APPENDIX A: Production Cost Concepts

Due to concerns about the market power of firms in network-based utility industries, regulators often regulate the prices that such firms are able to charge. In economics it is well established that efficiency or welfare is maximised in a perfectly competitive market where price is set equal to marginal cost. As in such industries a substantial proportion of the costs are capital costs,[1] a regulated price that is based on the short-run marginal cost may not necessarily provide the firm with the appropriate level of compensation. Subsequently, when setting cost-based prices, regulators have traditionally attempted to base prices for services on some estimate of the long-run marginal cost of production.[2] This compensates the firm for all costs that are directly attributable to the service being provided, including the opportunity cost of capital — i.e. a return of and return on the investment. However, setting such a price for each regulated service may still not provide the firm with the appropriate level of compensation, as it fails to allow for recovery of those costs that are not attributable to the provision of any particular service — i.e. what are often referred to as the common costs of production.

Common costs are significant in network-based industries such as telecommunications, where multiple services are often supplied by the same plant, productions operation, or network element. While the issue of common costs has becoming increasingly important with the advent of new technologies such as ADSL being offered over the copper line that was traditionally used to the provide only voice telephony services, it is by no means a new phenomenon. For example, Kahn and

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1 For example, the *Productivity Commission*, *National Access Regime*, Report No. 17, September 2001, available at http://www.pc.gov.au/inquiry/access/finalreport/access.pdf, outlines that a substantial proportion of the costs incurred by firms in utility industries are capital costs. It maintains (at p 353) that for access providers in the Australian gas industry, "around 70 per cent of total revenue is required to fund capital costs". Further, it quotes T.G. Parry, "Access Regulation: Are We Going Down the Right Path", in R. Steinwell (ed.), *25 Years of Australian Competition Law*, Butterworths, Sydney, 2000, who states (at page 140) that "it is the capital-related costs (return on and return of capital) that dominate the total revenue requirements for the infrastructure assets involved in access to major utilities such as electricity, gas, telecommunications and rail."

2 For example, the Australian Competition and Consumer Commission (ACCC) in setting the appropriate access price for interconnection to telecommunications networks, often uses the total-service-long-run-incremental-cost (TSLRIC) method, which is designed to estimate the long-run marginal cost of providing a service.

Shew identified the problem of appropriately properly apportioning common costs in a 1987 paper, stating at p 194 that:[3]

> At the core of almost all the pricing issues in telecommunications is the fact that the products of this industry are a large and increasing diversity of services issuing from *common* facilities.

This Section provides a detailed analysis of the cost concepts that are relevant for regulating prices in telecommunications. In particular it examines:

(i) The difference between short and long-run costs of production;

(ii) The long-run marginal cost, long-run incremental cost and the total service long-run incremental cost; and

(iii) The stand-alone cost;

(iv) common costs; and

(v) The difference between the total element long-run incremental cost (TELRIC) and total service long-run incremental cost (TSLRIC) methodologies.

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[3] A. E. Kahn and W. B. Shew, "Current Issues in Telecommunications Regulation: Pricing", *Yale Journal on Regulation* 4, 1987, pp 191-256.

A.1 Short and Long-Run Production Costs

The **short run** is a period of time where the quantity of **one or more inputs is fixed** and cannot be augmented or diminished (i.e. it is a *fixed input*). Consequently there are certain costs in the short run that cannot be avoided even if the firm where to stop its production. The **long run** is the period of time where **all inputs are variable** and **none fixed**. Consequently, in the long run, all costs of production will be variable, including those costs that are fixed in the short run.[4]

To illustrate how costs of production differ in the short and long run, an example is provided below, where the following notation is used and simplifying assumptions made:

- Two inputs z_i (i.e. $i = 1,2$) are used to produce some level of output of a single product Q (i.e. $Q = f(z_1,z_2)$). In many texts the two factors of production z_1 and z_2 are often thought of as being labour and capital. For the purposes of the exposition this convention is also adopted here. In the short run input z_2 or capital is fixed so that $z_2 = \overline{z}_2$.

- There is a competitive factor market, so each unit of input is paid a fixed amount $w_i = \overline{w}_i$, $i = 1,2$. The total cost of producing a given level of output $\overline{Q}$ is then $C = \sum_{i=1}^{2} w_i z_i^*(w, \overline{Q})$. For simplicity, the cost of each unit of capital w_2 is assumed to be equal to $1.

- It is assumed for the purposes of the exposition in this Section that in the long run the firm is subject to constant returns to scale production technology.

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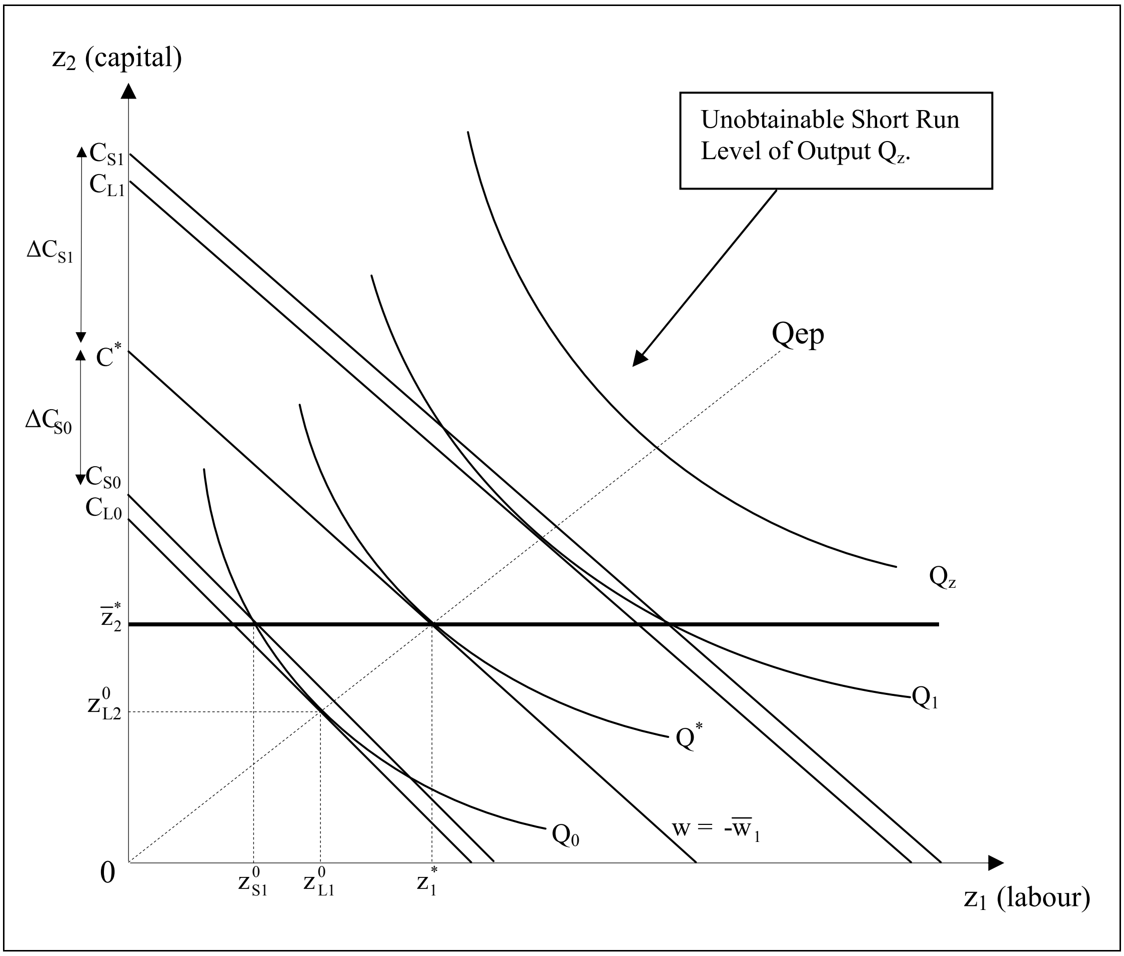
4 Similar definitions for the short and long run time periods and the short and long run costs, can be found in C.E. Ferguson, *The Neoclassical Theory of Production and Distribution*, Cambridge University Press, 1975, and J.S. Gans and S.P. King, "Comparing Alternative Approaches to Calculating Long-Run Incremental Cost", Melbourne Business School Working Paper, June 2004, available at: http://www.core-research.com.au/index.html.

To highlight the relationship between the short- and long-run costs of production, the input-space and price-quantity space diagrams in Figure A.1 and Figure A.2 are used.

FIGURE A.1 SHORT-RUN AND LONG-RUN COSTS IN THE INPUT SPACE DIAGRAM



Before proceeding to analyse the outcome in Figure A.1 it is important to understand a number of important features of the diagram:

- **The curved lines represent the isoquants.** These depict the combination of inputs z_1 and z_2 that are required to produce a given level of output Q.

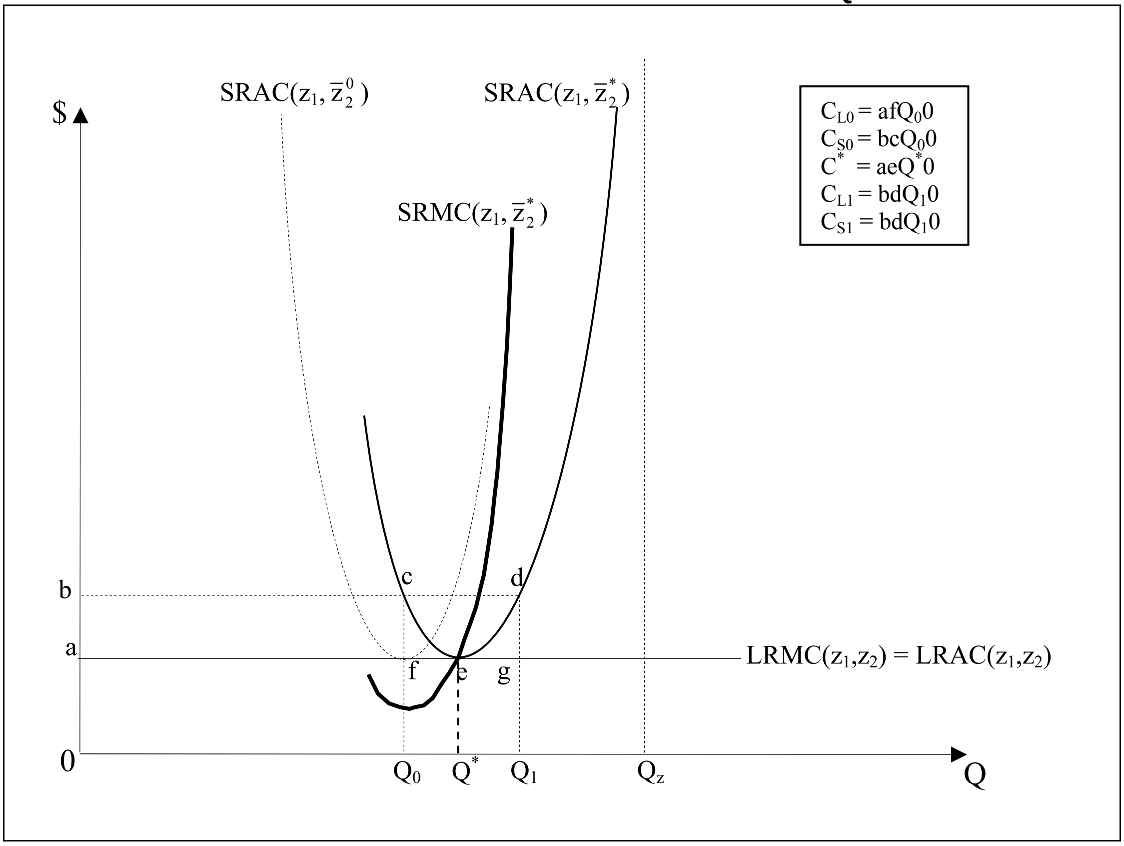
- **The straight lines labelled with slope w are the isocost lines.** These depict the combination of the factors of production z_1 and z_2 (i.e. labour and capital) where the cost of production to the firm and society is constant. The costs of production in the short-run and long-run are distinguished using the subscripts S and L. The relative wage rate w is ratio of the wage paid to a unit of each factor of production (i.e. $w = -\overline{w}_1/\overline{w}_2 = -\overline{w}_1$).

- **The tangency point between the isocost and isoquant lines represents the efficient cost of producing any given level of output. The output expansion path Qep is the locus of all these cost minimising points.** It is assumed that the Qep in the diagram depicts an instance where there are constant returns to scale production technology (i.e. $\alpha C(z_1, z_2) = C(\alpha z_1, \alpha z_2)$).

Figure A.1 shows that in the long run because the firm is able to adjust the level of all factors of production, it will always be able to operate at a point on the output expansion path Qep, minimising its costs of production for any given level of output Q. In contrast, in the short run, as capital is a fixed input equal to amount $\bar{z}_2^*$, the firm will only be production efficient at output Q^*. For any level of output $Q < Q^*$ the firm over-capitalises in its production, whilst for any level of output $Q > Q^*$ the firm under-capitalises in its production. For instance, in producing output Q_0, rather than employing the efficient long-run input mix (z_{L1}^0, z_{L2}^0) and facing the efficient cost of production of C_{L0}, in the short run the firm employs the input mix $(z_{S1}^0, \bar{z}_2^*)$ and faces the higher cost of production C_{S0}. Similarly in producing output Q_1, in the short run the firm is subject to cost C_{S1}, yet in the long run faces the lower cost C_{L1}. Further, the diagram highlights that in the short run because capital is fixed, certain higher levels of output such as Q_z will be unachievable. At this point in the short run, there is effectively an infinite cost of production.

Although the short-run average cost of production $SRAC(z_1, \bar{z}_2^*)$ is greater than the long-run average cost of production $LRAC(z_1,z_2)$ for all levels of production except output Q^*, the short-run marginal cost $SRMC(z_1, \bar{z}_2^*)$ will be less than the long-run marginal cost $LRMC(z_1,z_2)$ over some levels of output below Q^*. For example, in Figure A.1 at output Q_0, the short-run marginal cost $SRMC_0 = \frac{\Delta C_{S0}}{\Delta Q_0} = \frac{C^* - C_{S0}}{Q^* - Q_0}$ is less than the long-run marginal cost $LRMC_0 = \frac{\Delta C_{L0}}{\Delta Q_0} = \frac{C^* - C_{L0}}{Q^* - Q_0}$. Meanwhile, for levels of output beyond Q^*, such as Q_1, $SRMC_1 = \frac{\Delta C_{S1}}{\Delta Q_1} = \frac{C_{S1} - C^*}{Q_1 - Q^*}$ exceeds $LRMC_1 = \frac{\Delta C_{L1}}{\Delta Q_1} = \frac{C_{L1} - C^*}{Q_1 - Q^*}$.[5]

FIGURE A.2 SHORT-RUN AND LONG-RUN COSTS IN THE PRICE-QUANTITY SPACE



The information contained in the input-space diagram can be translated into the price-quantity space. This is done in Figure A.2. Due to the assumption of constant returns to scale production technology the long-run average and marginal costs in the diagram are equal and constant (i.e. $LRMC(z_1,z_2) = LRAC(z_1,z_2)$), and the cost of production in Figure 1.1 will now be captured by areas underneath the curves in Figure A.2 (eg $C_{L0} = afQ_00$). The short-run average cost where the fixed level of capital $\bar{z}_2^*$ is employed (i.e. $SRAC(z_1, \bar{z}_2^*)$) will be U-shaped and lie above the LRMC at all levels of output except Q^*, while the corresponding SRMC curve (i.e. $SRMC(z_1, \bar{z}_2^*)$)

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5 Although defined as marginal cost here, the above expressions are sometimes referred to as incremental costs as they capture the change in cost over a pre-selected increment of the service. The distinction between marginal and incremental costs is examined in greater detail in the Section A.2.

intersects the SRAC and LRAC curves at Q^*, and lies above both for all levels of output exceeding Q^*. The short-run can also be derived for other levels of the fixed input. For example, if the level of capital initially employed by the firm was z_2^0, then the corresponding short average cost curve SRAC $(z_1, \bar{z}_2^0)$ lies tangent to the LRAC at output Q_0, and above it for all other levels of production. By adjusting the amount of capital and mapping all the SRAC curves it can be established that the LRAC curve is the lower envelope of all the SRAC curves.[6]

The diagram in Figure A.2 also illustrates that pricing at the SRMC will not necessarily preclude the recovery of the firm's capital costs. For example, if the level of demand exceeds Q^*, SRMC-pricing will lead to over-recovery of the capital costs. This is consistent with Kahn (1971), who outlined that:[7]

> …pricing at short-run marginal cost need not be unremunerative in the long run or inconsistent with long-run equilibrium: the price need never explicitly be formulated to cover long-run or fixed costs, yet at certain terms, when demand is sufficient, it will do so or more than do so.

However, Kahn and Shew (1988) note (at p 221) that because telephone companies tend to build capacity in lumps, there is typically excess capacity and subsequently the "short-run marginal costs of subscriber access…are ordinarily below long-run or average costs."

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6 This is a geometric illustration of what is referred to as the envelope theorem.

7 A. E. Kahn, *The Economics of Regulation: Principles and Institutions*, Volume I, John Wiley & Sons Inc., New York, 1970. Reprinted A. E. Kahn, *The Economics of Regulation: Principles and Institutions*, The MIT Press, Cambridge 1988, p 74.

A.2 The Long-Run Marginal Cost, The Long-Run Incremental Cost, and The Total Service Long-Run Incremental Cost

A.2.1 The Long-Run Marginal Cost (LRMC)

Where there are 1,…n services, the total cost of production faced by the firm in the long run, where all factors of production are variable, is denoted by the cost function $C(Q_1,Q_{2\ldots,}Q_n)$. This total cost of production takes into account all costs, and will include any common costs that arise, which are not attributable to the provision of any particular service. (The significance of common costs is dealt with later in Section A.3). As technically the long-run marginal cost of service i ($LRMC_i$) represents the change in the total long-run cost of production as a result of an infinitesimally small change in the supply of service i, it is formally captured by the following derivative,

$$LRMC_i = \frac{\partial C(Q_1,\ldots Q_n)}{\partial Q_i} \quad \text{(A.1)}$$

As a derivative cannot be specified or measured in the real world, the long-run marginal cost for service i is often expressed as the increase in the total long-run cost of production faced by the firm when there is either, a small rise in output i,[8] or the output of service i increases by one unit.[9] In a perfectly-competitive market pricing service i at its long-run marginal cost induces the efficient outcome, as the value to the consumer of an additional unit of output will be exactly equal to the opportunity cost to society of the resources that are used to supply that unit of output.

A.2.2 The Long-Run Incremental Cost (LRIC) of Production

Baumol and Sidak (1994) outline (at p 57) that the long-run incremental cost of any service i is the change in the firm's total long-run costs $C(Q_1,Q_{2\ldots,}Q_n)$, when the

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8 W.J. Baumol and J.G. Sidak, *Toward Competition in Local Telephony*, MIT Press, Cambridge, 1994, p 56.

9 For example, see J.S. Gans and S.P. King, "Comparing Alternative Approaches to Calculating Long-Run Incremental Cost", Melbourne Business School Working Paper, 2004, pp 2-3, available at http://www.core-research.com.au/index.html.

output of service i is increased by some pre-selected increment. They note that the incremental cost will approximate the marginal cost for a small increment, but may differ substantially from marginal cost over a larger increment. Formally, the long-run incremental cost for some increase in good i from Q_i^0 to Q_i^1 (i.e. $\Delta Q_i = Q_i^1 - Q_i^0$) is:

$$LRIC_i = \frac{\Delta C(\Delta Q_i)}{\Delta Q_i} = \frac{C\left(Q_1^1,...Q_{i-1},Q_i^1,Q_{i+1},...Q_n\right) - C\left(Q_1^1,...Q_{i-1},Q_i^0,Q_{i+1},...Q_n\right)}{Q_i^1 - Q_i^0} \quad \text{(A.2)}$$

A.2.3 The Total Service Long-Run Incremental Cost (TSLRIC) of Production

The long-run incremental cost of providing the entire service is often referred to as the Total Service Long-Run Incremental Cost (TSLRIC). The TSLRIC for service i can be defined as either, the difference in the total cost with and without service i being supplied; the additional cost incurred as a result of the firm producing the entire service i; or the cost to the firm that is avoided by no longer supplying service i. $TSLRIC_i$ can therefore be mathematically written as,

$$TSLRIC_i = C\left(Q_1,...,Q_{i-1},Q_i,Q_{i+1},...Q_n\right) - C\left(Q_1,...,Q_{i-1},0,Q_{i+1},...Q_n\right) \quad \text{(A.3)}$$

By dividing equation (A.3) through by the total level of output Q_i, it is possible to derive a per-unit expression that approximates the long-run marginal cost of production for service i. This yields the total service long-run average incremental cost i (i.e. $TSLR(A)IC_i$), which is equal to,

$$TSLR(A)IC_i = \frac{TSLRIC_i}{Q_i} \approx LRMC_i \quad \text{(A.4)}$$

From equation (A.4) it is apparent that while the TSLR(A)IC is marginal with respect to service i, it is not marginal with respect to the units of output of the service. Further, it will just be equal to the long-run average cost of production where the firm is only supplying one service.

Also referred to by Baumol and Sidak (1994) at p57 as the average-incremental cost of production for an entire service i (AIC_i), TSLR(A)IC is considered to represent a lower bound on the price that should be charged, as it allows for the recovery of all long-run costs that are directly attributable to the provision of the service, but not any of the common costs.[10] Due to the practical difficulties associated with determining the long-run marginal cost, telecommunications regulators in numerous countries have subsequently adopted it to determine the appropriate cost-based access price for interconnection for the service.[11] Even though often expressed on a per-unit basis, regulators commonly refer to this price as a TSLRIC price rather than a TSLR(A)IC price. [12]

When estimating the TSLRIC using an engineering cost model, regulators generally employ some variant of forward-looking cost, rather than historical or backward-looking cost in their calculations. Gans and King (2004) stating at p 7 that:[13]

> The use of forward-looking costs to estimate TSLRIC-based interconnection prices and other cost-based pricing in telecommunications has become relatively standard worldwide.

Although now synonymous with forward-looking cost estimation, Gans and King note (at p 6) that TSLRIC is a "technology-dependent" measure. That is, it can be estimated by employing either backward-looking or forward-looking cost technology.

Finally, while the TSLRIC has only been defined for a single service in equation (A3), Baumol and Sidak note (at pp 82-3) that the TSLRIC can be defined over some sub-group of services k, where k = 1, i, n. In this instance, $TSLRIC_k$ will be equal to,

$$TSLRIC_k = C(Q_1, Q_2 \ldots Q_{i-1}, Q_i, Q_{i+1} \ldots Q_{n-1}, Q_n) - C(0, Q_2 \ldots Q_{i-1}, 0, Q_{i+1} \ldots Q_{n-1}, 0) \quad (A.5)$$

[10] For this reason TSLR(A)IC was originally used in the US as a price floor in the regulation of rail access and long-distance telecommunications access. For example see *Coal Rate Guidelines*, 1 I.C.C. 2d, 520, 1985.

[11] For example, in Australia, the ACCC has adopted the TSLRIC methodology, while in the US the FCC has employed a variant on TSLRIC, the total element long-run incremental-cost (TELRIC).

[12] The total service long-run average incremental cost concept has it origins in the contestable markets literature.

[13] J.S. Gans and S.P. King, "Comparing Alternative Approaches to Calculating Long-Run Incremental Cost", Melbourne Business School Working Paper, 2004, available at http://www.core-research.com.au/index.html.

A.3 The Stand-Alone Cost (SAC)

The stand-alone cost (SAC) is the cost that would be incurred by an efficient entrant to the industry if it chooses to produce a sub-group of the services 1,…n. For example, if the firm were to choose to produce the sub-group k = 1, i, n, the stand-alone cost of production would be,

$$SAC_k = C(Q_1, 0...0, Q_i, 0...0, Q_n) \tag{A.6}$$

If instead the firm only chose to produce service i, then the stand-alone cost will be,

$$SAC_i = C(0, ...Q_i...0) \tag{A.7}$$

The SAC concept is important, as while $TSLRIC_i$ is regarded as representing a lower bound on the amount that should be recovered from service i, the stand-alone cost represents an upper bound on the amount of revenue that should be recovered from any service or sub-group of services. Therefore, while the $TSLRIC_i$ has been used as a price floor in rail access disputes, the SAC has been adopted as a price ceiling. In instances where the SAC is exceeded, it suggests that the rail access provider will be engaging in monopoly pricing of the service.

The total cost along with the SAC can also be used to detect instances of anti-competitive cross-subsidisation, or predatory pricing outcomes.[14] For example, where the price on a sub-group of services –i (i.e. a sub-group including all services except service i) generates revenues exceeding SAC_{-i}, then it can be inferred that a firm subject to a zero profit constraint must be pricing service i below $TSLR(A)IC_i$. As $TSLR(A)IC_i$ approximates the long-run competitive market equilibrium outcome, it suggests the firm is using its revenues on the –i services to cross-subsidise service i, and prevent what would otherwise be an efficient entrant from supplying service i. The result is shown in Box A.3.1.

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14 This outcome was first highlighted by G. L. Faulhaber, "Cross-Subsidization: Pricing in Public Enterprises". *American Economic Review* 65, 1975, pp 966-77, and is also shown by Baumol and Sidak (1994) at pp 84-5.

Box A.3.1 Using Stand-Alone and Total Costs to Detect Predatory Pricing

Where the firm makes normal profits on its services total revenue from the supply of all services TR(.) will be equal to total cost TC(.). That is,

$$TR(Q_1,...Q_i...Q_n) = C(Q_1,...Q_i...Q_n)$$

Now assume that for the sub-group of products excluding service i, the total revenues earned exceed the total costs of providing the sub-group.

$$TR_{-i} = TR(Q_1,...0...Q_n) > SAC_{-i} = C(Q_1,...0...Q_n)$$

By then subtracting the above equations from one another,

$$TR_i < C(Q_1,...Q_i...Q_n) - C(Q_1,...0...Q_n) = TSLRIC_i$$

As the total revenue on service i is just equal to per-unit price P_i times quantity Q_i, (i.e. $TR_i = P_i \times Q_i$), it implies that,

$$P_i < TSLR(A)IC_i \approx LRMC_i$$

A.4 The Common Cost

In the example used in this Appendix, if there is an unattributable, unavoidable or common cost of providing access for the group of services $j = 1,...n$ of CC, then the total cost of production $C(Q_1,\ldots Q_n)$ can be written as,

$$C(Q_1,...Q_n) = \sum_{j=1}^{n} TSLRIC_j + CC \qquad (A.8)$$

As common costs cannot be attributed to any one access service, and cannot be avoided unless the production of all services ceases, it implies that where $Q_j \to 0$, $\forall j$, then $TSLRIC_j \to 0$, $\forall j$, and,

$$\underset{\forall Q_j \to 0}{C(Q_1,...Q_n)} = CC \qquad (A.9)$$

A.4.1 Methods for Recovering Common Costs

From equation (A.8) it is evident that if the regulator were to now price each access service 1,…n at its TSLR(A)IC, the firm would not be able to generate sufficient revenues to recover its common cost CC. Therefore, if the regulator does not permit multi-part access tariffs on the services, then it must allow some form of mark-up above the linear TSLR(A)IC-based access prices to ensure that the firm fully recovers its common costs.

Fully-Distributed Cost (FDC) pricing can be adopted to achieve common cost recovery. While FDC may involve any arbitrary mark-up on the TSLR(A)IC that achieves the required cost recovery, Braeutigam (1980) outlines three specific methods that were commonly used to allocate the common cost across each of the services:[15]

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[15] R.R. Braeutigam, "An Analysis of Fully Distributed Cost Pricing in Regulated Industries", *Bell Journal of Economics* 11, 1980, pp 182-96.

(1) Relative Output (i.e. $\alpha_j = \frac{Q_j}{\sum_{i=j}^{n} Q_j}$);

(2) Attributable Cost i.e. ($\alpha_j = \frac{C_j}{\sum_{j=1}^{n} C_j}$); and

(3) Gross Revenue i.e. ($\alpha_j = \frac{TR_j}{\sum_{i=1}^{n} TR_j}$).

While FDC pricing allows the access provider to fully recover the common costs CC, it has been shown that it is unlikely that it will generate the socially-optimal outcome.

Ramsey-Boiteux (R-B) pricing represents the most efficient linear pricing method for recovering the common costs of production.[16] In its simplest guise — i.e. where there are no cross-price effects — R-B pricing involves setting the price of good or service i so that the lower (higher) the own-price elasticity of demand ε_i is, where $\varepsilon_i = -\frac{\partial P_i}{\partial Q_i}\frac{Q_i}{P_i} > 0$, the greater (lower) the proportionate mark-up that is required in price P_i from the long-run marginal cost of production $LRMC_i$. Consequently, R-B pricing is often referred to as the "inverse-elasticity rule". While representing a theoretical ideal, Baumol and Sidak (1994) highlight that in practice, there are difficulties associated with calculating R-B prices. In particular, they highlight problems with estimating and using demand elasticities, stating on p 39 that:

> …up-to-date estimates of the full set of pertinent elasticities and cross-elasticities are virtually impossible to calculate, particularly in markets where demand conditions change frequently and substantially. As a result, an attempt to provide the regulator with an

[16] Ramsey-Boiteux pricing in the context of utility pricing, acknowledges the work of F.P. Ramsey, "A Contribution to the Theory of Taxation", *Economic Journal* 37, 1927, pp 47-61, who established the initial rule (i.e. the "Ramsey Rule") in the context of optimal taxation, and M. Boiteux, "Sur la Gestion des Monopoles Publics Astrient á L'Equilibre Budgetaire", *Econometrica* 24, 1956, who independently derived the same result in the context of cost recovery for a public utility.

> extensive set of Ramsey prices is likely to beset by inaccuracies, by obsolete demand data, and by delays that will prevent the firm from responding promptly and appropriately to evolving market conditions.

A detailed analysis of the theory underlying R-B pricing is provided in Appendix B.

Recognising the practical difficulties associated with calculating R-B prices and the need to recover common costs, regulators have generally allowed for a mark up in the standard TSLRIC-based access price to apportion the common costs of providing services. For example, in Australia, to determine the appropriate price for PSTN origination/termination access charges, the ACCC has used what it refers to as a TSLRIC+ estimate to account for the common costs associated with the customer access network (CAN).[17]

A.4.2 Common Costs verses Fixed Costs

The long run is that period of time where all factors of production are variable. As there are no fixed factors of production, technically there are also no fixed costs in the long run. However, many economists and industry analysts still often refer to the need to recover fixed costs when estimating long-run costs of production in network industries. For example, Emmerson (1999) states in relation to efficient pricing that:[18]

> …economic efficiency as defined by economist Vilfredo Pareto (1909), is achieved when market prices equal long-run marginal cost. It is long-run marginal cost that is relevant because of the present of fixed costs (then presumed to be only a short-run phenomenon) may require deviations from marginal cost pricing.

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17 In an addition to the mark up to take into account the common costs of production, the ACCC has also previously allowed Telstra to recover a mark-up on the terminating and originating PSTN access charge to provide recovery for some portion of the access deficit — i.e. the loss from the below-cost regulated prices applying to local services. The final price estimate where there is this double mark-up is referred to as TSLRIC++.

18 R. Emmerson, “Cost Models: Comporting with Principles”, in J. Alleman and E. Noam (eds.), *The New Investment Theory of Real Options and its Implications for Telecommunications Economics*, Kluwer Academic Publishers, Boston, 1999, p 88.

Similarly, Charles River Associate (2004) consistently talks of a mark-up being required on the TSLR(A)IC-based price to account for what it refers to as the "fixed and common costs".[19]

It appears that the confusing references to fixed costs arising in the long run, originates from the Contestable Markets literature, and in particular a paper by Baumol and Willig (1981).[20] In this paper, Baumol and Willig redefine the well-established economic meaning of the fixed cost. At Definition 1, on p 406, the authors provide a formal definition for the concept of a *Long-run fixed cost*. They go on to state that:

> It should be emphasized that here fixed costs mean costs that are fixed in the long run as well as in the short. Thus, investment in large-scale plant and equipment do not generally qualify. For, as the textbook aphorism says, such costs do indeed become variable in the long run.

When referring to "fixed costs" in the long run, Baumol and Willig and many other economists actually seem to be identifying either joint, shared or common costs of production that cannot be directly attributed or allocated to any particular service in the long run. While going against the traditional definition in the literature on costs, the Baumol and Willig definition of fixed costs, which identifies unattributable or unallocated costs as a long-run fixed cost, is in some ways understandable. That is, from equation (A.9), it is evident that the common costs do not vary with the level of services being supplied, and that they do remain "fixed" in the long run.

One problem with having two definitions for fixed costs is that it is open for network operators to exploit this confusion and potentially over-recover their costs. For example, by switching between the traditional and Baumol and Willig definitions for

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19 Charles River Associates (CRA), *Pricing Mobile Termination in Australia*, A Submission prepared on behalf of Singtel Optus, 22 December 2004, available at http://www.accc.gov.au/content/item.phtml?itemId=573237&nodeId=file425216ae7cd1d&fn=Appendix%20II%20to%20Optus%20MTAS%20undertaking%20submission.pdf. In particular, see pp 10-13.

20 W.J. Baumol and R.D. Willig, "Fixed Costs, Sunk Costs, Entry Barriers, and Sustainability of Monopoly", *The Quarterly Journal of Economics* 96, 1981, pp 405-31.

the fixed cost, a network operator can argue that it should receive some form of mark-up to account for "fixed costs", which are actually made up of a combination of Baumol and Willig fixed costs (i.e. common, shared or joint costs of production), and the traditional short-run fixed cost that should already have been compensated for in the TSLR(A)IC-based access price.

A.5 The Total Element Long-Run Incremental Cost (TELRIC)

Instead of defining the total incremental cost over the service, it is also possible to define the incremental cost over an element that is used to provide the service. This is the methodology that has been adopted in the US by the FCC to price access to the facilities of the incumbent local exchange carrier.

As TELRIC has been described as "a variant of the more widely known 'total-service long-run incremental cost' — TSLRIC",[21] most economists have chosen to use the two terms interchangeably. For example, when assessing the TELRIC-based access price Sidak and Spulber (1997) state (at p 404) that,

> To avoid redundancy, and because the economic analysis is the same in either case, we subsume our critique of TELRIC pricing within that of TSLRIC pricing.[22]

Further, the Productivity Commission (2001) has even claimed (at p 622, footnote 1) that the TELRIC and TSLRIC "distinction is somewhat arbitrary", and provide the example of the ACCC using TSLRIC, yet costing network elements such as the local loop.[23]

Some economists, however, suggest that there are significant differences between the two measures. For example, while Sidak and Spulber choose to subsume their critique of TELRIC pricing within that of TSLRIC pricing, they still maintain at p 404 that, "there is an important difference between TSLRIC and TELRIC that should be noted". They outline that while TSLRIC prices outputs and services, TELRIC prices the inputs of the firm, and hence according to Sidak and Spulber (at p 404), the choice

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21 A.E. Kahn, T.J. Tardiff and D.L. Weisman, "The Telecommunications Act at Three Years: An Economic Evaluation of its Implementation by the Federal Communications Commission", *Information Economics and Policy* 11, 1999, pp 319-365.

22 J.G. Sidak and D.F. Spulber, *Deregulatory Takings and the Regulatory Contract: The Competitive Transformation of Network Industries in the United States*, 1997, Cambridge University Press, Cambridge.

23 Productivity Commission, *Telecommunications Competition Regulation*, Report No. 16, 20 September 2001, available at http://www.pc.gov.au/inquiry/telecommunications/finalreport/index.html

of TELRIC by the FCC, "represents a significant increase in regulatory control" and "an additional level of regulator intrusiveness".

Gans and King (2004) outline that while the theoretical foundations of the two are similar, important differences exist in relation to the apportionment of common costs under the TSLRIC+ and TELRIC pricing regimes. They note (at p 11) that because of the element-by-element approach taken by TELRIC it has fewer common costs, and "avoids many of the cost-allocation issues associated with TSLRIC+". Using an algebraic example the authors show (on p 17) that there will be "different prices for telecommunications services whenever the network involves any element whose costs are partially common to a number of services and partially incremental to particular services." As such elements commonly exist in telecommunications networks, Gans and King conclude that there are likely to be inconsistencies between TSLRIC-based and TELRIC-based access price, and the TELRIC price for the service may either fall below the TSLRIC, or exceed the SAC. In a separate paper, prepared on behalf of AAPT, Gans and King use very similar analysis to establish that in practice, the TELRIC estimates obtained from using Telstra's PIE II cost-model will systematically overstate the true TSLRIC-based access charge.[24]

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[24] J.S. Gans and S. King, "Comparing TSLRIC and TELRIC", A Report on Behalf of AAPT Limited, 23 July 2003, p 19, available at http://www.core-research.com.au/index.html.