FINAL REPORT

Pricing Mobile Termination in Australia

Submitted to

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22 December 2004

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1. EXECUTIVE SUMMARY

In June 2004, Optus engaged Charles River Associates ('CRA') to estimate the economically efficient level of costs that should be recovered from mobile termination services in Australia. The basic approach has been to model efficient prices using an economic model of the mobile market that calculates efficient prices given appropriate cost inputs and demand parameters. The model was developed by Dr Rohlfs on behalf of, and is publicly available from, the UK Office of Communications (Ofcom). The model has been calibrated using a Forward-Looking Long-Run Incremental Cost (FL-LRIC) model of mobile costs developed by CRA with Optus support, and using Optus confidential data. Other necessary inputs have generally been publicly sourced.

This Report explains our modelling approach, how the necessary inputs to the Rohlfs model have been estimated, in particular by developing the FL-LRIC model, and presents the results. The key purpose of this Report is to assist the ACCC in assessing whether the prices proposed in Optus' undertaking are reasonable.

Modelling approach

In summary, the approach to estimating the welfare-maximising level of termination charges involved the following key steps.

- Optus identified costs relating to its GSM mobile business for 2003/04.

- Adjustments were made to the cost base so that asset values reflect current equipment prices, rather than historical costs. A cost of capital was estimated using a Weighted Average Cost of Capital approach that is in line with the approach taken by the ACCC in regulatory decision-making. A tilted annuity approach was then used to determine the level of capital costs to be recovered in each year.

- Optus' engineers estimated call routing factors that identify the extent to which each service uses particular network elements based on Optus' network configuration. Non-network costs were similarly allocated to services to the extent to which the services (mainly subscription) give rise to those costs. This enabled estimation of the long-run incremental costs of the major types of services, *viz.* (i) on-net calls; (ii) mobile-to-fixed calls; (iii) off-net mobile-to-mobile calls; (iv) termination of calls from other mobile and fixed operators; (v) SMS and data services; and (vi) subscription. Other types of services, which account in aggregate for less than one per cent of Optus' total mobile traffic, were not separately modelled. We scaled up Optus' actual fixed and common costs to market scale using Optus' market share of subscribers.

- The welfare-maximising level of termination charges was then estimated using the economic pricing model (the Rohlfs model) developed by the UK regulator, Ofcom (and its predecessor Oftel), for its Cost Benefit Analysis of the impact of termination regulation. In relation to the Rohlfs model, Oftel

  > *considers that the analysis by Dr Rohlfs is very useful to inform the judgement about the size of the reasonable mark-up on termination to reflect economic efficiency considerations…Oftel considers Dr Rohlfs' findings helpful and his approach sensible. The model elaborated by Dr Rohlfs is stable and its results do not seem to be unduly sensitive to changes in the assumptions or in the costs.*[1]

- The underlying structure of the Rohlfs model reflects the main intuition of Ramsey-Boiteux pricing – that welfare can be maximised by recovering fixed and common costs in a manner that minimises distortions to demand. The model goes beyond 'simple' Ramsey-Boiteux pricing to capture the complexity of the structure of demand for mobile services, including cross-elasticities of demand that take the form of externalities. The adoption of the Rohlfs model is consistent with a conservative approach – the estimated optimal termination charge level from the Rohlfs model was at the low end of the range of estimates produced by the demand models developed in the course of the UK regulatory inquiries.[2]

- In using the Rohlfs model to estimate the welfare-maximising level of termination charges in Australia, we employed cost, price and demand parameters (including elasticities) that were the best estimates available for the Australian market. However, the Rohlfs model also includes a number of constraints on particular parameters reflecting Oftel's assumption that externalities are largely internalised. We have retained these constraints to ensure a conservative approach, although we note that the alternative approach of using empirically derived values for these parameters would lead to a higher optimal termination charge being estimated.

Waterbed effect

One area of disagreement between the ACCC and mobile operators in the declaration inquiry related to the level of the waterbed effect, i.e. the extent to which prices to mobile customers would rise in response to a reduction in termination charges. Ofcom assumed a complete waterbed effect (i.e. no change in profits) in its Cost-Benefit Analysis of termination charge controls in the UK,[3] and the UK Competition Commission believed that "there will be a waterbed

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1 Oftel, *Ramsey prices and network externalities: Dr Rohlfs' analysis*, 23 May 2002, (available at http://www.ofcom.org.uk/static/archive/oftel/publications/mobile/ctm_2002/ramsey_cover0602.pdf).

2 See UKCC *Calls to mobiles report*, 2003, Table 9.1.

3 See, for instance, Ofcom, *Statement on Wholesale Mobile Voice Call Termination*, 1 June 2004, para. 6.117 (first bullet point).

effect, i.e. most of the reductions in revenue from termination charges being capped will be recovered from the retail market."[4] Conceptually, even if the mobile market were a monopoly, a substantial waterbed effect would be expected – the reduction in termination charges alters the profit maximising level of mobile retail prices as each subscriber would no longer be as profitable to acquire as previously.[5] In a market for mobile services that is effectively competitive or close to it, there would be expected to be a complete or near complete waterbed effect. In the case of Australia, there is already evidence of vigorous competition in the mobile market. Thus it would be reasonable to expect that as mobile market competition becomes even more intense over time, the waterbed effect would be complete or near complete over the same time horizon.

Results

Table 1 shows the estimated welfare-maximising level of Australian mobile termination charges.

Table 1: Estimated welfare-maximising level of termination charges (in 2004-05 Australian dollars)

	2004-05	2005-06	2006-07
Cents per minute (cpm) (in 2004-05 Australian dollars)	17.0	16.6	16.1
Nominal cpm (assuming CPI of 2.5%)	17.0	17.0	16.9

The estimated termination charges represent a conservative estimate of the welfare maximising level of termination charges based on robust economic theory encapsulated in Oftel's Rohlfs model and the best available information on the relevant parameter values for the Australian market. While there is a degree of uncertainty over some of the parameter values, we do not consider the extent of the uncertainty to be so great as to suggest that the adoption of an alternative 'rule of thumb' approach to recovering costs, such as an Equi-Proportional Mark-up approach, would be any more likely to maximise overall welfare.

4 UKCC Report, *Calls to mobiles*, 2003, para 2.563.

5 As discussed in Section 2.10 of this Report, even for a monopolist a 50 per cent waterbed effect would be expected with a linear demand curve. For other commonly assumed shapes of the demand curve, the waterbed effect would be higher.

Throughout the modelling, we have sought to take a 'conservative' approach. This means that where modelling decisions have had to be made, we have generally favoured the approach that results in a lower rather than higher estimated termination rate. We therefore believe that our modelling results provide a conservative estimate of the efficient price of termination in Australia. All things being equal, it is more likely that our results risk underestimating the efficient price of mobile termination in Australia. Further, given the way mobile prices interact with each other and with network subscription levels, we do not believe it would prudent to set mobile termination rates at or close to the lower bound of an estimated range of termination rates. For these reasons, we consider it reasonable to treat the estimates from our modelling exercise as indicative of the level of prices at or below which net social welfare losses are likely to materialise

Structure of Report

This Report is structured as follows:

- Section 2 discusses the methodology employed in calculating the FL-LRIC estimates for the supply of mobile termination and other mobile services needed to calibrate the Rohlfs market model;
- Section 3 introduces the Rohlfs model and sets out the basis for calibrating the model for the Australian market; and
- Section 4 presents the results of our modelling.

2. METHODOLOGY

2.1. FL-LRIC PRINCIPLES

A central result of economic theory is that equating the price of a product with its marginal cost of supply maximises allocative and productive efficiency. Essentially, this ensures that resources flow to the products that are most highly valued by consumers, i.e. a product will only be supplied if it is valued by consumers (who are thus prepared to pay the price for the product) at a level higher than the value placed on any alternative use of the resources that are employed in supplying that product.[6] In practice, it is difficult to measure the marginal cost incurred in the supply of an individual unit of a product (e.g. one call minute), so incremental cost is instead measured. Incremental cost is the cost incurred in supplying an increment of output of a product given that some level of output is already being produced. The marginal cost of the product can be approximated by choosing the smallest increment of output for which it is practical to measure its cost. In the long run, incremental costs will include both operating costs as well as capital costs (i.e. depreciation and a return on capital) that are incurred in the supply of the product.

Many products also involve fixed and common costs. Fixed costs are costs that do not vary with the level of output. To identify whether a cost is fixed, a timeframe should be chosen that is relevant to the particular economic decision being made. Common costs are costs that are incurred in the production of two or more products and that are not incremental to any one product. Where fixed and common costs are related to the same set of products they are typically treated together, as the economic problem of how to efficiently mark-up prices above marginal costs to recover either type of cost is identical.

Reflecting the need for operators to recover their total costs, regulators frequently apply a Long Run Incremental Cost (LRIC) approach that sets prices so as to ensure sufficient revenue to cover:

- The LRIC of supplying a service; and
- A mark-up to contribute towards the recovery of fixed and common costs.

In determining the pool of costs to be recovered, regulators often employ a forward-looking approach that estimates the costs that would be incurred by a new entrant in supplying the services. This has been argued to mirror the operation of a competitive market in which an operator that had inefficiently incurred costs in the past would not be able to recover those costs if it were in competition with an efficient new entrant.

6 If consumers did not value the product by more than its cost, the resources involved would be better used elsewhere in the economy.

The rest of this Section details the FL-LRIC approach we applied in estimating the cost of supplying mobile services.

2.2. CHOICE OF OPERATOR

The model was set up to estimate the costs that would be incurred in the supply of mobile services in Australia and thus reflects the particular country specific factors impacting on Australian mobile operators.

Where a FL-LRIC approach has been applied by regulators in other jurisdictions, a key question has been the choice of which size and type of operator to model. For instance, the UK Competition Commission recommended adopting a cost based on a market share that was achievable by all operators and commented:

> *It would be wrong, however, to penalize an MNO with a greater than average traffic market share for its success in winning customers … we therefore decided that the appropriate cost for all operators, in the short term, should be based on a 20 per cent market share, being the approximate share of T-Mobile and O2 [i.e. the smallest operators] in 2002. By 2006, the appropriate cost for all operators would be based on the DGT's original estimate of the share for that year of an average existing MNO following the launch of Hutchison 3G, being a 22 per cent market share.*[7]

The approaches in Malaysia and Sweden also appear to be based on modelling of an operator with an average market share.[8]

Whether mobile termination regulation should be based on a uniform charge or differential operator-specific charging is clearly a significant issue that needs to be addressed by regulators such as the ACCC. We have adopted a conservative approach of using Optus' actual traffic volumes that will lead to a lower cost estimate than the alternative approach of using the lower traffic volumes of an average or marginal Australian operator.

Our model is also based on the network technology and spectrum allocation of Optus' GSM network. This choice reflects the purpose of the modelling to determine a charge that would be reasonable for the recovery of the costs necessarily incurred by Optus in the supply of mobile termination. We note that in the modelling exercises in the UK, Malaysia and Sweden, where the regulation is to be applied to several operators, the regulators sought to determine prices that would allow each operator to recover its costs given its particular network technology and spectrum allocation. Thus the choice of Optus' technology and

7 Competition Commission, *Calls to mobiles report*, 2003, para. 2.278.

8 See Malaysian Communications and Multimedia Commission, *A consultation paper on access pricing*,13 May 2002, p.16 and Analysys, *Documentation for the Hybrid Mobile LRIC Model*, 29 March 2004, p.4.

spectrum to determine Optus' charges is consistent with the approaches adopted by the UK, Malaysian and Swedish economic regulators.

A related issue is the treatment of economies of scope arising from integrated fixed/mobile services (relative to mobile-only services). While this was not an issue in the UK after the separation of O2 from BT, we understand that the approaches in Malaysia and Sweden sought to model costs that would be achievable by all the mobile operators and thus were not adjusted downwards to the lower cost levels of the integrated fixed/mobile operators. In providing data to CRA, Optus reviewed its cost base and provided costs related to its mobile operations on a stand-alone basis.

2.3. Top-Down or Bottom-Up Approach

In developing an approach to regulate fixed incumbent operators, regulators were concerned that the costs of the incumbents may include significant inefficiencies given the age of the network and the fact that much of the design and investment in their networks were undertaken at a time when they were operating free from competitive constraints. To exclude the potential for the actual costs of the incumbents to harbour significant inefficiencies, regulators have often developed 'bottom-up' models of an efficient hypothetical operator. These, however, can be protracted exercises and prone to inaccuracy given the scope for the theoretical exercises to miss actual constraints on network design.

In contrast to the networks of fixed incumbents, a substantial proportion of investment in the Australian mobile networks has been undertaken relatively recently and in a competitive environment. Thus it is unlikely that the actual networks deployed by Australian mobile operators would exhibit any significant inefficiencies. This suggests that the efficient costs of supplying mobile termination in Australia can be reasonably estimated by the use of a top-down model based on actual operators' network design.[9]

International regulatory processes have also recognised this approach. For instance, while a bottom-up model was developed in the UK, the UK Competition Commission noted that "there was … a real risk that the model had created a hypothetical network that could be unrealistic"[10] and consequently the Commission adjusted the bottom-up estimates to reflect the actual networks of the UK operators, such as in relation to the number of base stations. Analysys noted, with reference to the model for the Swedish regulator:

9 Nonetheless, the model is not based on actual network costs as asset values have been adjusted to reflect modern equipment prices (see section 2.4).

10 Competition Commission, *Calls to mobiles report*, 2003, para. 2.274. A discussion of the adjustments made to bring the LRIC numbers in line with costs is at para. 2.291ff.

> *However, distinct from the fixed network, mobile operators in Sweden have been characterised by competitive infrastructure provision since the launch of GSM operations. On this basis, it is unlikely that any mobile operator has developed with significant inefficiencies, as such inefficiencies would be unlikely to be sustainable over a number of years.*[11]

The final Swedish estimate reflects a hybrid model that includes a top-down element drawn from operators' actual design.

Reflecting these considerations, we have used a top-down approach based on Optus' actual network design and costs to estimate the FL-LRIC incurred by Optus in supplying mobile termination services. We believe that the resulting estimates are suitable for the purpose of generating reasonable cost-based estimates of the long run marginal costs of mobile services.

2.4. Forward-Looking Approach

The modelling approach is forward-looking in the sense of measuring the cost that would be incurred by a new entrant supplying the GSM services rather than the historical costs of Optus' past equipment purchases. In particular, the model adjusts the asset values to reflect the costs that would be incurred if the equipment were bought today. Optus provided information on changes in its mobile network equipment prices over time.

2.5. Choice of Services

For the purpose of cost modelling, Optus' costs of its mobile business were allocated between:

- subscription;
- on-net mobile calls;
- off-net mobile-to-mobile calls;
- mobile-to-fixed calls;
- the termination leg of an off-net mobile-to-mobile call or a fixed-to-mobile call; and
- SMS and data services.

11 Analysys, *Documentation for the Hybrid Mobile LRIC Model*, 29 March 2004, p.5.

Costs and revenues attributable to data services, particularly SMS, were then removed and not included in the Rohlfs model in estimating the efficient set of mobile prices. Other mobile services, which account in aggregate for less than 1% of Optus' total traffic volumes, have not been explicitly modelled.

2.6. CHOICE OF INCREMENT

As discussed in Section 2.1 above, modelling the smallest increment of output practical will best approximate the marginal cost benchmark for allocative efficiency. In the model, we have separately estimated the incremental costs of the individual voice services and thus are able to recognise any differences between the incremental costs of the particular services. We have also explicitly recognised that an element of the network and non-network costs are fixed and common costs (see Section 2.7). The approach to recovering fixed and common costs is set out in Section 2.10.

We note that this approach contrasts with a Total Service Long Run Incremental Cost (TSLRIC) approach in that fixed costs are explicitly separated and recovered through a mark-up. A TSLRIC approach instead models the whole service as the relevant increment (effectively an average cost approach) so that any fixed costs incurred in supplying the service are included in the TSLRIC estimate rather than the mark-up.

2.7. FIXED AND COMMON COSTS

The supply of mobile termination services involves significant fixed costs, and as a result implies the presence of significant economies of scale.[12] As many of the network elements are used in the supply of a range of services, economies of scale from greater general traffic volumes also imply the existence of economies of scope in relation to the supply of the different types of services.

Both the modelling exercises for the UK and Swedish regulators recognised the existence of common costs, and allowed mark-ups for the recovery of the common costs in relation to:

- The network level, particularly arising from the provision of network coverage; and

12 A number of recent studies confirm the existence of significant economies of scale in mobile services, including M. Noguchi, *Economies of scale and scope in Japanese mobile markets and its policy implications*, 30 August 2004 (available at http://userpage.fu-berlin.de/~jmueller/its/conf/berlin04/Papers/noguchi.pdf), R.D. Foreman and E. Beauvais, *Scale Economies In Cellular Telephony: Size Matters*, Journal of Regulatory Economics, 16 (3), pp. 297-306, November 1999 and A Macpherson, *The size of fixed common costs in mobile networks: empirical evidence from Europe*, Vodafone Policy Paper Series, 1, pp.3-5. One earlier study found constant or decreasing returns to scale, although this study seems to suffer from severe data limitations including the use of only 28 observations (D. McKenzie and J. Small, *Econometric Cost Structure Estimates for Cellular Telephony in the United States*, Journal of Regulatory Economics, 12 (2), pp.147-157, September 1997).

- Non-network costs, such as administration and overheads.[13]

Two approaches exist to estimating the size of fixed and common costs in a particular network. One approach is to conduct an econometric study of how costs or network equipment varies with the major traffic driver, *viz.* busy hour Erlangs. This approach was employed by PricewaterhouseCoopers for a Vodafone Public Policy Paper.[14] The study estimated that fixed and common costs account for 14%, 23% and 45% of total network costs in Greece, the Netherlands and Spain respectively.

An alternative approach is to examine the individual network components. For instance, an Analysys report for the Swedish regulator examined what proportion of network elements in different areas were driven by demand for capacity (and hence incremental to traffic), and what proportion reflected the cost of providing network coverage.[15] The approach taken by Analysys in its report to the Swedish regulator is a refinement of their earlier approach taken in the work for Oftel. Analysys concluded that a small proportion of sites in suburban areas, between 45 – 60 per cent of sites in rural areas and some other network costs in Sweden were coverage related. Network coverage can be seen as a pre-condition to supplying any services in a mobile network as the distinguishing feature of mobile services is enabling subscribers to make and receive calls from anywhere within the network's coverage area. As such, coverage costs can be treated as a common cost across the different services.[16]

The identification of specific fixed and common costs at the network and non-network levels was undertaken so as to estimate the actual incremental costs of the particular services that do not include any fixed and common costs elements. There was then a need to estimate the overall level of fixed and common costs. There are a number of substantial practical difficulties with measuring overall cost levels on the basis of accounting cost data, including the need to recognise:

13 See, for instance, Oftel, *Review of mobile wholesale voice call termination markets - EU Market Review*, 15 May 2003, para. 7.48 and Analysys, *Documentation for the Hybrid Mobile LRIC Model*, 29 March 2004, p.12. The magnitude of fixed and common costs at the network level, while ultimately an empirical issue, was the subject of some debate – see, for instance, Europe Economics, *Cost structures in mobile networks and their relationship to prices – Responding to Oftel,* 22 July 2002.

14 A. Macpherson, "The Size of Fixed Common Costs in Mobile Networks: Empirical Evidence from Europe," Vodafone Policy Paper Serice, 1, pp. 3 – 5.

15 Analysys, *Final Position on Common Costs – Final Response to Industry and the PTS,* 13 February 2004.

16 Indeed, regulators have taken a significant interest in whether entrants to the mobile market have been able to negotiate 2G roaming agreements as an interim measure to achieve coverage while rolling out their networks. This specifically reflects the fact that coverage in effect is a large fixed and common cost that significantly disadvantages operators with small customer bases.

- Returns for *ex ante* risks incurred at the time the investments were undertaken, including the substantial technological and commercial risks associated with investments in mobile services.[17]

- Depreciation on past expenditures giving rise to intangible assets such as those produced by R&D, advertising activities and the reputation of years of good services;

- Returns to superior factor/s of production, such as superior management; and

- Timing issues, such as higher returns in the later years of an investment to compensate for losses in the initial years and higher returns in economic 'boom' years to sustain lower expected returns in other years.

The problems with the use of accounting data to identify economic costs and economic profit are well-recognised.[18] Recognising these difficulties, the established competition law approach assesses competition by reference to a number of indirect indicators, including market structure, barriers to entry and expansion and buyer power. The European Commission has developed a list of the criteria to be used by European national regulators in assessing competition in communications market (the list does not include (accounting) profitability).[19]

On the basis of the established competition law approach to the assessment of competition, there is strong evidence that the Australian mobile market is effectively competitive:

- Four operators and more than 13 mobile service providers competing aggressively for market share;[20]

- A market structure that is less concentrated than other mobile markets that have been found to be effectively competitive;[21]

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17 The Productivity Commission has drawn attention to this problem in regulation: "The fundamental problem stems from the difficulty that regulators have in distinguishing the ex post rewards for risky investments from monopoly rents, when just such a distinction is needed to achieve the required ex ante return for the investor" (PC, *Telecommunications Competition Regulation*, 2001, p. 288).

18 See F.M. Fisher and J.J. McGowan, "On the Misuse of Accounting Rates of Return to Infer Monopoly Profits", *American Economic Review*, Vol. 73, No. 1 (March 1983), pp. 82-97, reprinted as Chapter 4 of F.M. Fisher, *Industrial Organization, Economics, and the Law* (Hemel-Hempstead: Harvester-Wheatsheaf and Cambridge, MA: MIT Press), 1990-91.

19 *Commission guidelines on market analysis and the assessment of significant market power under the Community regulatory framework for electronic communications networks and services* (2002/C 165/03), para. 78.

20 For instance, see the Australian, "Xmas mobiles price war", 8 October 2004.

- Low barriers to expansion and low barriers to entry, including Hutchison's successful negotiation of roaming agreements, as well as currently idle spectrum;
- Low switching costs and high levels of switching;
- High fixed costs and low marginal costs and hence an incentive to compete strongly at the margin;
- Relatively high penetration rates consistent with a competitive market rather than output-restricting market power; and
- Rapid product and technological change.

Given the evidence of vigorous competition in Australia's mobile retail market, it seems reasonable to conclude that current industry revenues do not harbour significant levels of excess profits. Accordingly, any difference between industry revenues and the accounting costs of the operators is likely to reflect the other elements of costs that are not captured in accounting costs, such as returns to *ex ante* risks, depreciation of intangibles and timing differences. Therefore, although the costs and revenues in the model, which exclude data costs and revenues, almost balance and would show a profit if contributions from data (SMS in particular) were included, we do not think it would be appropriate to assume that 'excessive' profits are being made if data contributions were included. In our view, this modelling exercise is not capable of identifying the presence of economic profits. We have therefore not made any adjustments to the actual costs modelled to reflect contributions from data services.

2.8. Ramsey-Boiteux Pricing

Having identified the level and nature of the costs involved in supplying mobile services via the FL-LRIC modelling process, the next step is to determine what structure of prices would enable those costs to be recovered in a manner that maximises overall consumer welfare. This involves determining the mark-ups over the FL-LRIC estimates of the cost of mobile services, and of termination in particular, that maximise overall social welfare in the mobile market. In the context of mobile termination regulation, there are three key considerations impacting on the optimal structure of pricing:

- Ramsey-Boiteux pricing;
- Externalities; and

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21 For instance, see the European Commission's comments rejecting the opinion of the Finnish regulator that the Finnish mobile market was not effectively competitive, even with TeliaSonera having a market share over 60% (Commission Decision of 5 October 2004 pursuant to Article 7(4) of Directive 2002/21/EC (" Withdrawal of a notified draft measure") - CASE FI/2004/0082: Access and call origination on public mobile telephone networks in Finland).

- Rebalancing.

These issues are dealt with in the calculations undertaken within the Rohlfs model. This section considers Ramsey-Boiteux pricing while the following sections discuss network externalities and rebalancing.

The ACCC summarises the motivation for Ramsey-Boiteux pricing in the following terms:

> *Ramsey pricing concepts … deal with finding a configuration of prices that would ensure that these common costs are recovered in the least distortionary way. Under a Ramsey configuration, the structure of prices across a collection of services sharing common costs would ensure higher proportionate mark-ups above attributable costs for those services with relatively inelastic demands, according to the inverse elasticity or 'Ramsey-Boiteux' rule.*[22]

The welfare-maximising property of Ramsey-Boiteux pricing is well established in economic theory[23] and is discussed further in Appendix A. As the ACCC notes, Ramsey-Boiteux pricing essentially requires that contributions to fixed and common costs be higher on services that have relatively inelastic demand. In doing so, the overall level of deadweight losses arising from the need to recover fixed and common costs can be minimised.

In a simple case of independent demands, Ramsey-Boiteux pricing implies that the mark-up on each service to recover the fixed and common costs should be inversely proportional to the relative elasticity of the service. For instance, if one service has an own-price elasticity of -0.3 and another an elasticity of -0.6, then the first service should have a mark-up twice that of the second service. An alternative approach that simply allocated fixed and common costs equi-proportionately to the two services could imply a larger loss in welfare compared with Ramsey-Boiteux pricing.

Whether there are differences in the own-price elasticities of the various mobile services is ultimately an empirical issue. Our model has been based on averages of the estimates of own-price elasticities from the available econometric studies as representing the most robust source of information on elasticities.

The intuition behind Ramsey pricing also holds in the more complex case of interdependent demands. For instance, the price of a service should be lowered from the 'simple' Ramsey-Boiteux level determined with respect to own-price

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22 ACCC, *Mobile Services Review - Mobile Terminating Access Services*, June 2004, p. 145 (hereafter referred to as 'ACCC Final Decision').

23 For instance, W. Viscusi, J. Vernon and J Harrington, *Economics of Regulation and Antitrust (2nd Ed.)*, The MIT Press, 1995, p. 365-367. Laffont and Tirole identify the desirability of price discrimination to minimise the distortion resulting from the need to recover joint and common costs as one of five key insights in their book *Competition in telecommunications*, The MIT Press, 2000. A formal derivation of Ramsey-Boiteux pricing is provided in See Brown, S.J. and D. S. Sibley, *The theory of public utility pricing*, Cambridge University Press, 1986, section 3.3.

elasticities if doing so raises the demand for a complementary service. In the case of mobile services, as new mobile subscribers join a network they can be expected to make calls and so increase the number of mobile outgoing calls. This complementarity between subscription and mobile outgoing calls needs to be recognised in calculating the set of Ramsey-Boiteux prices so as to ensure that the overall distortion to demand from the recovery of fixed and common costs is minimised. The existence of complementarities requires Ramsey-Boiteux pricing to be defined with reference to *superelasticities* that include both own and cross price elasticities.[24]

A fuller discussion of Ramsey-Boiteux pricing is presented out in Appendix A and the model structure is described in Annex A of the report prepared by Dr Rohlfs for Oftel. Mobile services also give rise to externalities that will impact the socially optimal level of prices. These are discussed in the next section.

2.9. EXTERNALITIES

The Ramsey-Boiteux pricing theory extends logically to the situation in which there are externalities arising from cross-price elasticities between services. Consumption externalities arise when the consumption decision of one consumer impacts on the decisions of others and these effects are not taken into account. For telecommunication services, the most important type of externality is network externality, i.e. the benefit that other subscribers receive when an additional subscriber joins a network and that is not reflected in the marginal subscriber's decision to join. The importance of network externalities is recognised in relation to supporting higher numbers of fixed telephony subscribers via USO schemes. As Ofcom notes: "The economic rationale for USOs is based on network externalities."[25] In relation to mobile networks, the case for a subscription subsidy is stronger in light of empirical findings that mobile subscription is substantially more price elastic than fixed subscription and hence the social benefit of a subsidy would be expected to be higher.[26] In other words, externalities between the fixed and mobile networks do not 'balance out' because both the subscription elasticities and marginal costs are significantly different, with mobile services being more price elastic and more costly at the margin.

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24 See Brown, S.J. and D. S. Sibley, *The theory of public utility pricing,* Cambridge University Press, 1986, p.42-43 and the Appendix to Chapter 3.

25 Ofcom, *Strategic Review of Telecommunications Phase 1 Consultation Document*, 28 April 2004, para. G.35.

26 A survey of econometric studies suggests the reasonable range of fixed-access elasticities to be between -0.02 and -0.10, whilst mobile-access elasticities would be between -0.30 and -0.54 (Submission by Vodafone to the New Zealand Commerce Commission – Submissions on weighted revenue approach to calculation of TSO Liable Revenue, 6 October 2003).

We have noted the internal effect of an additional subscriber, i.e. an increase in the number of mobile outgoing calls as a result of the calls made by the new subscriber. However, other mobile and fixed subscribers will also make calls to the new subscriber. These additional calls also give rise to network externalities. As Oftel notes:

> *To a large extent the externality is reflected in the cross-elasticities of demand. For example, the demand for calls to mobile increases when the mobile subscription price falls, because this leads to an increase in the number of mobile subscribers, who are then called by the preexisting customers.*[27]

The size of externalities related to cross-elasticities of demand is an empirical matter, although the nature of these cross-elasticities is fairly intuitive. Increasing the extent to which costs are recovered in the price of mobile subscription can be expected to lead to fewer mobile subscribers than otherwise. This will lead to fewer mobile outgoing calls as a result of fewer callers and fewer people to call. Further, it will also lead to fewer fixed-to-mobile calls as there are fewer mobile subscribers to call. These cross-price effects increase the super-elasticity of mobile subscription and consequently reduce the socially optimal mark-up on subscription charges to recover fixed and common costs. The Rohlfs model incorporates the impact of network externalities on fixed-to-mobile callers but assumes that network externalities in relation to other mobile subscribers are largely internalised. This assumption is questionable as it requires mobile operators to take into account the externalities conferred upon customers on other mobile networks. To the extent that mobile network externalities are not largely internalised, the optimal level of termination charges will be higher than that estimated by the model.

A similar argument applies to mobile outgoing calls (and indeed other services sold to mobile subscribers) as higher mobile outgoing prices can be expected to reduce the number of mobile subscribers (i.e. a 'buy-through' effect). The lower number of mobile subscribers will again lead to fewer mobile outgoing call numbers and fewer fixed-to-mobile calls.

The case for regulation of mobile termination charges is based on the premise that mobile subscribers are highly insensitive to changes in fixed-to-mobile prices. If this were not the case, a network that offered lower termination charges could be expected to attract more mobile subscribers and thus competition for subscribers between mobile operators would lead to competition over the level of termination charges. Accordingly, the UK regulators assumed that the cross price elasticity between fixed-to-mobile prices and mobile subscription and mobile outgoing calls was zero.[28] Conceptually, it is possible that the level of fixed-to-mobile prices

27 Oftel, *Review of mobile wholesale voice call termination markets - EU Market Review* (15 May 2003), p. 214. A fuller analysis of externalities is presented in Oftel's *Review of the charge controls on calls to mobiles,* 26 September 2001, Annex 4.

28 UKCC Report, Table 9.11.

may impact on *fixed* subscriber numbers. However, as we have already noted above, the empirical evidence is that fixed subscription is extremely inelastic even with respect to fixed subscription charges and would be expected to be even more inelastic with respect to the price of one particular type of call.

In addition to the benefits from larger numbers of calls, subscribers may also enjoy an option externality from a particular subscriber being on a network. For example, a mobile phone may provide a point of contact in an emergency even if it is not regularly rung by a particular fixed caller. The Rohlfs model provides for a small addition in recognition of option externalities in addition to the un-internalised externalities related to cross-price elasticities.

The Rohlfs model incorporates network externalities via the Rohlfs-Griffin factor ('RGF'): this is the ratio of the social value (i.e. private plus external benefits) of an additional subscriber to the private benefits accruing to that subscriber upon joining a network. As the RGF is a ratio, it will remain fairly constant even if marginal subscribers bring lower external benefits than other subscribers (i.e. both private and external benefits may decline and the marginal social benefit will approach the marginal private benefit as subscriber numbers increase).[29] It is highly unlikely that additional subscribers will confer no external benefits. To the extent that marginal subscribers still incur some cost in joining a network they would only be expected to do so if they anticipate making or receiving at least some calls. As calls involve two parties, the other parties can also be expected to receive a benefit from that person subscribing to a network.[30] Accordingly, we note that even papers for fixed operators, such as that by Cave, Bomsel, LeBlanc and Neuman[31], do not suggest the marginal social benefit curve is 'kinked' in the highly unconventional form presented in the ACCC Final Decision.

The Rohlfs model incorporates an assumption that marginal customers only make and receive one third of the calls made and received by an average subscriber (in the model m=0.33). This assumption seems highly conservative. The evidence suggests that volumes per subscriber have not been declining significantly (indeed, they appear to have been increasing) despite the dramatic growth in Australian subscriber numbers. While the ACCC reports that ARPU declined from $65.66 to $51.13 per month over the period 1997-98 to 2002-03, this is more than accounted for by the 24.1 per cent fall in prices over the period.[32] Likewise, the ACCC reported that between 2001-02 and 2002-03, subscribers grew by some

29 See UKCC Report, para. 2.354.

30 To the extent that the calls are made and received by more than one other party, the external benefits will be spread out across parties and hence may not be able to be internalised via the other party simply buying a phone for the marginal subscriber.

31 Bomsel, O., M. Cave, G. Le Blanc & K. Neumann, "How mobile termination charges shape the dynamics of the telecom sector", 9 July 2003, p.22.

32 See ACCC Final Decision, p.166 and the ACCC, *Telecommunications Reports 2002-03 – Report 2,* p.132.

12% whereas usage grew by 17%,[33] implying significantly increasing average usage levels. This is consistent with a number of possible explanations, including falling prices driving growth and lifting the usage of all subscribers in parallel, the mix of new subscribers being similar to the existing base, existing subscribers making more calls to the expanded network base, or a mix of these possible causes.[34]

Calling externalities are a separate type of externalities that relate to the benefit (or cost) arising from being called. Calling externalities will be associated with all types of calls, including on-net, off-net, mobile-to-fixed and fixed-to-mobile.[35] The presence of calling externalities suggests that overall social benefits are likely to be maximised by a pricing structure that maximises overall call volumes (to the extent that each type of calls is assumed to give rise to similar calling externalities). In this regard, it is relevant to note that subscriber numbers are a major driver of call volumes and thus pricing structures that supports higher subscriber numbers should not be seen as necessarily antithetical to pricing to maximise overall call volumes. While Rohlfs held that calling externalities were fully internalized in his base case, the model does provide for calling externalities ('usage externalities') to be included. Including a degree of un-internalized externalities in the model (setting the usage externality to 1.1 for all call types) shows that calling externalities have little impact on the optimal fixed-to-mobile price, increasing the optimal price by around 1% in one year and reducing the optimal price by around 1% in a later year. This accords with the conventional economic view that calling externalities can be largely disregarded. For instance, Brown and Sibley state:

> *The call externality is probably not too important. It only involves two people and can probably be easily "internalized". For example, two frequent callers could arrange to share the cost of calling. Furthermore, not all call externalities are positive externalities; there are certain phone calls that one is annoyed to receive. Since the telephone company cannot be expected to distinguish between positive and negative call externalities, it is probably not useful to incorporate them into pricing formulas. For this reason, and because call externalities can probably be internalized fairly well, they do not provide a strong case for call price reductions.*[36]

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33 ACCC Telecommunications Market Indicator Report 2002-03.

34 Whatever the explanation, the market evidence does not obviously support the argument that new subscribers are significantly less valuable to the network as a whole than existing subscribers.

35 The ACCC Final Decision inexplicably discusses calling externalities only with reference to fixed-to-mobile calls.

36 Brown, S.J. and D. S. Sibley, *The theory of public utility pricing*, Cambridge University Press, 1986, p.197.

The Rohlfs model applies the conventional approach that both calling and subscription externalities are important in telecommunications networks, and can significantly impact optimal prices. However, subscription is considered to be the most important externality. There was no dispute between the UK Competition Commission, Oftel and its expert Dr Rohlfs (all on the one side) and the MNOs in the UK (on the other side) that the subscription externality should be specifically accounted for. The only area of dispute was the size of the correction to be made. We have used Ofcom/Rohlfs assumption, which we believe is conservative, and see no public interest rationale for rejecting efficient prices that include the externality factor in the calculation.

2.10. The Waterbed Effect

Regulation of mobile termination charges results in only one of the set of mobile prices being capped and thus leaves mobile operators free to adjust their other prices. As we discuss in this section, the interlinkages between the services imply that mobile retail prices can be expected to rise in response to termination charges being reduced. Following the UK Competition Commission, we refer to this effect as the 'waterbed effect'. Thus, in identifying the welfare-maximising level of termination charges it is necessary to take into account the impact on mobile retail prices. The UK Competition Commission concluded that "there will be a waterbed effect, i.e. most of the reductions in revenue from termination charges being capped will be recovered from the retail market."[37]

This section discusses the likely extent of the waterbed effect.

Theoretical grounds

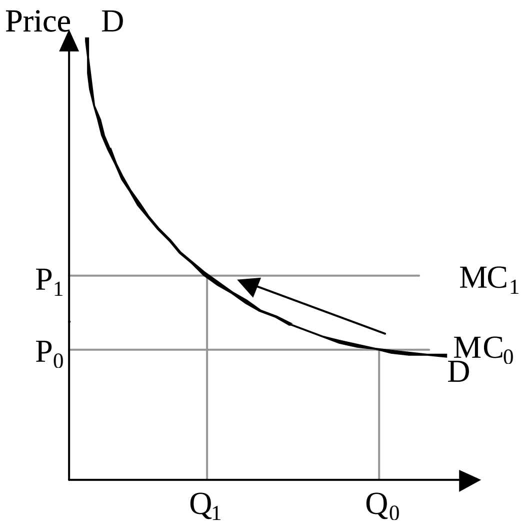
The simplest and most likely reasoning that is apparently behind the UK Competition Commission's view of a close to full waterbed effect is that if markets are effectively competitive, then prices will have to readjust in the long run to cover the cost of the service. This can be easily explained as follows. Reducing the contribution from termination services, which reduces the expected revenue per subscriber from termination, is equivalent to increasing the net cost to the mobile operator of acquiring subscribers. In particular, the bundle of termination revenues expected to be generated by a subscriber can be treated as an offset to the cost of acquiring the subscriber in much the same way as the amount that subscribers may pay themselves for their handsets reduces the net cost of the handsets from the perspective of the operator.[38] The effects of reducing

37 UKCC, *Calls to Mobiles Report*, 2003, para 2.563.

38 In the UK inquiries the effect of changing termination rates was often thought of in this way. In particular, the 'externality' surcharge – the mark-up over termination in order to increase the mobile networks' incentives to acquire subscribers and hence optimise the size of the overall network – was often described as a subscriber *subsidy*. That is, a contribution that in effect lowered the cost to networks of acquiring subscribers.

termination rates and increasing the cost to the networks are shown in Figure 1 below:

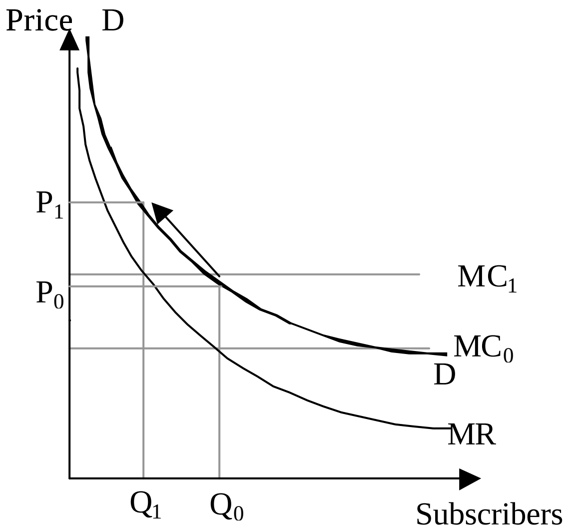
Figure 1: Increasing Subscriber Costs - Competitive Subscriber Market



In this analysis the reduction in termination rates increases the cost of subscribers that has to be recovered from the subscriber market. As the market is effectively competitive, prices are set at cost in the long run, and the cost increase results in an increase in prices from P_0 to P_1, and fall in subscriptions from Q_0 to Q_1.

This analysis is reasonably intuitive, and shows no more than the traditional conclusion of competitive market analysis, that prices must cover costs in the long run. However, it is not necessary to assume a competitive market in order to expect price rebalancing. If the termination contribution is viewed as a subsidy to subscribers that is set by the regulator, then a decision to lower the termination contribution will have a similar effect even if the mobile services market is supplied by a monopoly. That is, the intervention can be thought of as increasing the cost of subscribers to the network, due to the reduction in the 'subsidy' from expected termination revenues associated with each subscriber. This is shown in Figure 2 below, with broadly equivalent results.

Figure 2: Increasing Subscriber Costs - Monopoly Subscriber Market

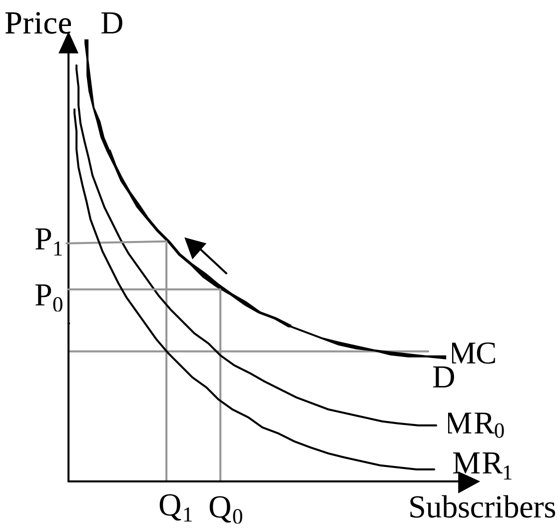


In the case of monopoly, the monopolist equates marginal costs and marginal revenues to optimise returns, and the effective increase in marginal costs results in similar changes from the competitive analysis with prices increasing from P_0 to P_1, and subscriptions falling from Q_0 to Q_1, although of course the relevant prices and quantities will differ. In particular the starting price P_0 will be higher, and the quantity lower, but this does not prevent a further increase in price.

Analysing the impact of reducing termination rates on *marginal revenues* rather than costs is another useful approach to considering the impact of reducing the price of termination in a market where subscriber services are sold in conditions of imperfect competition. From this perspective, the higher the termination rates, the higher the marginal revenue received per subscriber. The impact on subscriber prices of lowering termination rates can therefore be analysed by noting that the intervention lowers the monopolist's marginal revenue curve. This is shown in Figure 3 below.[39]

39 This figure depicts the case of a monopoly for reasons of simplicity only.

Figure 3: Reducing Subscriber Revenues - Monopoly Subscriber Market



Once again, with monopoly, the monopolist equates marginal costs and marginal revenues to optimise returns. However, in this case the fall in termination is modelled as a fall in the marginal revenue curve from MR_0 to MR_1, while marginal costs remain the same. The general result is the same as that obtained in Figure 2 above. With a lower marginal revenue curve, marginal revenues and costs equate at a point associated with higher prices (i.e. price increases from P_0 to P_1) and lower quantities (i.e. subscriptions fall from Q_0 to Q_1).[40]

Quantifying the size of the waterbed effect

By regarding the change in termination charges as equivalent to a change in the marginal cost of subscription, we can draw on the standard economic theory relating to pass-through of industry-wide cost changes. The ACCC seems to suggest that in the presence of economic profits retail prices may not rise:

> *If, as the Commission believes, the mobile industry is returning economic profits, then reductions in termination rates may be absorbed within overall economic profits such that the price of mobile services need not rise.*[41]

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40 This analysis is useful because it reveals another aspect of how changes in termination rates might affect subscriber prices. These are similar effects to that captured in the complementary monopoly problem identified by Cournot (the so-called *Cournot complements* problem). The Cournot complements problem is that two monopolists of complementary products will price each product higher than if both products were produced by a single monopolist. This is because the monopolist ignores the additional profit generated by sales of the complementary product, whereas a single monopolist takes these ‘flow on’ sales into account, and therefore sets a lower price. This is a horizontal form of the more traditional vertical problem of double marginalisation. The idea that termination and origination are maximised completely independently (implicit in the argument that ineffective competition will prevent rebalancing) ignores the complementary nature of subscriber prices and subscription on the one hand and termination revenues on the other.

41 ACCC Final Decision, p.129.

This view ignores the impact of changes in termination on operators' incentives, particularly the profit-maximising level of prices. Even if the mobile industry were a monopoly, substantial rebalancing of prices would still be predicted by economic theory. As can be seen from Figure 2, the extent of pass-through will depend on the shape of the demand curve. According to standard cost pass-through theory, if demand is linear, half of an increase in marginal costs will be passed through into higher prices.[42] In the case of constant elasticity of demand, price increases by *more* than the increase in costs, i.e. a waterbed effect of more than 100 per cent. Studies examining cost pass through in oligopolistic industries also find that substantial pass-through is likely.[43] The US Federal Trade Commission uses cost pass-through analysis in examining mergers and, for instance, estimated a cost pass-through of 85% for industry-wide cost changes in relation to a particular merger.[44]

The cost pass-through theory provides further theoretical support for the waterbed effect. There is also empirical evidence from the UK (see Appendix B) which is consistent with a substantial waterbed effect having taken place. In light of the indicators of vigorous competition in the Australian mobile market, we consider it reasonable to assume a full waterbed effect in our modelling.

2.11. Choice of Years

Optus has requested that the cost of mobile termination be estimated for the three years of its proposed undertaking: 2004-05, 2005-06 and 2006-07. The model takes into account factors such as a forecast of a continuing fall in new equipment prices as well as higher traffic volumes in calculating the change in efficient costs between years.

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42 See, for instance, Varian, H., *Microeconomic analysis* (3rd ed.), 1992, p.236-237.

43 See Seade, J. (1985) "Profitable Cost Increases and the Shifting of Taxation: Equilibrium Responses of Markets in Oligopoly", *University of Warwick Discussion Paper*, no. 260.

44 The proposed merger involved Staples and Office Depot. See *Federal Trade Commission vs Staples, Inc.*, 970 F.Supp. 1066, 1090 (D.D.C. 1997)(Hogan, J.). See also Ashenfelter et al. (1998) "Identifying the firm-specific cost pass-through rate", *FTC Working Paper*, no 217, p16; available at: http://www.ftc.gov/be/workpapers/wp217.pdf

3. THE ROHLFS MODEL AND ITS CALIBRATION FOR THE AUSTRALIAN MARKET

This Section introduces the Rohlfs model and documents the choice of input parameters based on the Australian mobile market. Ideally the model would be calibrated as a model of the Australian mobile market viewed in aggregate – with costs, prices and volumes that reflect the overall market rather than any particular individual operator. However, as the data needed to populate the model in this way is not available, the general approach we have taken is to use Optus data to calculate a representative estimate of the relevant costs and prices, and then scaled the model to volumes that are representative of the overall market.

3.1. THE ROHLFS MODEL

This model was developed by Dr Rohlfs for the UK telecoms regulator, Oftel. A full description of the model is provided in the report by Dr. Rohlfs, *A model of prices and costs of mobile network operators,* 22 May 2002.[45] The mathematical formulation of the model is provided in Annex C of Dr Rohlfs' report.[46] The model was used by Oftel, and subsequently Ofcom, to assess whether their proposed level of charge controls would generate greater social benefits than social costs.[47] For our purpose, we use the model to determine the welfare maximising level of termination charges in Australia (i.e. the level that maximises the value of social benefits over social costs). In doing so, we have specifically sought not to alter the structure of the model, but only the input parameters. The only code alteration we have made is to remove an artificial constraint on the retail fixed to mobile price (that fixes it at 6.76 pence per minute), introduced for the purposes of the last exercise Ofcom undertook with the model. Unfortunately the original ('clean') version of the model is no longer on Ofcom's website. However the alteration is minor, easily undertaken and is described fully in Appendix I. This modification returns the model to its original version as supplied by Dr Rohlfs (we have further verified this by comparison with an original version held by CRA in London).

45 A copy of the report and its annexes is available under the heading 'Ramsey prices and network externalities' (May) on Ofcom's website (http://www.ofcom.org.uk/static/archive/oftel/publications/mobile/ctm_2002/docs_index.htm). The model itself (in Mathematica) is available at http://www.ofcom.org.uk/static/archive/oftel/publications/mobile/2003/gain0703.htm.

46 The model itself (in Mathematica) is available at http://www.ofcom.org.uk/static/archive/oftel/publications/mobile/2003/gain0703.htm.

47 See, for instance, Ofcom, *Statement on Wholesale Mobile Voice Call Termination*, 1 June 2004, para. 6.105ff.

New input parameters have been included in the model to reflect the Australian market and these are set out in the respective sub-sections below. In particular, the new parameters cover initial volumes and prices, incremental and fixed costs and demand elasticities. Oftel's externality assumptions have been retained.

Given the input parameters, the Rohlfs model calculates a number of scenarios. The one of relevance to the Optus' undertaking is the welfare maximising set of prices, referred to by Rohlfs as 'the Ramsey model'. Rohlfs' paper also refers to an 'Unregulated model' which was chosen in the UK context to calculate the set of prices that were expected to result if the existing price caps had been removed. This model is not relevant for our present purpose. Rohlfs' paper also refers to a 'Principal-Agent model' that examines the impact of assuming particular behaviour by mobile operators and of setting termination for mobile-to-mobile off-net calls below costs. This model is unusual in a number of respects. For instance, it assumes that mobile operators will disproportionately lower call prices rather than subscription charges even though the evidence in Calling Parties Pays markets (if not in Dr Rohlfs own market of the US) is that mobile operators have tended to heavily subsidise subscription costs. Further, Dr Rohlfs himself notes that setting off-net termination charges below incremental cost may impact adversely on individual mobile operators. Accordingly, we do not consider the 'Principal-Agent model' to be relevant to Optus' proposed undertaking.[48]

Finally, we note that Rohlfs recommends the constant elasticity model, claiming that it produces a downward concave demand curve, which is consistent with the assumption of a diminishing marginal rate of substitution. However, constant elasticity demand curves are downward convex, so a linear demand curve would be more in line with the idea of a diminishing marginal rate of substitution. For this reason, and to avoid the unrealistic implication of infinite consumer surplus generated from inelastic constant elasticity demand curves, we use the linear demand curve model, which is more commonly used in applied demand analysis.

3.2. VOLUMES

3.2.1. Number of Subscribers

The actual average number of subscribers in the Australian market for the year ending June 2004 have been used. These have been sourced from the Telstra Annual Report 2004, the Singtel Financial Review 2004, Vodafone Key Performance Indicators 2004 and the Hutchison Half Year Report 2004. Optus also provided us with its subscriber figures.

48 A further examination of Rohlfs' principal-agent model is contained in the paper by G. Houpis and T. Valleti, "Mobile termination: what is the "right" charge?", March 2004 (available at http://wip.tu-berlin.de/workshop/2004/papers/Houpis_Valletti-Mobile_termination_charges.pdf).

Forecasts for the years 2005 – 2007 have been constructed using market growth forecasts publicly reported by IDC Australia.[49]

3.2.2. Volume of fixed-to-mobile calls

The volume of fixed-to-mobile calls for 2004 has been estimated from data publicly available from Telstra. The estimate was calculated by adjusting the stated number of fixed to mobile minutes handled by Telstra's fixed network and dividing by Telstra's estimate of its share of this market. This came to approximately 6,502 million minutes. Future volumes have been estimated using the subscriber growth forecasts described above, on the assumption that minutes per subscriber remain constant.[50]

3.2.3. Volume of mobile-originated calls

An estimate of the total number of mobile originated calls (mobile-to-mobile on- and off-net, mobile to fixed) was constructed. Actual figures for mobile originated calls in the year to June 2004 were available for Optus (supplied to us by Optus) and Telstra.[51] We then calculated a market estimate by dividing the sum of these two figures by the combined market shares of subscribers of Optus and Telstra (approximately 80%). Future volumes have been estimated using the underlying subscriber growth forecasts and the constant minutes per subscriber assumption, as described above.

3.2.4. Volume of off-net, mobile-to-mobile calls

Public estimates of the share of mobile originated calls that are off-net, mobile-to-mobile calls are not available. This figure was therefore estimated for the Australian market by applying the Optus share of mobile originated calls that are made to other mobile networks to the total estimates of mobile originated calls.

49 IDC press releases: 10 November 2003 and 24 May 2004 available, at www.idc.com.au. The model assumes penetration increases to 89% in 2008, implying subscriber growth of approximately 2% per annum.

50 We considered modelling a slight fall on average each year, as the idea of diminishing marginal returns as the network grows might suggest that minutes per subscriber should fall slightly over time. However, this assumption is not obviously supported by market experience to date which tends to show that the rate of growth of minutes has historically often exceeded subscriber growth rates. This also seems to hold true in Australia where the ACCC reported that between 2001-02 and 2002-03 subscribers grew by some 12% whereas usage grew by 17% (ACCC Telecommunications Market Indicator Report 2002-03). On balance, we have chosen the middle ground of using a constant number of minutes per subscriber.

51 Telstra Annual Report 2004, available at: http://telstra.com.au/communications/shareholder/docs/companyoverview.pdf

Table 2. Estimated Initial Quantities

Parameter	Value (2004-2005)
Number of Subscribers	15,441,357
Mobile Outbound Usage (minutes p.a.)	**[c-i-c]**
Fixed-to-Mobile Usage (minutes p.a.)	6,640,290,807
Off-net Usage (minutes p.a.)	**[c-i-c]**

3.3. PRICES

Given the volume and cost assumptions described above and in the following sub-sections, we have for the purposes of the model assumed that market expansion will be met with a fall in prices rather than an increase in industry profits. We assume that proportional reductions in price will be the same across the competitive services of the industry, such that industry profitability remains constant.

3.3.1. Subscription

The overall charge used in our model is an average of the price of subscription calculated separately for post and prepaid subscribers, combined using Optus' actual figures for the split of these types of call plan (**[commercial-in-confidence]** % post paid, **[commercial-in-confidence]** % prepaid), and Optus' estimates of the effective subscription price of each of these types of plan.

For prepaid subscribers, the subscription price consists of the average upfront fee for a handset (currently average of $**[commercial-in-confidence]**).[52] This figure is then annualised, by dividing by expected subscriber life in years.

Many post-paid subscribers do not pay an upfront amount for their handsets. The subscription charge that is used in the model is calculated from the average monthly subscription charge on an annual basis, adjusted for the inclusion of a significant usage component in this price. Most of this 'subscription' charge in fact relates to bundled minutes and other included usage charges, and is therefore more accurately viewed as a (prepaid) usage charge. In our view, the bulk of the charges should be treated as variable usage charges because, in any period other

52 Note that using an average upfront fee paid by subscribers as part of the subscriber costs in the model will return a higher implied subscription revenue than the revenues received by the MNO/Network, as the upfront fee is a retail charge levied by retailers at POS rather than as part of the network's package. This is one of a number of reasons as to why the model will not necessarily reconcile exactly with the network's accounting figures.

than the very short term (an inappropriate time-span for regulatory analysis), subscribers can move between plans implying these charges are not fixed.

There is no single uncontroversial way to unbundle a bundled call plan in order to calculate how much of the bundled charge is an implied subscription fee versus a usage charge. However we note that for Optus' bundled minute call plans at the bottom end of the spectrum ($25 per month) there is commonly an explicit $10 subscription fee,[53] while for higher value plans the value of calling included equals the subscription charge, but with lower call prices for a higher committed level of usage. In either case there is no doubt that the total value of the bundled subscription price cannot be treated as wholly or even largely an access price that only pays for network access and no usage. One way to estimate a reasonable figure is to note that for the bottom end bundled plan noted above, there is an explicit subscription fee of 40% of the monthly value ($10/$25). We consider it reasonable to assume that implicit subscription fees on higher value plans are less than this figure. However, as higher priced plans generally attract higher sales expenditures and lower call prices, it is perhaps reasonable to assume that some proportion of the price of higher value bundled plans is a payment covering these higher acquisition costs. This would suggest that overall subscription charges on post-paid plans might reasonably be expected to lie between 40% of the price and something above 0%. Using 10% as a lower bound assumption, and taking the average of the two, we have used an assumption of 25% of the charge being an implied subscription charge.

We believe that 25% is a reasonable estimate to use in the model. Using this assumption, and when combined with the prepay charge, it produces an subscription fee of approximately $**[commercial-in-confidence]** per month. This is not significantly above the implied monthly subscription cost that a prepaid subscriber faces (approx. $**[commercial-in-confidence]**), and means the overall figure used in the model is close to that faced by the most marginal subscribers (the most relevant basis for welfare analysis). Using a significantly lower assumption would reduce the price below the actual prepaid figure, which does not seem reasonable. While a higher figure might be justifiable, this would have the impact of increasing the estimated optimal termination charge. Hence we believe the 25% assumption is conservative.

53 For example, the Optus 'yes Extra 25' costs 25$ per month and includes $15 calling.

3.3.2. Calling

Price of mobile-originated calls

Call prices are Optus actual prices for the year 2003-04, calculated as the total revenue directly billed for calls of the relevant call type, divided by the total number of minutes of that call type. This figure was then adjusted for bundled minutes. The approach taken was to allocate the subscription charge estimated to be usage charges, and allocate to call minutes on the basis of revenue by call type, on the view that relatively expensive call types will also be relatively 'expensive' within the bundled price.[54] Price for the years 2005 – 2007 were forecast by projecting volumes as described above, and then adjusting prices to maintain a constant level of industry profitability.

Retail price of fixed-to-mobile calls

The retail price of fixed-to-mobile calling was the average retail price of 40.8 cents derived from the ACCC's *Review of Telstra's Price Control Arrangements - Draft Report*, November 2004, p.21-22 (weighted by the quoted market shares for Telstra and the other operators). This is assumed to remain constant throughout the modelled period.

Table 3. Estimated Initial Prices

Parameter	Estimated Value (2004-05 Base Case)
Subscription Price (p.a.)	$**[commercial-in-confidence]**
Mobile Outbound Price (per minute)	$**[commercial-in-confidence]**
Fixed-to-Mobile Price (per minute)	$0.408
Off-net Price (per minute)	$**[commercial-in-confidence]**

3.4. Costs

The costs used to construct inputs for the model have been based on Optus' data for the year ended March 2003-04. As noted earlier, in providing data to CRA, Optus reviewed its cost base and provided costs related to its mobile operations on a stand-alone basis. This is consistent with a competitive market in which the price is effectively set by the marginal players.

54 Hence mobile to mobile calling which is expensive relative to mobile outbound receives a larger allocation, increasing the price difference.

Using a top-down modelling approach, the costs contained in the accounts have been classified according to whether they are fixed or variable, and whether they are network traffic or subscriber driven. For variable costs, the costs have been grouped according to whether they are primarily driven by adding new subscribers to the network and maintaining those subscribers (subscriber base driven) or by traffic over the mobile network. The treatment of the particular categories of cost is described in more detail below.

3.4.1. Capital costs – depreciation

Before allocating costs to particular services, it was necessary to determine annual levels of capital costs. We have applied a tilted annuity approach that seeks to ensure:

- Full cost recovery over the life of each asset; and
- A time path of cost recovery that mimics the price path that would be charged in a competitive market as the price of inputs change.

Details of this approach, which was chosen to be consistent with the approach taken by the ACCC in previous regulatory decisions, are set out in Appendix C.

We have not applied a full economic depreciation approach that would determine cost recovery over the lifetime of the investment on the basis of the extent to which the network is being utilised in each year. An economic depreciation approach would be likely to result in lower cost recovery in the initial years of the Optus networks, when it was relatively underutilised, and higher levels of cost recovery in later years as utilisation has grown. Oftel found that economic depreciation, compared with straight line depreciation, results in a higher cost of termination for the period after 2000-01 for the UK mobile networks established in the early 1990s.[55]

3.4.2. Capital costs – return on capital

The model includes a reasonable return on investment calculated for mobile termination calculated using the Capital Asset Pricing Model (CAPM). The approach was applied in a manner designed to be consistent with previous ACCC decisions, although in some instances we have considered alternative parameter values to those that might be immediately apparent from the decisions. We estimated a vanilla WACC of **[commercial-in-confidence]** % and a post-tax nominal WACC of **[commercial-in-confidence]**%. The details are set out in Appendix C.

55 Oftel, *Mobile phones inquiry: mobile termination – accounting depreciation based cost estimates*, 3 May 2002, para. 18.

We note that CRA has previously used an Arbitrage Pricing Theory to estimate the cost of capital for mobile operators in the UK and found that it led to a significantly higher estimate than the CAPM approach.[56]

3.4.3. Subscription

The subscription costs entered in the model cover two main categories of subscriber costs: subscriber acquisition costs and subscriber servicing costs. The costs were calculated on an annual basis for each of these categories, as outlined below, and the results aggregated to produce an annual subscription cost.

Subscriber acquisition costs cover the costs of sales and marketing activities. These are calculated as the total of the cost of these activities during the modelled period, divided by the number of subscribers acquired in that period (that is, gross additions to the network). These costs are then annualised by dividing by the estimated average subscriber life.

Subscriber servicing costs include activities such as billing and customer call centre costs that are ongoing costs associated with maintaining the customer relationship. These costs are calculated as the total cost for the relevant accounting period, divided by the total number of subscribers on the network during this period.[57]

3.4.4. Calling

The Rohlfs model is designed to model a number of specific types of call. In particular these are classified as 'fixed to mobile' (termination), 'off-net mobile' (mobile to mobile off-net calling only), and 'mobile outbound' (which covers both on-net mobile-to-mobile and mobile-to-fixed calling).

The way calls are categorised in the Rohlfs model is not the most logical way to model the network costs associated with calling. In order to model network costs, calls have first been classified as inbound (from any other network), outbound (to any other network) or on-net. Whether a call was originated from or terminated to another fixed or mobile network is not relevant to the costing process as the calls are received or despatched through a point of interconnect in either case. However there are some differences in network handling of calls that creates some cost differences. On-net (mobile-to-mobile) calls are different, most significantly because they involve two mobile calling legs rather than one within the network. Nonetheless, a proportion of on-net calls can be expected to be switched locally

56 CRA, *Cost of capital for T-Mobile (UK)*, July 2003 (available at http://www.crai.co.uk/pubs/pub_3547.pdf).

57 As the network has grown significantly during the year, the figure used is a simple average for the year. This was calculated by adding the closing subscriber base for the previous year with the closing base for the current year, divided by two.

and hence require proportionately less transmission than calls going to or from other networks that must be handed over at a gateway exchange.

The general approach to costing these types of call was to identify (for each line item in the network accounts) how much of the cost was volume driven, and whether the cost was related to some or all of the above calling categories. Once this had been done, the costs were allocated to the underlying call volumes. In the process, a *routing factor* was applied to adjust the costs for the differing intensity of network usage by different call types.[58] The significant routing factors used are shown in Table 4.

Table 4: Routing factors[59]

Routing factors	Inbound	On-net	Outbound
BSS	**[c-i-c]**	**[c-i-c]**	**[c-i-c]**
NSS	**[c-i-c]**	**[c-i-c]**	**[c-i-c]**
HLR	**[c-i-c]**	**[c-i-c]**	**[c-i-c]**
STP/MNP	**[c-i-c]**	**[c-i-c]**	**[c-i-c]**
Gateway Switch	**[c-i-c]**	**[c-i-c]**	**[c-i-c]**
Transmission	**[c-i-c]**	**[c-i-c]**	**[c-i-c]**

Source: Optus

This process resulted in an estimated cost per minute for inbound, outbound and on-net calls. These figures are an approximation of the long run incremental cost of calls of each type. They do not include the fixed cost of mobile calls represented by the network costs of providing coverage (see section 3.4.3).

The cost of other call types was then constructed by taking one of these call types, and adding the necessary additional cost component. For example, the per minute cost of a MTF call is calculated as an outbound call minute, plus the average cost of fixed network termination. Likewise, a MTM (off-net) call is the sum of the outbound cost, plus mobile termination.[60] Using this approach, costs were calculated for inbound calling, outbound MTF and MTM, and on-net MTM. The 'mobile outbound' figure for use in the Rohlfs model, which covers both on-net

58 This process of classifying different costs and estimating the appropriate routing factors was undertaken by Optus staff who are thoroughly familiar with the structure and operation of the network as well as with the structure of the regulatory accounts.

59 Terminology: BSS - BSC and BTS or base station controller and base transceiver stations; NSS - MSC - mobile switching centre; HLR - home location register; STP/MNP - Signal transfer point/ Mobile number portability.

60 In the model the cost of an off-net mobile to mobile call is calculated as the network cost of a mobile outbound plus a mobile inbound call. The current mobile termination rate, which the model is designed to solve for, is not used as part of the cost of this type of call.

MTM and MTF calling, was calculated by combining the two call types, weighted appropriately.

Cost of fixed-to-mobile calls

The cost of a fixed-to-mobile call was modelled as the cost of mobile termination calculated by the LRIC model, plus Optus' estimated reasonable fixed retention cost of **[c-i-c]** cents per minute, which covers both the cost of fixed origination and the retail costs of the call. We note that this means that the model systematically overestimates the benefit of mobile termination regulation, as the model calculates the retail price of calls to mobiles as being significantly lower (with attendant larger increases in volumes) than is actually the case.[61] Nonetheless, we believe it would be inappropriate to use the actual but higher FNO margin, as the model would treat this as part of the cost of the call, and thus increase the termination mark-up calculation above its optimal level.[62] Hence, in keeping with our conservative approach to calibrating the model, we have used the cost based estimate of **[c-i-c]** cents per minute.

We have assumed that the fixed operators' margin on fixed-to-mobile calls remains constant over time. To the extent that reductions in termination charges are not fully passed through into lower fixed-to-mobile prices, this assumption will lead to the estimated level of termination charges being too low, as the model assumes full pass through by the fixed operator.[63]

The ACCC has expressed concerns that the market for fixed to mobile services is not effectively competitive,[64] and that the (alleged) above-cost wholesale termination rate contributes to this. This suggests that lowering termination might increase competition, lowering the fixed retention margin. We have seen no evidence to suggest that this might be the case. We note that:

61 In round terms, if the model calculates an optimal retail price of say **[c-i-c]** cents per minute (assume for example this is **[c-i-c]** cents for the MNO, plus **[c-i-c]** cents for the FNO margin), it calculates changes in retail price and hence on market volumes based on this price. In reality however, the FNO margin is much higher and the actual retail price will be around **[c-i-c]** cents per minute, with attendant lower volumes of fixed to mobile calls than the model is calculating.

62 The actual fixed margin is approximately **[c-i-c]** cents, calculated as 40.8 cents (retail) less **[c-i-c]** cents wholesale/MNO margin,

63 At the limit, if there is no pass through of the reduction in termination rates, regulation of the termination rate will definitely have a negative impact on the overall welfare generated by the mobile market. This because there is no benefit to the callers to mobiles (no rate reductions), while subscriber prices will rise as a result of the change in termination rates. The reasons for this rise being inevitable were outlined above in section 2.10.

64 See, for example *Telecommunications competitive safeguards for the 2002–03 financial year*, section 2.3.4.

- Telstra's share of fixed to mobile calling at 65% is very close to Telstra's overall share of national long distance calling which is reported as 63%, suggesting no significant difference in Telstra's market position as a result of the wholesale cost of fixed to mobile calls; and
- Optus' market share of fixed to mobile calling, reported at 15% is far below its share of mobile services which exceeds 30%, suggesting no 'integrated operator' advantage.

3.4.5. Fixed and common costs

As discussed in Section 2.7, we have identified certain fixed and common costs at the network and non-network levels and ensured that these were not included in the estimates of the incremental costs of the services.

In relation to network fixed and common costs, Optus' engineers have reviewed Optus' network costs and identified that around **[commercial-in-confidence]**% of certain, mainly site-related, costs are attributable to the provision of network coverage rather than being capacity driven. These costs have been classified as common network costs. Optus' actual fixed and common costs have been scaled up to market scale using Optus' market share of subscribers. This was because we felt that fixed and common costs should not be directly volume (minutes) related in theory, but would be more related to company size. In practice however these two variables are closely related, and the choice of one over the other has little impact.

In relation to non-network costs, we have identified particular costs as being incremental to subscribers, such as dealer commissions, handset subsidies, billing and customer management. These costs are dealt with as incremental costs. The remaining non-network costs that were not clearly identifiable as incremental to particular services have been treated as common costs across the services. These include central overheads such as corporate cost and central IT costs.

Table 5. Cost estimates

Parameter	Estimated Value (2004-05 Base Case)
Incremental Cost of Subscription	**$[c-i-c]**
Incremental Cost of Mobile Usage	**$[c-i-c]**
Incremental Cost of Fixed-to-Mobile (mobile)	**$[c-i-c]**
Incremental Cost of Fixed-to-Mobile (fixed)	**$[c-i-c]**
Incremental Cost of Off-net	**$[c-i-c]**

Incremental Cost of Mobile Origination without Termination	**$[c-i-c]**
Fixed & Common Industry Costs (including network and non-network costs)	**$[c-i-c]**

3.5. ELASTICITY ESTIMATES

The Rohlfs model incorporates a number of elasticities as inputs while other elasticities are derived in the model by assuming particular demand relationships. For the elasticities that need to be entered into the model, we have used averages of the identified econometric studies of elasticities as representing the most reliable source on which to base elasticity assumptions. Table 6 through to Table 9 report the elasticity estimates used.

Table 6. Subscription Own-Price Elasticity[65]

Study	Estimated elasticity
Ahn and Lee, 1999	-0.36
Dotecon, 2002	-0.37
Frontier Economics, 2002	-0.54
Grzybowski, 2004	-0.3
Hausman, 1999	-0.51
Madden, Coble-Neal and Dalziel 2004	-0.53
Rodini, Ward and Woroch, 2003	-0.43
Tishler, Venture and Watters 2001	-0.42

65 Source: Ahn, H. and M. Lee (1999) "An Econometric Analysis of the Demand for Access to Mobile Telephone Networks," *Information Economics and Policy*, 11, pp. 297-305 (implied elasticity of the monthly recurring charge as reported in Rodini, Ward and Woroch (see footnote 48); Dotecon as reported in UK Competition Commission, Calls to mobiles report, 2003, Table 8.2; Frontier Economics as reported in UK Competition Commission, Calls to mobiles report, 2003, Table 8.3; Lukasz Grzybowski, 'The Competitiveness of Mobile Telecommunications Industry Across the European Union', Centre for Information and Network Economics, Munich Graduate School of Economics, April 2004, as reported in the ACCC Final Decision. Hausman, J., "Cellular Telephone, New Products and the CPI," *Journal of Business and Economic Statistics*, 1999; G. Madden, G. Coble-Neal and B. Dalzell,'A Dynamic Model of Mobile Telephony Subscription Incorporating a Network Effect', *Telecommunications Policy*, 28, 2004, pp. 133-144; Rodini, M., M. Ward and G. Woroch, "Going mobile: substitutability between fixed and mobile access", *Telecommunications Policy*, 2003; Tishler, A., R. Ventura and J. Watters, "Cellular Telephones in the Israeli Market: The Demand, the Choice of Provider and Potential Revenues", *Applied Economics*, 33, 1479-1492, 2001.

Average	**-0.43**

A large number of studies were identified providing econometric estimates of the own price elasticity of mobile subscription. The range of these estimates was relatively small and generated an average of –0.43.

Table 7: Mobile outgoing own price elasticity[66]

Study	Elasticity
Dotecon 2002	-0.62
Hausman 2003	-0.55
Average	**-0.59**

Only two econometric studies were identified that produced estimates for the own price elasticity of mobile outgoing calls, although we note that other studies which modelled outgoing call prices together with mobile subscription produced similar elasticity estimates to those shown.[67] Other elasticity estimates identified were not included on the grounds that they were not based on econometric studies (for instance a Holden Pearmain study was based on a consumer survey which, in general, may be considered less robust than econometric studies) or were for a subset of mobile outgoing customers.

For the own price elasticity of off-net calls we have assumed the same elasticity as mobile outgoing, in the absence of any direct estimates of this elasticity. Rohlfs also assumes these two elasticities were equal.

Table 8: Fixed-to-mobile own price elasticity[68]

Study	Elasticity

66 Dotecon estimate as reported in UK Competition Commission, *Calls to mobiles report*, 2003, Table 8.2. Hausman estimate taken as mid-point of range of –0.5 to –0.6 reported in Submission by Vodafone to the New Zealand Commerce Commission – Submissions on weighted revenue approach to calculation of TSO Liable Revenue, 6 October 2003, p.10.

67 See Table (f) of the Submission by Vodafone to the New Zealand Commerce Commission – Submissions on weighted revenue approach to calculation of TSO Liable Revenue, 6 October 2003.

68 Dotecon elasticity as reported in UK Competition Commission, *Calls to mobiles report*, 2003, Table 8.2. Note that this is the average of the time of day elasticity estimates reported in the ACCC Final Decision, weighted by the volume of minutes at the different times of day. See, also, Dotecon, *Optimal fixed-to-mobile interconnection charges*, 2 September 2001, Table 1. Frontier Economics estimate as reported in UK Competition Commission, *Calls to mobiles report*, 2003, Table 8

Dotecon 2002	-0.43
Frontier Economics 2002	-0.18
Average	**-0.31**

The ACCC Final Decision estimated an own-price elasticity for fixed-to-mobile calls of -0.6. However, this was based partly on a range derived from Dotecon's separate elasticities for different times of day, rather than Dotecon's average elasticity for the whole service (i.e. effectively weighted by volumes at different times of day). The ACCC also had regard to assumed elasticities proposed by analysts, although these do not appear to be based on empirical econometric studies and no confidence intervals for these numbers were presented. As such, they have not been included in calculating the average for the model. A figure presented by Access Economics of -0.08 has also been excluded as relating to studies that are now very dated. A figure of -0.11 from the Holden Permain study has been excluded as not being based on an econometric study.

Table 9: Subscription fixed-to-mobile cross price elasticity[69]

Study	Elasticity
Dotecon 2002	-0.12
Frontier Economics 2002	-0.24
Average	**-0.18**

For the remaining cross-price elasticities, we maintained Rohlfs' formulation to derive these elasticities from the elasticities that are inputted into the model. This approach generated cross-price elasticities that were more conservative than those estimated by Frontier and Dotecon in their econometric studies.

In Rohlfs' base case, the ratio of the usage of the marginal subscriber to that of the average subscriber is one third. We use this value, together with the relevant own price elasticities and initial revenue values, to derive the cross-elasticities of subscription demand with respect to usage prices.

69 These are from the elasticities submitted by Frontier and Dotecon for UK Competition Commission inquiry and expressed in a form required for the Rohlfs model.

For the cross-elasticities of usage demand with respect to the subscription price, values for the externality parameters are required in addition to the values shown above. For the proportion of internalised cross-elastic mobile-outbound externality accruing to mobile subscribers, we use a value of 0.8, and for the proportion of internalised cross-elastic off-net externality accruing to mobile subscribers, we use a value of 0.7. These values are also the values used in Rohlfs' model and they represent a 'substantial, but not complete'[70] internalisation of the externalities. For further explanation of the meaning of these parameters, see Section 3.6.

Once these cross-elasticities have been derived, there is enough information to determine the cross-elasticities of usage demands with respect to usage prices. For example, we know how a change in the mobile outbound price affects the number of subscribers, and we know how a change in the number of subscribers affects the demand for FTM. Thus we are able to work out the cross-elasticity of FTM demand with respect to mobile outbound price.

The complete elasticity matrix used in our base case is shown in Table 10. For the mathematical derivation of all of the cross-elasticities, see Appendix G.

Table 10: Elasticity Matrix

Quantities	Prices			
	Subscription	Mobile Outbound	FTM	Off-net
Subscription	-0.44	-0.29	0.00	-0.21
Mobile Outbound	-0.18	-0.59	0.00	-0.09
FTM	-0.18	-0.09	-0.31	-0.09
Off-net	-0.20	-0.13	0.00	-0.59

3.6. MAGNITUDE OF EXTERNALITIES

While there was much agreement between the parties in the UK regulatory inquiries on the theoretical reasoning for incorporating network externalities in the calculation of the socially optimal termination charges, there were disagreement over the magnitude of the relevant externalities. Consistent with a conservative approach, we have adopted the parameter values considered reasonable by Oftel.

70 Rohlfs, J.H (2002). "A model of prices and costs of mobile network operators", Strategic Policy Research, p4.

The motivation for these assumptions is set out in pages 3-5 and Annex A of Rohlfs' paper. The main externality assumption relates to the Rohlfs-Griffin factor (RGF), i.e. the ratio of total social value of subscription to the private value accruing to the mobile subscriber. *A priori* reasoning suggests an RGF of 2. In particular, it is likely that on average both parties to a call receive the same benefit from the call so that the total social benefit generated by a call is twice that of the private benefit. Hence, when an additional subscriber joins a network and results in additional calls being made by, and to, existing subscribers the benefit to the existing subscribers in aggregate could be expected to be the same as the benefit to the new subscriber from joining. Nonetheless, Oftel postulated that externalities would be substantially internalised by a variety of means and considered that RGF would lie in the range 1.3 – 1.7 and chose the midpoint of 1.5 for its modelling. This is referred to as the Gross Externality Factor in the Rohlfs model. Much of the Gross Externality Factor is represented by cross-elasticities between the services.

The second externality component is the net externality factor that measures the extent of the gross externality factor that is not captured by the cross-price effects. Essentially, it reflects the option externality discussed above. This is believed to be small and the base scenario is set at 1.05 – 1.10 for the net externality factor.

A further factor models the internalisation by the MNOs of the externalities accruing to subscribers, through the MNOs' use of second-degree price discrimination (two- and three-part tariffs). There are three parameters reflecting the proportion of the internalisation of the network externality: one addresses the benefits accruing to mobile subscribers only (0.8); the second refers to fixed and mobile subscribers (0.4); and the third captures off-net usage (0.7).

Another factor is the usage (or calling) externality (modelled for fixed, mobile and off-net usage). Our base case, in line with Rohlfs base case, assumes that calling externalities on all call types (on-net, off-net MTM, MTF, FTM) are internalised. Sensitivity analysis indicated that assuming a degree of un-internalised calling externalities (i.e. setting the value to 1.1) has a negligible impact on the optimal termination charge, raising it by around 1% for the initial year and lowering the charge by around 1% in the next year.

As discussed above, the Rohlfs model incorporates an assumption that marginal customers only make and receive one third of the calls made and received by an average subscriber (in the model m=0.33). This assumption seems highly conservative, yet is a significant driver of the efficient termination price. We have maintained this assumption as our base case. However, given that this is a key assumption, we have also provided results for the case where marginal subscribers make and receive half the calls of the average subscriber (m=0.5).

Table 11. Assumed Externality Factors

Externality and elasticity parameter	Rohlfs' value
Gross network externality	1.5
Mobile-originated externality	1
FTM usage externality	1
Off-net usage externality	1
Proportion of internalized cross-elastic MO externality accruing to mobile subscribers	0.8
Proportion of internalized cross-elastic off-net externality accruing to mobile subscribers	0.7
Fraction of total cross-elastic externality that is internalized by MNOs	0.4
Fraction of fixed-to-mobile consumer surplus to fixed subscribers internalized by MNOs	0
Fraction of off-net consumer surplus internalized by MNOs	0.91
Fraction of option surplus internalized by MNOs	0.1
Ratio of usage of marginal subscriber to that of average subscriber	0.33

4. RESULTS

In this Section, we present the results for 2004-05, 2005-06 and 2006-07. All of the figures reported below are in real 2004-05 dollars, except for where they are explicitly labelled as nominal estimates. Forecasts have been constructed as described in the previous text, and a summary table of inputs is available in Appendix H. The Rohlfs model is available from Ofcom's website (refer to link in footnote 45), and can be used to replicate our modelling results.[71]

The results allow for a full waterbed effect. That is, the industry is able to recoup all of the contribution lost from the FTM service from the other subscriber services. In our view this is the most realistic assumption in the medium to long term. Table 12 shows the estimated welfare maximising prices calculated by the Rohlfs model.

Table 12: Results

	Results – Optimal Prices (2004-05 prices)		
	2004-05	2005-06	2006-07
Subscription ($pa)	$[c-i-c]	$[c-i-c]	$[c-i-c]
Mobile Outgoing Calls (excluding Off-net) (cpm)	$[c-i-c]	$[c-i-c]	$[c-i-c]
FTM Calls (cpm)	$[c-i-c]	$[c-i-c]	$[c-i-c]
Off-net Calls (cpm)	$[c-i-c]	$[c-i-c]	$[c-i-c]
Termination Charge (cpm)	**$0.170**	**$0.166**	**$0.161**
Nominal Termination Charge (cpm)[72]	$0.170	$0.170	$0.169
Nominal Termination Charge, (m=0.5, cpm)[73]	$0.198	$0.198	$0.197

71 Note that one very minor coding modification is needed. This is described in Appendix I.

72 An inflation rate of 2.5% was assumed for converting the input data into nominal terms. This was selected as the mid-point of the RBA inflation target range.

73 This scenario considers the case where marginal consumers are assumed to have half the usage of an average subscriber (m=0.5), whereas the base case uses the Ofcom/Rohlfs assumption of one third (m=0.33).

The results show that, for 2004-05, the real optimal termination charge is $17.0 cents per minute (cpm). The results also show that the optimal termination charge, in real terms, falls slowly over the 3 years (approximately 3% per annum). In all cases, the estimated optimal termination charge is significantly above the ACCC's target price of 12 cpm.

4.1. Interpreting the Results

4.1.1. Setting the results in context

In order to set the calculated efficient price of termination within the context of the overall cost of mobile services, we note that the average cost of a minute of mobile calling of any type (total costs in the model, divided by total mobile calling volumes) for 2004-05 in real terms is 34.6 cents per minute.[74] This compares with an estimated efficient termination rate of 17.0 cents per minute. This implies that the calculated efficient per minute price of termination is 49% of the overall per minute average cost of a mobile calling.

4.1.2. Conservative approach

- Throughout the modelling we have sought to take a 'conservative' approach. This means that where modelling decisions have had to be made, we have generally favoured the approach that results in a lower rather than higher estimated termination rate.[75] Further, we note in particular that key costs are excluded (e.g. intangible assets) and that the base case uses the Ofcom assumption as to the value of marginal consumers (that marginal consumers have one third the usage level of the average subscribers), which we believe may be a low assumption. As discussed in more detail in the Sections above, both of these issues potentially have a significant effect on the optimal price, and suggest the potential for our final estimate to be biased towards being too low.

74 See Appendix H for the data to replicate this calculation.

75 We note that there are assumptions in the model about which there is a degree of uncertainty. An example is the elasticity estimates. However, while these estimates could be in error (which could in turn cause a price estimation error), the estimated price is still the 'best' estimate that one could obtain on the basis of the modelling assumptions and appropriate cost inputs. The biases implicit in our conservative approach are different from estimation errors. In our view, our conservative biases systematically result in a 'lower' rather than 'higher' estimated efficient termination price.

4.1.3. The welfare cost of regulatory errors

We also note that the structure of the mobile pricing system is such that increasing termination rates leads to lower subscriber prices (as a result of competition for subscribers), resulting in more subscribers which in turn generate both more inbound and outbound calling. This reduces the social cost of increasing termination prices, including a situation where the termination price is set at a level is 'too high' relative to its optimal level. If lowering the termination rate reverses this process in the medium to long term, then setting the price 'too low' will equally be relatively costly in welfare terms. In other words, given uncertainty over the efficient price level, we believe that from an economic efficiency perspective it would be prudent to err on the side of setting the mobile termination price at a 'higher' rather than a 'lower' level. Although this is a general argument, we believe it is consistent with the empirical observation that RPP mobile pricing systems, which use low termination charges, have historically delivered significantly inferior social outcomes. As an example, the OECD suggested that the use of RPP in North America has been a significant factor in the relatively poor performance in these markets:[76]

> *In virtually all OECD countries, during the 1990s, the introduction of a new operator can be correlated with a lift in their ranking relative to other countries in the year that it occurred or in the year following. The two exceptions are Canada and the United States. Despite the introduction of new operators both countries' rankings have slipped relative to other OECD countries. The most likely explanation for this trend is that these two countries, along with Mexico, have had RPP pricing structures during the initial boom in pre-paid cards.*

4.2. Concluding Comment

In our view, the modelling results provide a conservative estimate of the efficient price of termination in Australia. The results of the model are, all things being equal, more likely to risk underestimating the efficient price of mobile termination in Australia. Further, given the way mobile prices interact with each other and with network subscription levels, we do not believe that it would be prudent to set mobile termination rates at or close to the lower bound of an estimated range of termination rates. For these reasons, we consider it reasonable to treat the estimates from our modelling exercise as indicative of the level of prices at or below which net social welfare losses are likely to materialise.

76 OECD, Directorate For Science, Technology And Industry Committee For Information, Computer And Communications Policy Working Party on Telecommunication and Information Services Policies, *Cellular Mobile Pricing Structures And Trends*, May 2000, at page 20.

APPENDIX A: RAMSEY-BOITUEX PRICING

A.1 MOTIVATION AND RATIONALE

Where a multi-product firm operates with high fixed and common costs, pricing services at corresponding long-run marginal costs will result in a deficit because the revenues raised will be insufficient to cover total costs. In the absence of external sources of funding, the firm will need to set prices above marginal costs in order to fully recover its cost. The Ramsey-Boiteux pricing rule was derived from 'solving' a constrained welfare-maximising problem, i.e. maximise social welfare (as defined by the sum of consumers' surplus or benefits) by choice of a set of prices that meets the revenue requirement of the firm to breakeven (the so-called 'revenue constraint').

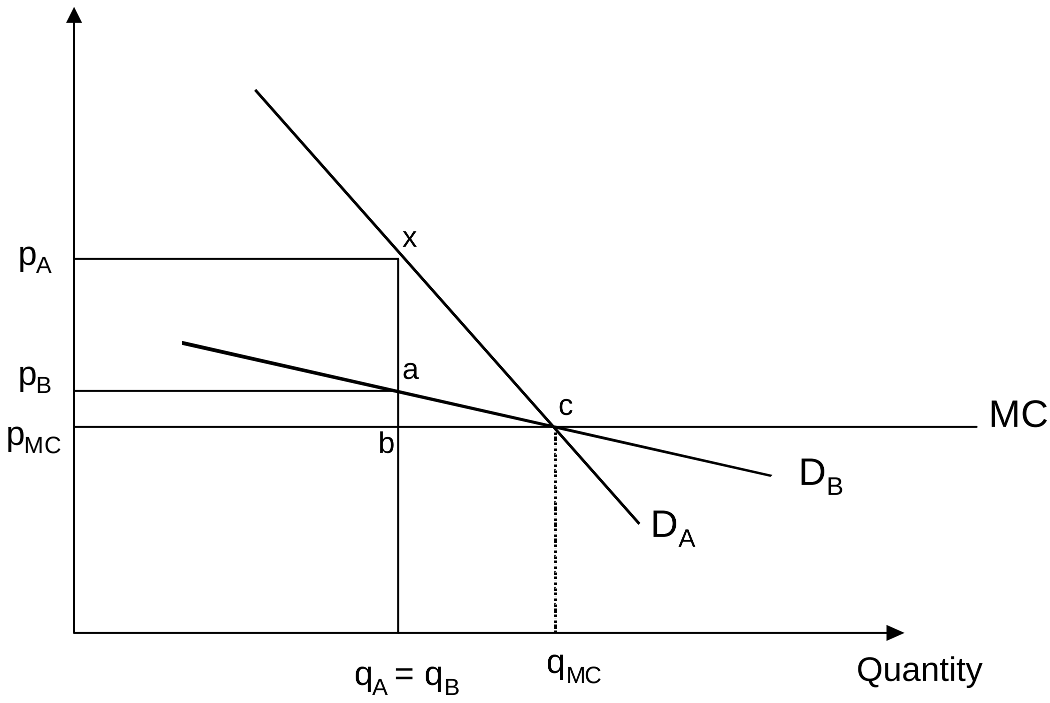
The Ramsey-Boiteux pricing rule (for the case of independent demands) is expressed as follows:

$$\frac{p_i - c_i}{p_i} = \frac{a}{e_i} \text{ for all } i$$

where p_i is the price of service i, c_i is the corresponding marginal cost and e_i is the (absolute) price elasticity of demand for that service. The α parameter, which lies between the values of 0 and 1, is the so-called *Ramsey number*. Closer examination of the Ramsey-Boiteux pricing rule would reveal that is but a generalisation of the marginal cost pricing and (unregulated) monopoly pricing rules. If profit maximisation is paramount (and no regard is given to consumers' surplus) then setting $\alpha = 1$ would yield the familiar (unregulated) monopoly pricing rule. At the other extreme, setting $\alpha = 0$ would yield the marginal cost pricing rule that maximises consumers' surplus. In other words, the Ramsey number determines the monopolist's general price *level* that trades-off consumers' surplus for profits, while e (for all i) determine the price *structure* that is needed to meet the monopolist's revenue requirement.

The intuition behind the characterisation of the Ramsey-Boiteux pricing rule as an inverse-elasticity mark-up pricing rule can be seen easily in Figure 4 which depicts the independent demands for two services with the same marginal cost. To avoid the deficit that would be incurred by marginal cost pricing, the monopolist could raise revenues by marking up prices above marginal cost. With downward sloping demand curves, the monopolist faces a trade-off between the revenues that would be gained from higher prices and the revenues that would be lost from changes in the volume demanded of its services. From a social welfare perspective, this is equivalent to compensating for the loss in consumers' surplus by the increase in total revenues that is needed by the monopolist to breakeven.

Figure 4. Ramsey-Boiteux pricing



As shown in Figure 4, the demand for service *A* is relatively more inelastic than service *B*, and the mark up over marginal cost is accordingly higher for service *A* than service *B*. At the price p_A the larger increase in net revenue of $(p_A - MC)q_A$ compensates for the larger loss in consumers' surplus of triangle *xbc*. At the price p_B the relatively smaller increase in net revenue of $(p_B - MC)q_B$ compensates for the smaller loss in consumers' surplus of triangle *abc*. Put in another way, the price in an inelastic market should be marked up higher to elicit a higher contribution to the required revenue (for breakeven). Only then would the revenue requirement be met with minimum loss in consumers' surplus. This is the reason why Ramsey-Boiteux pricing is compatible with both welfare-maximising and (zero) profit-maximising behaviour.

In the case of interdependent demands, the Ramsey-Boiteux pricing rule is expressed as:

$$\frac{p_i - c_i}{p_i} = \frac{a}{g_i} \text{ for all } i$$

where γ_i is the so-called 'superelasticity'. This superelasticity is measured as follows:

$$g_i = \frac{\sum_j R_j}{R_i} \cdot \frac{1}{e_{ji}} \text{ for all } i, j$$

where R_i and R_j is the revenue from service i and j respectively and e_{ji} is the cross-price elasticity. For the simple case of two interdependent services (say i and j), the expression noted above reveals the following implications:

- If service i is complementary to service j, i.e. $e_{ji} < 0$, then the mark up over marginal cost for service i should be smaller than otherwise. This is because raising the price of service i would cause the demand for both complementary services to fall, with the consequence of lowering the contribution that would be made by both services to revenue requirement.

- If service i is a substitute for the other service, i.e. $e_{ji} > 0$, then the mark up over marginal cost should be larger than otherwise. Increasing the price of service i would increase the contribution to revenue requirement by the substitute service.

A.2 ACCC'S CONCERNS

In its Final Decision, the ACCC states that:

> *Given such elasticity estimates as are available are subject to disagreement across a broad range of values, that cross-price elasticity estimates are virtually non-existent, and that their misapplication could generate inferior efficiency-in-use consequences than they try to correct for, the Commission believes at this stage that it would not promote the LTIE to base mark-ups to account for common organisational-level costs on a Ramsey-Boiteux framework.*[77]

First, the factual basis for the Commission' statement is questionable. As discussed in Section 3 of this Report, the existing and available own-price and cross-price elasticity estimates derived from econometric studies, while displaying a degree of uncertainty, appear well within the range that economic regulators accept as a reasonable basis for informing regulatory analyses and decisions. For instance, the ACCC does not disregard the CAPM model because it relies on parameters that are uncertain. While the Final Decision does refer to some assumed elasticities used by analysts that are different to those derived from econometric studies, no evidence has been put forward (e.g. on confidence intervals) to indicate why any weight should be attached to those assumptions. We also note that cross-price elasticity estimates do exist, including those estimated by Dotecon's econometric analysis that the ACCC refers to elsewhere in the Final Decision. In addition, cross-price elasticities can be derived from own-price elasticities and cross-volume effects.[78]

77 ACCC Final Decision, p.210.

78 For instance, the cross-price elasticity of fixed-to-mobile calls with respect to the price of subscription will depend on the own-price elasticity of subscription and the extent to which changes in the volumes of subscribers results in changes in the volumes of fixed-to-mobile calls.

More generally, there is no economic rationale for preferring an entirely arbitrary approach, such as EPMUs, that is in conflict with the commonly accepted understanding of the relative elasticities and of choosing the best available estimate of the welfare-maximising charge level based on market information. While the difficulty of designing effective regulation is a key matter to be taken into account in deciding whether any regulation should be imposed, if charges are to be regulated then it is critical that it takes account of all available information.

If the ACCC considers it cannot form a reliable view of market elasticities, then we do not believe the ACCC has any basis to conclude that current prices are inefficient. Absent of a finding of inefficient prices, there would be no grounds for regulation.

In terms of elasticity estimates, there are bounds for the estimates that are commonly accepted. To the best of our knowledge, no one has suggested that termination services are more elastic than outgoing services. Further, it is commonly accepted that the cross-price elasticity between outbound calling and subscription is higher than the cross-price elasticity between inbound calling and subscription – if subscribers did care as much about inbound calling as outbound calling there would be no basis for termination regulation. Thus, there is solid support, on the basis of a widely accepted understanding of the different elasticities, that efficient inbound rates should be above outbound rates. The degree to which the rates should be higher can be determined by taking account of a reasonable range for the elasticity estimates.

In the ACCC Final Decision (p.170ff), a number of other concerns were raised with Ramsey-Boiteux pricing. These are largely concerns relating to whether Ramsey-Boiteux pricing by MNOs can be expected in unregulated markets. This is, of course, a different proposition to the one that is being put forward in this Report: *viz.* is Ramsey-Boiteux pricing a reasonable and sound commercial rule for setting mobile termination charges in a regulatory undertaking.

In the following, we address the ACCC's concerns that may impact on its assessment of the reasonableness of Ramsey-Boiteux pricing.

First, the ACCC raised concerns as to whether particular Ramsey-Boiteux approaches, in practice, cover all of the mobile services and their respective costs and elasticities. As discussed, in the body of this Report, Optus' costs have been allocated to 6 services: subscription, on-net, MTF, off-net MTM, termination, and SMS and data services. These services cover over 99% of Optus' mobile volumes. In relation to the Rohlfs model, the costs and revenues associated with SMS and data services are excluded. This implies that SMS and data services (and indeed the other excluded services) are assumed to continue to contribute at least as much as they currently do. Further, the marginal cost of SMS (the most significant product) is very low, implying that within a Ramsey framework the optimal level of cost recovery from SMS would be also low if modelled within the system, which would, if anything, increase the optimal level of cost recovery from termination. In other words, we believe its exclusion is more likely to reduce than increase the optimal termination price calculated. Elasticity assumptions are based on the average of the available econometric studies. For on-net, MTF and off-net MTM, average elasticities for mobile outgoing calls (i.e. the group that comprises these three services) were used.

The ACCC also raised a concern as to whether subscription subsidies are consistent with Ramsey-Boiteux pricing. A simple Ramsey-Boiteux approach needs to be adjusted in the presence of interdependent demands to ensure welfare-maximising prices. The existence of network externalities in particular can imply that welfare-maximising prices involve subscription subsidies. Further, we note that subscription is arguably not a service, but part of a two-part tariff charging structure for paying for voice call and data services, including the recovery of the network and handset costs incurred in delivering those services. In many other industries, customer acquisition costs are fully recovered at the time products are actually sold and no one would, for instance, debate the merits or otherwise of a 'shopping subsidy' because a shopkeeper does not charge an entry fee to recover the costs of its marketing.

The ACCC is further concerned that Ramsey prices "can be set at any level ranging from cost recovery to full monopoly exploitation" and that "Ramsey pricing at any level requires market power, without which carriers could not hold prices above attributable costs." These comments reflect particular definitions of Ramsey prices and market power. As the ACCC itself notes (footnote 386 of the Final Decision) Ramsey-Boiteux pricing was developed in the context of determining how a public utility could raise sufficient revenue to cover its costs in a manner that minimised the efficiency loss. Ramsey-Boiteux pricing thus formally results in a firm just covering its costs. It has since been recognised that profit-maximising firms may also adopt a structure of prices similar to Ramsey-Boiteux pricing even if the level is higher than that consistent with Ramsey-Boiteux pricing. Laffont and Tirole clarify this point:

> *the price structure is the same in the presence or absence of regulation: the ratio of the relative markups over the marginal costs of two services is equal to the ratio of the inverse elasticities of demand. Put more crudely, the Ramsey-Boiteux-Boiteux prices are the same as those of an unregulated monopolist, just a notch down*.[79]

In practice, it is a difficult exercise to determine the level of industry revenues consistent with no economic profits being earned. Indeed, for industries with significant *ex ante* risks, it may be impossible to identify the level of *ex post* profits consistent with just providing a return sufficient to compensate for those *ex ante* risks. This is why competition authorities generally assess the level of competition by reference to a range of indirect indicators such as market structure, the size of barriers to entry and expansion and the existence of buyer power. Trying to assess the level of competition by examining profitability alone has long been recognised as being highly misleading.

79 Laffont, J.J. and J. Tirole, *Competition in telecommunications*, The MIT Press, 2000, p.63.

Finally, the ACCC has commented that Ramsey-Boiteux pricing requires market power. This seems to be based on a definition of market power that is not particularly useful. If market power is defined as the ability to price above marginal cost then by definition Ramsey-Boiteux pricing and, indeed, any method of internally recovering fixed and common costs (including Equi-Proportionate Mark-Ups) must require market power. However, competition authorities should only be concerned with market power if it results in firms setting overall revenues greater than overall costs. This is not the case with Ramsey-Boiteux pricing as formally defined. Indeed, in competitive markets where production involves fixed and common costs, firms may be forced to price in accordance with Ramsey-Boiteux principles so as to maximise the volumes over which to recover their costs. A firm that instead sought to target only the more valuable customers may not be able to compete against the lower unit costs of 'full-market' players. Laffont and Tirole make the following observation:

> *[Unregulated businesses] indeed engage in sophisticated marketing strategies. They offer discounts to high-elasticity-of-demand customers, adjust their prices to competitive pressure, and carefully coordinate the pricing of substitutes or complements. The structure of unregulated firms' prices (though not the level if the firms have substantiated market power) thus reflects Ramsey-Boiteux precepts.*[80]

80 Laffont, J.J. and J. Tirole, *Competition in Telecommunications*, MIT Press, 2000, p131-132. Price Discrimination Without Market Power, Michael E Levine, Feb 2000 is another useful reference that can be located at: www.law.harvard.edu/programs/olin_center/papers/pdf/276.pdf.

APPENDIX B: UK EVIDENCE ON THE WATERBED EFFECT

In the UK, termination regulation was imposed on a market in which significant annual price reductions had been occurring. Price reductions were expected to continue as a result of more intense competition, particularly with the entry of Hutchison '3' and continuing declines in new equipment prices.[81] The UK Competition Commission (UKCC) estimated that the impact of regulation would be to reduce the rate of fall of mobile prices:

> *… average retail prices would still fall but by, on average, about half of the rate as shown in the MNOs' business plans, that is, by about 3 per cent a year [compared with reductions of around 5.5 per cent per year in the business plans].*[82]

The new controls that were imposed on the 2G voice termination services of the four UK 2G mobile operators (but not on the termination charges of the 3G-only entrant, '3') required:

- A 15 per cent real reduction (around a 14 per cent nominal reduction) in termination charges on 24 July 2003; and
- A further reduction of around 30 per cent on 1 September 2004 to 5.63ppm for the combined 900/1800MHz operators and 6.31ppm for the 1800MHz operators.[83]

There is evidence in relation to the impact of the regulated reductions in July 2003 on the prices and volumes of the main services in UK. However, only limited evidence is so far available on the larger reduction that took place in September 2004.

With regards to fixed-to-mobile calls, Ofcom's statistics show that average revenue per minute was 13.5ppm in the second quarter (April-June) 2003 and was 12.8ppm in the second quarter 2004, i.e. a reduction of around 0.7ppm.[84] The July 2003 nominal reduction in termination charges of 14 per cent lowered average mobile termination charges from around 10.2ppm to 8.8ppm, i.e. by 1.4ppm. This implies that only around 50 per cent of the July 2003 reduction in termination

81 For instance, in June 2003 Hutchison announced plans to undercut the prices of similar packages of other operators by up to 50% (BBC news, "UK 3G operator to cut prices", 5 June 2003 available at http://news.bbc.co.uk/1/hi/business/2967132.stm).

82 UKCC Calls to mobiles report, paragraph 2.565.

83 See Ofcom, *Wholesale Mobile Voice Call Termination Statement*, 1 June 2004, paragraph 6.87.

84 Based on fixed-to-mobile call revenues and volumes in Ofcom, *The Communications Market*, Quarterly Update October 2004, Tables 4 and 5.

charges was passed through into lower fixed-to-mobile prices.[85] In relation to the September 2004 reduction, BT has passed through around 70 per cent of the reduction based on our calculations.

In terms of the impact on fixed-to-mobile call volumes, information is available in relation to the July 2003 reduction, but not as yet on the September 2004 reduction. Between the second quarter (April-June) 2003 and the second quarter 2004, the volume of fixed-to-mobile calls was virtually unchanged (increasing by less than half of one per cent).[86]

With regards to mobile retail prices, Ofcom's statistics show that average mobile call revenue per minute increased by 3.9% between the second quarter 2003 and the second quarter 2004.[87] Given that mobile operators set their prices with the purpose of achieving a commercial return over the lifetime of the subscriber, operators will set prices for their packages taking into account any further reductions in termination charges. UK operators were aware of the July 2003 cut following the Competition Commission's January 2003 report. It is therefore likely that some increase in retail prices was already factored into the second quarter 2003 prices (similarly the second quarter 2004 prices may reflect some factoring in of the September 2004 cuts in termination charges). Comparing average mobile call revenue per minute between the first quarter 2003 and the second quarter 2004 shows an even larger increase of 6.6%.[88]

Oftel has compiled a series of data on mobile prices up until October 2003.[89] The series shows a price fall (excluding handset prices) for the assumed profile of 1.6% between May and October 2003. However, once handset prices were included, the overall cost of mobile telephony was estimated to have increased. Indeed, the series shows that the overall cost of mobile telephony had fallen by around 10.6% from October 2001 to reach a low point in February/March 2003 and then had virtually reversed the reduction of the previous 18 months, rising by 10.8% by October 2003. Oftel noted that the price increases were focused on low

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85 This assumes no significant changes in the mix (say between peak and off-peak). This assumption is likely to be reasonable for a 12-month period. We note that taking a shorter period of comparison, i.e. comparing the quarter immediately before the price cut (April-June 2003) with the quarter after the price cut (October-December 2003), does not greatly alter the result with around 53% of the termination cut being passed on.

86 Ofcom, *The Communications Market*, Quarterly Update October 2004, Tables 4 and 5.

87 Ofcom, *The Communications Market*, Quarterly Update October 2004, Tables 1 and 2.

88 Oftel, *Market Information – Mobile Update*, October 2003. Average revenue per minute figures are vulnerable to changes in mix, although the information contained in Ofcom's statistics does not suggest any substantial change in mix with, for instance, the share of higher priced outgoing international calls falling and calls while roaming abroad only increasing from 2.2% to 2.3% of all calls.

89 This price series is based on an assumed average usage profile. See Oftel, *Mobile price monitoring*, available at http://www.ofcom.org.uk/static/archive/oftel/publications/market_info/mobile1003.pdf (with links to the actual data series).

users: "Once handset cost is included, zero and low usage customers saw their average mobile bills increase by 14% and 8% respectively."[90]

Ofcom's most recent report (for the second quarter 2004) on the market states that there has been "flat to slightly rising prices over the past 12 months".[91] It appears that this statement excludes handset prices - the earlier Oftel analysis suggests that including handset prices is likely to show a greater increase in the total cost of mobile telephony.

According to a September 2004 report by Enders Analysis which examined changes in mobile retail prices in the UK, "mobile prices have in fact risen in the last two years".[92]

In terms of the regulatory impact on volumes, Ofcom latest statistics suggest that growth in mobile call and SMS volumes is starting to taper off:

> *The average number of mobile voice calls also failed to show any signs of a significant increase in the three months to June, although the total proportion of voice calls made from mobile phones grew slightly over the same period … The average number of SMS message per active customer also remained flat quarter on quarter, although up year on year.*[93]

Ofcom's consumer research suggests that the proportion of UK adults with a mobile phone was around 75% in May 2003, 73% in August 2003 and was around 79% in the second quarter 2004.[94] While more recent data is not available, the Ofcom's consumer research also suggested that penetration amongst low-income earners (with household income below £17,500) had fallen from 64% to 60% between May and August 2003.[95] We note that if increases in mobile retail prices have been focused on handset prices, then such increases would be only likely to impact subscriber numbers in the medium term as existing handsets become lost, stolen or broken and some subscribers faced with the higher prices for new handsets decide to drop out of the mobile market altogether. In addition, the loss in affordability for certain groups may not show in overall penetration rates, if other structural changes in demand are occurring such as take-up by older age groups which appeared to be a factor in the UK.

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90 Oftel, Mobile price monitoring, p.3.

91 Ofcom, *The Communications Market*, Quarterly Update October 2004, p.36.

92 Enders Analysis, UK Mobile call charge trends, 22 September 2004.

93 Ofcom, *The Communications Market*, Quarterly Update October 2004, p.8.

94 Ofcom, *The Communications Market*, Quarterly Update October 2004, p.35 and Oftel, Consumers' use of mobile telephony - Q14 August 2003, 27 October 2003, p.6.

95 Oftel, Consumers' use of mobile telephony - Q14 August 2003, 27 October 2003, p.7.

All of the data and statistics cited above shows that despite an expectation (on the part of UK regulators) that termination controls would act only to slow the expected reduction in mobile retail prices, such prices appear to have remained constant or, indeed, increased once handset prices are taken into account. This is consistent with a rebalancing of mobile retail prices induced by the waterbed effect.

APPENDIX C: COST OF CAPITAL FOR MOBILE TELEPHONY

We have estimated the cost of capital for mobile telephony based on a standard approach used by the ACCC. In some instances, we have considered alternative parameter values to those that might be immediately apparent from ACCC determinations.

C.1 REGULATORY DETERMINATIONS

Our analysis refers to seventeen ACCC decisions, as well as a number of other relevant reports. To simplify the reference to the ACCC decisions, we adopt the summary references shown in Table 13.

Table 13. Selected ACCC Determinations

Reference	Date	Decision
ACCC 2004d	October 2004	Assessment of Telstra's undertakings for PSTN, ULLS and LCS, Draft Decision
ACCC 2004c	September 2004	Pricing Principles for Declared Transmission Capacity Services – Final Report
ACCC 2004b	28 April 2004	NSW and ACT Transmission Revenue Caps – Transgrid 2004/05-2008/09
ACCC 2004a	28 April 2004	NSW and ACT Transmission Revenue Caps – Energy Australia 2004/05-2008/09
ACCC 2003d	10 December 2003	Tasmanian Transmission Network Revenue Cap 2004 – 2008/09
ACCC 2003c	2 October 2003	East Australian Pipeline Limited Access arrangement for the Moomba to Sydney Pipeline System
ACCC 2003b	1 October 2003	Murraylink Transmission Company Application for Conversion and Maximum Allowed Revenue
ACCC 2003a	October 2003	Final determination for model price terms and conditions of the PSTN, ULLS, and LCS services
ACCC 2002c	11 December 2002	South Australian Transmission Network Revenue Cap 2003 – 2007/08
ACCC 2002b	11 December 2002	Victorian Transmission Network Revenue Caps 2003-2008
ACCC 2002a	13 November 2002	GasNet Australia access arrangement revisions for the Principal Transmission System
ACCC 2001b	1 November 2001	Queensland Transmission Network Revenue Cap 2002 – 2006/07
ACCC 2001a	12 September 2001	Access Arrangement proposed by Epic Energy South Australia Pty Ltd for the Moomba to Adelaide Pipeline System
ACCC 2000c	30 June 2000	Access Arrangement by AGL Pipelines (NSW) Pty Ltd

Reference	Date	Decision
		for the Central West Pipeline
ACCC 2000b	25 January 2000	NSW and ACT Transmission Network Revenue Caps 1999/00 – 2003/04
ACCC 2000a	July 2000	A report on the assessment of Telstra's undertaking for the Domestic PSTN Originating and Terminating Access services
ACCC 1999	June 1999	Assessment of Telstra's Undertaking for PSTN Originating and Terminating Access: Cost of Capital (Revised)

C.2 THE WEIGHTED AVERAGE COST OF CAPITAL

The ACCC typically calculates a "vanilla" WACC that it applies to post-tax cashflows.[96] For our current purposes, however, a post-tax nominal WACC is more appropriate. This is because tax obligations depend on the modelled revenue and depreciation streams, and these depend on the assumed asset values and the cost of capital. Using a vanilla WACC requires explicit modelling of all cash flows relating to taxation, including franking credits, and subsequent allocation of the financial costs and benefits of these flows to the different assets. In order to facilitate the development of a model where capital asset values can more readily be updated to reflect the latest data, and modelled TSLRIC costs adjust accordingly, it is appropriate to include tax effects in the modelled WACC.

We calculate both the Officer post-tax WACC and the vanilla WACC. The Officer model is common in Australia, has been proposed by the ACCC for the new regulatory test for electricity transmission investment,[97] and is applied by some other Australian regulatory authorities.

In summary, the formula for the vanilla WACC applied by the ACCC is:[98]

$$WACC = r_e \cdot \frac{E}{V} + r_d \cdot \frac{D}{V}$$

where: D/V is the proportion of total capital financed out of debt;
E/V is the proportion of total capital financed out of equity;
r_e is the return on equity; and
r_d is the return on debt.

The formula for the Officer model is:

96 See for example, ACCC (2000a, 2004a, 2004b).

97 ACCC (2004) *Review of the Regulatory Test for network augmentations*, Draft Decision, 10 March, p. 37.

98 See for example, ACCC (2000a, 2003d).

$$WACC = \frac{(1-te)}{(1-te(1-g))} \cdot r_e \cdot \frac{E}{V} + (1-tc) \cdot r_d \cdot \frac{D}{V}$$

where tc is the marginal corporate tax rate;
te is the effective tax rate for equity investors; and
γ captures the ability of investors to use imputation credits.

Each of these terms is discussed below. First, however, we review the risk-free rate, which is a key component of both the cost of debt and the cost of equity.

C.3 RISK-FREE RATE

Although the "on the day" risk free rate may be more theoretically appropriate for decisions taken on the day, common practice for regulatory purposes is to use an average across a period to smooth out random fluctuations. For example, in its' latest decisions on electricity transmission, the ACCC uses a 10-day average of the relevant government bond.[99]

In the past, the ACCC has applied a five-year risk-free rate in the electricity, gas, and telecommunications industries because the term of the instrument matches the length of the regulatory period. However, the conventional view of economists is that the duration of the instrument used should match the duration of the investment being made, which in practice means that the ten-year bond is likely to be more appropriate for durable infrastructure investments. The ACCC's application of a five-year rate in the gas industry was over-turned in favour of a ten-year rate by the Australian Competition Tribunal,[100] and in subsequent decisions the ACCC has applied a ten-year risk free rate.[101]

[commercial-in-confidence]

C.4 GEARING

Gearing can be measured either by the market value of debt and equity (a market value ratio) or the book value of debt and equity (a book value ratio).

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99 See ACCC (2002b), p.15; ACCC (2002c), p.18; ACCC (2003d), p.75; ACCC (2004a), p. 82; ACCC (2004b), p. 79..

100 Australian Competition Tribunal, Application by GasNet Australia (Operations) Pty Ltd, [2003] ACompT 6, 23 December 2003.

101 See, for example, ACCC (2004d), p. 92.

In its 1999 assessment of Telstra's PSTN undertaking, the ACCC used a market value ratio of 10.1% debt, which was slightly less than Telstra's actual market value ratio of 13.6%.[102] However, in its July 2000 assessment of Telstra's PSTN undertaking, the ACCC moved to a book value ratio of 40%.[103] This approach was reaffirmed in the PSTN, ULLS, and LCS determinations.[104] The ACCC's approach in the electricity and gas industries has also been to use a book value ratio.

We note that the theoretically rigorous approach is to use a market value ratio. However, estimating and applying a market value ratio is difficult when dealing with unlisted firms or unlisted parts of a firm. We also note that large changes in the gearing ratio applied have very little impact on the WACC.

[commercia-in-confidence]

C.5 Cost of Debt

The cost of debt is calculated as the sum of the risk-free rate (discussed in section C.3 above), debt premium, and debt raising costs. The debt premium and debt raising costs are discussed below.

C.5.1 Debt Premium

The debt premium is the margin above the risk-free rate at which a firm can borrow. The debt premium depends on:

- the industry, as riskier industries will attract a higher debt premium;
- the firm's credit rating, as higher grade debt attracts a lower premium; and
- creditor perceptions of the firm's future profitability (i.e. perceptions of future credit risk).

In its July 2000 assessment of Telstra's PSTN undertaking, the ACCC applied a debt premium of 0.8% for Telstra's debt, and a gearing ratio of 40%, based on reported book value gearing ratios. This debt premium was retained in the PSTN, ULLS, and LCS determination.[105]

102 ACCC (1999), table 1, p.5.

103 ACCC (2000a), p.67.

104 ACCC (2003a), p.39; ACCC (2004d), p. 92.

105 ACCC (2003a), p.39; ACCC (2004d), p. 92.

SingTel Optus currently has a Standard & Poor's credit rating of A+. However, the ACCC typically applies a debt margin that would apply for the minimum investment grade rating of BBB+.

CBA Spectrum from the Commonwealth Bank of Australia provides standard yield curves for corporate bonds. Table 14 shows the yields for A+ and BBB+ rated securities for the 10 days ending 11 May 2004, and Table 15 shows the corresponding spreads above the Commonwealth Government bond rate. The average spreads over this time are 80 points (A+ grade) and 106 points (BBB+ grade) for ten-year bonds. **[commercial-in-confidence]**.

Table 14: Yields from CBA Spectrum Standard Yield Curves

Date	10 Year Bond Yields		
	Govt	A+	BBB+
11-May-04	6.09%	6.90%	7.17%
10-May-04	6.08%	6.89%	7.16%
7-May-04	5.99%	6.78%	7.04%
6-May-04	5.97%	6.77%	7.03%
5-May-04	5.94%	6.74%	7.00%
4-May-04	5.94%	6.74%	7.00%
3-May-04	5.95%	6.74%	7.00%
30-Apr-04	5.98%	6.76%	7.02%
29-Apr-04	5.96%	6.75%	7.01%
28-Apr-04	5.88%	6.66%	6.92%
Average	5.98%	6.77%	7.04%

Table 15: Spreads Above 10 Year Commonwealth Bonds from the CBA Spectrum Standard Yield Curves

	Credit Rating	
Date	A+	BBB+
11-May-04	0.81%	1.08%
10-May-04	0.81%	1.08%
7-May-04	0.79%	1.05%
6-May-04	0.80%	1.06%
5-May-04	0.80%	1.06%
4-May-04	0.80%	1.06%
3-May-04	0.79%	1.05%

30-Apr-04	0.78%	1.04%
29-Apr-04	0.79%	1.05%
28-Apr-04	0.78%	1.04%
Average	0.80%	1.06%

C.5.2 Debt Raising Costs

The ACCC has provided an allowance for debt raising costs on top of the debt margin. The ACCC notes that:

> *Some commercial banks indicated that debt raised on capital markets is likely to incur 8–12.5 basis points of the amount as fees as well as the debt margin.*[106]

In a recent electricity transmission-related decision, the ACCC has adopted a margin of 10.5 basis points.[107] However, it has moved from providing this as part of the return on capital to providing an explicit opex allowance for debt raising costs.[108]

In the recent GasNet decision, the Australian Competition Tribunal provided an allowance of an additional 25 basis points per annum above the debt margin to reflect debt raising costs.

[commercial-in-confidence]

C.5.3 The Cost of Debt

Table 16 summarises our parameter estimates for the cost of debt, and provides the calculation of the pre-tax nominal cost of debt.

Table 16: Estimated Cost of Debt

	Low	High	Point Estimate
Risk-Free Rate	**[c-i-c]**%	**[c-i-c]**%	**[c-i-c]**%
Debt Premium	**[c-i-c]**%	**[c-i-c]**%	**[c-i-c]**%
Debt Raising Costs	**[c-i-c]**%	**[c-i-c]**%	**[c-i-c]**%
Pre-tax Cost of Debt	**[c-i-c]**%	**[c-i-c]**%	**[c-i-c]**%

106 ACCC (2003d), p. 82.

107 ACCC (2002b), p.22; ACCC (2002c), p.27; ACCC (2003d), p.82.

108 ACCC (2003d), p.82; ACCC (2004a), p. 86; ACCC (2004b), p. 83.

C.6 THE COST OF EQUITY

C.6.1 The Capital Asset Pricing Model

The cost of equity is calculated as:

$$r_e = r_f + be(r_m - r_f)$$

where: r_f is the risk-free rate-of-return;
be is the equity beta; and
r_m-r_f is the market risk premium.

The equity beta is calculated according to the Monkhouse formula:

$$be = ba + \left[(ba - bd)(1 - t(1-g))\frac{D}{E}\right]$$

where be is the equity beta;
ba is the asset beta;
bd is the debt beta;
t is the tax rate; and
D, E, and g are as previously defined.

With the model applied by the ACCC, t is the effective tax rate. However, in the implementation of the Officer model, t is also often estimated as the statutory corporate tax rate.

C.6.2 Market Risk Premium

The ACCC has consistently adopted a market risk premium of 6%. This figure is used in most regulatory determinations in Australia. The ACCC's most recent electricity transmission revenue cap decision cites several recent studies that provide continued support for the 6% estimate.[109] **[commercial-in-confidence]**.

C.6.3 Tax Rate

The ACCC's early decisions employed the statutory tax rate of 30%, but it has now moved to using effective tax rates. Effective tax rates used in selected recent determinations are shown in Table 17 below. The majority of the tax rates are less than the statutory corporate tax rate, and the simple average of the tax rates in Table 17 is 21.83%. **[commercial-in-confidence]**

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109 See ACCC (2003d), p.83 for references to three studies, and ACCC (2004a), p.86.

Table 17: Effective Tax Rates applied in Selected ACCC Determinations

Date	Industry	Reference	Tax Rate
October 2004	Telecommunications	ACCC 2004d	20%
September 2004	Telecommunications	ACCC 2004c	20%
28 April 2004	Electricity Transmission	ACCC 2004b	20.81%
28 April 2004	Electricity Transmission	ACCC 2004a	27.15%
10 December 2003	Electricity Transmission	ACCC 2003d	21.49%
2 October 2003	Gas Pipelines	ACCC 2003c	23.5% (mainline) 13.8% (regional)
1 October 2003	Electricity Transmission	ACCC 2003b	21.29%
October 2003	Telecommunications	ACCC 2003a	20%
11 December 2002	Electricity Transmission	ACCC 2002c	39.05%
11 December 2002	Electricity Transmission	ACCC 2002b	23.20%
13 November 2002	Gas Pipelines	ACCC 2002a	7%
1 November 2001	Electricity Transmission	ACCC 2001b	22.47%
12 September 2001	Gas Pipelines	ACCC 2001a	11.3%
30 June 2000	Gas Pipelines	ACCC 2000c	30% (statutory)
25 January 2000	Electricity Transmission	ACCC 2000b	30% (statutory)
July 2000	Telecommunications	ACCC 2000a	20%

C.6.4 Dividend Imputation and Franking Credits

Under a classical income tax regime, company profits are taxed twice – firstly as taxable income of the company, and secondly as taxable dividend income in the hands of shareholders.

Double taxation is eliminated under a dividend imputation system because the payment of company tax is imputed, or notionally allocated, to shareholders by means of imputation credits attached to "franked" dividends. Shareholders who receive a dividend out of a company's taxed profits include not only that dividend in assessable income, but can also deduct the tax paid by the company from their own tax liability. The tax paid by the company and passed to the shareholder is known as an "imputation credit" or a "franking credit".

The effectiveness of a dividend imputation regime depends on the ability of shareholders to utilise franking credits. Australian resident taxpayers who would ordinarily pay tax are able to utilise franking credits up to the full amount of their tax liability. From 1 July 2000, excess franking credits have been available to carry forward against future income. Tax-exempt organisations are unable to utilise franking credits. The ability of non-resident taxpayers to utilise franking credits depends on the existence of terms of any tax treaty between Australia and the non-resident's home country. Australia has comprehensive agreements with a number of countries that aim to eliminate double taxation. However, non-residents remain liable for withholding tax on dividend, interest and royalty income. This tax is withheld before the income is remitted overseas. Fully franked dividends paid to non-residents are exempt from withholding tax. The non-resident's repatriated income is then subject to their home country tax rates, less any credits that can be claimed for tax paid in Australia.

In summary, the ability of different classes of taxpayer to utilise franking credits is as follows:

- Australian resident taxpayers are able to fully utilise franking credits;
- Tax-exempt entities are unable to utilise franking credits;
- Non-resident taxpayers may be able to utilise franking credits to avoid dividend withholding tax, but the repatriated income is then subject to their home country taxation regime, which may not recognise Australian franking credits.

The gamma (γ) value in the CAPM cost of equity captures the ability of investors to use imputation credits. There has been significant debate over the appropriate value of gamma, with various submitters to the ACCC arguing for anything from zero to one.[110] The ACCC has preferred to adopt the mid-point estimate of $\gamma = 0.5$, explicitly stating that it is "inappropriate for the Commission to lead in this area".[111]

Gamma may be defined as:

$$g = U\frac{IC}{TAX}$$

110 For an example of the latter, see Lally, M. (2002) *The Cost of Capital Under Dividend Imputation*, prepared for the Australian Competition and Consumer Commission, June, pp. 12-13, and Lally, M (2003) "Regulation and the Cost of Equity Capital in Australia", *Journal of Law and Financial Management*, Vol 2, No. 1.

111 See, for example, ACCC (2002c), p.31.

where U is the utilisation rate for imputation credits;
IC is the imputation credits paid out by the firm; and
TAX is the tax paid by the firm.

Credit Suisse First Boston estimates that SingTel Optus' dividends will remain unfranked for the foreseeable future,[112] which reduces the ratio IC/TAX to zero. An Optus-specific value of gamma would therefore also be zero, and this would result in a higher cost of capital.

C.6.5 Asset and Equity Beta

The appropriate equity beta for use in the cost of equity calculation is calculated by first determining the appropriate asset beta and then applying the leverage, gamma, and effective tax rate assumptions to calculate the equity beta.

Leverage Formula

To re-lever asset beta to obtain equity beta, the ACCC applies the Monkhouse formula:

$$b_e = b_a + (b_a - b_d)\left[1 - \left(\frac{r_d}{1+r_d}\right)(1-g)Te\right]\frac{D}{E}$$

Given the cost of debt, gamma, and effective tax rates assumed above, the term in square brackets can be assumed to be equal to 1 with no material error.[113]

The Monkhouse formula thus simplifies to:

$$b_e = b_a + (b_a - b_d)\frac{D}{E}$$

The ACCC further assumes that the debt beta is equal to zero[114] – an assumption that is essentially correct for investment grade debt – so the Monkhouse formula is further simplified to:

$$b_e = b_a\left(1 + \frac{D}{E}\right)$$

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112 Credit Suisse First Boston (2004) *Singapore Telecom (Optus), March quarter result: another solid quarter from Optus*, 7 May, p.1.

113 **[commercial-in-confidence]**

114 See, for example, the ACCC (2000a), pp.80-81, as well as any of the subsequent determinations in Table 13. .

Estimates of the Asset Beta

[commercial-in-confidence]

Summary

[commercial-in-confidence]

C.7 CONCLUSION

Table 18 summarises the parameters and calculation of the WACC for mobile termination. Based on the parameters discussed above, we recommend a vanilla WACC of **[c-i-c]**% and a post-tax nominal WACC of **[c-i-c]**%.[115]

Table 18: Calculation of a WACC for Mobile Termination

Parameter	Low	High	Point
Debt Ratio (D/V)	**[c-i-c]**%	**[c-i-c]**%	**[c-i-c]**%
Equity Ratio (E/V)	**[c-i-c]**%	**[c-i-c]**%	**[c-i-c]**%
Risk-Free Rate	**[c-i-c]**%	**[c-i-c]**%	**[c-i-c]**%
Asset Beta	**[c-i-c]**	**[c-i-c]**	**[c-i-c]**
Equity Beta	**[c-i-c]**	**[c-i-c]**	**[c-i-c]**
Market Risk Premium	**[c-i-c]**%	**[c-i-c]**%	**[c-i-c]**%
Effective Tax Rate (Te)	**[c-i-c]**%	**[c-i-c]**%	**[c-i-c]**%
Imputation Factor (γ)	**[c-i-c]**	**[c-i-c]**	**[c-i-c]**
Cost of Equity	**[c-i-c]**%	**[c-i-c]**%	**[c-i-c]**%
Debt Premium	**[c-i-c]**%	**[c-i-c]**%	**[c-i-c]**%
Debt Raising Costs	**[c-i-c]**%	**[c-i-c]**%	**[c-i-c]**%
Pre-tax Cost of Debt	**[c-i-c]**%	**[c-i-c]**%	**[c-i-c]**%
Corporate tax rate (Tc)	**[c-i-c]**%	**[c-i-c]**%	**[c-i-c]**%
Vanilla WACC	**[c-i-c]%**	**[c-i-c]%**	**[c-i-c]%**
Post-tax Nominal WACC	**[c-i-c]%**	**[c-i-c]%**	**[c-i-c]%**

115 **[commercial-in-confidence]**

[commercial-in-confidence]

APPENDIX D: [COMMERCIAL-IN-CONFIDENCE]

APPENDIX E: THE TILTED ANNUITY FOR ANNUAL CAPITAL COSTS

The objective of using a tilted annuity is to mimic the price path that would be charged in a competitive market as the price of inputs change over time. The ACCC uses tilted annuities as a standard part of its assessment of the price of telecommunications services.

The approach that is adopted is to analytically calculate a stream of cash flows that has its NPV equal to the initial asset value, and with the growth rate of the stream of cash flows determined by the rate of growth of the price of inputs. The NPV rule is known as the "NPV=0" rule, and is assumed to mimic the competitive market outcome of zero economic profits.

E.1 THE TAX SHIELD AS INCOME

When evaluating cash flows on a post-tax basis, any tax shield provided by depreciation (using either a vanilla WACC or a post-tax WACC) and interest (using a vanilla WACC) reduces the tax payable on income, thereby also reducing the size of the charge that is required to recover an NPV=0 revenue stream.

In the analysis below we show how the tax shield alters the sum to be recovered from capital charges.

The annual post-tax cash flow (C) is revenue net of operating costs (R) less tax paid (T):

$$C = R - T$$

Let d be tax depreciation expressed as a percentage of the initial asset value (V_0). At this stage we make no assumption about the profile of d through time. Taxes (T) are calculated as:

$$T = t(R - dV_0)$$

Where t is the corporate tax rate. The annual post-tax cash flow is therefore:

$$C = R - t(R - dV_0) = R(1\text{-}t) + dV_0t$$

It is immediately clear that there are two components to the annual post-tax cash flow: the post-tax revenues and the depreciation tax shield.

The NPV rule requires that:

$$NPV(C) - V_0 = 0$$

$$V_0 = NPV(R)(1\text{-}t) + NPV(dV_0)t$$

And hence that:

$$NPV(R) = [V_0 – NPV(dV_0)t]/(1-t) = V_0 [1 – NPV(d)t]/(1-t)$$

This states that the post-tax NPV of the revenue stream must equal the initial asset value less the value of the depreciation tax shield.

This is true in a strictly post-tax framework. If, however, a vanilla nominal WACC is used rather than a post-tax nominal WACC, then the tax shield should also incorporate the interest tax shield. Denoting the debt ratio as (D/V) and the interest rate as (i), the formula then becomes:

$$NPV(R) = V_0 [1 – NPV(d+(D/V)i)t]/(1-t)$$

One final adjustment required in the Australian context is to incorporate the effect of dividend imputation via the parameter gamma (?):

$$NPV(R) = V_0 [1 – NPV(d+(D/V)i)t(1- ?)]/(1-t(1- ?))$$

We now proceed to calculate the tilted annuity formula for NPV(R) and then solve the above formula for the special case of straight-line tax depreciation.

To simplify the following analysis we define:[116]

$$f = [1 – NPV(d+(D/V)i)t(1- ?)]/(1-t(1- ?))$$

so that

$$NPV(R) = V_0 f$$

E.2 The Tilted Annuity

We now introduce subscripts to the revenue amounts so that we can denote the period in which they occur.

Suppose that the annual revenue amounts grow at the constant rate g, so that $R_N = R_1(1+g)^{N-1}$. Given a discount rate of k, the NPV of the revenue stream is:

116 Note that the factor f is similar to the tax adjustment that Telstra uses in Annexure M, p. 3.

$$\mathrm{NPV}(\mathrm{R}) = \sum_{t=1}^{L} \frac{R_t}{(1+k)^t}$$

$$= \frac{R_1}{(1+k)} + \frac{R_1(1+g)}{(1+k)^2} + \frac{R_1(1+g)^2}{(1+k)^3} + \cdots + \frac{R_1(1+g)^{t-2}}{(1+k)^{t-1}} + \frac{R_1(1+g)^{t-1}}{(1+k)^t}$$

$$= \frac{R_1}{(1+k)}\left[1 + \left(\frac{1+g}{1+k}\right) + \left(\frac{1+g}{1+k}\right)^2 + \cdots + \left(\frac{1+g}{1+k}\right)^{t-2} + \left(\frac{1+g}{1+k}\right)^{t-1}\right]$$

Hence:

$$\left[1 - \left(\frac{1+g}{1+k}\right)\right]\mathrm{NPV}(\mathrm{R}) = \frac{R_1}{(1+k)}\left[1 - \left(\frac{1+g}{1+k}\right)^L\right]$$

$$\mathrm{NPV}(\mathrm{R}) = R_1 \frac{1}{(k-g)}\left[1 - \left(\frac{1+g}{1+k}\right)^L\right]$$

To satisfy the NPV=0 rule, the NPV of the revenue stream must equal $V_0 f$, which means that we calculate the period 1 revenue amount as:

$$\mathrm{NPV}(\mathrm{R}) = R_1 \frac{1}{(k-g)}\left[1 - \left(\frac{1+g}{1+k}\right)^L\right] = V_0 f$$

$$\Rightarrow R_1 = V_0 \frac{(k-g)}{\left[1 - \left(\frac{1+g}{1+k}\right)^L\right]} f$$

Note also that the price of inputs is changing at the rate α, so that:

$$V_N = V_0(1+\alpha)^N$$

It therefore follows that:

$$R_2 = V_1 \frac{(k-g)}{\left[1 - \left(\frac{1+g}{1+k}\right)^L\right]} f$$

$$R_1(1+g) = V_0(1+a)\frac{(k-g)}{\left[1 - \left(\frac{1+g}{1+k}\right)^L\right]} f$$

$$g = a$$

Thus, the growth rate in output prices (g) is equal to the growth rate in input prices (α).

The tilted annuity is therefore calculated as:

$$R_N = V_0 (1+a)^{N-1} \frac{(k-a)}{\left[1-\left(\frac{1+a}{1+k}\right)^L\right]} f$$

The term (k – α)/[] can also be expressed as:

$$\frac{(k-a)}{\left[1-\left(\frac{1+a}{1+k}\right)^L\right]} = \frac{(1+k)^L (k-a)}{(1+k)^L - (1+a)^L}$$

This is the same as the formula σ used by Telstra, where Telstra use the symbol "R" in place of k, and α is Telstra's "PriceTrend".[117]

The tilted annuity formula for the revenue in period N is therefore:

$R_N = V_0 AF_N$[1 – NPV(d+(D/V)i)t(1- ?)]/(1-t(1- ?))

Where the annuity factor (AF_N) is given by:

$$AF_N = (1+a)^{N-1} \frac{(1+k)^L (k-a)}{(1+k)^L - (1+a)^L}$$

E.3 Straight Line Tax Depreciation

By adopting the simplifying assumption that taxes are calculated on a straight-line basis over the life of the asset, we have the result that the depreciation tax shield is a constant amount in each period:

d = 1/L

NPV(d+(D/V)i) = NPV(1/L+(D/V)i)

The NPV of a constant annuity over the life of the asset is:

$$\text{NPV}(a) = a\frac{1}{k}\left[\frac{(1+k)^L - 1}{(1+k)^L}\right]$$

117 Annexure A, p. 12.

Hence:

$$\text{NPV}\left(1/L+(D/V)i\right)t(1-g)=\left(1/L+(D/V)i\right)\frac{1}{k}\left[\frac{(1+k)^{L}-1}{(1+k)^{L}}\right]t(1-g)$$

The tilted annuity formula can therefore be expressed as:

$R_N = V_0AF_N[1 – NPVTS]/(1-t(1- ?))$

Where the NPV of the tax shield (NPVTS) is calculated as:

$$\text{NPVTS}=\left(1/L+(D/V)i\right)\frac{1}{k}\left[\frac{(1+k)^{L}-1}{(1+k)^{L}}\right]t(1-g)$$

E.4 DIFFERENCE FROM TELSTRA'S FORMULA

Telstra appear to have assumed that the tax shield grows at the same rate as the input prices, whereas we assume that the tax shield is a constant value for an asset of a given vintage.

Assuming that the tax shield grows at the constant rate α produces:

$$\text{NPVTS}=\left(1/L+(D/V)i\right)\frac{1}{(k-a)}\left[1-\left(\frac{1+a}{1+k}\right)^{L}\right]t(1-g)$$

$$=\left(1/L+(D/V)i\right)\left[\frac{(1+k)^{L}-(1+a)^{L}}{(1+k)^{L}(k-a)}\right]t(1-g)\quad ;$$

$$=\left(1/L+(D/V)i\right)\left[\frac{1}{AF_N}\right]t(1-g)$$

Hence the tilted annuity becomes:

$R_N = V_0 [AF_N – (1/L+(D/V)i) t(1- ?)]/(1-t(1- ?))$

which is equivalent to the formula used by Telstra.[118]

118 Annexure A, p. 12.

E.5 SUMMARY

The tilted annuity formula (simplified by assuming straight line tax depreciation over the life of the asset) for calculating the capital cost of the assets is:

$R_N = V_0 AF_N[1 – NPVTS]/(1-t(1- ?))$

Where:

$$AF_N = (1+a)^{N-1} \frac{(1+k)^L (k-a)}{(1+k)^L - (1+a)^L};$$

$$\text{NPVTS} = (1/L + (D/V)i)\frac{1}{k}\left[\frac{(1+k)^L - 1}{(1+k)^L}\right]t(1-g);$$

R_N is the required revenue from the asset in period N;

V_0 is the value of the (new) asset in period 0;

α is the price trend for the asset;

k is the WACC;

L is the economic life of the asset;

D/V is the debt ratio;

i is the interest rate;

t is the corporate tax rate; and

γ is the imputation factor.

The tilted annuity calculated with these formulae includes all depreciation costs and a return on capital equal to the WACC. No further allowance is necessary for depreciation.

The interest term in the tilted annuity formula is only included if a vanilla WACC is used. If a post-tax WACC is used then the interest term should be set equal to zero.

APPENDIX F: ESTIMATING THE VALUE OF MODERN EQUIVALENT ASSETS

The calculation of LRIC estimates and tilted annuities requires an estimate of the replacement cost (RC) of Modern Equivalent Assets (MEAs). There are two main approaches that can be used for estimating the RC of MEAs:

- Obtain up-to-date quotes from suppliers for individual assets, and apply those values to the firm's asset register; or
- Adjust the asset values in the firm's asset register to reflect underlying price trends.

We have applied the first approach.

F.1 THEORETICAL BASIS FOR CALCULATING MEAS

Optus' asset register provides the total cost (not written down) of the assets that are currently on the register. The total cost will be comprised of assets of different ages and different prices, and will reflect the level of capital expenditure undertaken in each year.

For a given asset we therefore have:

$$TC = \sum_{i=1}^{L} q_{-i}\, p_{-i}$$

where TC is the total cost of the assets recorded in Optus' books, q_{-i} is the quantity of assets commissioned in year $-i$, p_{-i} is the price of the assets commissioned year $-i$, L is the economic life of the asset, and $-i$ is the number of years before the present that the assets were commissioned.

Prices reflect the nominal price trend assumed in the tilted annuity so that:

$$p_N = p_0(1+a)^N$$

where p_0 is the RC of the MEA.

The total cost of the asset is therefore:

$$TC = \sum_{i=1}^{L} q_{-i}\, p_0 (1+a)^{-i} = p_0 \sum_{i=1}^{L} q_{-i} (1+a)^{-i}$$

We now define Q as the total quantity of investment:

$$Q = \sum_{i=1}^{L} q_{-i}$$

We divide both sides by Q to obtain:

$$\frac{TC}{Q} = p_0 \sum_{i=1}^{L} \left(\frac{q_{-i}}{Q} \right) (1+a)^{-i}$$

Rearranging, we have:

$$p_0 Q = TC \Big/ \sum_{i=1}^{L} w_i (1+a)^{-i}$$

where:

$p_0 Q$ is the RC of the MEAs; and

$w_i = q_{-i}/Q$ is the weight for year i.

The summation term can be thought of as a weighted price index, with the weights being the volume of capital expenditure in each year (i.e. the number of assets rather than their cost or price).

F.2 Practical Considerations

Ideally the weights in the weighted price index for each asset should be calculated using the actual volume of capital expenditure for that asset, with data going back for as many years as the asset's economic life. As a practical matter, we only had access Optus' total capital expenditure (value) for the 5 years 1999/00 – 2003/04.

The total capital expenditure values were used to construct weights for the 5 years 1999/00 – 2003/04. Those weights were then halved, and additional weights of 0.1 were assumed for the years 1994/95 – 1998/99, providing 10 years of capital expenditure weights.

For an asset with an economic life less than 10 years, the sum of the weights over the relevant period is less than 1. To rectify this problem, the weighted price index was divided by the sum of the weights. This produces the same value for the weighted price index as if the weights were uniquely calculated over the economic life of each individual asset.

APPENDIX G: THE COMPLETE ELASTICITY MATRIX

Quantities	Prices			
	Subscription	**Mobile Outbound**	**FTM**	**Off-net**
Subscription	a_1	a_2	a_3	a_4
Mobile Out-bound	b_1	b_2	b_3	b_4
FTM	f_1	f_2	f_3	f_4
Off-net	g_1	g_2	g_3	g_4

Quantities	Prices			
	Subscription	**Mobile Outbound**	**FTM**	**Off-net**
Subscription	-0.44	$a_1 m \frac{p_{2i} q_{2i}}{p_{1i} q_{1i}}$	0.00	$a_1 m \frac{p_{4i} q_{4i}}{p_{1i} q_{1i}}$
Mobile Out-bound	$a_1 m + (1 - j_2) f_1$	-0.59	$a_3 \frac{b_1}{a_1}$	$a_4 \frac{b_1}{a_1}$
FTM	-0.18	$a_2 \frac{f_1}{a_1}$	-0.31	$a_4 \frac{f_1}{a_1}$
Off-net	$a_1 m + (1 - j_4) f_1$	$a_2 \frac{g_1}{a_1}$	$a_3 \frac{g_1}{a_1}$	-0.59

Notation:

m - ratio of the usage of marginal subscriber to that of average subscriber

j_2 - proportion of internalised cross-elastic mobile-outbound externality accruing to mobile subscribers

j_4 - proportion of internalised cross-elastic off-net externality accruing to mobile subscribers

APPENDIX H: THE COMPLETE TABLE OF INPUT COSTS, VOLUMES AND PRICES FOR THE 4 YEARS BETWEEN 2003 AND 2007

Value amounts in this table are in current 2004-05 dollars.

	2003-04	2004-05	2005-06	2006-07
Mobile Industry Incremental Costs	**$[c-i-c]**	**$[c-i-c]**	**$[c-i-c]**	**$[c-i-c]**
Mobile Industry Fixed and Common Costs	**$[c-i-c]**	**$[c-i-c]**	**$[c-i-c]**	**$[c-i-c]**
Total Revenue	**$[c-i-c]**	**$[c-i-c]**	**$[c-i-c]**	**$[c-i-c]**
Incremental Costs				
Subscription	**$[c-i-c]**	**$[c-i-c]**	**$[c-i-c]**	**$[c-i-c]**
Mobile outbound	**$[c-i-c]**	**$[c-i-c]**	**$[c-i-c]**	**$[c-i-c]**
Fixed-to-mobile (mobile)	**$[c-i-c]**	**$[c-i-c]**	**$[c-i-c]**	**$[c-i-c]**
Fixed-to-mobile (fixed)	**$[c-i-c]**	**$[c-i-c]**	**$[c-i-c]**	**$[c-i-c]**
Off-net mobile calls	**$[c-i-c]**	**$[c-i-c]**	**$[c-i-c]**	**$[c-i-c]**
Industry Volumes				
Number of Subscribers	15,118,702	15,441,357	15,764,012	16,086,667
Mobile outbound minutes	**[c-i-c]**	**[c-i-c]**	**[c-i-c]**	**[c-i-c]**
Fixed to Mobile minutes	6,501,538,462	6,640,290,807	6,779,043,152	6,917,795,497
Off-net mobile call minutes	**[c-i-c]**	**[c-i-c]**	**[c-i-c]**	**[c-i-c]**

Prices				
Subscription	**$[c-i-c]**	**$[c-i-c]**	**$[c-i-c]**	**$[c-i-c]**
Mobile outbound	**$[c-i-c]**	**$[c-i-c]**	**$[c-i-c]**	**$[c-i-c]**
Retail fixed-to-mobile	$0.40775	$0.40775	$0.40775	$0.40775
Off-net mobile calls	**$[c-i-c]**	**$[c-i-c]**	**$[c-i-c]**	**$[c-i-c]**
Growth rates				
Price growth rate	-	**-[c-i-c]**%	**-[c-i-c]**%	**-[c-i-c]**%
Subscriber growth rate	-	**[c-i-c]**%	**[c-i-c]**%	**[c-i-c]**%
Minutes growth rate	-	**[c-i-c]**%	**[c-i-c]**%	**[c-i-c]**%

APPENDIX I: A CODING ALTERATION TO RESTORE THE ROHLFS MODEL TO ITS ORIGINAL VERSION

The original Rohlfs model, which was located at:

http://www.ofcom.org.uk/static/archive/oftel/publications/mobile/ctm_2002/ramsey_math0602.nb

is no longer publicly available. The only version that is publicly available is at:

http://www.ofcom.org.uk/static/archive/oftel/publications/mobile/2003/gain0703.nb

This is a constrained version of the original, i.e. the optimal Ramsey prices are subject to a constraint that restricts the retail fixed to mobile price to always be 6.76 pence per minute. In this constrained version, the Ramsey price calculation, which can be found under the section entitled **"RAMSEY PRICING"** in the model's coding is as follows:

xb=FindRoot[{profit=0,p3[q1,q2,q3,q4]=.0676,dsq1=lambda dprofitq1+nu dp3q1,dsq2=lambda dprofitq2 +nu dp3q2,dsq3=lambda dprofitq3 + nu dp3q3,dsq4=lambda dprofitq4 +nu dp3q4},{q1,q10},{q2,q20},{q3,q30}, {q4,q40}, {lambda, -1}, {nu, -1}, {MaxIterations ® 100}]

The code shows that p3, the fixed-to-mobile price, is set to a specific numeric value. Note that the cross-partial derivatives **nudp3q1, nudp3q2, nudp3q3** and **nudp3q4** reflect the impact of this constraint on the prices and quantities of the other mobile services. To remove the constraint, we simply need to remove the **p3[q1,q2,q3,q4]=.0676** term and these cross-partials. Thus, unconstrained Ramsey prices can simply be calculated as follows:

xb=FindRoot[{profit=0,dsq1=lambda dprofitq1,dsq2=lambda dprofitq2, dsq3=lambda dprofitq3,dsq4=lambda dprofitq4},{q1,q10},{q2,q20}, {q3,q30},{q4,q40}, {lambda, -1},{MaxIterations ® 100}]

This is the system of equations that the CRA modelling employs in deriving Ramsey prices. It is also the system of equations in the unconstrained model originally available from Ofcom's website.