



**Cost Structures in Mobile Networks and  
their Relationship to Prices**

**Responding to Oftel**

**A Note by Europe Economics**

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## 1 INTRODUCTION

- 1.1 Following receipt of Europe Economics' study entitled "Costs Structures in Mobile Networks and Their Relationship to Prices", Oftel published a number of critical comments.<sup>1</sup>
- 1.2 Oftel claims that Europe Economics' report has chosen a "contrived" *definition of coverage*, and from this reached erroneous conclusions about the *size of joint or common costs*. Oftel believes that coverage costs are small and that there are *constant returns to scale* in mobile networks.<sup>2</sup> This note explains why Europe Economics disagrees with Oftel on these three points, and why as a result there is a need to emphasise *demand as well as cost factors* when considering regulation of mobile charges.
- 1.3 These issues are important in the UK partly because of their possible relevance to Oftel's proposals to regulate the wholesale charge for call termination on mobile networks, currently before the Competition Commission. The economic model underlying Oftel's proposals allocates the total costs attributed to traffic according to the proportions of network usage accounted for by termination, origination and other services to reach a narrow band for estimated termination costs. However, if the analysis of Europe Economics' report is correct, then the band of estimated termination costs may be larger than suggested by this model. This would in turn imply that specifying a cost-based price for termination would be correspondingly more problematic for a regulator, and that fuller consideration would also need to be given to other factors, as discussed in detail in Europe Economics' report.

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<sup>1</sup> See Oftel (2002) "Europe Economics' view of costs of mobile networks: Oftel's response", [www.oftel.gov.uk/publications/mobile/ctm\\_2002](http://www.oftel.gov.uk/publications/mobile/ctm_2002). Europe Economics' report was submitted to the European Commission in November 2001 and subsequently published; it is most readily available at [www.europe-economics.com](http://www.europe-economics.com). Because Oftel's comments on Europe Economics' report were set out in the form of a set of slides rather than a paper, it is not always easy to cite from them. From time to time, other public Oftel documents are cited in addition where this helps show Oftel's views.

<sup>2</sup> Oftel, op cit Slide 5.



## 2 DEFINING COVERAGE

- 2.1 Oftel and Europe Economics agree that the factors determining costs (referred to as cost drivers) on mobile networks include the geographical areas covered by a network as well as the number of subscribers and the volume of traffic.
- 2.2 Coverage costs can in principle be recovered from subscribers either in access or connection charges or from those making and receiving calls. Section 4 of Europe Economics' report discusses different possible ways of defining services. However the subsequent analysis is conducted treating the provision of coverage as included in a call termination or origination bundle so that the costs of coverage are assumed to be recovered from the charges for traffic services. This approach appears consistent with that used by Oftel.
- 2.3 However, that is where agreement ends. Oftel criticises Europe Economics' report on the grounds that the definition of coverage is "contrived" and that this leads to cost figures that are "highly misleading."<sup>3</sup> Europe Economics believes these criticisms to be mistaken.
- 2.4 Europe Economics' report makes clear that there are a number of possible ways to define coverage. Page 21 of the report notes four as follows:
- *"A network provides coverage if all customers can connect with the network in that place at all times. Under this definition, the network would require a huge capacity so that even if a great many subscribers are in the same area, perhaps at a major sports event, they can all make or receive a call. Probably no networks would provide coverage under this definition.*
  - *"Another view is that coverage relates to the network as it has been designed, since its design optimises the ability of a subscriber to connect with the network, recognising the trade-off between the cost of increasing capacity versus the desirability of being able to connect to the network at any time in any place.*
  - *"Coverage is the capability or option to make a single call from any point of the network at a point in time. All additional capacity is due to conveyance.*
  - *"Coverage is the site locations necessary for an MNO to construct a network to which people within a defined area could connect to a network. All of the telecom equipment necessary to permit a connection is due to conveyance."*
- 2.5 Europe Economics report suggested that for the purposes of cost modelling option (c) is the most suitable. Oftel favours a definition close to option (d), including only site costs

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<sup>3</sup> Oftel Slide 3.



and network management system costs in the costs of coverage, arguing that more than 80 per cent of costs of a typical cell relate to the costs of providing capacity.<sup>4</sup>

- 2.6 However, consider the following two examples. Suppose a mobile operator ran an advertising campaign claiming 100 per cent coverage in a country. Such a claim may well be deemed misleading if it were based on the definition Oftel prefers. Similarly a regulator seeking to ensure minimum network roll-out by imposing coverage requirements may not consider option (d) appropriate. This is because under Oftel's preferred definition there would be "coverage" even if no-one could make or receive a call.
- 2.7 These examples strongly suggest that Oftel's definition of coverage does not satisfy what is normally meant by the term, whereas that preferred in Europe Economics' report is more natural.

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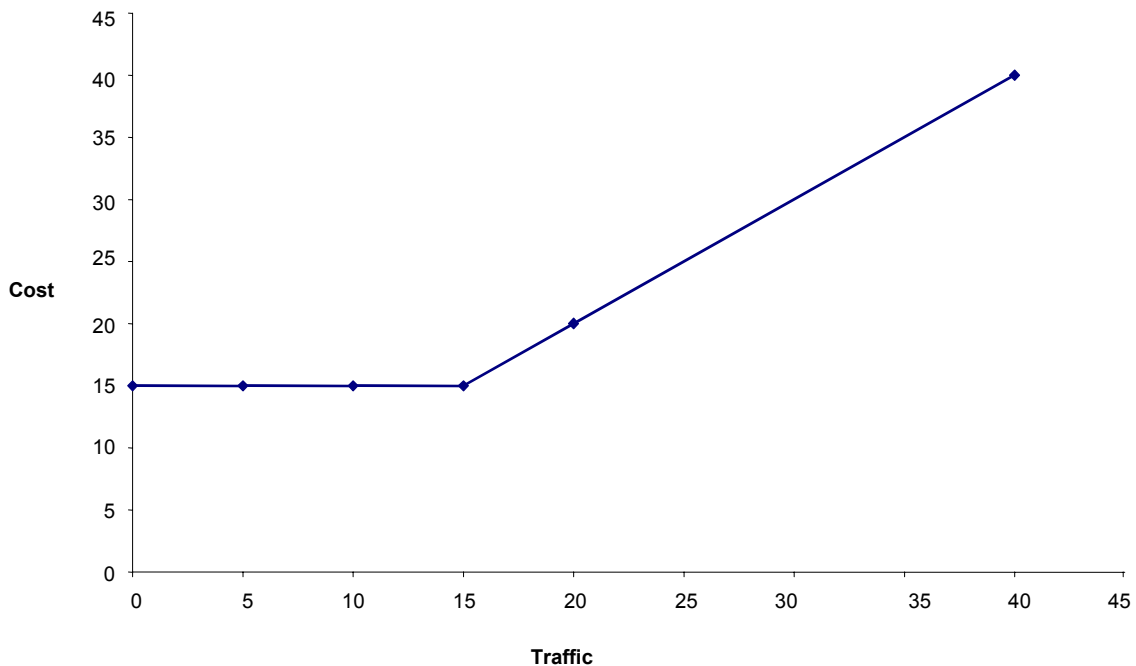
<sup>4</sup> Oftel op cit, Slide 7. See also Different Views of Oftel and MNOs on Network Common Costs, Oftel June 2002 ([www.oftel.gov.uk](http://www.oftel.gov.uk)). Paragraph 4.



### 3 OFTEL'S CALCULATIONS

- 3.1 This section comments on calculations presented by OfTel in order to consider whether or not Europe Economics' definition of coverage leads to erroneous conclusions about the extent of joint or common costs between different mobile services.
- 3.2 The worked examples that follow are based on the "simplified but realistic" diagram of the cost of a base station on Slide 11 of OfTel's presentation to the ONP, replicated in Chart 1 below.<sup>5</sup> As OfTel notes, simplifications implicit in the diagram include that origination and termination services use substantially the same equipment so that the marginal cost of either is the same and changing a unit of termination for a unit of origination does not affect total cost.

**Chart 1: OfTel's Cost Function for a Single Site including Coverage Costs**



- 3.3 In this example, for a network providing 20 units of traffic the total cost is 20 and the marginal cost of providing an extra unit of either origination or termination is 1. The standalone cost (SAC) of 10 units of traffic — whether origination or termination is immaterial — is 15.

<sup>5</sup> OfTel op cit. Slide 11.



- 3.4 The cost in this example of 10 units of termination, *incremental to 10 units of origination*, is 5. (The cost of taking total traffic from 10 to 15 units is zero, and the cost of a further 5 units is 5.) Similarly, the cost of 10 units of origination, *if incremental to 10 units of termination*, is 5. Of tel's calculation summing these two incremental costs and the common costs (15) yields 25, a figure higher than the total cost of providing 10 units of origination and 10 units of termination. Of tel's Slides 11-12 state that this means that common costs given by the cost of coverage are overstated.
- 3.5 However, Of tel's conclusion on this point is not correct; there is no reason why in an example like this the total cost of services A and B should equal the sum of common costs between A and B plus the incremental cost of A (given the provision of B) plus the incremental cost of B (given the provision of A). There are many relationships of cost to traffic volume for which the incremental cost of each service plus the common costs will exceed the total cost, including some relationships with increasing returns to scale.<sup>6</sup>
- 3.6 Of tel notes that the marginal cost (1) is above the average incremental cost of termination which it calculates as  $(5/10=0.5)$  when there are 10 units of termination and 10 units of origination. From this observation, Of tel claims that Europe Economics' analysis is "fundamentally flawed" on the grounds that it provides a "false implication" of diseconomies of scale.<sup>7</sup>
- 3.7 In fact, no such result can be derived from the data summarised in Of tel's chart reproduced above, or in any other way. That the marginal cost is above or below the average cost of certain increments as defined in Of tel's examples does not imply decreasing returns to scale: the reasoning reflected in Of tel's slides 14 and 15 is not valid.
- 3.8 Thus Of tel's calculations do not show anything in Europe Economics' treatment of costs that leads to incorrect or contradictory results.

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<sup>6</sup> Section 5.4.5 of Europe Economics' report discusses the problem that the calculation of incremental costs for different services may appear to depend on the sequence in which they are calculated.

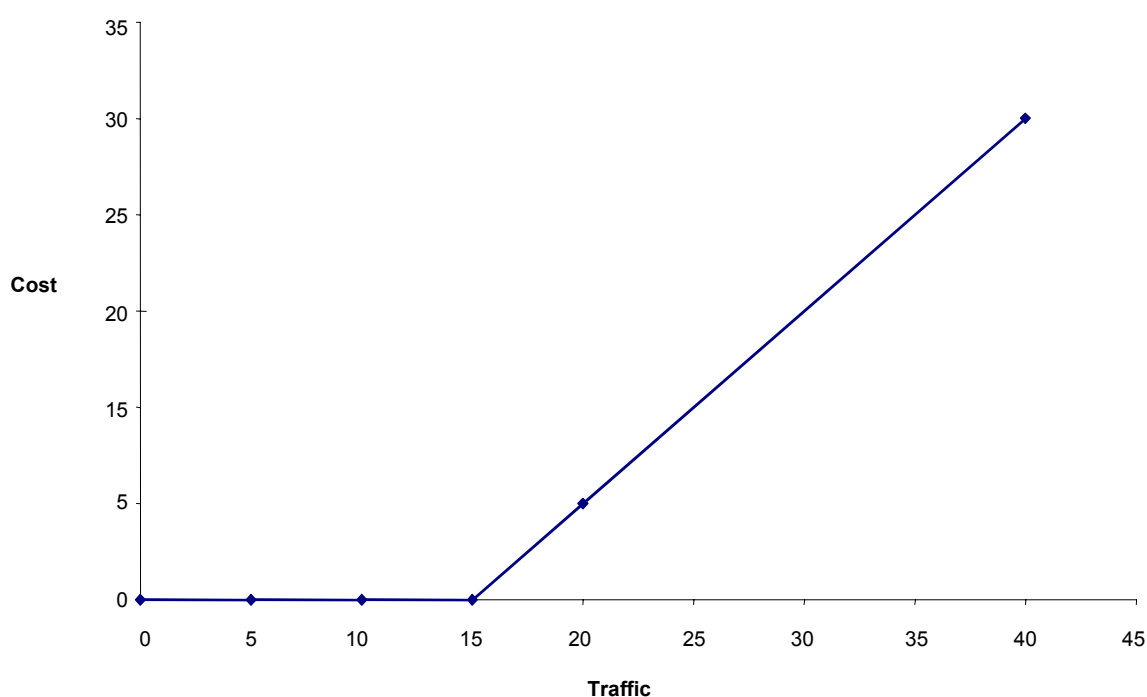
<sup>7</sup> Of tel Slides 14 and 15.



## 4 THE RELEVANCE OF COVERAGE TO THE MEASUREMENT OF COSTS

4.1 Chart 2 is consistent with OfTel's stylised example for the costs of a base station reproduced in Chart 1. The difference is that the costs (15) necessary to allow even a single call are now explicitly treated as coverage costs, and not as traffic costs. Thus Chart 2 can be seen as embodying the definition of coverage that Europe Economics adopted in its report.

**Chart 2: Cost Function for a Single Site, excluding Coverage Costs**



4.2 From this diagram, the traffic-driven cost of providing just 10 units of call termination (no origination) is zero, but of course there is a pool of coverage costs (15), that needs to be recovered.<sup>8</sup> The same would naturally apply if looking at origination instead of termination.

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<sup>8</sup> This note ignores the costs of handsets, including SIM cards.



- 4.3 One advantage of calculating coverage costs separately is that a regulator can then more easily examine the significance of recovering some or all of these costs in subscription or access charges rather than in charges based on traffic.
- 4.4 If, however, it is decided to recover coverage costs (using Europe Economics' definition) from traffic-based charges, then for a network providing 20 units of traffic (say, 10 units of termination and 10 units of origination) the prices charged for this traffic should generate revenues of 20. The appropriate revenue recovered from each of the two services will depend on demand conditions and regulatory objectives, and will not necessarily be the same for each service, or for each unit of each service.
- 4.5 Now suppose that traffic with most sites is sufficient, as Oftel states, to make the flat part of Chart 2 less relevant for determining incremental costs i.e. that there were significantly more than 15 units provided of each of call origination and call termination. In this case, if it had been decided that coverage costs were to be recovered from charges for origination or termination, then on the assumptions in this example pricing at marginal cost (1) would allow full cost recovery, as Oftel states.<sup>9</sup>
- 4.6 However, what the presentation in Chart 2 shows more clearly is that this charging structure would imply an equi-proportional mark-up of charges related directly to traffic in respect of the costs of coverage (15 in the example). The convenient result that marginal cost pricing gives full cost recovery depends on the assumption that all the costs of coverage are recovered from traffic charges and on the precise specification of the example provided by Oftel.
- 4.7 This section has shown that under the specific example provided by Oftel of the cost functions of mobile networks, and on the basis that coverage costs are to be recovered in traffic charges, different definitions of coverage do not have a material effect on the pricing results derived by Oftel. Under other assumptions, however, the definition of coverage will have an impact.

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<sup>9</sup> Oftel slide 16.



## 5 CONSTANT RETURNS TO SCALE

5.1 Oftel states that mobile networks in the UK exhibit constant returns to scale.<sup>10</sup>

5.2 Table 1 below provides calculations for the costs of various levels of service based on Oftel's assumptions about network cost structures as presented in Chart 1.

**Table 1: Oftel Example of Network Costs: Costs of Different Levels of Services**

	x=5 units of origination, y=5 units of termination	x=20 units of origination, y=20 units of termination
<b>Total Cost</b>	15	40
Marginal cost of termination (origination), given x(y) units of other service	0	1
Stand alone cost of origination (no termination)	15	20
Stand alone cost of termination (no origination)	15	20
Incremental cost of origination, given y units of termination	0	20
Incremental cost of termination, given x units of origination	0	20

5.3 For the higher levels of service shown in the second column

- marginal cost pricing allows full cost recovery; and
- the incremental and standalone costs of providing a service are identical.

These results follow directly from the way constant returns to scale are built into the example.

5.4 There are however several reasons why mobile networks might not exhibit constant returns to scale. The first relates to the way a mobile telephony network is made up a large number of individual cells and there are bound to be some non-linearities at low levels of volume in particular cells, as illustrated in Chart 1 and in the first column of Table 1 above. If volume increases uniformly across all cells, there will be some cells for which the additional volume adds little to the cost.

5.5 Secondly, aggregating for the whole network, the size of joint costs between coverage and other services will depend on the proportion of base stations serving areas with

<sup>10</sup> Oftel Slide 20.



relatively low demand. The more base stations there are in areas with low numbers of subscribers, the more important such joint costs are likely to be. Hence the observation in Europe Economics' report that the difference between incremental and standalone costs is likely to be greater in countries with low population densities or mountainous regions. (This might also explain why another National Regulatory Authority (NRA) commenting on Europe Economics' paper expressed the view that economies of scale are important, while Oftel believes they are not.)

- 5.6 Thirdly, if traffic volumes double, it may be possible to order larger-scale equipment that does not cost twice as much. Or it may be possible to configure cells and call management more efficiently. Alternatively, in theory at least, diseconomies of scale may set in because of the need to use worse sites with higher per site costs.
- 5.7 MNOs do not offer 100 per cent coverage in any country, including the UK. There are some areas where it is not profitable to install a base station. Presumably there are also some marginal base stations that only carry a limited number of calls; they are only just economically viable. In such areas, the cost of small increments of traffic may well be negligible.<sup>11</sup>
- 5.8 Oftel's view is that in the UK the costs of most base station sites are traffic driven, and that rural sites where this is not so represent only a minority of sites.<sup>12</sup> It can readily be seen from the above discussion that whether there are constant returns to scale in mobile telephony networks is an empirical question.
- 5.9 Increasing returns to scale could be the result of a non-linear cost function.
- 5.10 Increasing returns to scale could also result from a linear cost function which did not pass through the origin. Suppose the example given by Oftel is altered just slightly, so that the minimum initial investment in capacity costing 15 allows only 10 units of either origination or termination to be provided (rather than 15), but the marginal cost is then one as before. In that case, the second column of results shown in Table 1 above would then be as shown in Table 2 below.

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<sup>11</sup> It is possible that some of these base stations are built for marketing reasons rather than any prospect that the demand to make calls using the base stations will cover costs. One criterion consumers make when choosing which MNO to subscribe to will be the geographical area from which they can make calls. Developing this idea might lead to the conclusion that coverage costs should be recovered from subscribers rather than call minutes, since they are costs incurred persuading people to join a network. This point is discussed in more depth in Section 4.2 of Europe Economics' report. If a regulator setting prices decided that coverage costs should be paid for by subscribers, then the choice of definition is important.

<sup>12</sup> Oftel Slide 18.

**Table 2: Alternative Example of Network Costs: Costs of Different Levels of Services**

	x=5 units of origination, y=5 units of termination	x=20 units of origination, y=20 units of termination
<b>Total Cost</b>	15	45
Marginal Cost of termination (just origination), given x(y) units of other service	0	1
Stand alone cost of origination (no termination)	15	25
Stand alone cost of termination (no origination)	15	25
Incremental cost of origination, given y units of termination	0	20
Incremental cost of termination, given x units of origination	0	20

5.11 Despite being generated by a minimal change to the cost specification put forward by Oftel, the alternative example analysed in Table 2 would have different implications for the pricing of origination and termination:

- marginal cost pricing does not lead to full cost recovery at higher levels of output;
- the incremental and standalone costs of providing call origination or call termination differ materially, such that a range of cost recovery patterns is now consistent with a competitive outcome, whereas before only one was.

5.12 Both results arise because the common costs between call origination and call termination arising from coverage costs do not, as before, neatly “fall out” from assuming they are to be allocated equi-proportionally between those two services.

5.13 If the marginal cost of an additional unit of traffic declined as output increased, then the incremental cost of call termination, given the provision of other traffic services, could be much less than the standalone cost. Only the exact cost specification given by Oftel in its example will lead to the results Oftel finds. Any other will reveal the two results shown in Paragraph 5.12 above, and a specific judgement will be needed on how to allocate the resulting common costs between services.

5.14 This section has shown that once the cost structure of a mobile network departs from the specific functional form used in Oftel’s illustration, and in particular if there are reducing marginal costs as traffic increases (which is quite likely), then there will be common costs to be recovered. Europe Economics’ report set out to show how such areas of common cost would arise and their implications for the pricing of mobile services.



## 6 THE RELEVANCE OF DEMAND CONDITIONS

- 6.1 Europe Economics report argues that it is insufficient to consider only costs. If the objective is economic efficiency or to realise an outcome reconcilable with competitive markets, then it is necessary also to consider demand.
- 6.2 Suppose person A is willing to pay 14 for 10 units of origination, and person B is willing to pay 9 for 10 units of termination. It is economically efficient for a network to provide 10 units of termination and 10 units of origination. The cost would be 20, the willingness to pay of the customers is 23.
- 6.3 Setting all prices equal to marginal cost is not ideal. If the firm were to charge one per unit of termination or origination then person B would choose not to purchase the 10 units of termination, since his willingness to pay (9) is less than the total price for this service (10). Everything unravels and the end result is that no origination or termination service is provided. (A network would be unwilling to offer only 10 units of origination unless prices were set to recover the standalone costs of 15, which exceeds person A's willingness to pay.) This is not efficient, since services for which willingness to pay exceeds costs are not being provided.
- 6.4 Nor is this an outcome that would be expected in a competitive outcome. There is a profitable opportunity to enter the market and supply the two services. A firm could offer to charge person A 1.4 per unit of origination and person B 0.9 per unit of termination, prices at which the customers would be willing to purchase 10 units of origination and 10 units of termination respectively. This would yield profits of three. (In a competitive market, such prices would not be sustainable, since a rival could undercut these prices offering, say, 1.3 per unit of origination and 0.7 per unit of termination.)
- 6.5 This is a stark example, where the customers buy 10 or no units. Other examples could be constructed with more realistic demand functions. The basic point though is illustrated. Setting regulated prices for termination and origination solely on the basis of their marginal cost will not necessarily realise either an efficient or a competitive outcome. Demand conditions are also important when there are joint costs.
- 6.6 What prices might be appropriate for the examples contained in Table 1? If the output were five units of origination and five units of termination, it would clearly be unsustainable for the firm to price at marginal or incremental cost for either product, i.e. to give all its products away. The firm incurs costs of 15 to provide network coverage which costs have to be recovered. All of these costs are necessarily incurred to provide either origination or termination. If there were almost no willingness to pay to have calls terminated, but an MNO has a customer willing to pay 15 to originate five units of calls, then it would be (a) efficient for this network to be set up and (b) a potentially competitive outcome in that no excess profits were being earned with the MNO setting prices of zero for termination and 3 per unit for origination. The price is above marginal cost, but this is necessary to permit full cost recovery.



- 6.7 Under diminishing marginal costs of additional traffic units, the common costs within traffic increments and those arising from coverage costs could well be material. There is no cost-based principle that justifies a particular allocation of those common costs, which would naturally be allocated with respect to demand and to regulatory objectives.
- 6.8 This discussion shows that there are many circumstances in which demand as well as cost factors will be important when considering possible regulation of charges for mobile services.



## 7 CONCLUSIONS

7.1 This note has argued that Oftel's criticisms of Europe Economics' report are misplaced, for the following reasons:

- the definition of coverage in Europe Economics' report is more natural and persuasive than that proposed by Oftel;
- the examples provided in Oftel's slides do not show any errors or misunderstanding in Europe Economics' approach;
- there are unlikely to be constant returns to scale almost everywhere in UK mobile networks as Oftel suggests; and
- it is necessary to assess demand as well as cost factors when considering possible regulation of mobile charges.



## APPENDIX 1: GLOSSARY OF TERMS

A1.1 Concepts referred to in this note are consistent with definitions given in Oftel's website glossary of terms.<sup>13</sup> The following are of particular importance.

- **Common Costs** — costs that are incurred in the supply of all or a group of products or services provided by the company and cannot be directly attributed to any one product or service.
- **Economies of Scale** — reductions in unit cost which occur when a product is produced in greater quantities.<sup>14</sup>
- **Economies of Scope** — cost savings which occur when two or more products are produced together, i.e. the provision of service B reduces the unit cost of supplying service A.
- **Incremental Costs** — costs that arise as a result of the provision of the "increment". In contrast to fully allocated costs [q.v.], the incremental costs include only those costs that are caused by the provision of the increment. So long as revenue exceeds incremental costs, the company increases its value by providing the increment.
- **Marginal Cost** — the cost of producing an additional unit. Where there are economies of scale, the marginal cost will be lower than the average cost. In circumstances where all the costs of production are fixed (e.g. a television programme) the marginal cost for each additional viewer will be zero.
- **Stand Alone Costs** — the costs to a single product firm of providing a service. The stand-alone costs of a service exceed the incremental costs to a multi-product firm if there are economies of scope.

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<sup>13</sup> Definitions taken from [www.oftel.gov.uk/publications/glossary](http://www.oftel.gov.uk/publications/glossary) on 27 May 2002.

<sup>14</sup> Oftel's glossary says "reductions in unit costs savings" but this is clearly an error.