electricity grids) are natural monopolists safe from any practical economic risk of private sector investors or governments replicating the main trunks of their transmission networks. Following the principles set down in the *Report on National Competition Policy* (Commonwealth of Australia, 1993), federal and state governments have established 'access regimes' to enable other companies, including downstream users and competitors in energy supply markets, to access (i.e., rent) part of the capacity of these otherwise monopolized assets. Arrangements between asset owners and asset users are on an artificially commercial

---

David Johnstone is a Professor in the Department of Accounting and Finance, University of Wollongong.
This research has been completed with the financial support of BHP Petroleum Pty Ltd and the Australian Research Council (Small Grant Scheme). Discussions with Eric Groom (IPART), Murray Wells (Emeritus Professor, University of Sydney), John Trowell (University of Wollongong), Ken Peasnell (University of Lancaster) and Graeme Dean (University of Sydney) are acknowledged with appreciation.

basis, intended to bring about competition in energy supply markets and reduce downstream energy costs:

> An access regime is a set of procedures for allowing a third party to use services provided by significant infrastructure facilities owned or operated by another party on fair terms . . . Common types of infrastructure include electricity transmission lines, gas pipelines, telecommunications networks and rail track. For example, Energy Australia can sell electricity to a customer located in another distribution area, owned by, say, Integral Energy . . . The common benefits of competition are lower prices, choice of service provider, more innovative and better quality services and a more efficient utilization of a network. Competition will improve productive efficiency as service providers minimize their operating costs to provide services at the lowest possible price. In turn this will increase the competitiveness of the downstream goods and services markets that use the infrastructure. (IPART, 1999a, p. 5)

In exchange for access to their networks, infrastructure owners ('service providers') are paid transmission tariffs in amounts determined by independent regulatory agencies, including primarily the ACCC (Australian Competition and Consumer Commission), ORG (Office of the Regulator-General, Victoria) and IPART (Independent Pricing and Regulatory Tribunal of New South Wales). Federal government industry policy on tariff determination written into the National Electricity and National Gas Codes, and reaffirmed by the ACCC (1998a, pp. 6–15; 1999a, pp. viii–xiv), requires that tariff settings be 'cost-reflective' and generally consistent with prices in efficient and competitive markets (Productivity Commission 2001, p. 198).

These overriding yet imprecisely articulated criteria leave regulators with wide discretion, but also with the difficult task of contriving defensible market-like outcomes where there are no actual markets. The fundamental problem is one of logical circularity—tariffs cannot be fixed at levels consistent and fair in relation to the market value of the services (energy load transmission) and service infrastructures (pipelines, etc.) when in fact those market values are only determined once tariff levels are set. There is no observable market for energy transmission services independent of the regulators' decisions (Bonbright *et al.*, 1988, pp. 216–17; Whittington, 1998b, p. 30; IPART, 1998, p. 18; ACCC, 1999a, p. 39).[1]

Undaunted by this inherent circularity, regulators have developed and relied almost exclusively on a model claimed to emulate market determinations, and described as the 'building block approach' (ACCC, 1998a, p. 6; 1999a, p. x; Productivity Commission, 2001, p. 209; IPART, 1999b, p. 4; 1999d, Vol. 1, p. 138). Put simply, this model categorizes the period costs of owning (financing) and operating the necessary transmission infrastructure assets and totals these to give a maximum or upper limit (a 'price cap') on allowable period tariff revenue. In general, total period costs are taken as the sum of *operating costs* and *capital costs*, where capital costs are defined as (a) depreciation (i.e., loss of asset value) plus (b)

[1] Walker *et al.* (2000a) following Clarke (1998) note that this circularity problem has long been recognized within rate-of-return price setting and regulatory regimes; several references are provided, beginning with Bonbright (1937).

opportunity cost—that is, foregone return—incurred when capital is committed to physical (infrastructure) assets.

Expressed as a formula, the maximum allowable tariff revenue (MAR) in period t is

$$\textit{operating expense}_t + \textit{depreciation}_t + \textit{opportunity cost}_t \quad (1)$$

where *depreciation*$_t$ is the decline in asset value $V_{t-1} - V_t$ over period t (however measured) and *opportunity cost*$_t$ is the dollar return on capital that could have been earned had a cash amount equal to the period opening asset value V_{t-1} been invested elsewhere for the duration of the period (ACCC, 1999a, pp. x–xiv). The intuitive justification for this formula is that asset owners are reimbursed for their (efficient) periodic operating costs and for any consequential loss of capital (depreciation), and rewarded at a specified rate of return, determined by the regulator, for their commitment of capital, as would be expected of a rational and competitive capital market. The capital intensity of energy transmission businesses causes capital costs greatly in excess of operating costs (ORG, 1998a, p. 9; Parry, 2000, p. 140). When assessed on a replacement cost basis, capital costs are typically 70–80 per cent of total costs (Davis, 1999a, p. 5; Zauner, 2000, p. 1).

The regulators' tariff formula averts or at least minimizes the circularity problem by defining entity asset value in an 'accounting' rather than 'economics' way as a sum of book values, or in other words, by applying a 'balance sheet' approach to the valuation problem. Individual asset book values are measured on a basis independent of the assets' use in regulated energy transmission. Possible valuation bases are current market realizable (scrap) value, 'historical' or actual cost, current replacement cost, and deprival value. Of these, the last has been considered favourably by regulators, but rejected because of its inherent reference to future cash flows (tariffs) and hence the circularity problem (ACCC, 1999a, pp. x–xi).[2] Each of the other three valuation bases applies without obvious circularity—specifically, the amount that an asset (such as, say, a pump or a pipe) cost when it was acquired, or would cost to replace, or could be removed and sold for, does not depend directly on how it is being used, or moreover on what tariffs it is helping to generate.[3]

Any of these three possible valuation bases might have been adopted within the 'building block approach'. However, from the start and with little apparent reservation, there has been consensus between Australian regulators, particularly the

[2] Walker *et al.* (2000b, p. 132) hold that in Australia '[t]he deprival value accounting variant of replacement cost has become the dominant public sector accounting method'. A COAG agreement of August 1994 instated deprival value as the preferred valuation rule for network assets (IPART, 1998, p. 35; ACCC, 1998a, p. 8). The institutional history of this concept, particularly in the Australian public sector, is documented in Clarke (1998) and Walker *et al.* (2000a). Whittington (1998b) details similar developments in the United Kingdom.

[3] Some second order circularity will surely remain. In imperfect markets, quotes for the replacement of infrastructure assets, especially highly specialized items, will tend to be higher when these can be employed to produce higher tariff revenues. Similarly, the scrap value of such assets will be greater if there is a secondary market for them driven by their potential for use elsewhere in tariff generation.

ACCC and ORG, that the single or most appropriate valuation basis for tariff setting is current replacement cost, or more specifically, *depreciated optimized replacement cost*, commonly abbreviated to DORC. By definition, the DORC of an asset is the written-down replacement cost of its optimal or most efficient replacement (in an engineering or cost efficiency sense):

> Optimized replacement cost is a variant of the replacement cost valuation methodology which measures the cost of the most efficient method of providing the services of the current asset. (ACCC, 1998a, p. 9)

> DORC is the replacement cost of an 'optimized' system, less accumulated depreciation. It allows for the depreciated state of the asset and also incorporates engineering optimization of the utility's asset. An optimized system is a re-configured system designed to serve the current load plus expected growth over a specified period using modern technology. This method excludes any unused or under utilized assets beyond the specified planning horizon, and allows for potential cost savings which may have resulted from technological improvement.[4] (IPART, 1999d, Vol. 1, p. 52)

The Australian regulators' acceptance of DORC has significant economic and political consequences, and has attracted both support and annoyance from within the industries and companies affected. The main issue, immediately obvious to academics who have followed the waxing and waning over three decades of current cost accounting (CCA) proposals in the private sector, is that DORC valuations tend to inflate asset book values (relative to either historical cost or market realizable value) and hence to increase any related measure of the asset owners' capital costs, thereby raising the regulated tariff stream flowing from energy users and wholesalers to transmission asset owners. The ready appeal of DORC-based tariff streams to incoming (and incumbent) asset owners has assisted governments, particularly the state government in Victoria, to maximize the proceeds from infrastructure privatizations. Moreover, the direct connection between prices gained from the sale of infrastructure assets and the basis on which these are valued on paper (on the regulatory balance sheet) has undoubtedly brought much political pressure on regulators to adopt and endorse DORC, and must in some part explain their commitment to its application.[5]

The economic, political and social consequences of regulators' near universal reliance on DORC asset valuations may be very significant. At worst, there is the potential to hamstring the development of Australian industry by inflating the costs of energy to downstream producers, thus unnecessarily rationing industry's use of existing ('sunk') energy transmission networks and known energy reserves. On the other hand, transmission asset owners have argued that an asset valuation

[4] Zauner (2000, p. 4) notes that in the experience of his engineering valuation firm, the 'O' in DORC is relatively ineffective: 'The optimization approach is necessarily subjective and receives much debate even though it typically only results in a write-down of the order of 5–10% of the un-optimized value'.

[5] IPART (1999, p. 51) implicitly acknowledged direct interference by the N.S.W. State government in its recognition of DORC for electricity distribution assets in N.S.W. See also, for example, the Victorian State Treasury *Energy Projects Division* submissions, emphasizing the validity and relevance of DORC (ACCC, 1999a, p. 41), to the ORG/ACCC joint enquiry on the Victorian Gas Distribution Access Arrangements (Final Decision 6 October 1998; ORG, 1998b, and ACCC, 1998b).

base which leads to lower tariffs will jeopardize their profitability and hence stifle growth and investment in additional and spin-off infrastructure.

Given the importance of transmission tariff settings, both to energy dependent industries and to infrastructure investors, it is essential that there be proper review of the Australian regulators' adoption and advocacy of DORC asset valuations. This article seeks to contribute towards such a review. In particular, it reconstructs the regulators' conceptual framework, including particularly the role of DORC in the tariff formula, and questions the analytical arguments that have been put for DORC and expressly endorsed by regulators in their published proceedings. A secondary objective of the paper is to bring to the notice of regulators and others involved in the tariff setting debate relevant aspects of the established literature on replacement cost valuation in accounting, emphasizing particularly the problems caused by their innate subjectivity.

The most contentious and consequential regulatory asset valuation decisions entail 'sunk' assets. Assets yet to be built (new investments) will be added to the regulatory asset base (RAB) at the same dollar figure irrespective of whether the asset valuation basis is depreciated actual cost, known as DAC, or optimized replacement cost (DORC). Although the subsequent treatment of those assets' values may not be the same (see discussion below), the likely tariff consequences of the regulator's choice between DAC, DORC and other valuation rules are relatively less significant or at least not so immediate for assets yet to be constructed as for those already existing. Because of the relative importance of the initial regulatory asset base (RAB_0) and the likely precedent attached to its determination, this article is primarily concerned with the valuation of existing assets.

THE REGULATORS' TARIFF EQUATION

The building block approach equation (1) for MAR can be written as

$$\textit{operating expense}_t + (V_{t-1} - V_t) + V_{t-1}r \tag{2}$$

where r is the periodic rate of return on capital granted to the asset owner by the regulator. In principle, this percentage return is meant to equal the asset owner's *weighted average cost of capital* (WACC), or in other words the risk-related rate of return demanded of such an investment by an efficient capital market.

The regulators' discretionary determination of WACC (set at a real rate of return of 7.75 per cent in the ACCC/ORG 1998 determinations) has been as controversial, and subject to the same political lobbying as their reliance on DORC. Again there is an issue of logical circularity since the market required risk-adjusted return on investment in energy transmission assets hinges on the regulators' choice of, and commitment to, a given figure for WACC, and on the (systematic) risk of changes to regulatory arrangements in the future (known as 'regulatory risk'). There are, however, more relevant external benchmarks for WACC than for RAB, such as, for example, typical market rates of return on subjectively comparable assets, and the rates of return earned by equivalent entities in other countries. Nonetheless, there is no obviously correct or fair answer for WACC and the regulator can only adjudicate between the various affected parties' disparate and obviously self-interested views. References on the recent Australian regulatory debate over WACC include Officer (1998), Davis (1999a; 1999b), Johnstone (1999c) and IPART (1999d, Vol. 1, pp. 105–23).

Replacing the corresponding terms in (2) with the acronyms RAB and WACC, the regulator's tariff equation is written in its now familiar form as

$$operating\ expense_t + (RAB_{t-1} - RAB_t) + RAB_{t-1}WACC. \tag{3}$$

where WACC is the regulated rate of return to asset owners, and theoretically their weighted average cost of capital.

THEORETICAL FOUNDATIONS OF THE TARIFF EQUATION

The tariff formula can be rationalized in terms of present value (PV), using the formal reconciliation between cash and 'accruals' measures of capital costs clarified by Peasnell (1981, pp. 53–4; 1982, p. 365) and Edwards *et al.* (1987, pp. 12–31), and first arising in Hotelling (1925) and Preinreich (1938).[6] Specifically, after being reimbursed for their periodic operating expenditures (e.g., wages, etc.) asset owners receive net cash (tariff) flows in period *t* equal to

$$(RAB_{t-1} - RAB_t) + RAB_{t-1}WACC.$$

Discounting this cash flow sequence at rate r = WACC, the discounted present value (PV) of the tariff stream to asset owners is

$$PV = \sum_{t=1}^{T} \frac{(RAB_{t-1} - RAB_t) + RAB_{t-1}WACC}{(1 + WACC)^t}$$

where $t = T$ represents the time at which the regulatory asset base is fully depreciated ($\text{RAB}_T = 0$).

Simplifying this equation as follows

$$\begin{aligned} PV &= \frac{(RAB_0 - RAB_1) + RAB_0WACC}{(1 + WACC)^1} + \frac{(RAB_1 - RAB_2) + RAB_1WACC}{(1 + WACC)^2} + \ldots \\ &\quad \ldots + \frac{(RAB_{T-1} - RAB_T) + RAB_{T-1}WACC}{(1 + WACC)^T} \\ &= \frac{RAB_0(1 + WACC)}{(1 + WACC)} + \frac{RAB_1(1 + WACC) - RAB_1(1 + WACC)}{(1 + WACC)^2} + \ldots \\ &\quad \ldots + \frac{RAB_{T-1}(1 + WACC) - RAB_{T-1}(1 + WACC)}{(1 + WACC)^T} - \frac{RAB_T}{(1 + WACC)^T} \\ &= RAB_0 \end{aligned} \tag{4}$$

6 This analytical connection between cash flows (finance) and 'accrual' measures of costs (accounting) underlies the theory of clean surplus accounting. Brief and Peasnell (1996) discuss the history and consequences of this theory, and provide a collection of important related papers.

reveals that the PV of the regulated tariff stream, calculated at discount rate equal to the regulated WACC, is equal to the amount of the initial ($t = 0$) regulatory asset base, RAB_0. This result makes obvious the asset owner's economic imperative for negotiating the highest possible initial asset book value, RAB_0. If the regulated WACC is in fact the true cost of capital, then the PV of the ensuing tariff stream equals exactly the RAB_0 granted by the regulator.

Three further results follow immediately:

1. Any asset revaluation agreed to by the regulator amounts to an NPV windfall to asset owners equal to the amount of the (upward) revaluation. To prevent this 'free lunch' the regulator must either prohibit asset revaluations or treat them explicitly as income in the tariff equation, thus reducing tariffs (cash flow) in the period of the revaluation by the amount of that revaluation.[7] The expanded tariff equation satisfying this requirement is

$$\textit{operating expense}_t + \textit{depreciation}_t + \textit{opportunity cost}_t - \textit{revaluations}_t. \qquad (5)$$

2. Any new investment in infrastructure by asset owners offers NPV equal to the difference between the corresponding increase in the RAB and the actual cash amount invested. To fix this incremental NPV equal to zero, as is characteristic of an efficient capital market, expenditure on new assets must be brought onto the regulatory balance sheet at actual cost (which is, presumably, also the then optimized replacement cost of the new asset).
3. For given total depreciation ($RAB_0 - RAB_T$), PV is constant regardless of the time pattern of period depreciation charges. It makes no difference over what interval $0 \le t \le T$ assets are written down, or how aggregate depreciation expense is distributed within this interval. More specifically, given $RAB_T = 0$, PV equals RAB_0 whatever the depreciation scheme. This point is of sufficient importance to bring about repeated explanation over many years: for example, Preinreich (1938), Edwards and Bell (1961, pp. 68–9), Schmalensee (1989), King (1997, p. 6), Newbery (1997, p. 3), Whittington (1998a, pp. 97, 100) and Davis (1999a, pp. 7–8, 1999b, p. 2).

The financial effect of the regulators' tariff equation can be described intuitively as follows. In essence, the regulator creates a 'bank account' of initial amount RAB_0 in the name of asset owners. Against this account, owners are paid periodic interest at effective interest rate WACC (granted by the regulator). Interest is calculated on the period opening RAB value. Each period the RAB or account balance falls by the amount of depreciation in that period. This sum is paid to the asset owner, and equates to a period end cash withdrawal from the asset owner's interest bearing account. In aggregate, the period tariff includes both a sum of interest ('return on capital') and a withdrawal ('return of capital'). When at $t = T$ all remnant capital is withdrawn ($RAB_T = 0$), cash flows (tariffs) cease. In practice

[7] A closely related argument in an accounting context by Peasnell and Archer (1984) requires that, to avoid double counting, holding gains on debt be credited to the income account rather than directly to equity.

RAB will likely never approach zero, because the asset owner will over time make further investments in its infrastructure assets. The amounts spent on new assets will have the same effect as cash deposits into the owners 'bank' (RAB) account. Each further deposit (asset acquisition) will earn interest until fully withdrawn through asset write-downs (depreciation). An important aspect of this analogy is that all interest is paid out in cash—none accumulates in RAB. The only way to add to RAB is to invest in new assets.

THE METHOD OF DEPRECIATION

The method by which regulators depreciate ORC to arrive at DORC has been subject to much discussion (e.g., ACCC, 1999a, pp. 57–9; IPART, 1998, pp. 40–1; 1999a, pp. 16–17; 1999c, pp. 46–7; 1999d, Vol. 1, pp. 91–104; ORG, 1999, pp. 15–16) and like other contentious 'building block' inputs, has been regarded as a matter for negotiation. The two main issues are: (a) to what extent are existing assets already depreciated, or put another way, how is the initial (t = 0) asset value $RAB_0 = DORC_0$ to be found from ORC_0, and (b) by what algorithm is $DORC_0$ to be written down from that time onwards? The regulators' answers to these questions, thus far, can be summarized as follows:

1. $DORC_0$ is obtained as a linear (with respect to asset age) proportion of ORC_0 by the formula

$$DORC_0 = ORC_0 \frac{l_e - a}{l},$$

   where a is the age of the existing asset, l_e is the estimated total life of the existing asset and l is the estimated life of either the existing asset or its modern equivalent (ACCC, 1999a, pp. 46–7; Zauner, 2000, p. 6). The ambiguity over whether l should refer to the asset already in place or its new equivalent is typical of replacement cost valuation generally and related to the more general issue of what constitutes asset 'replacement' (see below). Not all of the Australian regulators' published decisions state the ORC value from which the initial value of DORC is found, but where this information is provided $DORC_0$ is typically in the region of 50–80 per cent of ORC_0 (e.g., IPART, 2000, pp. 273–4). Large percentages are to be expected given the generally very long lives of the assets in question, or their modern equivalents.
2. The regulators' standard depreciation algorithm is (real) straight line (ACCC, 1998b, pp. 44–5; 1999a, p. 47; ORG, 1998b, pp. 94–7). Where there is no inflation, nominal DORC reduces linearly over time. With inflation, it is the real rather than nominal value of DORC that reduces linearly. This algorithm works as follows. Take year 3 say of an asset being depreciated straight-line over $T = 5$ years (20 per cent per year). At $t = 3$, only 40 per cent of the asset remains. Its nominal ORC at that time is its initial ($t = 0$) value of \$100 indexed up to \$100 $(1.05)^3$ = \$115.76 to allow for 5 per cent annual inflation. Hence DORC at this point is 40% (\$115.76) = \$46.31, in nominal time 3 dollars, or

$\$46.31/(1.05)^3 = \$40$ in real (time 0) dollars.[8] Full example calculations are provided and explained below.

TABLE 1

BUILDING BLOCK MODEL EXAMPLE CALCULATIONS

Time	0	1	2	3	4	5
Zero inflation						
ORC	100.00	100.00	100.00	100.00	100.00	100.00
DORC	100.00	80.00	60.00	40.00	20.00	0.00
Depreciation		20.00	20.00	20.00	20.00	20.00
Return on capital (10%)		10.00	8.00	6.00	4.00	2.00
Total cash flow		30.00	28.00	26.00	24.00	22.00
Present value ($r = 10\%$)		27.27	23.14	19.53	16.39	13.66
Total present value	100.00					
5% inflation – all values nominal						
ORC	100.00	105.00	110.25	115.76	121.55	127.63
DORC		84.00	66.15	46.31	24.31	0.00
Depreciation		16.00	17.85	19.85	21.99	24.31
Return on capital (15.5%)		15.50	13.02	10.25	7.18	3.77
Total cash flow		31.50	30.87	30.10	29.17	28.08
Present value ($r = 15.5\%$)		27.27	23.14	19.53	16.39	13.66
Total present value	100.00					
Real cash flow (time 0 dollars)		30.00	28.00	26.00	24.00	22.00

Example Calculations

The workings of the building block tariff model are illustrated in the spreadsheet calculations shown in Table 1, adapted from Davis (2000, p. 12). Calculations are provided for the cases of zero inflation and 5 per cent inflation. For the purpose of the illustration, the opening RAB value is $RAB_0 = \$100$. Assets are assumed to have a remaining life of $T = 5$ years. The regulated WACC is taken as 10 per cent real. This implies a nominal WACC of $1.10 \times 1.05 - 1 = 0.155 = 15.5\%$ when the inflation rate is given as 5 per cent. The assumed depreciation scheme is the 'real linear' method endorsed by the ACCC and to date applied by all Australian regulators (see references above). Davis (2000) refers to this as 'competition depreciation', a term used by the ACCC (1999a, pp. 28, 47) to describe depreciation schemes that imply a constant or near constant real tariff stream. Tariffs are then largely unaffected by the age of the service providers' assets. This tariff

[8] In current cost accounting (CCA) where asset values are expressed in nominal terms, the cumulative adjustment required to achieve a given pattern of depreciation (e.g., straight line) in real rather than nominal terms—to ensure that accumulated depreciation keeps up with inflation—is known as the 'depreciation backlog' (Whittington, 1983, pp. 164–6).

characteristic is thought to mirror product prices in actual competitive markets for capital intensive products (e.g., airline tickets [ACCC, 1999a, p. 47]).

The real linear depreciation scheme employed by the ACCC and other Australian regulators can be described mathematically as follows. Nominal written down asset value at time t is

$$DORC_t = ORC_0(1+i)^t \left\{ \frac{T-t}{T} \right\}$$

where i is the inflation rate, T is asset expiry date and ORC_0 is the nominal opening asset value.

Nominal depreciation expense in period t is then

$$\begin{aligned} DORC_{t-1} - DORC_t &= ORC_0(1+i)^{t-1} \left\{ \frac{T-(t-1)}{T} \right\} - ORC_0(1+i)^t \left\{ \frac{T-t}{T} \right\} \\ &= ORC_0(1+i)^{t-1} \left\{ \frac{1-(T-t)i}{T} \right\} \\ &= 100(1.05)^2 \left\{ \frac{1-(5-3).05}{5} \right\} = \$19.85 \quad \text{for } t = 3, \end{aligned}$$

and the sum of depreciation expenses over all T periods is

$$ORC_0 \sum_{t=1}^{T} (1+i)^{t-1} \left\{ \frac{1-(T-t)i}{T} \right\} = ORC_0 .$$

The economic incentives of the asset owner in relation to its chosen depreciation scheme are straightforward. Depreciation is a return of capital out of the pool (RAB) earning a regulated ('guaranteed') rate of return (WACC). If the regulated WACC is acceptable—or more than acceptable—then the asset owner will want to depreciate its assets only minimally or not at all. The reason for this is that once a depreciation expense is recognized, the owner is 'paid out' that amount and hence does not earn a regulated WACC return on it any more. Note that neither the NPV of the investment nor its IRR (here equal to the regulated WACC) is affected, only its duration. All else being equal, an investment returning a high IRR (regulated WACC) will be extended as far as possible. This is achieved by minimizing and thus effectively postponing ('back-loading') depreciation write-downs. Constraining the service provider's economic desire for minimal depreciation is its obligation to pay interest and dividends. Asset write-downs provide cash flow and in this way are advantageous. Ultimately the asset owner will have to compromise between its competing desires of maximizing the asset pool earning the regulated WACC and at the same time paying a stream of dividends to shareholders of sufficient amount and consistency.

PRIVATE SECTOR REJECTION OF RC VALUATION AS TOO SUBJECTIVE

DORC and its close relatives (DRC and 'deprival value') have a long and chequered history in the accounting literature. During the era of high inflation in the 1970s and 1980s there was a strong push in the U.K., Australia and New Zealand for shifting the basis of external financial reporting in the private sector away from the traditional historical cost (DAC) framework onto a replacement cost (RC) footing (Clarke, 1982; Tweedie and Whittington, 1984). Ultimately, after extensive scrutiny, the RC proposal was defeated from both within and outside the accounting profession (Pong and Whittington, 1996; Tweedie and Whittington, 1997). This was for a multitude of reasons, of which perhaps the most telling was the inherent practical difficulty of measuring the RC of assets in any way 'objective' or independently verifiable,[9] and hence the latitude for management interference in the asset values and related cost measures: 'There is no way in which the resultant income and capital measures can be treated as being independent of management' (Peasnell, 1984, p. 192).

Because of their subjectivity, Whittington, a stalwart of the RC debate and an in-principle supporter of RC for financial reporting purposes (although not tariff regulation), effectively dismisses the possibility of RC methods becoming standard financial accounting practice:

> The accounting standard perspective suggests that CCA [replacement cost accounting] is, at best, a remote prospect as standard accounting practice in the UK. Systematization of the valuation base, to include more current values, possibly on a VTB [deprival value] basis, has been proposed rather tentatively. However, the subjectivity of such valuations, especially for specific operating assets, such as plant and machinery, is likely to rule them out as standard practice for some time. (Whittington, 1994, pp. 88–101)

> [T]he U.K. government decided (in 1982, and contrary to earlier indications) that CCA was too unreliable to be used as a basis for corporate tax. (Whittington, 1998b, p. 28)

DORC is Unauditable

Auditing in the sense of independent corroboration (Wolnizer, 1987) is impossible with DORC. No two firms of valuers working independently can be expected to come up with equal or even nearly equal DORC valuations. The problem is that DORC valuations embody multiple subjective and at worst completely arbitrary choices, and can only be verified when these are specified and taken as given:[10]

[9] There were also problems with finding any workable concept of financial or operating 'capital'. These are essentially irrelevant here because the tariff equation has its theoretical justification not in an accounting concept of 'capital maintenance' but in its reconciliation with the NPV (economic value) of the tariff stream (Whittington, 1998a, p. 96).

[10] Walker *et al.* (2000a) have recently shown up this deficiency in the financial reports of several water and electricity utilities in N.S.W. IPART (2000, pp. 75–6) recognizes 'the considerable range in estimates of the DORC value of AGLGN's assets', noting one expert valuation of ' "new entrant" DORC of $1,900m–$3,300m'.

> It is very easy for experts to disagree on DORC valuation, since it requires the exercise of a large amount of discretion, and of engineering judgment in particular. It is not unusual to find that even a minor change in assumptions can result in a DORC valuation differing from an original assessment by 30% or more, and there are already examples of this range of variation in the various regulatory decisions in both electricity and gas in Australia . . . In the case of the Victorian transmission network, the author is aware of studies which showed that the entire 500kV network in that State could be replaced with a 330kV network involving the same number of tower lines and performing the same functions—but perhaps involving 60–70% of the cost. This degree of optimization would have substantially reduced the DORC valuation of the transmission network assets, but was not undertaken by the Government (Booth, 2000, pp. 8–9).

The unavoidable discretionary choices that underlie all DORC valuation occur in response to the following problems:

1. The *asset definition* problem: The cost of replacing an asset depends on how that asset is defined. Is it the physical item in question (e.g., a pump) or its future service potential (the latter, following Fisher, 1906, and Canning, 1929, is the usual accounting definition of an asset). Since the measurement required is ORC rather than RC, it is implicitly the latter. But what specifically constitutes ‘service potential’, and for how long and to whom, and by what measure? This raises the issue of expected useful life. Just how much service potential does an existing asset have left? Is it 25 per cent or 55 per cent depreciated in this regard? Will it be bypassed and will the energy (e.g., gas) available at its source remain economically extractable? There are no objective (uniquely sensible) criteria on which to answer any of these questions. The engineering valuer has no alternative but to rely on discretionary ‘professional judgment’ and therefore retains the ability to arbitrarily affect the bottom line.
2. The *optimization problem*: By what engineering criteria is an asset or arbitrary grouping of assets optimized? How far is the engineer allowed to go in hypothetically re-designing the asset base? Is it only a matter of fine-tuning or should the engineer start with a blank canvass (e.g., green-fields Melbourne)?[11] What customer base (throughput) is relevant: is it the current situation or a projection of demand in five or twenty-five years time? Does the notion of asset optimization relate only to cost or more to a set of engineering parameters? If both, which should be given more emphasis? Moreover, if the notion of an engineering optimum depends on cost, is there a different optimum for every different cost level?
3. The *quote variance problem*: If the valuer relies on just one estimate of the RC of a particular asset (however defined for the purpose of getting a quote) then the valuation is subject to high sampling error (variance). If a larger sample of quotes is drawn, which of the widely differing valuations should be given the most weight?

[11] For example, Ergas and Smart (2000, p. 14) in discussing the DORC value of Sydney airport find that the efficient (minimum) replacement cost ‘is likely to be represented by a green field airport on relatively cheap land’.

4. The *aggregation* or *additivity* problem: In general, the RC of a conjunction of assets {*a*, *b*, *c*, *d*, *e*} is not equal to the sum of the RCs of the individual assets {*a*}, {*b*}, {*c*}, {*d*}, {*e*}. Nor is it equal to the sum of the replacement costs of any mutually exclusive and jointly exhaustive subsets of those assets, such as, for example, {*a*, *b*, *c*} ∩ {*d*, *e*}. Moreover, by re-partitioning the asset set into another of its possible groupings, such as, say, {*a*, *b*} ∩ {*c*, *d*, *e*} or {*a*} ∩ {*b*, *c*, *d*} ∩ {*e*}, the aggregate replacement cost can be made arbitrarily higher or lower. To escape this arbitrariness, practitioners suggest that the appropriate asset bundling is that which minimizes aggregate RC, a rule consistent with the notion of 'optimized' RC (ACCC, 1999a, p. 44). The problem with this *ad hoc* criterion is that it generally leads to a very high level of aggregation. Natural economies of scale mean that hypothetical asset replacement cost is minimized, in the limit, when infrastructure is replaced as a 'single' asset. But at such high levels of aggregation, RC quotes are bound to exhibit extreme variance from one estimate to another, based on different guesses about the potential economies of such large scale construction. The 'least cost' rule is therefore generally ineffective in removing subjectivity and discretionary latitude from the bottom line. By culminating in the entirety of the firm's assets being defined as one, it effectively defeats the purpose of a 'balance sheet' (sum of assets) approach to asset valuation.

Bureaucratic Suppression of Criticism

During the private sector RC debate of the 1970s and 1980s, DORC style asset valuations were disparaged and ultimately rejected for their incorrigible subjectivity and inherent susceptibility to 'creative accounting'. There is nowadays a consensus among academics who fuelled this debate that little of what was learned has reached or been heeded by those now advocating RC for use in the public sector:

> [W]hat does seem to be unjustifiable is the apparent lack of a coherent approach to the issue of 'current value' accounting in the non-business sector. There seems to have been no concerted effort to draw lessons from the ultimately unfavourable attitude of business. The various regulations give the impression of as many *ad hoc* choices, sometimes leading to possibilities of opportunistic accounting policies, sometimes resulting in figures which even the entities involved have difficulty interpreting. (Camfferman, 1998, pp. 25–6)

> Clearly those who have promoted the drift of both DV [deprival value] and ODV into the public sector have either not heeded that experience with CCA, DV and related concepts in the private sector, or did not know of it. If it is the former, then the public sector reformers must be considered to suffer a certain lack of candour. (Clarke, 1998, p. 16)

RC-based accounting has been promulgated at all levels within the Australian public sector. In 1994 the Steering Committee on National Performance Monitoring (SCNPM, 1994) set out to institutionalize an RC framework by its publication and wide dissemination of asset valuation guidelines closely resembling those of the various CCA (current cost accounting) proposals of the 1970s. In supporting RC (in fact 'deprival value') without qualification or reference to any of the relevant academic or professional literature, this publication (known as the 'red book') effectively suppressed all existing criticism of RC valuation methods, thereby raising questions of the competence if not integrity of the political process that led to RC being adopted (Johnstone and Gaffikin, 1996; Johnstone and Wells, 1998a, 1998b). The same questions now arise in regard to the regulators' all but unqualified and seemingly ideological support for DORC. In all their various publications dealing with the asset valuation issue, there is no mention whatsoever that RC has an extended history of rejection in the private sector.

The other significant precedent overridden or ignored by regulators—and unmentioned in their written deliberations—is that in the U.S.A. where asset valuation for the purposes of tariff setting has a hundred year history and a vast literature, replacement-cost-based asset valuation has either not been taken seriously or considered and rejected. The authoritative American text on asset valuation for regulation purposes, Bonbright *et al.*, (1988, pp. 296–8), rejects replacement cost valuation as being administratively impractical. For example (see also later quotes):

> [T]he answer must lie in a recognition by practical minded judges, commissioners, and experts, that estimates of the cost that would be incurred in replacing the service by means of a new type of plant if the existing plant were to disappear into thin air are altogether too speculative and too litigious for purposes of feasible administration. When one considers, moreover, that the replacement might well take the form of a change in the very nature of the service, and not just a change in the design and location of the plant —a change, say, from house-heating by gas to heating by electrically-operated heat pumps, etc.—one need not be surprised that the replacement-cost-of-service theory remains today a paper theory. (Bonbright *et al.*, 1988, p. 298; in the words of Bonbright 1961)

> Persons who dislike reproduction cost condemn it for its confusion, its indeterminacy, and its invitation to endless controversy between corporate or investor interests and consumer interests. For reasons . . . presented by Professor Bonbright (1930, pp. 334–410), our convictions support [this] position. (Bonbright *et al.*, 1988, p. 222)

THE REGULATORS' ARGUMENT FOR DORC

Asset owners' formal submissions to regulators and the written determinations of the regulators themselves (particularly ACCC and ORG) contain repeated, albeit scantly supported, claims that replacement cost asset valuation, particularly DORC, has a derivation in economic theory (e.g., ORG, 1998b, pp. 12–13; ACCC, 1999a, pp. 39–40). This view has been recited to the point that its validity is widely taken for granted, albeit without demonstration or acknowledged authority (cf. Productivity Commission, 2001, pp. 216, 220, 222).[12]

[12] The consultant on tariff setting issues with most sway over the ACCC is economist Stephen King of the University of Melbourne. In several of his papers King has argued that DORC (and possibly the building block model in general) is inappropriate in this function (e.g., 1996, p. 295). For example, King (2000a, p. 7) writes 'as I have noted elsewhere, the contestability justification for DORC is dubious and it may not be desirable to replicate the fictitious path of revenues that result from the contestability model' (see also p. 2). However, in his most recent work, King (2001a, p. 5) concedes that despite his previously oft-stated critique of DORC, he will for the sake of assisting in current deliberations take DORC as given. This resignation would seem to be indicative of the ACCC's committed and apparently axiomatic acceptance of DORC.

The economic argument on which the regulators justify their commitment to DORC, as best as can be construed from their published statements, is that RAB = DORC emulates rational market settings by producing the highest possible tariffs short of those at which a new entrant might be encouraged to duplicate the existing provider's infrastructure (and compete for those tariffs). According to this argument, a profit maximizing asset owner, operating opportunistically in a free market, would fix tariffs at this level for the long run:

> One interpretation of DORC is that it is the valuation methodology that would be consistent with the price charged by an efficient new entrant into an industry, and so is consistent with the price that would prevail in the industry in long run equilibrium. (ACCC, 1999a, p. 39)

> [A]ny value that is in excess of DORC is likely to produce Reference Tariffs that will expose the Service Provider to being by-passed. (ORG, 1998b, p. 58)

The economic theory underlying this conclusion is built around a construct called Tobin's *q*, after its inventor, Nobel prize winning economist James Tobin. Tobin's *q* is defined as the ratio of the value of the firm to the replacement cost of its assets. That is:

$$q = \frac{M}{ORC_{used}} ,$$

where M is defined as the market value of the firm's securities (debt plus equity) and ORC_{used} is the minimum (optimized) cost of replacing its current productive capacity, making allowance for the fact that some of its assets are not of the same capability as when they were new (i.e., they are used). Tobin introduced the *q* ratio as a way of measuring the level of monopoly power of the firm (Brainard and Tobin, 1968; Tobin, 1969) and of assessing the market incentive for further capital investment. Large *q* is associated with monopoly profits or economic rents (i.e., profits exceeding costs, including capital costs), these being capitalized by the market in its assessment of M.

In the absence of monopoly rents, the value of *q* is expected to be near one. For *q* to exceed one, the market value of the firm (the present value of its projected net cash flows) must be greater than the RC of its assets. In these conditions there are incentives for new entrants or for expansion by existing firms, with the effect that prices will be reduced and *q* driven towards a value of one:

> The essence of the argument is that for a competitive firm, one would expect q to be close to one, and as we examine firms with increasing monopoly power (increasing ability to earn above a competitive return), q should increase. If a firm's q is greater than one, the market value of the firm is in excess of its replacement cost. If there is free entry other firms could enter the industry by purchasing the same capital stock as the existing firm. Furthermore, they would anticipate an increase in value over their investment because its market value would exceed its cost. Thus, in the absence of barriers to entry and exit, q will be driven down toward one as new firms enter. (Lindenberg and Ross, 1981, p. 2)

According to Tobin's argument, $q = 1$ characterizes a firm operating in a competitive market in long run equilibrium. In these circumstances, the firm is extracting the maximum attainable income stream (product price) without admitting any opportunity to potential price cutting competitors. Conversely, if q was less than one there would be no incentive for existing firms to renew their assets and the number of competitors would shrink to the point where prices could be raised and q pushed back towards one.

The economic logic of $q = 1$ is easily understood in the context of a simple example. Suppose that a shopkeeper pays a carrier x per parcel for deliveries. At some point (dependent on volume) x becomes so high that the shopkeeper can more economically buy a truck and employ a driver. Or a new entrant can set up and displace the existing carrier. This is the price at or below which the contractor must work if he is to hold on to his customer base and maximize profits (return on capital) over the long run. On the basis of this logic, $q = 1$ is taken to be the definitive feature of an appropriately regulated monopoly, stripped of monopoly rents (i.e., of returns above costs, including capital costs):

> [A] firm which is regulated so as to earn no monopoly rents would have a q close to one. A monopolist, however, who can successfully bar entry and is not adequately regulated will earn monopoly rents in excess of ordinary returns on the employed capital. The market will capitalize these rents, and the market value of the firm will exceed the replacement cost of its capital stock, that is q will persist above one. (Lindenberg and Ross, 1981, p. 2)

> It can be argued that in a competitive market, if a supplier charges a price above minimum efficient cost of supply, then new entrants will be attracted into the market by the abnormal profits which are available; as a result, market prices for outputs, and the market value of business enterprises supplying those outputs will tend towards cost . . . The above propositions are consistent with the theory of the relationship between the market value of assets and their replacement cost developed by the economist James Tobin. The ratio of the market value of a company's debt and equity to the current replacement cost of its assets is known in the finance literature as *Tobin's Q*. Tobin argued that when Q is greater than 1 (that is, when capital equipment is worth more than it costs to replace), firms have an incentive to invest, and that they will stop investing when Q is less than 1 (when equipment is worth less than its replacement cost) . . . On this basis . . . it is accepted, in principle, that the use of ODRC [DORC] asset values and a market based estimate of the WACC is intended to mimic the outcomes of a competitive market. (ORG, 1998a, p. 5)

To measure q the regulator has to find the minimum ('optimized') RC of the firms used assets, or more precisely, of the cost of replacing the partially depleted productive capacity represented by those used assets. With there being no second-hand markets for the kinds of assets in question (excepting scrap metal markets), regulators have treated DORC as a proxy for the cost of used assets, and hence implicitly re-defined Tobin's q as

$$q = \frac{M}{DORC}.$$

The final step in the regulators' program to impose $q = 1$ is to fix the initial regulatory asset base, RAB_0, such that the market value of the entity, M, equals DORC. Thinking of M as the PV of the tariff stream, this requires merely that $RAB_0 = DORC$, since $PV = RAB_0$ as shown by equation (4) above.

THE REGULATORS' THEORY CORRECTED

The regulators' standpoint on asset valuation, reiterated as faithfully as possible above, is that DORC-based tariffs mimic the discipline of a competitive market. More specifically, DORC is held out as the upper limit on RAB, above which a new entrant would be attracted, and is therefore the asset base on which a profit maximizing asset owner would fix tariffs in a contestable market:

> A return on replacement cost is the maximum that a monopoly firm could earn in a perfectly contestable market. (ACCC, 1998b, p. 32)

> [I]f prices reflect a value that is in excess of DORC, then users would be better off if the existing system were scrapped and replaced by new assets. (ACCC, 1999a, p. 40)

This argument requires that DORC equals or approximates the amount that a new entrant would have to pay to replicate existing infrastructure. The difficulty, however, is that a new entrant in the market for energy transmission services would have to pay full (undepreciated) ORC to duplicate (bypass) existing infrastructure. There is no second hand market on which one can buy an *in situ* electricity grid or a gas pipe network, or even the individual components thereof.

Allowing for this market reality, King (2001a, p. 8) specified a present value model which correctly defines the competition exclusion limit on the regulatory asset base. This model is clarified and completed below. The end result is a logical reconstruction of DORC effectively correcting the regulators' theoretical framework.

Consider the position, at time t, of a potential new entrant under the assumption that any replaced assets last 'forever' (i.e., to the point that subsequent cash flows make no difference in PV terms). Suppose that the new entrant expects to take from the incumbent a proportion ρ of the existing (projected) tariff stream, tariffs being set by the regulator based on the incumbent's book DORC (as per tariff equation (3) above).

Under these assumptions, the new entrant, commencing operations at time t, would earn tariffs worth (at time t)

$$\left\{P_t + \frac{ORC_t(1+g)^{T-t}}{(1+WACC)^{T-t}}\right\}\rho$$

where ORC_t is the time t replacement cost of all new assets, g is the (technology dependent) growth rate of this replacement cost, WACC is the regulated and actual cost of capital, T is the time at which the incumbent's assets require replacement, and $P_t = \mathrm{RAB}_t$ is the present value at time t of the tariff stream to be earned by the incumbent from existing assets over the years between t and T. The second term within the parentheses represents the PV (at time t) of the tariffs generated by new assets built by the incumbent at time T (when existing assets expire).

There is no obvious basis on which to estimate the new entrant's possible market share, but to be consistent with the regulators' argument, it is assumed that $\rho = 1$, meaning that the new entrant will completely displace the incumbent, taking over the entire tariff market (ORG, 1999, p. 17). This is of course an unrealistic possibility (see below), and can be treated only as a 'theoretical' limiting case. Its event would require circumstances where, for example, the new entrant, before making any investment, tied all asset users into very long term (e.g., thirty year) futures contracts. Equivalently, the new entrant might theoretically be a co-operative of all asset users, bound together by long term agreements to self-supply using newly constructed assets bypassing those of the incumbent.

Taking the indifference condition for new investment as NPV = 0 (at discount rate r = WACC), a potential new entrant is motivated to enter the market provided that the PV of its tariff revenues equals the cost of all new assets, ORC_t. Thus, on the assumption of $\rho = 1$, the time t new entrant condition is

$$\left\{P_t + \frac{ORC_t(1+g)^{T-t}}{(1+WACC)^{T-t}}\right\} = ORC_t. \tag{6}$$

Put another way, the PV of future (remaining) tariffs flowing from existing assets (RAB_t) required to motivate a new entrant is

$$P_t = ORC_t\left\{1 - \left[\frac{1+g}{1+WACC}\right]^{T-t}\right\}.$$

Provided that the asset inflation rate g is not greater than or nearly equal to WACC, and the remaining life of the incumbent's assets $T - t$ is large, it follows that P_t is approximately ORC. These conditions are typical of energy infrastructure assets ('pipes and wires'), the replacement cost of which is commonly contained or even reduced by technological progress. In effect, therefore, the regulators' economic framework implies a RAB close to ORC, and thus invites the incumbent to 'arrange' an ORC valuation such that book DORC—however set by the regulator—approximates true ORC, thereby laying claim to a stream of tariffs consistent with existing transmission assets being all near new. For instance, suppose the regulator agrees to DORC at 75 per cent of ORC, as is quite typical of Australian regulatory determinations. Then book ORC can be inflated to 1/0.75 = 133% of true ORC without introducing any opportunity for a new entrant.

Dynamic Reconstruction of DORC

It is clear from their statements of economic logic that the ACCC/ORG intended in principle (if not consequence) to employ the new-entrant-exclusion condition, here represented by equation (6), to set the initial regulatory asset base, $RAB_0 = P_0$. Given that existing infrastructure assets will generally not require replacement for many years (if ever), this static application of (6) almost always leads to RAB_0 near ORC_0, as shown above. There has been no suggestion, however, that the same economic logic will play any part in determining subsequent written down asset values, RAB_1, RAB_2, etc. Rather, regulators have not committed to any one depreciation scheme, and have generally treated the time pattern of depreciation as something to be settled between themselves and the various interested parties, particularly asset owners and users (see above).

To be consistent in their proposed regulatory asset valuation logic over time, equation (6) must be applied continually over time, re-setting RAB_t at the end of each year (at each time $t \leq T$) to its maximum possible, new entrant exclusion level P_t. Such dynamic application of (6), introduced in a submission to the ACCC by Agility Management (2000) and clarified by King (2001a), makes sense of the regulators' argument for DORC. It requires that DORC be re-defined dynamically, not as an essentially arbitrary (e.g., straight line) function of ORC, but specifically as the time-dependent new entrant tariff threshold P_t. That is,

$$DORC_t = P_t = ORC_t \left\{ 1 - \left[\frac{1+g}{1+WACC} \right]^{T-t} \right\} \tag{7}$$

where $DORC_t$ represents the value of DORC at period end t. Understood this way, $DORC_t$ is by definition the theoretical new entrant exclusion bound on RAB_t (i.e., on RAB_1, RAB_2. . . . etc.), and the regulators' economic argument for DORC is rationalized. However, to meet the requirements of this corrected theory, the ACCC and other regulators must recognize and apply the full consequences of (7), including particularly its implied depreciation scheme.

Implied Depreciation

Definition of $DORC_t$ as the competition exclusion limit P_t implies a scheme of depreciation where the period t write-down, $P_{t-1} - P_t$, is from (7)

$$ORC_{t-1} \left\{ 1 - \left[\frac{1+g}{(1+WACC)} \right]^{T-(t-1)} \right\} - ORC_t \left\{ 1 - \left[\frac{1+g}{(1+WACC)} \right]^{T-t} \right\}.$$

Simplifying this expression gives period t depreciation

$$P_{t-1} - P_t = ORC_{t-1} \left\{ WACC \left[\frac{1+g}{1+WACC} \right]^{T-t+1} - g \right\}$$

$$= ORC_T \left\{ \frac{WACC}{(1+WACC)^{T-t+1}} - \frac{g}{(1+g)^{T-t+1}} \right\}. \tag{8}$$

If the economic logic underlying regulatory asset valuation is to continually re-set RAB_t over all $t \leq T$ to the theoretical maximum no-new-entrant level, any other depreciation pattern (e.g., straight line) is inadmissible. This point of economic logic is stressed by King (2001a) in his commissioned report to IPARC (Independent Pricing and Regulatory Commission) responding to the Agility submission: 'No other form of adjustment from ORC to DORC is consistent with the economic justification for DORC' (King, 2001a, p. 10).

Although not by design, equation (8) with $g = 0$ coincides with the ACCC (1999a, p. 66) definition of 'annuity depreciation' (a special case of their 'competition depreciation'; see above). The term 'annuity depreciation' arises for the reason that when $g = 0$ the tariff stream ensuing from depreciation defined by (8) is an annuity. That is, tariffs are constant over all periods $t \leq T$. This is demonstrated below.

Effect on Tariffs

The full tariff consequences of the reconstruction of DORC_t specified in equation (7) are revealed as follows. Apart from operating costs, the tariff paid to asset owners at time t is from equation (3)

$$[P_{t-1} - P_t] + (P_{t-1} \times WACC).$$

Substituting for P_{t-1} and $P_{t-1} - P_t$ using (7) and (8) gives a time t tariff equal to

$$ORC_{t-1}\left\{WACC\left[\frac{1+g}{1+WACC}\right]^{T-t+1} - g\right\} + ORC_{t-1}\left\{1 - \left[\frac{1+g}{(1+WACC)}\right]^{T-t+1}\right\}WACC$$

which simplifies to

$$ORC_{t-1}[WACC - g]. \tag{9}$$

In the case of infrastructure assets, g is likely near zero (in real terms). With $g = 0$, period t tariff is a constant (ORC × WACC), where ORC is the initial and constant (since $g = 0$) optimized replacement cost of all new assets. This is in effect the same result as if the asset owner postponed all depreciation until asset expiry date T. A full return of ORC would be reimbursed at that time T, which from today's (time t) perspective would have effectively zero present value (again assuming large $T - t$).

A corollary of this equivalence (in present value) between annuity depreciation and non-depreciation is that if the regulated WACC exceeds the true WACC, asset owners' optimal depreciation scheme is annuity depreciation. In these circumstances, owners would prefer to take no depreciation returns of capital (thus not reducing the pool producing the positive spread between regulated and true WACC). This is not allowed, but for long-lived assets, annuity depreciation produces mathematically the same result. More formally, as $T - t$ increases, the owner's NPV based on annuity depreciation approaches that based on no depreciation at all, and for $T - t = 30$ say, this equivalence is virtually exact.

Numerical consequences of the DORC reconstruction outlined above are exhibited in Figures 1 and 2 below.

Figure 1 graphs the behaviour of DORC_t over all periods $t \leq T$ ($T = 30$) under the parameter values $g = -0.02$, $g = 0$ and $g = 0.05$. These results are based on an ORC_0 of \$100 and a WACC of 7.75 per cent. Figure 2 shows corresponding period t tariffs over the same time interval $t \leq T$, with the same three possible values of g.

FIGURE 1

DORC OVER TIME $t \leq T$ ($T = 30$ AND $ORC_0 = 100$)

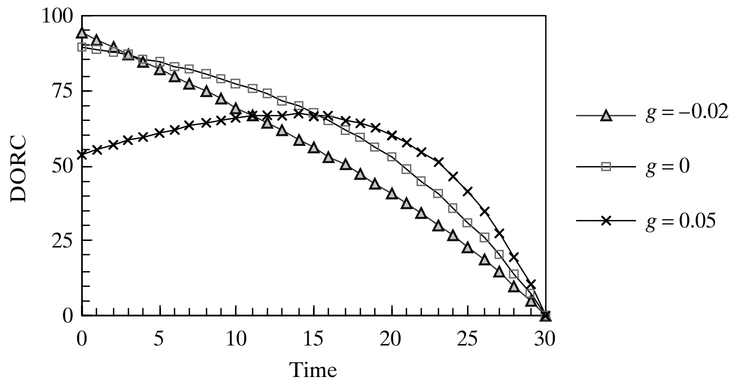
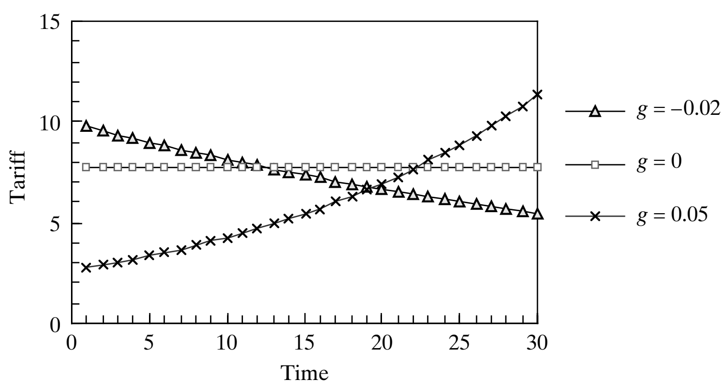


FIGURE 2

PERIOD TARIFF OVER TIME $t \leq T$ ($T = 30$ AND $ORC_0 = 100$)



Some explanation of these functions is warranted. To understand the behaviour of $DORC_t$, it is helpful to rewrite (7) as

$$DORC_t = ORC_t - \left[\frac{ORC_t(1+g)^{T-t}}{(1+WACC)^{T-t}}\right]$$
$$= ORC_t - \frac{ORC_T}{(1+WACC)^{T-t}}\,. \tag{10}$$

This alternative expression reveals that $DORC_t$ is equal to ORC_t minus the present value of the cost of new assets due at T. In general, therefore, $DORC_t$ falls as T (asset replacement) approaches. The exception to this rule is where g is high meaning that ORC_t increases rapidly over time, in which case $DORC_0$ is very low relative to ORC_0. This can be explained by the insight that with high g the cost of new assets is growing quickly, and therefore a new entrant is more motivated than when g is zero or negative to invest immediately rather than wait until T. To close off this heightened threat of system bypass, the incumbent can afford only low DORC_t in the early periods. Tariffs then rise for a time with increasing ORC_t, and finally, as expiry draws closer, the physical state (short remaining life) of existing assets takes over and their value approaches zero regardless of the cost of their replacement (i.e., regardless of the asset inflation rate g).

Turning now to Figure 2, note from (9) that time t tariff is a linear function of ORC_{t-1}. When ORC_{t-1} is constant ($g = 0$), so are tariffs, and when ORC_{t-1} increases (decreases) tariffs do also, provided that WACC > g. Such direct positive connection between maximum (new-entrant-exclusion) tariffs and the replacement cost of the underlying infrastructure is an intuitively plausible aspect of the reconstructed theory of DORC. The most striking observation in Figure 2 is the initially very low level of tariffs under high g. This relates to the correspondingly low DORC and is explained (the same way) by the added impetus to bypass aging assets when their replacement cost is rising quickly.

To see the 'g effect' clearly at work, imagine that g = WACC. In this case, DORC_t and thus period tariff is always zero as per equations (7) and (9). There are several ways to understand this. The most intuitive is that because the cost of new assets is growing at a rate equal to the cost of capital, there is no reason not to make their inevitable replacement immediately. By implication, existing assets are redundant and valueless.

A formal proof of this result is as follows. The cost of new assets at any time t is ORC_t. If g = WACC, this is exactly equal to the present value of the cost of new assets in one period's time. That is,

$$ORC_t = \frac{ORC_t(1+g)}{(1+WACC)} = \frac{ORC_{t+1}}{(1+WACC)}.$$

It follows, therefore, that the investor (either the incumbent or a new entrant) is indifferent between buying new assets today or at any time in the future. Replacement of existing infrastructure will therefore occur immediately unless transmission services are provided by the incumbent free of any capital charge. Existing assets are thus of no value.

The more extreme possibility is g > WACC. In these circumstances, the incumbent or new entrant is motivated to buy new assets as soon as possible, since their cost is increasing at a rate greater than the cost of capital. In this case, existing infrastructure takes not zero, but negative value, since the capital component of tariffs must be negative (owners must pay users) if system bypass is to be prevented. This will of course not occur, since the incumbent is better off ceasing all operations. System replacement will therefore proceed immediately, as is sensible in the circumstances.

Note that the dynamic DORC reconstruction described above, including all equations and calculations, holds either in real or nominal terms. All that is required is consistency. Thus, if WACC and g are expressed in real (nominal) terms, then P_t, ORC_t, and DORC_t must be in real (nominal) dollars.

New Entrant IRR

System bypass with tariffs defined by (9) offers, at any time t, an IRR equal to the regulated WACC. Proof is as follows. A new entrant invests ORC_t at time t, and acquires the remaining tariff stream from existing assets (beginning at time $t + 1$ and ending at time T), plus a tariff perpetuity thereafter (beginning at time $T + 1$). The IRR on this investment is given by r such that

$$ORC_t = \sum_{j=t+1}^{T} \frac{ORC_{j-1}(WACC - g)}{(1 + r)^{j-t}} + \sum_{j=T}^{\infty} \frac{ORC_j(WACC - g)}{(1 + r)^{j+1}} .$$

Simplifying this equation gives

$$ORC_t = ORC_{t-1}(WACC - g)\left[\frac{1}{(1 + k)} + \frac{1}{(1 + k)^2} \ldots + \frac{1}{(1 + k)^{\infty}}\right]$$

$$= \frac{ORC_{t-1}(WACC - g)}{k}$$

where $(1 + k) = (1 + r)/(1 + g)$, and then eliminating k

$$(1 + g) = \frac{(WACC - g)(1 + g)}{(1 + r) - (1 + g)}$$

leaves r = WACC. It follows, therefore, that a time t new entrant obtains IRR = WACC, regardless of t.

Bell and Peasnell (1997)

Although developed independently, the mathematical model of regulatory asset valuation and depreciation detailed above has much in common with a model proposed by Bell and Peasnell (1997) defining the value of a used asset (of arbitrary age) as a function of (a) the replacement cost of a new asset, (b) the different lives and maintenance cost streams of used and new assets, and (c) the opportunity cost of capital. Apart from superficial differences such as those of context and formal presentation (e.g., expression in terms of equivalent annual cost measures rather than actual cash flows) the two models are analogous. The only differences of any substance are that (a) the model above allows for asset price changes over time (real or nominal) through its growth factor g, and (b) in the regulatory case, there is no need to allow for the disparity in maintenance cost streams between new and used assets as the regulators' tariff formula simply reimburses the owner for these regardless of whether they are high because of old assets or low because of new ones. To our knowledge (personal communication, 2002), no like model exists in economics literature on the theoretical market value of a used asset (regulated or otherwise) relative to the price of a new replacement and the respective (differential) capital costs. This would seem to be an important topic for further development in the three related disciplines, finance, accounting and economics.

MORE PRACTICAL CONSIDERATIONS

In theory, $DORC_t \equiv P_t$ is the RAB level at which a new entrant (system bypass) is economically viable. More realistically, it is likely that even full ORC underestimates the level required of RAB to entice a new entrant. Indeed, even at tariff levels well above those based on 100 per cent ORC, the real world possibility of large scale network bypass is likely to remain negligible. Supposing tariffs were so high as to induce a competitor, or user cooperative, to contemplate green-fields duplication of such massive infrastructure, what market share would such a new entrant be guaranteed when the incumbent could hit back with lower tariffs commensurate with the relatively very low marginal capital costs attaching to sunk assets? At this point the two competing networks would both be sunk, forcing the competitors into either sharing the market or a price war based in the extreme on short run marginal costing. Neither prospect is likely to appeal to any potential new entrant. For very much the same reason, Baumol *et al.* (1982, pp. 290–1) interpreted the incumbent's sunk costs as effectively a barrier to new entrants:

> Sunk costs to some degree share with entry barriers the ability to impede the establishment of new firms . . . the incremental cost, as seen by a potential entrant, includes the full amount of the sunk costs, which is a bygone to the incumbent. Where the excess of prospective revenues over variable costs may prove, in part because of the actions of rivals, to be insufficient to cover sunk costs, this can constitute a very substantial difference. This risk of losing unrecoverable entry costs, as perceived by a potential entrant, can be increased by the threat (or the imagined threat) of retaliatory strategic or tactical responses of the incumbent . . . The additional expected revenue that a potential entrant requires as compensation for the excess of its incremental cost and incremental risk over those of the incumbent becomes an entry cost as defined here and permits the incumbent to earn corresponding profit (rent).

Consider, for example, a new entrant with the prospect of, say, a 50 per cent market share. Thinking in no more than these simple terms, tariffs would have to be based on a RAB (book DORC) of double-ORC or more before any genuine possibility of economically driven duplication could occur. Given the manifest risks, technological and other barriers to entry, and general political inconceivability of any investor, private or government, duplicating already functional and typically much less than fully-utilized energy transmission networks, the RAB level truly required to prompt such a decision is hard to imagine. In reality it is only in circumstances where existing infrastructure assets are at or approaching full usable capacity, or grossly below par (e.g., technologically defective or greatly inefficient in terms of operating costs) that there is actually any threat of a new entrant. This is openly conceded by the ACCC, at least in relation to the main trunks of existing networks: 'While the significant entry and exit costs that characterize electricity transmission make large-scale duplication of the existing system unlikely, by-pass may be feasible at the edges of the network' (ACCC, 1999a, p. xi). The practical effect of this economic and political reality is that incumbent asset owners, establishing their initial RAB, are virtually unrestrained by the risk of competition, contrary to the regulators' economic logic. In practice, initial DORC could be set at double-ORC and there would remain negligible chance of a new entrant and large scale system bypass. This must be obvious to asset owners, and is bound to encourage pervasive overstatement of asset values (ORCs and thus DORCs).

The most effective constraint on existing asset owners' initial DORC valuation, apart from any indirect benchmarking by the regulator, is the level to which the 'independent' engineering valuers, hired by asset owners to find this value, are ready to stretch. Given the alleged failures of independence of auditors in other, innately less subjective asset valuation contexts, the analogous economic incentives applying to engineering based DORC-valuers in tariff setting, and the scope for 'creative engineering', should be of serious concern to regulators.[13] When seen in this light, the market discipline purportedly inherent to tariff settings based on DORC is more a product of economic sophistry than economic theory.

BROADER ECONOMIC ARGUMENTS AGAINST REPLACEMENT COST

The practicalities raised above suggest that DORC, interpreted as the new entrant exclusion threshold, is wrong on its own terms. Whereas a shopkeeper might be motivated by carrier price rises to buy a delivery vehicle, an oil and gas producer is not so readily convinced to duplicate a thousand kilometres of gas pipeline. Widening the economic criteria on which replacement cost valuation of existing assets is evaluated strengthens this rejoinder. The following economic arguments are all relevant and all point to DORC as either having no special significance or being flawed and bound to produce undesirable outcomes. These arguments are provided not in any order of importance.

(i) DORC Not Necessary to Ensure Continued Optimal Asset Use

From the point of view of optimal resource allocation, sunk assets should be viewed only in terms of what they have left to contribute, either in use or by sale. If they are more valuable for what they can add to future production, they should be retained. Otherwise they should be sold for their remaining net realizable (scrap) value (NRV). Their cost to replace is of no relevance. The entity has already built them and the current cost of doing so again makes no difference to the present (sole remaining) decision of how best to utilize them.

Taking this resource allocation perspective, regulators must ensure that essential transmission assets are valued at or above their NRV. If the RAB value of an asset is lower than its NRV, the incumbent asset owner will rationally sell the asset (its NRV will exceed the NPV of its contribution to the tariff stream). The economic lower bound on RAB is thus NRV (Whittington, 1998a, p. 94; King, 1997, pp. 5–6; 1998, pp. 1–3). Provided RAB is not less than NRV, existing productive assets will remain in current (presumably optimal) use. Apart from the

[13] The valuer J. P. Kenny (commissioned in March 1996 by the Gas Council to audit the AGLGN ORC estimates) revealed its own dissatisfaction with what was manageable and conceded that it was only the time and other constraints imposed on it that justified its 'interactive' (with AGLGN) approach to the AGLGN valuation. See Johnstone (1999a) and Energy Markets Reform Forum (2000) for general discussion regarding the AGLGN valuation process.

fact that for specialized infrastructure assets, DORC is generally (much) greater than NRV, the economic objective of continued optimal allocation of existing assets affords no special significance to RAB ≡ DORC.

(ii) DORC Harms Downstream Allocative Efficiency

The marginal capital cost of using an existing asset when that asset has little realizable value is by necessity very low. Moreover, marginal access costs are greatly overstated if capital charges are based on DORC or any asset valuation significantly higher than NRV. This leads to systematic under-use of existing transmission assets by energy users. King (1996, p. 293–5; 1998, pp. 3–4) refers to this unfortunate consequence of RC-based asset valuation as a type of allocative inefficiency. In essence, users ready to pay the long run marginal cost of access are priced out of the market by tariffs significantly greater than marginal cost:

> The deprival value methodology promoted by the draft electricity access code will set an initial base for transmission utility assets that significantly exceeds scrap value. These inflated valuations of existing, sunk assets will feed into retail electricity prices, resulting in a reduction in allocative efficiency . . . The valuation rules chosen by the NGMC [National Grid Management Council] are likely to be administratively difficult, contentious and inefficient. (King, 1996, p. 295)

> To the degree that regulated asset valuations feed into uniform prices that exceed (congestion adjusted short-run) marginal cost, either directly or further down the production chain, then the deviation of price from marginal cost will lead to a reduction in trade from the economically efficient level. Such a reduction leads to what economists call an ‘allocative inefficiency’ or a ‘dead weight loss’. It represents a decrease in gains from trade from the production and consumption of the relevant product(s) compared to the best achievable level of gains from trade. (King, 1998, p. 4)

Closely related arguments on allocative efficiency underpin the rejection of replacement cost valuation by Bonbright *et al.* (1988):

> With a public utility system operating at a scale at which further enhancements in rates of output can take place with less than a proportionate increase in operating and capital costs (conditions of decreasing unit costs), such rates will exceed the incremental or marginal costs of the service. Yet, under the economists’ theory of socially optimum pricing, the important relationship between prices and costs is an equality, under long-run equilibrium conditions, between prices and *marginal* costs. Hence, if socially optimal resource allocation were to be accepted as the primary objective of ratemaking policy, as the replacement-cost advocates insist, what would be required is not a mere transfer from an original-cost standard to a replacement-cost standard, but rather a transfer from *any* standard of total cost to a standard of incremental cost . . . if we accept provisionally the assumption that most public utility enterprises are operating under conditions permitting the enjoyment of further economies of scale, and if we also assume that current replacement costs of service would be higher than historical costs, the acceptance of a replacement-cost principle would seem to be a step in the wrong direction.

From an obvious practical viewpoint, there is something wrong with a tariff base that works against expanded and perhaps even existing use of a sunk gas or electricity transmission network currently working at much less than full capacity. For a nation to build such long-lived infrastructure at great sacrifice and then not use it to anything like its available capacity for the reason that it would cost a lot to replace verges on economic absurdity. The anomalies brought about by replacement-cost-based charges for the use of under-utilized sunk infrastructure were raised in a submission by the National Farmers' Federation (2000, p. 6) to the Productivity Commission concerning the national rail access regime:

> High fixed charges for rail access may simply mean some areas go out of cultivation for bulk crops. It is worth noting that road transport does not have access charges and this is the optimal pricing strategy for public network infrastructure in the absence of congestion. If roads were charged for on the basis of fixed access charges, most regional and rural communities would be closed down. Why should other infrastructure be charged for in such a detrimental way?

It might be reasonable to restrict usage of something which has already been built if usage of itself meant deterioration, and thus additional maintenance and refurbishment costs, or if additional usage brought quickly forward the time at which the network was no longer large enough and required parallel enlargement. But in the case of Australian gas pipelines, main trunks are typically at approximately half or much less than full capacity and the additional throughput does not cause wear and tear or any economic loss.[14] Rather, the life of the network, if not effectively infinite or limited only by the energy deposits at source, is affected by corrosion rather than usage. Regardless of whether assets will require eventual replacement or not, each period of under-use represents an irrecoverable opportunity to make something of an asset which is already in place and able to be used at negligible marginal cost: 'a gasoline pipeline is available for use both now and later and a failure to use it now does not prolong its life later' (Lim and Dwyer, 2001, p. 31).

This way of thinking raises concern over the net benefits to the Australian economy of selling off infrastructure assets by attaching an artificial DORC-based profit stream to them, locking in tariffs at the high end of economic plausibility, and thus mechanically inflating asset sale proceeds. The antithetical philosophy is that there exists already a largely unused infrastructure, where extra use causes only low marginal cost, and hence an opportunity to build competitive advantage and sponsor industry by judicious transmission pricing. The choice between these two models reduces to one between money now (the proceeds of privatization) and money later (profits from downstream economic activity). Representatives of a group of Australian energy dependent companies called the Energy Markets Reform Forum have argued before the ACCC that the latter of these possibilities is overlooked in the regulators' push to enshrine DORC:

> In these cases (of natural monopoly infrastructure enjoying increasing returns to scale) marginal cost pricing is efficient and *should* result in losses. But those losses will be offset

[14] Regarding gas pipelines, B. Henson (personal communication, 18 August 1999) writes: 'Wear and tear is all but totally insensitive to throughput. There are no moving parts except a few valves, and these move in response to variations in flow, not the absolute flow rate . . . The pipe lives that have been assumed for depreciation are just that—assumptions—as there is little or no experience of replacing "natural gas era" pipelines (the last 30 years).' Henson notes also that no gas trunk built in the U.S.A. since World War II has been replaced.

> by external benefits and spin-offs. The infrastructure will generate investment, profits, employment and wages in downstream industries. (Energy Markets Reform Forum, 1999, p. 2)

It could be argued that access prices that are 'too low' equally result in allocative inefficiency, by encouraging the establishment and expansion of user businesses which cannot remain viable once existing network assets require replacement and tariffs are increased to match costs of replacement (i.e., once the new assets come onto the RAB at cost). However, in the unique case of existing long life infrastructure operating well below capacity, and expected to remain this way for many years, this otherwise logical argument is inapplicable. In these circumstances, an economically sensible and more broadly responsible pricing approach by regulators would admit the notion that existing infrastructure need not return as much to owners as if it had to be built at today's prices. This does not mean that regulators need take the other extreme and price existing infrastructure at NRV. Rather there is much to be said for some middle ground solution, allowing fairly and pragmatically for the service providers' historically accumulated interest commitments and obligations to equity investors.

There are of course many subtleties ignored by the simple notion that existing infrastructure can be operated at relatively negligible marginal cost, including capital cost. Newbery (1997, p. 3) explained that low transmission tariffs based on heavily written-down asset values might prevent strategically preferable infrastructure expansion. His example is that of north sea gas being transported into the south of England through existing gas pipelines rather than power being generated in Scotland, near the beach-head, and then carried to south-west England through a reinforced electricity grid.

(iii) DORC Provides Existing Asset Owners With a Free Lunch

Under the regulators' tariff formula (3) each dollar granted in RAB locks in place a future tariff stream with present value (at discount rate r = WACC) of one dollar. By writing up the value of existing assets to DORC, the asset owner gains the amount of that write-up (revaluation) in NPV. This NPV windfall—and accordant share price increase—is achieved by a mere book entry with no actual cash outlay.

Whittington (1994, p. 93, 1998a, p. 93) made this same observation in relation to some British gas and water privatizations. It was typical in Britain that the amounts paid by the new private owners of these entities were significantly less than aggregate asset book values. Whittington warned that tariffs based on book values rather than the actual cost (cash spent) asset base would present the new asset owners with large wealth windfalls at the expense of gas and water consumers who would be left to pay the inflated RAB-based tariffs:

> To adopt a replacement cost or current cost approach at this late stage would involve a very large transfer of wealth from the consumer to the shareholder, which would be inconsistent with the requirement that the regulator strike an appropriate balance between these interests by allowing a return sufficient to justify the shareholders' investment but not excessive from the perspective of the consumer. (Whittington, 1998a, p. 93)

The legacy of inflated asset values according to Whittington (1994, p. 93) is that regulators will have committed to a tariff stream that over time looks increasingly anomalous.

In Australia, the case of AGLGN (Australian Gas Light Gas Network) differs from the British experience only in that the company already owned all existing assets. AGLGN has been arguably better treated than the British investors, in that it is has been allowed a large upward shift in its asset values above depreciated cost, and consequently a significantly enhanced tariff stream, all for no additional investment. It is difficult in the AGLGN case to value objectively the 'free lunch' allotted to the company by the regulator's acceptance of DORC. When a DORC-based tariff stream is bought by additional investment, as in the circumstances described by Whittington and those of the Victorian privatizations, the NPV windfall is measured by the difference between the amount paid and the deemed RAB (on which subsequent tariffs are based). But when a DORC-based tariff stream is simply decreed to an incumbent owner whose existing assets have no objective current market value—that is, no value independent of their regulated book value—there is no theoretical benchmark against which to compare the PV of the new tariff stream.

Perhaps the only reasonable comparison is that of the so-called 'line in the sand approach'. This was a notion initially favoured by IPART (e.g., 1998, p. 35, 1999a, p. 9), where to get around the problem of the non-existent market value of existing assets, the regulator worked backwards taking pre-existing tariff levels as a pragmatic starting point. The imputed asset value is then the capitalized value of future tariffs, where their existing level is specified and taken as given like a 'line in the sand' (ACCC, 1998a, p. 27; King, 1998, p. 11). Taking this approach, the windfall to the existing owner can be gauged by simply comparing the new DORC-based tariff stream with the old tariffs as they existed when regulatory reforms and 'access regimes' were initially introduced.

In the case of AGLGN, DORC-based tariffs are appreciably greater than their pre-existing levels. Since these tariff increases have been achieved without corresponding investment in new assets, it is reasonable to argue that the advent of DORC has presented AGLGN with an NPV windfall. The amount of this windfall is obscured by doubts over the legitimacy of pre-existing tariff levels (ORG, 1998b, p. 59; IPART, 2000, pp. 80–1). For example, one point of view put by AGLGN is that these were 'artificially' low and therefore not commercially sustainable. The stiffest possible response to this, as noted by Lim and Dwyer (2001, p. 25), is that because AGLGN assets were already sunk, any tariff level exceeding one based on scrap value is 'sustainable' in a strict economic sense:

> A ruthless application of economic logic might suggest that as the assets are sunk assets with no alternative use except as scrap, the initial capital base should be close to zero. There is no opportunity cost where capital has been sunk. No regulated revenue stream has to be awarded to induce investment to create what already exists or to keep in place what has no alternative use.

From this perspective, AGLGN was really in no position to argue. Quite to the contrary, the regulator might have chosen to enact a distinction in principle between sunk assets and those not yet built. Sunk assets could have been valued at DAC or even lower, even at NRV (scrap), without prompting any misallocation of resources. Even at RAB approaching NRV, AGLGN would have no economic choice but to use existing assets in their existing (presumably optimal) way. When seen this way, the regulator's decision to treat existing and new assets alike appears unnecessarily generous. By opting essentially arbitrarily to base tariffs for existing assets on DORC, regulators have guaranteed the profitability of asset owners and gambled that infrastructure users and downstream energy consumers will cope without politically manifest damage to their profitability and economic expansion.

(iv) DORC Not Necessary to Promote New Investment

The underlying economic rationale of tariff equation (3) is that asset owners earn a 'market' rate of return on their investments. This is achieved equally whether new investments are brought onto the regulatory balance sheet at DORC or DAC; or more precisely at ORC or AC, since for new assets there is no accumulated depreciation. Moreover, for a new asset RC = AC by definition, and assuming the investment is 'optimized', ORC = OAC = AC (ACCC, 1998b, p. 31). Provided that subsequent asset revaluations are precluded under either an ORC or AC approach, it makes no difference practically whether the amount spent on new assets, and added to the regulatory balance sheet, is called RC or AC (ORC or OAC). Either way, the PV of the ensuing tariff stream is equal to the cash amount invested and hence the NPV (at r = WACC) is zero, as expected of an efficient capital market.

For there to be any difference between DORC and DAC (DOAC) in regard to new assets, regulators must envisage that DORC and DAC asset values (and thus periodic tariff flows) will not remain the same over time despite their initial equivalence. This could be for two reasons. The first is that DORC and DAC depreciation patterns may be different. Of itself, however, a difference in the time allocation of a given depreciation sum makes no difference to the NPV of the tariff stream (see above) and hence does not explain why DORC rather than DAC is technically necessary to secure new investment. A better explanation is that regulators foresee subsequent asset revaluations (book value increases without new investment) under one approach but not the other.

The Treatment of DORC Revaluations.

In its *Draft Statement of Principles*, the ACCC clearly acknowledged its anticipation of periodic DORC revaluations:

> It is conceptually possible to consider a notional DORC revaluation of the regulatory asset base on an annual basis as the main basis for assessing how the RAB should move over time and what allowance should be made for depreciation within the cost of service calculations. (ACCC, 1999a, p. 48)

> The NEC [National Electricity Code] does not preclude the regulator from periodically revaluing the regulatory asset base according to a valuation methodology such as DORC. (ACCC, 1999a, p. 49)

Other ACCC statements similarly supportive of DORC revaluations are not hard to find. For example:

> The maintenance of revenue streams over time at a level that is consistent with a DORC asset valuation will minimize the likelihood of significant shocks to tariffs as the replacement of assets becomes necessary. As the existing assets will dominate the capital base and therefore tariffs for a number of years, this objective of maintaining comparability of tariffs from one generation of assets to another can only be achieved if the existing assets are re-valued over time at or close to DORC. (ACCC, 1999b, p. 1)

The 'no free lunches' principle precludes asset revaluations—that is, real increases in RAB by mere book entry—unless these are treated as income, using the extension (5) of the usual tariff equation explained above. Thus far in Australia, regulators have given no clear decision on how they will treat revaluations. It should be noted, however, that if they apply the new-entrant-exclusion logic (dynamic DORC) model reconstructed above, then revaluations will be treated correctly as income. This is implicit in equation (8) which effectively reduces the period depreciation expense (cash reimbursement) to owners by the amount of an asset revaluation (increase in DORC_t) attributable to growth in the replacement cost of new assets, ORC_t. It can be seen from (8) that the change in asset value over the period, for which owners are compensated in cash, includes (a) the effect of assets being one period older

$$ORC_T\left\{\frac{WACC}{(1+WACC)^{T-t+1}}\right\} \tag{11}$$

less (b) a revaluation recognizing the increase in ORC_t over the period and consequent upward effect on DORC_t

$$ORC_T\left\{\frac{g}{(1+g)^{T-t+1}}\right\} = ORC_{t-1}\,g. \tag{12}$$

Service providers are therefore reimbursed in cash for the depreciation of assets caused by age (11) by way of a cash amount (8) plus a capital gain (12). In effect, the capital gain is taken as income, thus reducing the period tariff (cash) paid to asset owners, the more so the greater g. Note, for example, the initially small tariffs when $g = 0.05$. In these early periods, the new entrant asset value $\text{DORC}_t \equiv P_t$ is growing, and thus the incumbent earns period returns that are partly capital gain (increase in DORC_t) and correspondingly less cash (i.e., less tariff income). Eventually, of course, these 'capital gains' accrue to the incumbent in the form of cash when finally the asset value falls to zero and all capitalized wealth (asset value) is paid out.

Ignoring this logic—on which asset revaluations offer owners a re-scheduling of tariff receipts but no NPV windfall—regulators may argue that if service providers are to lose stranded (all non-optimal) assets off their regulatory asset bases without compensation, then they should equally be rewarded when the replacement costs of their optimized assets increase.[15] On this model, asset owners face an unpredictable tariff stream. Indeed, investors unready to take on the risk of asset redundancies and subsequent NPV write-offs as a result of technological advances (or general reductions in replacement costs) will prefer DAC over DORC (King, 1997, pp. 16–17; 2001b, pp. 7–8).

King (1997, pp. 15–17) and Small (2000, pp. 1–2) note the unpredictability (volatility) of tariffs as a deficiency of DORC in regard to encouraging new investment. Added volatility increases the value of the 'option to wait' (McDonald and Siegal, 1986) and thus, all else equal, slows the rate of new investment:

> [V]ariations in the cost of replacement over time will feed into the permitted earnings of a regulated firm . . . the volatility effect of replacement cost valuations will generally delay investment in new assets . . . The value of the option to delay investment is increasing in the volatility of earnings, with the result that in any given time period the firm is less likely to invest, *ceteris paribus*. (Small, 2000, p. 2)

The intuition underlying this options argument is as follows. Once an apparently acceptable investment has been identified, the firm must decide whether to invest immediately or wait. The cost of waiting is the immediate net cash inflows foregone,[16] but the benefit is the extra information arising while waiting and thus a better based (more likely correct) decision. In theory, investment should occur only when the expected benefits from waiting are exceeded by the expected cash flows foregone (both measured in PV terms). The greater the volatility of earnings, the greater the expected (average) benefits from waiting, and thus the slower the rate of investment. From this perspective, asset owners should be wary of DORC. It adds to the risk of their investments and causes them to forego cash (returns on capital) while waiting for successful investments to reveal themselves as sufficiently certain.

More realistically, perhaps, the attraction to service providers of DORC is that once an investment is made (any waiting is over), revaluations are more likely than write-offs, and will presumably be allowed by regulators as NPV windfalls rather than regarded as income. For most energy infrastructure assets, the threat of technological redundancy (falling ORC) is negligible, and the economic rents from investment are limited only by the service provider's ability to convince regulators of the need for DORC revaluations. This is consistent with the allegation common among asset users and acknowledged by regulators that infrastructure

[15] Like revaluations, the regulatory treatment of stranded assets is not certain. ORG (1999, p. 19) noted that much of the risk of asset stranding is not within owners' control, and rather than making the regulated entity bear such 'market risks', asset strandings should be pre-empted with discretionary depreciation write-downs returning asset value to the owner before it disappears. If combined with the possibility of revaluations not treated as income, this ORG philosophy would mean that DORC is in fact 'DORC with an option on DAC', or put another way, 'DORC, or your money back', and thus presents the best of all worlds to asset owners.

[16] More precisely, the cost of waiting is the dollar return *on* capital foregone. This is the only opportunity cost of not investing immediately. The return *of* capital component is not an opportunity cost as it merely reimburses the owner for the period depreciation (loss of asset value) that occurs after an investment is made.

owners prefer DORC (rather than DAC) for the very reason that it allows them to take advantage of information asymmetries:

> [E]xperience has shown the network service provider's preference for the use of DORC valuation, in that the method produces the highest feasible asset values, and creates a significant information asymmetry in favour of the network owner. As information asymmetry is one of the biggest problems for the regulator (and interested parties) this cedes a significant advantage to the network owner, which it hopes can be translated into rents. (Energy Markets Reform Forum, 2000, pp. 24–5)

In its final determination on access arrangements for AGLGN, IPART (2000, p. 7) noted the consistent concerns of asset users over the non-disclosure by AGLGN of desired information. For reasons such as the scale and technical complexities of their networks, and their privileged access to proprietary data, asset owners much more understand the replacement costs and non-optimalities of their assets than either users or regulators, and are therefore in a strong position to exploit the subjectivity and potential for periodic asset revaluation inherent in DORC (King, 1997, p. 16). Asset users have complained that the financial incentives regarding regulatory reviews are biased in favour of infrastructure owners who have vastly more to gain than any individual user has to lose, and who are reimbursed for their expenditures on review negotiations as part of the tariff formula:

> Any review process, extending over 18 months, necessarily involves the commitment of substantial resources, both financial and human, by the regulator, the access applicant and other stakeholders, especially customers. Apart from the legal, economic and financial complexities of [access applications], users are particularly disadvantaged by a lack of resources to enable effective participation in extended reviews of such nature. The access arrangement applicant has obvious financial incentives to seek favourable outcomes. In any case, the costs incurred are paid for by users of the network, as the regulator allocates such costs to the regulated revenues. In the AGLGN case, its access arrangement information indicates costs for 'regulatory relationships' of $1 million. (Energy Markets Reform Forum, 2000, p. 11)

These disparities tip the outcomes of regulatory disputes in favour of owners (including governments intent on further infrastructure privatizations) against users and regulators alike.[17] Given that owners have these inherent advantages, it is perhaps little wonder that they generally prefer DORC over the more familiar but much less pliable DAC. This is, of course, hardly the kind of advantage that regulators, who have statutory obligations to energy users and downstream consumers, are wont to encourage.

Treatment of Easements

Easements are the legal rights under which infrastructure owners are permitted to build their networks across land owned by other parties. The DORC doctrine, advocated and adhered to most religiously by the ACCC and ORG, treats existing easements and other non-system assets (e.g. buildings) like any other asset.

[17] Davis (1999a, p. 16, 1999b) observed that the ORG/ACCC negotiations over WACC have been similarly lopsided in asset owners' favour.

Again this is for reasons of economic principle, namely the principle of ensuring that the RAB equates to whatever total costs a new entrant would currently incur to replicate the existing network: 'The normal DORC methodology would assign values to such assets reflective of their market value . . . The advantage of this approach is that the valuation remains comparable to costs faced by a potential entrant' (ACCC, 1999a, pp. 45–6).

Easements present the *reductio ad absurdum* of DORC. For the most part, they have been obtained historically by existing asset owners, with the authority of government legislation, at zero or low cost. And yet having acquired these 'access corridors' for generally little or no outlay, asset owners are now to be paid a return on their current 'market values' (however determined)[18] as if they were purchased today at today's prices. The DORC valuation of easements, more than any other asset, shows up the readiness of regulators to allow asset owners returns on investments that were never made. By insisting on the theoretical necessity for DORC, regulators find themselves bound to provide asset owners a conspicuous 'free lunch'. Moreover, this is not only a free lunch but also a long lunch, since the ACCC (1999a, p. 45) maintains that easements do not depreciate like other assets and hence will remain on the regulatory balance sheet in perpetuity.

Clearly less committed ideologically to DORC than the ACCC and ORG, IPART (e.g., 1999, pp. 51–2; 2000, p. 91) in New South Wales has decided that unlike, other assets, DORC does not apply to easements.[19] Its determination is to include easements in RAB at their actual costs, often zero. The rationale provided for this decision is revealing. Rather than conceding that there is any general absurdity about DORC-based tariffs for existing assets, IPART distinguished easements from other assets on the basis that they will never be replaced and hence will never present asset owners with any additional cost: 'For the incumbent, existing easements formerly acquired will not need to be replaced. Hence, such costs will not form part of the forward looking costs of maintaining and replacing existing capacity' (IPART, 1999d, Vol. 1, p. 60).

The first problem with this renouncement is that much of the physical infrastructure asset base is virtually permanent, requiring only maintenance rather than replacement, and should for consistency be valued the same way, or at least in equal recognition of its negligible (in PV terms) future cost of replacement. And second, the supposed economic rationale for DORC is not about 'the forward

[18] Small (2000, pp. 7–8) observes that market valuation of easements is an intractable problem for reasons such as the uncertain connection between the value of land (ownership) and the value of a limited right to use land conferred by an easement. Moreover, there is a logical circularity between the value (presence) of the easement and the value of surrounding land. For example, easements associated with Sydney Airport are over land made much more valuable by the presence of the airport (and its related easements).

[19] Of all the Australian regulators, IPART has produced the most balanced and well reasoned discussions on DORC, and is clearly aware of DORC's theoretical and practical deficiencies. Perhaps to signal empathy with those critical of its implementation of DORC, especially in regard to AGLGN and its large sunk asset base, IPART (1998, p. 35) pledged explicitly that it retained no necessary commitment to DORC as the regulatory asset base.

looking costs of maintaining and replacing existing capacity'. Maintenance expenses will be returned through the tariff formula, and capital expenditures are financed by capital markets which exist for this very reason. This latter point has been emphasized by King (1997, p. 6, 2000b) and Whittington (1998a, p. 96) in response to suggestions that infrastructure asset valuation should provide for physical capital maintenance in some sense. It is likewise accepted and restated by IPART (1999d, Vol. 1, p. 96), adding to the impression of the regulator clutching at straws, in its reference to easements causing no future capital replacement cost as the basis for their not being included at DORC:

In another of its determinations IPART again included easements at actual cost, albeit with a different purported rationale: 'To include a market value for easements in the initial asset base would be of no economic benefit . . . The restrictive nature of easements (i.e., being an easement for electricity distribution lines only) may mean that they have no value to any other entity' (1999, p. 52). This alternative explanation is similarly *ad hoc* and unrelated to the DORC-inclined theoretical framework meant to underlie regulatory asset valuation. The fact that easements have little or no realizable value does not mean that they have low replacement cost. Rather, their replacement cost would seem to be one of the largest deterrents facing any new entrant attempting system bypass.

It would seem that by advocating DORC on grounds of general economic principle, regulators find themselves painted into a corner when it comes to valuing easements. The supposed theoretical basis for DORC is that it captures the cost of a new entrant or system replication. If this oft repeated argument is to be taken seriously, it cannot be opportunistically set aside for certain assets where its consequences are most obviously open to ridicule. Moreover, if the truly apt economic principle is to set capital costs at the highest level short of those achievable by a new entrant, then DORC must necessarily include the price that a new entrant would pay for all necessary easements. This is clearly acknowledged by the Queensland Competition Authority (2001, p. 142):

> A new entrant is typically defined as a business installing a new gas reticulation network in an existing area where there is no existing network owned by the new entrant. In this situation there are no existing easements, pipelines, network layouts and so on. Costs incurred would therefore include all project management, design, easement, construction and restoration costs.

Qualifying these remarks, the QCA (2001, p. 151) restated the IPART observation that easements would never need replacement, and conceded that inclusion of easements in the RAB on some current replacement cost basis would increase tariffs significantly. The Authority's decision upon such contradictory indications was to expressly defer any pronouncement on easement valuation, averting the issue with the observation that '[t]he appropriate valuation method for easements is currently the subject of much discussion Australia-wide, especially in electricity'. That regulators insist on one hand that they have developed an appropriate and coherent economic logic for regulatory asset valuation—namely DORC—while at the same time expressly awaiting discovery of the particular single all-appropriate valuation rule for easements, is of itself indicative of the general intellectual pretence and fragility of their pronouncements on asset valuation.

The ACCC, defeated by the competing (mutually exclusive) objectives of adhering rigorously to their own professed DORC new-entrant-exclusion doctrine while at the same time avoiding politically unforgivable 'tariff shock', came to similarly vacillatory determinations on easements. The essence of the ACCC proposal on DORC is that easements be carried in RAB at actual cost modified in some nondescript way over time 'in line with' DORC:

> Given the strong link with real estate values there is a likelihood that the value of easements will escalate continuously over time . . . The question is how to introduce such assets into the regulatory framework in a consistent way. One consistent approach would require: [t]he contribution to the RAB be based on the actual cost to the TNSP [service provider] of obtaining the easement rights updated periodically in line with what would be the DORC based valuation of easements. (ACCC, 1999a, p. 45)

Apart from being virtually incomprehensible, this proposed valuation rule is revealing for its unexplained rejection of DORC and recourse to actual cost. The problem not acknowledged is that inclusion of easements at DORC would typically, particularly if easement values are equated with neighbouring land values, lead to a 50 per cent or greater increase in RAB, and thus in transmission tariffs (Weickhardt, 1999, pp. 2–3). IPART (personal communication, 2001) has found cases in its jurisdiction where the RAB would approximately double with easements included at estimated (grossly subjective) replacement cost. In one case of a potential 70 per cent increase in RAB (and consequent tariff increase of 25–30 per cent), its openly stated view is that such material tariff shock is 'unacceptable' (IPART, 1999d, Vol. 1, p. 60).

That the ACCC holds rigidly to DORC as a point of economic principle, yet does not implement it for all assets when the resulting tariffs are 'too high', invites intellectual scepticism. It is difficult to avoid the inference that the entire DORC opus owes its existence to the broad (albeit not fail-proof) political acceptability of its answers, rather than to the veracity of its theory. Another telling aspect of the ACCC's confusion in regard to easements is the suggestion that revaluations taking place over time in easement book values should be treated as income in the way described by the modified tariff formula (5) above (derived on the basis of NPV = 0). More astonishingly, it is suggested that this is true of other assets as well:

> To the extent that easement valuations are judged to vary over time, the variations in value should be reflected in depreciation allowances linked with the asset in precisely the same way as other assets. If the easement appreciates in value over time then the allocated depreciation would be negative in nominal terms and serve to offset the higher capital returns associated with an appreciating asset. (ACCC, 1999a, p. 46)

The proposition here is that all asset revaluations be regarded as income; that is, subtracted from the cash tariffs received by the service provider in the period of the revaluation. This would make sense if the ACCC decided to invoke the 'no free lunches' principle, as would be consistent with its new-entrant-exclusion logic. However, no such intention is evident in other ACCC statements on asset revaluations. The appearance of such a glaring inconsistency is indicative of the contortions forced on the ACCC by its willing but not ready application of DORC to easements.

CONCLUSION

Provided that infrastructure assets are valued at NRV or higher, they will remain in use and not be scrapped. And provided the regulatory asset base is no higher than DORC, defined correctly as the new-entrant-exclusion limit, there is no theoretical (let alone realistic) chance of needless system duplication. Within these conceptual limits, NRV ≤ RAB ≤ DORC, the regulatory asset base is open to negotiation and political influence. In Australia, regulators have settled on the upper end of the 'realizable value to bypass value' (NRV to DORC) feasible range, opting for DORC and effectively underwriting the financial performance of asset owners (new and existing) including governments.

Abstractions invoked by regulators to support this position verge on the surreal. In particular, downstream industry and other consumers are told that tariffs must be so high because assets that will be maintained and possibly extended but never replaced would cost a great deal to replace. If this economic wisdom is not appreciated, then another rationalization favoured by regulators is that access charges for sunk assets, operating well below full capacity and at very low incremental costs, will have to be increased when eventually existing assets are replaced, and hence should be set high now so as not to increase later. Asset users maintain that in their reality, preference would be for somewhat lower tariffs now, on which to build businesses that can afford higher tariffs ('tariff shock') when they are much later (never) necessary.[20]

The theoretical and practical absurdity of the above propositions is apparent to those without contrary economic or political interests, but has caused regulators little embarrassment. Their only notable discomfort has arisen unexpectedly in applying DORC to non-system assets, particularly easements, which were to begin with largely overlooked (probably because they were mostly not included in their owners' pre-existing historical cost financial statements). No potential new entrant in energy transmission can exist without easements, but when DORC is applied to these, in strict accord with the regulators' new-entrant-exclusion logic, the balance sheets of the service providers become more akin to those of property developers. In some cases the DORC of easements exceeds that of system assets. This is all the more anomalous for the fact that easements were generally

[20] 'The proposition "pay more now so you are familiar with paying more later" has little appeal with end users. To start with, they are not sure they will be in business in the future, so they may not be around to see the price shock . . . The other point is that natural gas pipelines have never been replaced in Australia. Natural gas has been around for 30 years and unlike the old towns gas, is non-corrosive. Modern cathodic protection has all but eliminated corrosion, as has the use of plastic pipe for low pressure service. Wholesale replacement will not happen—gradual replacement over decades mostly to upgrade capacity or replace old towns gas pipes means that the asset base will never reach zero followed by a price shock. The U.S. experience bears this out. There utilities build rate base mostly through expansion or extensions to offset depreciation.' (B. Henson, personal communication, 13 October 1999)

acquired by the service providers at zero or low cost under statutory powers. If included at DORC, easements would become a singularly rich source of economic rents to their owners, in perpetuity.

Of greater potential concern to regulators wedded to DORC is a corrected account of their own economic logic, implicit in work by Agility Management (2000) and King (2001a) and reformulated by way of equations (6)–(10) above. These equations describe a dynamic theory of regulatory asset valuation and depreciation based on replacement cost. The basis of this theory is the principle—widely advocated by Australian regulators—that the regulatory asset base RAB_t should be set and held at all times t (i.e., continually re-set) at the uppermost level short of that admitting asset duplication. Logically, this upper limit on RAB_t is a function of the replacement cost of all new assets, ORC_t. Its value, $DORC_t$, is defined for all times t and therefore, unlike current regulatory practice, requires no exogenous depreciation scheme. To date, regulators have depreciated ORC using the 'real linear' (straight line) algorithm, which has the appealing corollary that tariffs are fairly constant in real terms. However, apart from this incidental attraction, real linear depreciation is essentially arbitrary (diminishing balance or other patterns could equally apply) and thus without theoretical justification.

The new-entrant-exclusion logic underpinning $DORC_t$ (dynamic DORC) embodies the free market ethos advocated by Australian regulators, particularly the ACCC. Its practical consequences, however, in terms of the initial RAB value (and subsequent tariff levels) applicable to sunk assets are generally much less agreeable. In particular, sunk assets with long remaining lives typically have an initial DORC near 100 per cent ORC. As a consequence, service providers with dated but very long-lived assets will earn practically the same tariffs as if their infrastructure was entirely new and built at today's prices. Such lastingly high DORC values are prone to be well outside the bounds of political sustainability. They will be perceived on superficial analysis as making no allowance for the fact that assets are 'used' rather than brand new, much like a back street car rental firm with ten-year-old vehicles asking for the same tariffs as Hertz and Avis.

Thus far, regulators employing replacement cost asset valuation have avoided this 'anomaly' by essentially arbitrary or at least highly subjective write-offs in their settings of the initial DORC (e.g., $DORC_0 = 65\%\ ORC_0$). The regulators own economic logic, reconstructed in this article, precludes such subjective and possibly political inspired starting points, and produces its own initial DORC figures characteristically not much less than ORC (i.e., $DORC_0 \approx ORC_0$). Notwithstanding their logical coherence (internal consistency) and thus theoretical appeal, such high initial DORC figures will alter political perceptions of the benefits of replacement-cost-based regulatory asset valuation, and severely test Australian regulators' ideological commitment to DORC.

REFERENCES

ACCC, *National Electricity Market: Statement of Regulatory Intent for the Regulation of Transmission Revenues*, Commonwealth of Australia, May 1998a.

——, *Victorian Gas Transmission Access Arrangements Final Decision*, October 1998b.

——, *Draft Statement of Principles for the Regulation of Transmission Revenues*, May 1999a.

——, *Letter from Michael Rawstron (General Manager Regulatory Affairs) to Energy Markets Reform Forum*, September 1999b.

Agility Management, *The Construction of DORC From ORC*, submission to IPARC (Independent Pricing and Regulatory Commission), August 2000.

Baumol, W. J., J. C. Panzar and R. D. Willig, *Contestable Markets and the Theory of Industry Structure*, Harcourt Brace Jovanovich, 1982.

Bell, P. W., and K. Peasnell, 'Another Look at the Deprival Value Approach to Depreciation', in T. E. Cooke and C. W. Nobes (eds), *The Development of Accounting in an International Context*, Routledge, 1997.

Bonbright, J. C., Report of the Commission on the Revision of the Public Service Commission Laws, N.Y. Legislative Doc. No. 75: 334–410, 1930 (cited in Bonbright *et al.*, 1988, p. 649).

——, *Valuation of Property*, McGraw-Hill, 1937.

——, *Principles of Public Utility Rates*, Columbia University Press, 1961.

Bonbright, J. C., A. L. Danielson and D. R. Kamerschen, *Principles of Public Utility Rates*, 2nd ed., Public Utilities Reports, Inc., 1988.

Booth, R. R., 'Utility Asset Valuation—a Users' Perspective', paper presented at the ACCC Asset Valuation Forum, 16 June 2000.

Brief, R. P., and K. V. Peasnell, *Clean Surplus Accounting: A Link Between Accounting and Finance*, Garland, 1996.

Brainard, W. C., and J. Tobin, 'Pitfalls in Financial Model Building', *American Economic Review*, No. 2, 1968.

Camfferman, K., 'Deprival Value in the Netherlands: History and Status', *Abacus*, March 1998.

Canning, J. B., *The Economics of Accountancy*, Ronald Press, 1929.

Clarke, F. L., *The Tangled Web of Price Variation Accounting: The Development of Ideas Underlying Professional Prescriptions in Six Countries*. Garland, 1982.

——, 'Deprival Value and Optimized Deprival Value in Australasian Public Sector Accounting: Unwarranted Drift and Contestable Serviceability', *Abacus*, March 1998.

Commonwealth of Australia, *National Competition Policy: Report by the Independent Committee of Enquiry*, AGPS, 1993.

Davis, K., 'Public Policy and Efficiency: Some Lessons from Reform of the Australian Gas Industry', Working Paper, Department of Accounting and Finance, University of Melbourne, June 1999a.

——, 'WACC, Tax and Depreciation in Regulatory Access Pricing Models', Working Paper, Department of Accounting and Finance, University of Melbourne, September 1999b.

——, 'Asset Valuation and the Post-Tax Rate of Return Approach to Regulatory Pricing Models', Working Paper, Department of Accounting and Finance, University of Melbourne, June 2000.

Edwards, E. O., and P. W. Bell, *The Theory and Measurement of Business Income*, University of California Press, 1961.

Edwards, J., J. Kay and C. Mayer, *The Economic Analysis of Accounting and Profitability*, Clarendon Press, 1987.

Energy Markets Reform Forum, submission by letter to ACCC, October, 1999.

——, *AGLGN: A Case Study of Third Party Access in New South Wales*, November, 2000.

Ergas, H., and M. Smart, 'Land and Easement Valuation in Pricing for Networked Businesses—a Critical Appraisal', Working Paper, Network Economics Consulting Group, June 2000.

Fisher, I., *The Nature of Capital and Income*, Macmillan, 1906.

Hotelling, H., 'A General Mathematical Theory of Depreciation', *Journal of the American Statistical Association*, Vol. 20, 1925.

IPART, 'Pricing for Electricity Networks and Retail Supply: Issues Paper'. *Discussion Paper DP-25*, September 1998.

——, 'Rolling Forward the Regulatory Asset Bases of the Electricity and Gas Industries', *Discussion Paper DP-31*, 1999a.

——, 'Regulation of Electricity Network Service Providers: Incentives for Regulation', *Discussion Paper DP-32*, 1999b.

——, *Aspects of the NSW Rail Access Regime: Final Report*, Review Report 99-4, April, 1999c.

——, *Pricing for Electricity Networks and Retail Supply*, 2 vols, June 1999d.

——, *Regulation of New South Wales Electricity Distribution Networks: Determination and Rules Under the National Electricity Code*, National Electricity Code Determination 99-1, December, 1999e.

——, *Final Decision: Access Arrangements for AGL Gas Networks Ltd*, July 2000.

Johnstone, D. J., 'The Regulatory Asset Base of AGLGN', *Australian Gas Users' Group Submission to IPART*, July 1999a.

——, 'Comments on Tobin's *q* and the Supposed Economic Justification for Replacement Cost (DORC) Regulatory Asset Valuation', Energy Markets Reform Forum Submission to ACCC, August 1999b.

——, 'Comments on the Cost of Capital with Regard to Regulated Gas Transmission Entities: Incitec Pty Ltd Submission to the ACCC Public Forum on EAPL', November 1999c.

Johnstone, D. J., and M. J. R. Gaffikin, 'Review of the Asset Valuation Guidelines of the Steering Committee on National Performance Monitoring of GTEs', *Australian Accounting Review*, Vol. 6, No. 1, 1996.

Johnstone, D. J., and M. C. Wells, 'Utility Pricing and Valuation Mechanisms Involving NPV, WACC and Asset Book Values', Business Council of Australia Energy Working Group Submission to the ACCC Public Forum on the Weighted Average Cost of Capital: Gas Distribution, 1998a.

——, 'Utility Valuation and the Problems with DORC', Advisory Paper prepared for the Business Council of Australia Energy Working Group, July 1998b.

King, S., 'Efficiency and Access: Analysing the Draft Access Code for Australian Electricity Transmission', *Australian Economic Review*, 3rd quarter, 1996.

——, 'Asset Valuation and Access', *Discussion Paper No. 365*, Centre for Economic Policy Research, Australian National University, 1997.

——, *Economic Review of GSN Access Arrangements* (Report to IPART), Department of Economics, University of Melbourne, December 1998.

——, *Report on Agility's Approach to DORC Valuation* (Report to IPARC), Department of Economics, University of Melbourne, November 2000a.

——, Presentation at the ACCC Asset Valuation Forum, 16 June 2000b.

——, *Report on the Construction of DORC from ORC* (Report to IPARC), February 2001a.

——, *Incentive Regulation in Australia: A Hybrid Approach* (Report to ACCC), Department of Economics, University of Melbourne, December 2001b.

Lim, B., and T. Dwyer, 'What Price Access? Access to Gas and Electricity Networks in Australia', BHP Petroleum Submission to the Productivity Commission Inquiry into the National Access Regime, February 2001.

Lindenberg, E. B., and S. A. Ross, 'Tobin's *q* Ratio and Industrial Organization', *Journal of Business*, Vol. 54, 1981.

McDonald, R., and D. Siegal, 'The Value of Waiting to Invest'. *Quarterly Journal of Economics*, Vol. 101, No. 1, 1986.

National Farmers' Federation, *Submission to the Productivity Commission Inquiry into National Access Regimes*, December 2000.

Newbery, D.M., 'Determining the Regulatory Asset Base for Utility Price Regulation', *Utilities Policy*, Vol. 6, 1997.

Office of the Regulator-General, Victoria, 'Weighted Average Cost of Capital for Revenue Determination: Gas Distribution', *Staff Paper Number 1*, May 1998a.

——, *Access Arrangements—Multinet Energy Pty Ltd, Westar (Gas) Pty Ltd and Stratus (Gas) Pty Ltd—Final Decision*, October 1998b. (NB: There are two versions of this document each with the same date—the version cited here is that of 237 pages total).

——, *2001 Electricity Distribution Price Review: Cost of Capital Financing*, May 1999.

Officer, R. R., *A Note on the ACCC's and the Office of the Regulator-General's Cost of Capital for the Gas Industry*, University of Melbourne, July 1998.

Parry, T. G., 'Access Regulation: Are We Going Down the Right Track?' in R. Steinwell (ed.), *Twenty Five Years of Australian Competition Law*, Butterworths, 2000.

Peasnell, K. V., 'On Capital Budgeting and Income Measurement', *Abacus*, June 1981.

——, 'Some Formal Connections Between Economic Values and Accounting Numbers', *Journal of Business Finance and Accounting*, Autumn 1982.

——, 'Technological Change and Other Aspects of the Definition of Replacement Cost for Managerial Purposes', in J. Klassen and P. Verburg (eds), *Replacement Costs for Managerial Purposes*, Elsevier, 1984.

Peasnell, K. V., and G. S. H. Archer, 'Debt Finance and Capital Maintenance in Current Cost Accounting', *Abacus*, December 1984.

Pong, C. K. M., and G. Whittington, 'The Withdrawal of Current Cost Accounting in the United Kingdom: A Study of the Accounting Standards Committee', *Abacus*, March 1996.

Preinreich, G., 'The Theory of Depreciation', *Econometrica*, July 1938.

Productivity Commission, *Review of National Access Regime: Position Paper*, Commonwealth of Australia, March 2001.

Queensland Competition Authority, *Final Decision: Proposed Access Arrangements for Gas Distribution Networks: Allgas Energy Limited and Envestra Limited*, October 2001.

Schmalensee, R., 'An Expository Note on Depreciation and Profitability Under Rate of Return Regulation', *Journal of Regulatory Economics*, September 1989.

Small, J., 'The Valuation of Regulated Assets', Working Paper, Centre for Research in Network Economics and Communications, University of Auckland, 2000.

Tobin, J., 'A General Equilibrium Approach to Monetary Theory', *Journal of Money, Credit and Banking*, February 1969.

Tweedie, D., and G. Whittington, *The Debate on Inflation Accounting*, Cambridge University Press, 1984.

——, 'The End of the Current Cost Revolution', in C. Nobes and T. Cooke (eds), *The Development of Accounting in an International Context*, Cambridge University Press, 1997.

Walker, R. G., F. L. Clarke and G. W. Dean, 'Use of CCA in the Public Sector: Lessons From Australia's Experience With Public Utilities', *Financial Accountability and Management*, February 2000a.

——, 'Options for Infrastructure Reporting', *Abacus*, June 2000b.

Weickhardt, P., *Letter to the ACCC on Behalf of Business Council of Australia Energy Reform Task Force*, August 1999.

Whittington, G., *Inflation Accounting: An Introduction to the Debate*, Cambridge University Press, 1983.

——, 'Current Cost Accounting: Its Role in Regulated Utilities', *Fiscal Studies*, Vol. 15, No. 4, 1994.

——, 'Regulatory Asset Value and the Cost of Capital', in M. E. Beesley (ed.), *Regulating Utilities: Understanding the Issues*, (IEA Readings 48), Institute of Economic Affairs, 1998a.

——, 'Deprival Value and Price Change Accounting in the U.K.', *Abacus*, March 1998b.

Wolnizer, P., *Auditing as Independent Authentication*, Sydney University Press, 1987.

Zauner, R., 'Valuation Principles and Tariff Setting Framework', paper presented at the ACCC Asset Valuation Forum, 16 June 2000.