



# **Network Externality Surcharge**

**A report for Optus**

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## 1. Executive summary

1. Optus has asked CEG to estimate the extent to which the regulated price of termination onto its mobile network should be marked up above the cost of termination to reflect the value of network externalities. Optus has further requested that CEG base its calculation of the optimal surcharge using methods that are generally supported by international regulatory precedent.
2. We note that the United Kingdom telecommunications regulator Ofcom (formerly known as Oftel) has developed a methodology for estimating the network externality surcharge that it has applied in determining the mobile termination access charge, both in 2004<sup>1</sup> and in 2006.<sup>2</sup> The technique that it has applied is derived from work previously conducted by the Competition Commission in 2003, and has been subject to public scrutiny for a number of years. Accordingly, we consider the Ofcom methodology to be a reasonably well-tested approach for determining the network externality surcharge.
3. In this report we largely follow Ofcom's modelling approach but calibrate its methodology using Australian data, where this is obtainable. To aid transparency, we have based our estimates on publicly available and referenced data, rather than commercial-in-confidence numbers sourced from Optus.
4. In estimating the network externality surcharge we have sought to use conservative assumptions. For example, except for one case, when selecting elasticity estimates we have chosen the estimate from the range which results in the lowest calculated surcharge. In addition, we have modelled the network externality surcharge based on mobile operators' ability to use the increase in termination revenue to target only marginal subscribers with lower subscription prices.
5. We have modelled three scenarios which capture the range of potential targeting. The first involves no ability to target whatsoever, that is, the lower price subscriptions cannot be targeted to any particular mobile subscriber. In our view this is quite likely and consistent with the ability and incentives of the operator to target in a competitive market. The second scenario assumes that the mobile operator can target the lower price subscriptions only to marginal subscribers. The third scenario captures the extreme case in which the mobile operator could perfectly target marginal subscribers at an individual level. The results of these scenarios are reported in Table 1.

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<sup>1</sup> Ofcom, *Wholesale Mobile Voice Call Termination*, 1 June 2004.

<sup>2</sup> Ofcom, *Mobile Call Termination*, 13 September 2006.



**Table 1: Optimal surcharge under different targeting assumptions**

<b>Scenario</b>	<b>Surcharge (cents/minute)</b>
No targeting	0.35
Targeting of marginal subscribers	0.17
Targeting and perfect discrimination of marginal subscribers	0.10

6. Consistent with the approach adopted by Ofcom we have modelled a scenario in which there is a 'leakage' of termination revenue – reflecting a less than perfect waterbed effect. That is, in this scenario it is assumed that some of the termination revenue raised through levying a network externality surcharge is not passed through in the subscription market – requiring a higher termination rate in order to achieve the optimal number of subscribers. Ofcom has modelled a leakage scenario of up to 75%. Based on Australian data we estimate the network externality surcharge at 0.28 cents per minute (assuming an ability to target marginal subscribers but not perfectly discriminate pricing to individual marginal subscribers) using an assumption of 75% leakage.
7. Finally, for completeness we have modelled a final scenario, similar to that reported by Ofcom. This scenario assumes an RGF of 1.7 and an ability to target marginal subscribers (but not perfectly). In this scenario we also use the average of the elasticity estimates surveyed. The result of this scenario is a network externality surcharge of 0.26 cent per minute, assuming no leakage, and 0.47 cents per minute, assuming 75% leakage.
8. The remainder of this report is set out as follows:
  - section 2 reviews the basic economic theory associated with network externalities and explains how these can be internalised by levying a surcharge; and
  - section 3 calculates the optimal network externality surcharge using data for the Australian markets for mobile subscription and termination.



## 2. Internalising the network externality

9. An externality is a cost or benefit resulting from an activity that accrues to someone other than the parties directly involved. Externalities are not taken into account by decision makers because, by definition, they do not affect the parties to a decision.
10. A classic example of a negative externality is a company's decision to build a widget factory which may cause pollution that decreases the quality of life of inhabitants in a nearby town. If the true costs of this pollution accrued to the company it is likely that it would build a smaller factory than would otherwise be the case, or choose to locate it elsewhere. In principle, if externalities can be 'internalised' into decisions in this way then it is possible to achieve the socially optimal outcome.

### 2.1. What is a network externality?

11. In the context of telecommunications networks, the connection of an individual user to a network provides value to all users who can contact that network since it allows the possibility for subscribers to the network to contact the new user. This type of consumption externality associated with subscription to telecommunication services is often referred to as a 'network externality' and is the most widely recognised externality.<sup>3</sup> The existence of network externalities means that the benefit to society of a new user connecting to a network is at least as high as the private benefit to that user.
12. This means, in turn, that if this externality is not internalised through a subsidy (from users of the network) to new subscribers, then the number of subscribers to the network will be less than is socially optimal. That is, given a price for network subscription, non-subscribers will exist with a private benefit less than this price, but for whom society as a whole would benefit if they did subscribe.
13. The Australian Competition Tribunal (ACT) has accepted that network externalities could be taken into account in principle in determining the efficient charge form mobile termination but called for a more comprehensive examination of all relevant factors. The ACT stated, in particular, that:

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<sup>3</sup> Calling externalities are also widely recognised but differ from network externalities. Calling externalities relate to the external benefit of actually being called (or the external cost if the call is unwanted). These are discussed further below.

*"We have come to the view that if externalities are to be considered in pricing services, they need to be surveyed with some degree of thoroughness. It is not sufficient to include some externalities in the analysis and ignore others purely on an a priori basis that they matter less. This is especially the case where the possibility of countervailing effects is being ignored, and where major changes in the telephony market are likely to be altering demand patterns and levels of substitution between services... That said, in any consideration of the effects of price changes on markets beyond the most immediate one where the price is charged, a line must be drawn. Not everything can be taken into account" [at 289-290].*

14. The ACT judgement raises a number of key aspects requiring further examination. In particular, it is concerned with the potential implications of consumption externalities other than the positive externality identified by additional subscribers to mobile networks. Economic literature examining the effect of externalities on telecommunications prices grew naturally out of the general public utility pricing literature with perhaps the seminal work being undertaken by Hazelwood (1950)<sup>4</sup>. The most comprehensive surveys of consumption externalities<sup>5</sup> in telecommunications have been undertaken by Taylor (1994)<sup>6</sup> and Hermalin and Katz (2002)<sup>7</sup>. The literature identifies and distinguishes between two types of externalities. From Hermalin and Katz (2002):

*One is an **access externality** [alternatively termed a network externality], whereby benefits accrue to existing members of a network when a new user joins the network and thus can receive messages that the original members value sending to her. The other is a **call externality**, which comprises the benefits enjoyed by a user who receives a message initiated by another user. [emphasis in original]*

15. In the context of mobile termination pricing, parties have historically focussed on the positive mobile network externality created for existing fixed and mobile subscribers when additional subscribers join mobile networks. The potential for substantial fixed network externalities (the externality created for existing fixed and mobile subscribers when addition subscribers join fixed networks) has

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<sup>4</sup> Hazelwood, A., (1950) "Optimum Pricing as Applied to the Telephone Service" *Review of Economic Studies*, Vol. 18(2), No. 46., (1950-1951)

<sup>5</sup> Consumption externalities can be distinguished from production externalities, the later being commonly investigated under the guise of joint production and economies of scope.

<sup>6</sup> Taylor, L.D. (1994), *Telecommunications Demand in Theory and Practice*, Springer, Chapter 9.

<sup>7</sup> Hermalin, B. E. and Katz, M., (2002) "Retail Telecommunications Pricing in the Presence of External Effects," in Gary Madden, ed., *International Handbook on Emerging Telecommunications Networks*, Edward Elgar.



generally been considered to be low (or irrelevant) and the implications of calling externalities have been discounted. We discuss these issues further below.

16. In addition the ACT judgement raises concerns regarding the reliability of elasticity estimates when externality (and other, ie., Ramsey-Boiteux) mark-ups have been calculated. This is also discussed below.

#### 2.1.1. The fixed network externality

17. The fixed network externality is the additional benefit created for existing subscribers to fixed and mobile networks from additional subscriptions to the *fixed* network.
18. Whilst somewhat unclear, the ACT's comments on the relevance of the fixed (subscription) network externality seem, in part, to reflect a misunderstanding. In particular, the ACT notes that the earlier modelling makes no allowance for any fixed subscription network externality and then immediately quotes Rohlfs:<sup>8</sup> "... the primary goal in taking account of network externalities should be to ensure that potential external benefits to fixed subscribers are not lost through the absence of appropriate corrective pricing". The inclusion of this quote is curious because it is in relation to the benefit to fixed subscribers of additional mobile subscribers, ie., the mobile network externality.
19. Nonetheless, the existence of a large positive external benefit from a person subscribing to *any* network is likely to be significant. The external benefits may be larger if the first network a person chooses to subscribe to is a mobile network (because they would be available anywhere and at anytime) but if the subscriber joins a fixed network, the ability for them to be contacted, at all, creates significant benefit to existing users of all networks. The reasonable questions then are i) whether that externality is already being internalised in prices and, if not, ii) is it relevant to the efficient pricing of mobile termination.
20. Whether the fixed line externality is being internalised in existing prices for fixed line networks may in large part be a question of determining the adequacy of the universal service regime. As noted by Ofcom:<sup>9</sup>

*"The economic rationale for USOs is based on network externalities ... [and noted that] competition tends to make it more complicated to internalise this externality"*

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<sup>8</sup> Application by Optus Mobile Pty Limited & Optus Networks Pty Limited [2006] ACompT 8, paragraph 282

<sup>9</sup> Ofcom, *Strategic Review of Telecommunications Phase 1 Consultation Document*, 28 April 2004, para. G.35.

21. To the extent the universal service regime provides adequate funding to ensure that fixed line access telephony is uniformly priced at a level above users' marginal valuation of access then it is reasonable to conclude that it is already taking into account the fixed network externality. The universal service regime effectively raises the price of mobile services to help subsidise fixed subscription – the funding of the USO is done by taxing all telecommunications operators' revenue.
22. In the event that this subsidy was viewed as inadequate the question then is whether the fixed network externality is relevant to the efficient price of mobile termination or whether it should more appropriately be reflected in a mark-up on fixed termination. It is conceivable that cross-price effects increase the super-elasticity of fixed subscription and consequently reduce the socially optimal mobile termination rate. Empirical evidence strongly suggests that these cross-price effects are low. For example, estimates of own-price elasticities for fixed subscription in the UK have been estimated to range from -0.06 and -0.1.<sup>10</sup> Whilst non-zero, the likely effects appear marginal, and in combination with a reasonably effective universal service regime, could reasonably be noted but ignored (as has largely been done by international regulators) in the context of mobile termination regulation and considered directly in the context of fixed termination regulation.

### 2.1.2. Calling externalities

23. The ACT noted that:

*“Dr Rohlfs did examine the impact of a small calling externality (that is, allow for a small proportion of the externality not to be internalised) as a variant in his UK modelling and found that this significantly reduced the welfare optimising termination charge. He considered, however, that call externalities are largely internalised.” [para. 284].*

24. In fact, not only did Dr Rohlfs dismiss any need to include calling externalities because he considered that they were largely internalised, he also estimated that they would only alter the optimal fixed-to-mobile termination charge from 4.87 pence per minute to 4.74 pence per minute.

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<sup>10</sup> Gassner, K., (1998) An Estimation of UK Telephone Access Demand Using Pseudo-Panel Data, Cahier de recherches économiques du DEEP No 9817.

25. The theoretical literature has given mixed emphasis to the presence of calling externalities. As noted by Hermalin and Katz (2004):<sup>11</sup>

*With a few notable exceptions, previous theoretical work on communications pricing has tended to note the possibility of call externalities and then ignore them. This treatment typically is justified by one of two assumptions: either the receiving party enjoys no benefit from a message exchange, or the effects between the parties are internalized. The first assumption clearly is unrealistic. Were it correct, we would never answer the telephone or read our email. The second assumption is applicable only to a limited set of situations in which either the communicating parties behave altruistically or have a repeated relationship.*

26. Hermalin and Katz (2004) demonstrate that pricing which accounts for calling externalities requires an understanding of the (uncertain) expected values parties might place on either making or receive a call. They examine “the strategic game between the parties as to who will be the sender and who the receiver” and find that when parties have a common distribution of the expected value of calls it is welfare enhancing for the costs of calls to be shared (though they provide other cases in which alternative cost sharing rules improve welfare).
27. In the context of mobile termination regulation there is no mechanism to share the higher costs of mobile networks with fixed network subscribers symmetrically. That is, if it were said to be welfare enhancing to have mobile users bear half the cost of mobile terminating calls, then it would be appropriate to have fixed users bear half the cost of mobile originating (fixed terminating) calls. Under the calling payment convention in Australia (in which the calling party pays for the call, including their own network’s costs and the cost of termination charged by the terminating carrier) this is not straightforward.
28. There is therefore no simplistic analysis in which the welfare benefit of setting a higher termination rate (to account for network externalities) is offset by the welfare benefit of setting a lower termination rate (to account for calling externalities) without adjustment to other prices (reducing mobile outgoing charges and having fixed subscribers bear some of those costs).
29. Calling externalities might reasonably be regarded as a ‘bigger theoretical’ issue for pricing of telecommunications services which does not bias the question of how network externalities should affect prices. In our empirical framework (and that used by Ofcom) we expect calling externalities to have little impact. For

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<sup>11</sup> Hermalin, B.E., and Katz, M. (2004) “Sender or Receiver: Who Should Pay to Exchange an Electronic Message?” RAND Journal of Economics, vol. 35, no. 3.



example, if the value each party places on a call is proportional then call externalities would increase both the cost of having higher termination rates (reducing the call externality for the originator of the fixed to mobile call) and the benefit of having more mobile subscribers (increasing the call externality for the originator who would not have otherwise made calls to that mobile subscriber) in proportion – not effecting the overall result of our analysis as to whether there is a welfare gain from a network externality surcharge.

### 2.1.3. Elasticity estimates

30. Accurately estimating the price elasticity of demand for mobile services requires a sufficiently long series of meaningful price and market volume data. However, the range of mobile tariffs plans makes estimating a market price difficult. Further, we understand that obtaining Australian volume data for each service over a sufficient period would require significant cooperation between operators. Even with the cooperation of other operators, the data collection process would be likely to take months albeit that the econometric estimation could be carried out relatively quickly once the data was available.
31. The alternative approach to directly estimating elasticities for the Australian market is to rely on the statements of the ACT and the ACCC which discuss a range of possible elasticity values as well as reviewing new estimates. By choosing the most conservative values of the elasticity estimates (rejecting any values that are clearly unreasonable), a value can be estimated for the network externality which would also be conservative. For the purpose of valuing the network externality surcharge we have adopted the most conservative elasticity estimate in the range of elasticity estimates identified in the literature.
32. For the regulator to then reject such a value would create a downward bias in regulation would reasonably be regarded as being against the long term interests of end users. In particular, regulatory price setting frequently requires judgements in relation to uncertain values given the available information. It makes no more sense to disregard the network externality because of uncertainty about its precise value than it would be to disregard allowing the cost of capital because the WACC is uncertain.



## 2.2. The waterbed effect

33. The 'waterbed effect' describes the link between the termination prices paid by callers to mobile networks and the price of new subscriptions. It is well defined by Ofcom in its 2006 mobile call termination consultation:<sup>12</sup>

*"The intensity of competition determines the extent to which competitive pressures drive MNOs' excess profits to zero (i.e. MNOs make a return no greater than their cost of capital).*

*If competition fully removes excess profits, then any excess profit from terminating calls to mobiles would be competed away in an efficient manner through lower retail prices ("waterbed effect"). In this case all revenues in excess of costs obtained by MNOs from termination would be passed through to consumers in the form of lower retail prices for mobile services.*

*If competition between MNOs is imperfect and it does not completely remove excess profits the waterbed effect is likely to be reduced. In this case, some of the revenues obtained by the MNOs from a surcharge on termination charges may be passed through to consumers in the form of lower retail prices but some may be retained by MNOs as profits."*

34. That is, in the presence of effective competition, greater profits caused by higher termination charges for calls to mobile networks will be competed away in the market for subscription. Raising termination prices can be thought of as a tax on network users who call mobile phones and the waterbed effect distributes (or transfers) this to new subscribers in the form of reduced subscription prices.<sup>13</sup>
35. The Australian Competition and Consumers Commission views on the waterbed effect have been stated most recently in the Draft MTAS Pricing Principles Determination. The ACCC states that it considers that:<sup>14</sup>

*"the behaviour attributed to the waterbed effect as a general principle may be inconsistent with profit maximisation"; and*

*"the arguments for the existence of a waterbed effect in the Australian context were not sufficiently developed to enable a substantial*

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<sup>12</sup> Ofcom, *Mobile Call Termination*, 13 September 2006, paras.A16.9-11.

<sup>13</sup> The form of the distribution is not important to the analysis, it could occur as a lump sum payment or a discount on some good that subscribers want (eg, a handset).

<sup>14</sup> ACCC, *Draft MTAS Pricing Principles Determination*, November 2008, p.17

*understanding of the effects of a change in the MTAS charge on retail mobile prices.”*

36. The ACCC’s opinion in relation to profit maximisation appears to be predicated on a view that prices are established independently in the subscription and calling markets. This does not take into account the related nature of the services, both from the perspective of these services being jointly produced by mobile network operators and jointly consumed by mobile subscribers.<sup>15</sup> The waterbed effect (which describes a dynamic of competition in mobile markets in which operators set termination rates and then compete for subscribers on the basis of expected termination revenues) has been the basis of almost all economic articles examining mobile termination regulation including Armstrong (2002)<sup>16</sup>, Gans and King (2000),<sup>17</sup> Wright (2002)<sup>18</sup>, Houpis and Valletti (2004)<sup>19</sup> and more recently, Armstrong and Wright (2007)<sup>20</sup>. A waterbed effect is accepted by prominent economic regulators including Ofcom and the New Zealand Commerce Commission.
37. We note that the ACCC’s empirical analysis of the existence of the waterbed effect is based on data obtained from a few years and does not attempt to control for factors such as the growth in subscribers that would have occurred in any case. It appears to be based on the misguided notion that evidence of the waterbed effect requires that it be able to observe mobile subscription price increases, rather than evidence that mobile subscription prices are higher than they otherwise would be. Empirical support for the waterbed effect is beyond the scope of this report but has been assessed in a cross-jurisdiction study (including Australia) by Genakos and Valetti (2008) using panel data to find a strong (but incomplete) waterbed effect. They conclude that the “waterbed effect is stronger

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<sup>15</sup> In effect the ACCC appears to be using an *assumption* of no relationship between the markets to conclude that there *is* no relationship between the markets.

<sup>16</sup> Armstrong, M. (2002) “The theory of access pricing and interconnection,” in M. Cave, S. Majumdar, and I. Vogelsang (eds.), Handbook of Telecommunications Economics, North-Holland.

<sup>17</sup> Gans, J.S. and S.P. King (2000) “Mobile network competition, customer ignorance and fixed-to-mobile call prices,” Information Economics and Policy, 12: 301 – 327.

<sup>18</sup> Wright, J. (2002) “Access pricing under competition: An application to cellular networks.” Journal of Industrial Economics, L: 289 – 315.

<sup>19</sup> At [http://userpage.fu-berlin.de/~jmueller/its/conf/berlin04/Papers/Houpis\\_Valletti.pdf](http://userpage.fu-berlin.de/~jmueller/its/conf/berlin04/Papers/Houpis_Valletti.pdf)

<sup>20</sup> Armstrong, M and Wright, J, Mobile Call Termination (September 2007). Available at SSRN: <http://ssrn.com/abstract=1014322>



the more intense competition is in markets with high levels of market penetration and high termination rates<sup>21</sup>.

### 3. Calculation of the optimal network externality surcharge

38. Ofcom's presentation "Mobile Call Termination: Network externality surcharge" of 14 May 2008 presents an approach to estimating the optimal externality mark-up. The approach presents the following condition as determining the socially optimal number of mobile subscribers:

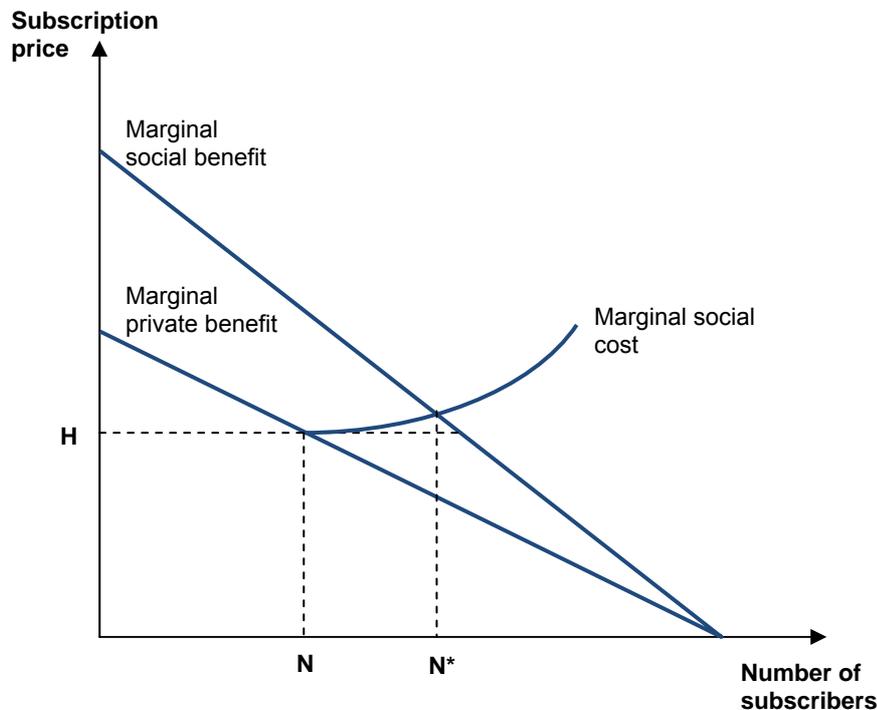
$$\textit{Marginal social benefit} = \textit{Marginal social cost}$$

39. Here, the marginal social benefit includes both the marginal private benefit accrued from becoming a mobile subscriber and the external marginal benefit to existing subscribers. Marginal social cost includes both the cost of subscription to marginal subscribers and the deadweight loss created from a surcharge on calls to mobiles.
40. This can be displayed graphically, as in Figure 1 below, adapted from Ofcom's presentation. We note that the marginal social benefit line lies above the marginal private benefit line, with the difference reflecting the existence of the network externality. The extent to which social benefits are greater than private benefits is captured in the Rohlfs-Griffin factor (RGF).

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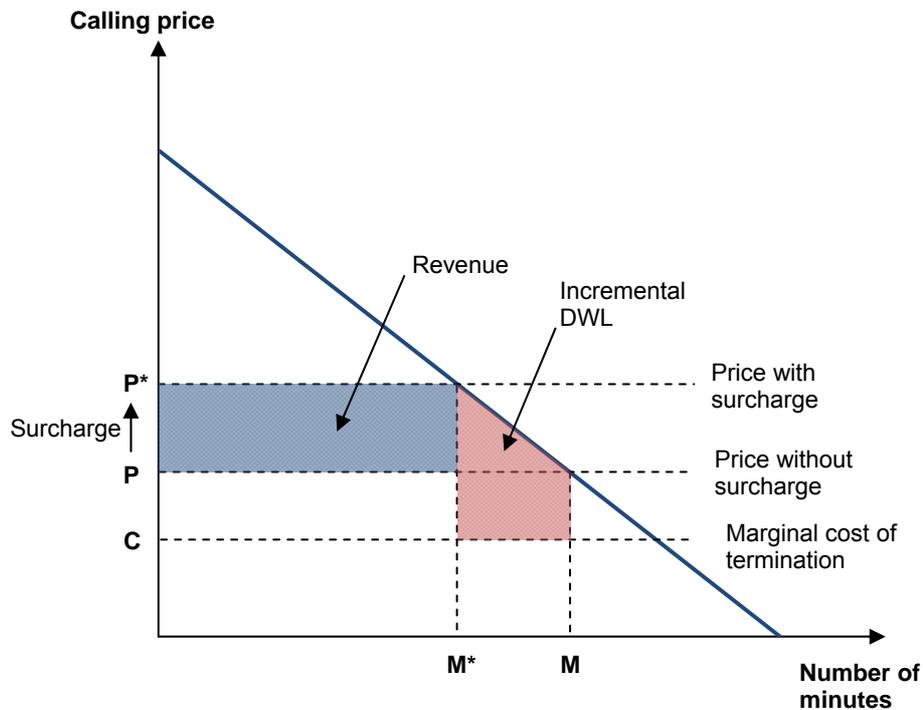
<sup>21</sup> Genakos, Christos and Valletti, Tommaso M., Testing the 'Waterbed' Effect in Mobile Telephony (January 2008). CEIS Working Paper No. 110. Available at SSRN: <http://ssrn.com/abstract=1114856>

**Figure 1: Determining optimal mobile subscriber numbers**



41. Next, consider the marginal social cost function. When subscription is unsubsidised, this is simply equal to the marginal cost of subscription. For simplicity, we can label this the cost of the handset, although it should also reflect other costs incurred in bringing additional subscribers on to the network. For subscriber numbers to increase beyond the point at which the marginal private benefit equals the marginal cost of subscription would require a subsidy. However, as noted above, offering a subsidy would require funding by means of higher termination charges.
42. To the extent that higher termination charges are passed through into higher prices for calls to mobiles, demand for such calls will reduce and create a deadweight loss. If termination prices are already higher than marginal cost, then higher termination charges will increase the existing deadweight loss, as shown in Figure 2

**Figure 2: Welfare impact of externality mark-up on calls to mobile**



43. Returning to the subscription market, we can see that the upward slope of the marginal social cost line is caused by the presence of deadweight losses on the termination side. In fact, it is necessarily the case that the area under the marginal social cost curve above the cost of the handset is equal to the incremental deadweight loss area shown in the termination market and both areas total to the same monetary amount.
44. Using data on existing prices and quantities in the market and elasticities derived from a number of academic articles, we are able to resolve this system and so derive the optimal number of subscribers and the required mark-up on termination charges for calls to mobiles commensurate with this number.

### 3.1. Subscription market

45. We begin by assuming a linear demand system and deriving the equations of the marginal private benefit and marginal social benefit lines.



46. Optus financial results indicate that there are approximately 22 million mobile subscribers in Australia.<sup>22</sup> We have assumed a present cost of handsets at \$150, based on a review of publicly available low-end handset prices for prepay phones. Prepay phones were specifically sampled because the prices for these are likely not to be 'cross-subsidised' by contract revenue. Low-end prices were selected because these are likely to be the prices faced by marginal subscribers.
47. Marginal subscribers are not likely to replace their handset every year, and to be consistent with the assumptions used in the market for terminating calls, the subscription charge should be expressed on an annual basis. We have approximated the annual charge as \$50, on an assumed handset life of three years.<sup>23</sup>
48. Table 2 below shows the results of a number of international studies into the elasticity of demand for mobile subscription. These indicate that, on average, the own-price elasticity of demand for mobile subscription is -0.44, though as noted above, throughout this report unless otherwise state we have used the most conservative elasticity (the one that yields the lowest network externality surcharge) – which for mobile subscription would be the least elastic point estimate (-0.36).

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<sup>22</sup> Singtel, *Management Discussion and Analysis of Financial Condition*, 12 November 2009, p.42

<sup>23</sup> This is consistent with the assumption adopted by Ofcom – see: Ofcom, *Mobile Call Termination*, 13 September 2006, para. A16.58.

**Table 2: Estimated elasticities for mobile subscription<sup>24</sup>**

Study	Estimated elasticity
Ahn and Lee, 1999	-0.36
Dotecon, 2002	-0.37
Frontier Economics, 2002	-0.54
Grzybowski, 2004	-0.36
Hausman, 1999	-0.51
Madden, Coble-Neal and Dalziel 2004	-0.53
Rodini, Ward and Woroch, 2003	-0.43
Tishler, Ventura and Watters, 2001	-0.42
<b>Average</b>	<b>-0.44</b>

### 3.1.1. Marginal private benefit

49. We use the above elasticity estimate to determine the gradient of the marginal private benefit line by assuming that it is a reasonable estimate of the point elasticity around current prices and quantities. An own price elasticity is defined as:

$$\varepsilon = \frac{\left(\frac{dq}{q}\right)}{\left(\frac{dp}{p}\right)}$$

50. Thus we can write:

<sup>24</sup> 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;

Frontier Economics as reported in UK Competition Commission, Calls to mobiles report, 2003;

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 (average for years 1998-2002).

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.



$$\varepsilon \frac{q}{p} = \frac{dq}{dp}$$

51. Hence the gradient of the marginal private benefit line is:

$$\frac{dp}{dq} = \frac{1}{\varepsilon} \frac{p}{q}$$

52. In this case, we can calculate this gradient as:

$$b = \frac{dp}{dq} = \frac{1}{-0.44} \frac{50}{22} = -5.17$$

53. By substituting this gradient and existing prices and quantities into the linear demand equation, we can determine the intercept:

$$a = p - bq = 50 - 22 \times (-5.17) = 163.6$$

54. The marginal private benefit function can therefore be expressed as:

$$MPB = 163.6 - 5.17q$$

### 3.1.2. Marginal social benefit

55. The RGF defines the extent to which social benefits of additional subscribers joining a network are greater than private benefits to the new subscribers. A priori, it is reasonable to expect an RGF of between 1 and 2.

56. An RGF of 1 implies that there are no benefits to existing subscribers from additional subscribers joining the network. That is, the social benefit is equal to the private benefit of the new subscribers. An RGF of 2 implies that the new subscribers create benefits to other subscribers to the network that are equal to the private benefit to the new subscribers from joining.

57. While some internalisation of the network externality may occur, we expect this to be relatively low. In particular, since externality benefits can reasonably be expected to be spread across a range of individuals, there is little scope for individuals to internalise the externality by buying phones for other people. In addition, operators have little scope to internalise these externalities as the benefits of such a policy would also derive to customers on other mobile and fixed networks.



58. For the purposes of our base case, we assume an RGF of 1.5, at the midpoint of this range. This assumption yields a marginal social benefit line equal to 1.5 times the marginal private benefit, that is:

$$\text{MSB} = 245.5 - 7.75q$$

### 3.1.3. Number of marginal subscribers

59. Surveys conducted by Ofcom and the Competition Commission in the United Kingdom report that marginal subscribers may account for approximately 34% of existing subscribers and, on average, 19% of all people who currently do not subscribe.<sup>25</sup>
60. Statistics from a survey conducted in Australia in 2007<sup>26</sup> find that approximately 12% of Australians aged 14 and over did not own a mobile phone.<sup>27</sup> ABS reports that, based on the most recent data, there 17.5 million Australians aged over 14,<sup>28</sup> suggesting that 2.1 million of these do not own a mobile phone and 15.4 million do.
61. Applying the results of the United Kingdom surveys to the Australian data, there may be approximately 5.6 million marginal subscribers in Australia, or about 25% of total subscriptions.<sup>29</sup> However, for the purposes of this report we have, in effect, assumed that all existing subscribers are infra-marginal. That is, we have estimated the incremental increase in subscribers assuming that existing subscriptions have not been funded by any above cost termination pricing (despite mobile termination rates being significantly above 9 cents per minute over the last few years).

## 3.2. Termination market

62. The demand for termination on mobile networks is derived (demand) from calls originating on fixed networks and calls originating from other mobile networks. In principle, both types of callers should contribute to a subsidy for marginal mobile

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<sup>25</sup> As reported in: Ofcom, *Mobile Call Termination*, 13 September 2006, p.230.

<sup>26</sup> AMTA, *The Impact of the Mobile Phone on Work/Life Balance: Preliminary Report*, June 2007. Available online at [http://polsc.anu.edu.au/staff/wajcman/pubs/Report\\_on\\_Mobiles\\_and\\_Work\\_Life\\_Balance\\_June\\_07.pdf](http://polsc.anu.edu.au/staff/wajcman/pubs/Report_on_Mobiles_and_Work_Life_Balance_June_07.pdf).

<sup>27</sup> However, this does not imply penetration of 88% because many people, particularly high income individuals, reported owning more than one mobile phone.

<sup>28</sup> ABS, *Population by Age and Sex, Australian States and Territories*, Catalogue No. 3201.0, Table 9.

<sup>29</sup> Calculated as  $0.19 \times 2.1 + 0.34 \times 15.4$ . We assume, conservatively, that for mobile phone owners with multiple subscriptions can only hold, at most, one marginal subscription.



subscribers since both benefit from being able to make calls to and receive calls from new mobile subscribers.

### 3.2.1. Demand and prices for terminating calls

63. Statistics for fixed-to-mobile calls are available from ACCC reports and also from Telstra annual reports. The 2007 Telstra annual report indicates fixed-to-mobile demand of 4,687 million minutes from its network.<sup>30</sup> The ACCC Telecommunications Market Indicator Report 2005/06 indicates that Telstra had a 73.8% share of fixed-mobile calls in the 2005/06 financial year. These figures together suggest total fixed-to-mobile volumes of 6,351 million minutes in the 2007 financial year.
64. The data from the ACCC market indicator report indicate total revenue of \$1,978 million associated with total fixed-to-mobile volumes of 6,076 million minutes, implying an average price of 32.6 cents/minute for this service. This estimate is broadly consistent with equivalent estimates derived from Telstra's 2007 annual report.
65. Statistics for off-net mobile call volumes are more difficult to obtain, since these are not directly reported by mobile network operators or the ACCC. Modelling commissioned by the ACCC has estimated the average proportion of incoming calls to 2G mobile networks to be 35.7% of total volume.<sup>31</sup> The ACCC later estimate the total volume relevant to this measure to be approximately 40 billion minutes,<sup>32</sup> implying a total volume of incoming calls of 14,280 million minutes.
66. This estimate is deficient for our purpose in that it does not include calls terminating on 3G networks. It also necessarily includes the estimate of fixed-to-mobile minutes that was previously estimated.
67. Data from the 2007 Telstra annual report indicates that 3G and CDMA volumes could be approximately accounted for by uplifting 2G volumes by 55%.<sup>33</sup> Applying this to 2007 volumes and netting out fixed-to-mobile calls gives rise to a rough estimate of mobile-to-mobile termination volumes as 15,769 million minutes for the 2007 financial year. We note that this uplift is likely to increase

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<sup>30</sup> Telstra Annual Report 2007, p.8. Data from the 2007 annual report have been used in preference to those from the 2008 annual report since the latter publication reports only fixed-to-mobile volumes from the PSTN.

<sup>31</sup> ACCC, *Draft MTAS Pricing Principles Determination*, June 2007, p.112.

<sup>32</sup> ACCC, *MTAS Pricing Principles Determination*, November 2007, p.95.

<sup>33</sup> Telstra Annual Report 2007, p.20. This uplift is calculated on the basis of subscribers and assumes similar call volumes across 2G and 3G customers.



significantly in future years, but will also be associated with gradually declining call volumes on 2G networks.

68. The Telstra annual report also provides a basis upon which to estimate average mobile call costs. Telstra reports annual revenue for mobile access and call charges of \$2,682 million on total mobile calling volumes of 8,640 million minutes in the 2007 financial year. This suggests an average call charge of 31.0 cents/minute, but is likely to underestimate the charges specific to off-net calls to other mobile networks, since these are likely to be priced higher than on-net calls to Telstra mobiles.
69. We have assumed that all access and call revenues are, in effect, call charges. We recognised that for post paid customers, customer are levied a charge which is termed an access or subscription charge, but we note that this generally includes an equivalent amount of 'included' calls. For example, Telstra's uncontracted 'casual' plans generally include free calls up to the value of the monthly minimum spend. The only exception appears to be its cheapest plan which costs \$10 per month but has no included calls.<sup>34</sup>

### 3.2.2. Marginal cost of call termination

70. The social cost of raising prices in the termination market (and reducing terminating traffic) is equal to the difference between the new price and the underlying additional cost of producing those minutes.
71. In order to estimate this cost we need an estimate of the addition cost of producing terminating traffic. We have estimated the cost<sup>35</sup> of termination at 20.96 cents per minute based on data reported by the ACCC in its March quarter imputation report for Telstra's fixed to mobile service.<sup>36</sup> The estimated cost is equal to the sum of interconnection costs (including mobile termination paid by Telstra to other mobile networks<sup>37</sup> and its internal access price for fixed

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<sup>34</sup> [http://www.telstra.com.au/mobile/plans/casual\\_plans.html](http://www.telstra.com.au/mobile/plans/casual_plans.html)

<sup>35</sup> Strictly the appropriate cost concept would be a marginal one, given at any time it is likely that most of the assets used to supply the terminating service will be sunk and not need to be replaced for some time. Using the average cost concept implied in the ACCC's numbers will therefore understate the efficiency cost of increasing termination charges, though a sensitivity analysis indicates it is not significant. We note that this same issue applies (with the reverse effect) for estimating the efficiency benefits of reducing subscription prices.

<sup>36</sup> ACCC, *Imputation Testing and Non-Price Terms and Conditions Report Relating to the Accounting Separation of Telstra for the March Quarter 2008*, March 2008, weighted average of business and residential.

<sup>37</sup> In March 2008 the indicative price for the mobile terminating access service was 9 cents per minute. See ACCC, *Draft MTAS Pricing Principles Determination and indicative prices for the period 1 January 2009 to 31 December 2011*, November 2008.



termination) and the retail cost of transforming the interconnection services into a retail service.

### 3.2.3. Own-price elasticity terminating calls

72. Table 3 and Table 4 report estimates of own-price elasticities for fixed-to-mobile and mobile outgoing calls. Generally, these are in a similar range to the elasticities reported for subscription.

**Table 3: Estimated elasticities for fixed-to-mobile calls**

Study	Estimated elasticity
Dotecon, 2002	-0.43
Frontier, 2002	-0.18
<b>Average</b>	<b>-0.31</b>

**Table 4: Estimated elasticities for mobile outgoing calls**

Study	Estimated elasticity
Dotecon, 2002	-0.62
Hausman, 1999	-0.55
Rodini, Ward and Woroch, 2003	-0.13
Tishler, Ventura and Watters, 2001	-0.80
<b>Average</b>	<b>-0.53</b>

### 3.2.4. Summary of volume, prices and elasticities for calls to mobiles

73. Table 5 below summarises the total volume and average prices and elasticities for all terminating calls to mobiles on the basis of the data reported above.

**Table 5: Volumes, prices and elasticities for terminating calls to mobiles**

Call type	Volume (million minutes)	Price (cents/minute)	Elasticity
Fixed-to-mobile	6,351	32.6	-0.31
Off-net mobile	15,769	31.0	-0.53
<b>Weighted average</b>	<b>22,120</b>	<b>31.5</b>	<b>-0.47</b>

74. We assume that the prices of fixed-to-mobile and off-net mobile calls reported above do not already incorporate a network externality surcharge.



### 3.2.5. Estimation of termination demand function

75. Using the volume, price and elasticity information shown in Table 5 above, we can estimate a linear function for mobile termination, against assuming that the elasticity is a reasonable point estimate around existing prices and quantities.

76. Hence the gradient of the demand curve is:

$$b = \frac{dp}{dq} = \frac{1}{\varepsilon} \frac{p}{q} = \frac{1}{-0.47} \frac{0.315}{22,120} = -0.0000303$$

77. By substituting this gradient and existing prices and quantities into the linear demand equation, we can determine the intercept:

$$a = p - bq = 0.315 - 22,120 \times (-0.0000206) = 0.985$$

78. The demand function for mobile termination can therefore be expressed as:

$$p = 0.985 - 0.0000303q$$

### 3.3. Setting marginal social cost equal to marginal social benefit

79. Economic theory tells us that the number of subscribers will be socially optimal at the point where:

$$\textit{Marginal social benefit} = \textit{Marginal social cost}$$

80. When this equality is satisfied, the incremental deadweight loss caused by the surcharge in the termination market will be exactly offset by the increased social benefits created by the subsidy.

81. It is not easy to express the solution to this equality in closed form, due to non-linearities in the system. We have solved for the optimal solution using numerical techniques. However, the methodology required to replicate this analysis can be set out in a few simple steps.

#### 3.3.1. Calculate the total subsidy

82. For a given number of subscribers, N, the price of subscription can be calculated according to the previously derived marginal private benefit as:



$$p = 163.6 - 5.17N$$

83. The extent to which this price is lower than the unsubsidised cost of subscription for marginal subscribers, estimated above as \$50 per year, gives rise to a subsidy. If the subsidy can be targeted at each individual subscriber (in the manner of perfect price discrimination), then the level of the required subsidy will be:

$$\text{subsidy} = \frac{1}{2}(50 - p) \times (N - N_{\text{unsubsidised}})$$

84. If the subsidy can be targeted only to the level of the marginal subscriber, but not beyond this (ie, discrimination within this group is not possible) then the level of the required subsidy will be:

$$\text{subsidy} = (50 - p) \times (N - N_{\text{unsubsidised}})$$

85. Finally, if price discrimination is not possible in the subscription market, then the subsidy cannot be targeted and all subscribers, including non-marginal subscribers, will receive the subsidy. In this case:

$$\text{subsidy} = (50 - p) \times N$$

### 3.3.2. Calculating the required surcharge to fund the subsidy

86. Assuming that there is no leakage from the revenue gained in the termination market flowing through to subsidies to marginal subscribers in the market for subscription, then the following holds:

$$\text{subsidy} = \text{revenue} = s \times M$$

where:  $s$  is the network externality surcharge; and

$M$  is the volume of terminating minutes with the surcharge in place.

87. This relationship can be combined with the demand function in the termination market to solve for the surcharge for a given subsidy:

$$p + s = a + bM$$

$$\Rightarrow sp + s^2 = as + bMs$$



$$\Rightarrow s^2 + (p - a)s - b \times \text{revenue} = 0$$

$$\Rightarrow s^2 - 0.67s + 0.0000303 \times \text{revenue} = 0$$

88. The relationships above provide the important linkage between the subsidy paid in the subscription market and the required surcharge to fund this in the termination market.

### 3.3.3. Calculating marginal social cost and marginal social benefit

89. The marginal social benefit of a subsidy that generates N subscribers can easily be calculated using the function previously derived:

$$\text{MSB} = 245.5 - 7.75N$$

90. The calculation of marginal social cost is considerably more difficult. As noted earlier, the marginal social cost curve is defined by its relationship with the deadweight loss in the market for termination – the area under the marginal social cost curve but above the unsubsidised cost of subscription is equal to the deadweight loss. This gives rise to the equation:

$$\text{MSC} = \frac{d}{dN}(\text{DWL}) + H$$

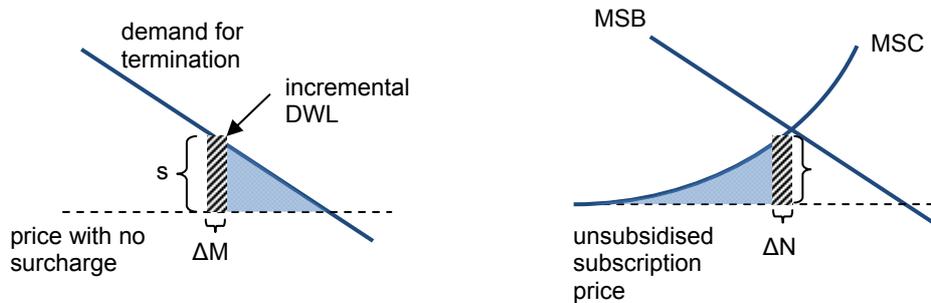
where H is the unsubsidised cost of subscription.

91. This deadweight loss, in turn, can straightforwardly be calculated, for a given surcharge s as:

$$\text{DWL} = \frac{1}{2} \frac{s^2}{b} = -16502s^2$$

92. Numerical techniques can be used to estimate the path of the marginal social cost function. In their essence, these techniques simply calculate an incremental slice of deadweight loss caused by an extra subscriber and estimate the average value of MSC function per subscriber that would be required to match this area under the curve.

**Figure 3: Estimating the MSC curve using numerical techniques**



93. We note that for the purpose of the calculations in this report we have assumed linear demand functions. This is in part based on the difficulty in adopting alternative demand functions, ie, constant elasticity demand functions, without good information regarding the maximum price at which demand for each service is likely to be negligible. Our approach is consistent with that of Ofcom who noted that:<sup>38</sup>

*The demand for termination is also modelled as a linear demand function, there are a range of different demand functions and Ofcom considers that a linear function is a reasonable approach in the absence of detailed information concerning this demand function.*

### 3.4. Value of the optimal network externality surcharge

94. The techniques described above, applied to the parameters introduced earlier have been applied to calculate an optimal number of subscribers of 25.20 million, 3.20 million more than currently exist.<sup>39</sup> This is associated with a surcharge of 0.47 cents/minute, which raises a total subsidy of \$93 million that is targeted perfectly at marginal subscribers.
95. We noted earlier that to the extent that it is not possible to perfectly target marginal subscribers, then this will increase the total amount of subsidy that is required and therefore the mark-up required to fund this subsidy. To date the focus of regulators has been to consider whether targeting was possible, that is

<sup>38</sup> Ofcom, *Mobile Call Termination*, Proposal for consultation, 13 September 2006.

<sup>39</sup> Whilst this may seem significant, it must be recalled that data shows that for low income group as many as 16% of people do not presently have a mobile phone (see AMTA, *The Impact of the Mobile Phone on Work/Life Balance: Preliminary Report*, June 2007) despite overall market penetration being reported in excess of 100% (see Singtel, *Management Discussion and Analysis of Financial Condition*, 12 November 2009).



whether plans could be designed that are attractive to marginal subscribers that would not be attractive to infra-marginal subscribers.

96. This focus potentially misses another important constraint on operators' ability to target – their commercial incentive to target in light of competition for subscribers. Because the increased termination rate must apply to all incoming calls (it appears virtually impossible to discriminate incoming traffic in existing commercial arrangements), including those to infra-marginal subscribers, a surcharge increases the 'value' of all customers in proportion to the rate increase. This means that infra-marginal subscribers become even more 'profitable' to the operator and the incentive to attract these customers increases. Therefore, if a single operator attempts to 'use' the increased revenue from infra-marginal subscribers to attract (or target) marginal subscribers then that operator's infra-marginal subscribers would be vulnerable to a competing operator who did not target marginal subscribers but 'used' the increased revenue to attract infra-marginal subscribers.
97. We have modelled three scenarios which capture the range of potential targeting. The first involves no ability to target whatsoever, that is, the subsidy cannot be targeted to any particular mobile subscriber. As noted above, in our view this is most likely and consistent with the incentives of the operator. The second scenario assumes that the mobile operator can target the subsidy only to marginal subscribers. The third scenario captures the extreme case in which the mobile operator could perfectly target marginal subscribers at an individual level.

**Table 6: Optimal surcharge under different targeting assumptions**

Scenario	Surcharge (cents/minute)
No targeting	0.35
Targeting of marginal subscribers	0.17
Targeting and discrimination of marginal subscribers	0.10

98. In addition, a less than perfect waterbed effect will imply a 'leakage' of termination revenue. That is, it will imply that some of the termination revenue raised through higher mobile termination rates is not passed through in the subscription market – requiring a higher termination rate in order to achieve the optimal number of subscribers. Ofcom has modelled a leakage scenario of up to 75%. Based on Australian data we estimate the optimal surcharge at 0.28 cents per minute (assuming an ability to target marginal subscribers but not perfectly discriminate pricing to individual marginal subscribers) using an assumption of 75% leakage.



99. Finally, for completeness we have modelled a final scenario, similar to that reported by Ofcom. This scenario assumes an RGF of 1.7 and an ability to target marginal subscribers (but not perfectly). In this scenario we also use the average of the elasticity estimates surveyed. The result of this scenario is a network externality surcharge of 0.26 cent per minute, assuming no leakage, and 0.47 cents per minute, assuming 75% leakage.