Mobile call termination market review 2015-18

Annexes 11 - 17

Consultation

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Contents

Annex 11

MCT cost model approach and design

Introduction

A11.1 This annex outlines the approach we have taken to developing a new MCT cost model and explains its functionality. The current version of the model (the '2014 MCT model') is published alongside this consultation. We propose to use this model to calculate the costs of MCT.

A11.2 The model uses a bottom-up approach to estimate the costs of a hypothetical efficient national MCP which is then calibrated against top-down data. It is capable of calculating both the LRIC and LRIC+ of MCT, but as explained in Section 6 and consistent with the 2009 EC Recommendation, we propose to use the LRIC standard to set the charge control on MTRs.

Modelling process

A11.3 The charge control on MCT implemented in 2011 was set using the 2011 MCT model.[1] Having considered the requirements for the 2014 MCT model, in our view the 2011 MCT model had a sufficient level of functionality to serve as a reasonable starting point for the development of a new MCT model.

A11.4 In October 2013, Ofcom commissioned Analysys Mason to assist with the development of a new MCT model for the 2015 MCT review. On 23 October 2013 we held a stakeholder workshop in which we outlined our initial views on some of the key issues that we were proposing to consider as part of the 2015 MCT review and we sought stakeholder views on these issues. The slides presented at this workshop are published on the Ofcom website alongside stakeholder responses to the workshop.[2]

A11.5 We have collected data from the four largest MCPs using our information gathering powers under section 135 of the Communications Act 2003. We sent information requests to the four largest MCPs on 8 November 2013 requesting detailed information in relation to:

- Historical demand for network services;
- Historical numbers of assets deployed and their unit costs;
- Forecasts for traffic growth;
- Information about planned changes to network architectures; and
- Forecasts of asset price trends and operating cost trends.

[1] The charge control was amended as part of the 2012 CAT Judgment. These amendments can be found in release 4 of the 2011 MCT model, see http://www.ofcom.org.uk/static/wmvct-model/model-2011.html.

[2] See http://stakeholders.ofcom.org.uk/consultations/mobilecallterm/workshop2015-2018/.

A11.6 Based on our initial work and the information gathered up to that point we published a draft MCT model on 17 January 2014 (the 'draft MCT model').[3] On 23 January 2014 we held a second stakeholder workshop to discuss the draft MCT model and issues related to our cost modelling. The slides presented at the workshop are published on Ofcom's website alongside stakeholder responses to the workshop and the draft MCT model.[4]

A11.7 We sent further section 135 information requests on 14 February 2014 and 18 March 2014 to each of the four largest MCPs that sought further information in relation to network design and network costs.

Structure of this annex

A11.8 The remainder of this annex is structured as follows:

- An explanation of the 2014 MCT model's aims and the technologies modelled;
- A summary of the major differences between the 2011 MCT model and the 2014 MCT model;
- An overview of the 2014 MCT model and its constituent modules, namely:
    - Module 0, 'Scenario Control';
    - Module 1, 'Traffic';
    - Module 2, 'Network';
    - Module 3, 'Cost',
    - Module 4, 'Economic';
    - Module 5, 'HCACCA'; and
- A detailed explanation of each of these modules.

A11.9 Further details in relation to modelling are provided in the following annexes:

- Annex 12 is an Analysys Mason report explaining the details of the 'Network' and 'Cost' modules;
- Annex 13 describes the model calibration process;
- Annex 14 contains the details of the WACC calculation;
- Annex 15 sets out our analysis in relation to other modelling issues including spectrum holdings and valuation, administrative costs and HLR updates;

[3] See http://stakeholders.ofcom.org.uk/telecoms/policy/mobile-policy/mobile-call-termination-review-2015-2018/mct-review-2015-18-january2014/draft-MCT-model/.
[4] See http://stakeholders.ofcom.org.uk/telecoms/policy/mobile-policy/mobile-call-termination-review-2015-2018/mct-review-2015-18-january2014/.

- Annex 16 summarises the model outputs and sensitivity analysis; and
- Annex 17 is a Brattle report estimating the equity and asset betas for UK MCP owners.

Model overview and aims

A11.10 The purpose of the 2014 MCT model is to forecast the cost of providing MCT for an average efficient MCP during the period 1 April 2015 to 31 March 2018. The forecast costs derived from our 2014 MCT model are then used to inform our proposals for setting a charge control on MTRs.

Technology choice

A11.11 In order to build a bottom-up network cost model, we need to decide which network technology or combination of technologies to model. As with our general approach to modelling, we wish to select a combination of technologies that reflect the decisions that would be taken by an average efficient MCP. Therefore, our interest in network technology choice is a means to an end, not an end in itself. In estimating a cost-based MTR for an average efficient MCP, we consider that new technologies will only be deployed if they are at least as efficient as the existing technologies, meaning that they are capable of delivering the same services at the same or lower cost.

A11.12 In choosing between technologies we have borne in mind:

- The technologies modelled in the 2011 MCT model, and technological and market developments since that time;
- Our economic objectives in setting cost-based charges;
- The 2009 EC Recommendation;
- The technologies modelled by other NRAs for the purposes of setting MTRs; and
- The views of respondents to the questions we posed at our modelling workshops in October 2013 and January 2014.

A11.13 Based on our analysis of these points we propose to continue to model 2G and 3G networks and to also model a 4G[5] network carrying data and 4G voice, i.e. voice over LTE (VoLTE). The reasoning underlying this proposal is set out in the following sub-sections.

[5] 4G telecommunication systems are those which comply with the requirements defined by the International Telecommunications Union (ITU) in its International Mobile Telecommunications – Advanced (IMT-Adv) performance requirements (http://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-M.2134-2008-PDF-E.pdf). ITU has identified LTE Advanced (LTE-A) radio interface technology as a technology which satisfies its IMT-Adv requirements (https://www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.2012-1-201402-I!!PDF-E.pdf). While LTE does not meet the IMT-Adv requirements (and therefore is not a '4G' system), it is perceived by many as the first commercial 4G system, partially because it introduces the core technology that LTE-A will be based on. In this document we use the terms '4G' and 'LTE' interchangeably.

A11.14 More detailed technological considerations including infrastructure sharing and the deployment of S-RAN technology are considered as part of our explanation of the network module of the 2014 MCT model below.

Background

The 2011 MCT model and market developments

A11.15 The 2011 MCT model was a bottom-up model that estimated the costs of an average efficient operator in the UK, and was based on the technologies and spectrum bands that were being used by national MCPs in the UK at that time. Specifically it included:

- 2G in the 1800 MHz band; and
- 3G, including High-Speed Packet Access (HSPA), in the 2.1 GHz band.

A11.16 We recognised in our consultation on the 2011 MCT model that market expectations pointed towards the likely adoption of 4G technologies during the 2011/12 to 2014/15 charge control period.[6] We considered including 4G technology in the 2011 MCT model but found that, at that time, the precise choice of next generation technology, the deployment timeframe and the migration rate were highly uncertain. 4G technologies were then commercially unproven in the UK, and we also recognised that there was considerable uncertainty about the availability of spectrum and equipment for 4G deployment.

A11.17 Since the beginning of the last charge control period, we have seen market developments in the form of spectrum being liberalised and allocated by auction, and 4G network deployment. The four largest MCPs now have live 4G data networks, and 4G data traffic is expected to increase considerably both before and during the next charge control period.

A11.18 Furthermore, although VoLTE is not currently being used in the UK, the evidence we have is consistent with VoLTE being included in the 2014 MCT model.

Economic objectives in setting cost-based charges

A11.19 In setting a charge control for MTRs, our main objectives are:[7]

11.19.1 Allocative efficiency, meaning that prices reflect forward looking marginal (or incremental) costs.

11.19.2 Productive efficiency, meaning that MCPs face incentives to minimise costs and there are efficient “build or buy” signals.

11.19.3 Dynamic efficiency, meaning that there is scope for increases in output possible from existing resources (as techniques of production are improved) and/or new services are developed. Dynamic efficiency is driven by successful investment and innovation. Delivering dynamic efficiency in

[6] See paragraphs 9.83 to 9.87 of the April 2010 Consultation.

[7] These same objectives were used in the context of setting cost based charges for fixed termination and origination rates in the 2013 Fixed Narrowband Market Review (‘FNMR’). See paragraph A5.38 et seq. of the 2013 FNMR Statement.

regulated markets typically involves providing the opportunity (but not a guarantee) for firms to recover efficiently incurred costs, consistent with what would be expected in a competitive market.

11.19.4 Effective competition, meaning that our intervention promotes competition (i.e. those able to do things more efficiently can do so using their own resources and infrastructure) but does not unnecessarily restrict the ability of MCPs or other CPs already operating in regulated markets from competing.

A11.20 However we recognise that tension can exist between these objectives. For example:

11.20.1 Pricing at forward looking marginal or incremental cost, while good for allocative efficiency, may not allow the recovery of sunk costs. Regulating in a way which does not provide an opportunity to recover sunk costs is undesirable from the point of view of dynamic efficiency because it undermines incentives to invest in new assets which, once acquired, are themselves sunk.

11.20.2 Setting prices on the basis of full replacement costs, typically determined by reference to the cost of a Modern Equivalent Asset (MEA), is likely to foster effective competition.[8] This is because access seekers face appropriate "build or buy" signals. However, prices based on full replacement costs may not generate allocative efficiency because prices will depart from marginal/incremental costs if replacement costs involve making new sunk investments when there are already usable sunk assets in place. Moreover, if investment in competing infrastructure is not practicable or commercially viable, prices set on the basis of replacement cost may result in access seekers, and ultimately consumers, paying a higher price than the MCP needs for cost recovery.

2009 EC Recommendation

A11.21 The 2009 EC Recommendation provides guidance on the technologies to include in a bottom-up LRIC model for the purposes of setting MTRs. It states that:

"The cost model should be based on efficient technologies available in the timeframe considered by the model. Therefore the core part of both fixed and mobile networks could in principle be Next-Generation-Network (NGN)-based. The access part of mobile networks should also be based on a combination of 2G and 3G telephony".[9]

A11.22 In making our technology choice for the 2014 MCT model we have taken utmost account of this recommendation, as we are required to do under Article 19(1) of the Framework Directive and section 4A of the Act. We explain this further below.

[8] An MEA approach is an approach to setting charges that bases costs on the most cost efficient proven technology that can offer the full range of regulated services.

[9] 2009 EC Recommendation, point 4.

Technology choices made by other European NRAs

A11.23 We note that NRAs have recently taken a range of views to the choice of technology to include in the construction of MCT models, as shown in Table A11.1 below.

Table A11.1: Technology choices made by other NRAs

NRA, Country	Year implemented	Technologies modelled
ACM, Netherlands	2013	2G, 3G
ARCEP, France	2012	2G, 3G (with 4G data implicit in HSPA modelling, no VoLTE)
NPT, Norway	2013	2G, 3G (with some 4G economies of scope implicitly accounted for in site costs)
PTS, Sweden	2013	2G, 3G, 4G (data only, no VoLTE)
DBA, Denmark	2012	2G, 3G
CMT, Spain	2013	2G, 3G, 4G (data only, no VoLTE)
BNetzA, Germany	2012	2G, 3G, 4G (data only, no VoLTE)

Source: Analysys Mason, Ofcom.

Stakeholder responses to the October 2013 industry workshop

A11.24 At the October 2013 stakeholder workshop we explained that 2G and 3G are both proven technologies, and that we considered that 4G was also proven and expected to be deployed in the UK by the start of the charge control period. We sought views on this, and also on the possibility of removing either 2G or 3G technologies from our modelling.[10]

A11.25 We received responses on this topic from EE and from BT. EE sought clarity on the principles on which the choice of technology would be based.[11]

A11.26 BT considered that MTRs should be based on the LRIC of a 4G network, arguing that "*an efficient new entrant would not build a national 2G/3G network*" and that "*the best available technology for an efficient operator entering the market now is LTE, with voice to be provided either as an Over The Top service, or as VoLTE*". It

[10] See slide 25 of the presentation available at http://stakeholders.ofcom.org.uk/binaries/consultations/mobilecallterm/MCT_slides.pdf.
[11] See p11 of EE's response, available at http://stakeholders.ofcom.org.uk/telecoms/policy/mobile-policy/mobile-call-termination-review-2015-2018/responses/.

observed that 4G technology has been deployed in a number of other countries (citing China, USA and South Korea).[12]

A11.27 BT also noted that "*Ofcom did not allow dual running costs in the fixed market and should not do so for MTRs*", arguing that, consistent with its view of the policy adopted in the 2013 FNMR, the model (for the 2015 MCT review) should be forward looking and not based on the legacy deployments of existing networks.

Stakeholder responses to the January 2014 industry workshop

A11.28 At our January 2014 stakeholder workshop we explained that our framework for technology choice is unchanged from previous MCT modelling exercises. Specifically we estimate the cost of MCT of an average efficient MCP using proven technologies, and in doing so take the view that new technologies will be deployed only if they are at least as efficient as existing technologies (meaning that they allow the delivery of existing services at the same or lower cost).[13]

A11.29 We explained that we anticipate that the existing 2G and 3G networks would continue to be used to provide services during the next charge control period. We noted that we had not seen any evidence that the 2G and 3G networks would be decommissioned during the next charge control period, and hence included them in the draft MCT model.

A11.30 We also included 4G and VoLTE functionality in the draft MCT model, and explained our preliminary view that it was appropriate to include 4G data services in the model. For VoLTE we noted that although evidence from MCPs suggested that VoLTE was likely to be enabled within the next charge control period it was not yet active anywhere in the UK. We explained that we had therefore included the capability in the model to include VoLTE services, but sought stakeholder views on both the inclusion of VoLTE and its implementation in the model.

A11.31 On the subject of technology choice, the inclusion of VoLTE and its technical implementation, we received responses from BT, EE and H3G.

A11.32 BT reiterated and refined its point (see paragraph A11.27 above) that the 2015 MCT model "*should follow the precedent established in the FNMR and consist of a modern multi-mode network built in 2011 and fully loaded by 2015*". BT explained that the draft MCT model contained largely separate 2G, 3G and 4G networks, and that an efficient entrant would instead build an S-RAN and benefit from economies of scale and scope. As such the costs of running legacy networks should not be included, consistent with the regulatory treatment of the fixed network in the 2013 FNMR.[14]

A11.33 [✂].[15]

A11.34 EE noted that VoLTE represented one of a possible range of technologies relevant to supporting improvements to voice services over the period of the next MCT price

[12] See p9 of BT's response, available at http://stakeholders.ofcom.org.uk/telecoms/policy/mobile-policy/mobile-call-termination-review-2015-2018/responses/.
[13] See slide 20 of the presentation available at http://stakeholders.ofcom.org.uk/binaries/telecoms/policy/mobile/MCT_23January14_Industry_workshop_final.pdf.
[14] BT's response, p.4 http://stakeholders.ofcom.org.uk/binaries/telecoms/policy/mobile/bt-2014.pdf.
[15] [✂].

control and beyond. [✂] EE is considering how Ofcom's cost model should reflect these costs going forward.

A11.35 H3G did not provide a view on the inclusion of VoLTE services but commented on the efficiency of VoLTE services as included in the draft MCT model. It noted that the draft MCT model suggested that 4G radio technology is 50 times more efficient than 3G radio technology in serving voice traffic.[16] This point is addressed by Analysys Mason in Annex 12 and we agree with its views on this issue.

Consultation proposals on technology choice

A11.36 In light of our initial considerations above and stakeholder comments on the choice of technology, our proposals for the consultation are set out below and reflected in the 2014 MCT model.

Relevant competitive constraint to be modelled

A11.37 As noted in paragraph A11.32 above, BT commented that it would be appropriate to model a network "*built in 2011 and fully loaded by 2015*". This would effectively imply the modelling of a more recent entrant to the mobile market than that used in the 2011 MCT model, which has a modelling period beginning in 1990/91 and assumes entry in 1993/4.

A11.38 Our longstanding approach to MCT modelling[17] involves the use of economic depreciation, which reflects the on-going nature of investment and the recovery of these costs over a period of time significantly in excess of the duration of any individual charge control. The purpose of this approach is to mimic outcomes in a competitive or contestable market, which provides an appropriate benchmark for regulation.

A11.39 In modelling this competitive constraint we take account of both potential competition from new entrants and actual competition between incumbents. This involves assuming that entry is sustainable in the long run and there is sufficient competition between MCPs to remove super-normal profits, i.e. the modelled operator is assumed to recover the projected present value of lifetime network costs discounted at the weighted average cost of capital (WACC).

Continued inclusion of 2G and 3G technologies

A11.40 As explained in paragraph A11.26 above, BT argued that the cost of MCT should be based on 4G network technology, such as VoLTE, and that it would not be appropriate to include the costs of 2G and 3G 'legacy' technologies when calculating the efficient costs of MCT. However, we have concerns about excluding 2G and 3G technology from the model.

A11.41 We consider that the economic objectives explained in paragraphs A11.19 and A11.20 require the continued modelling of 2G and 3G technologies. While modelling only a 4G network might better reflect replacement costs of the MEA (and hence competitive/contestable market principles) it could threaten the opportunity to

[16] H3G's response, p2, http://stakeholders.ofcom.org.uk/binaries/telecoms/policy/mobile/Three.pdf.
[17] The origins of this approach stretch back to the 2001 Oftel Statement 'Review of the charge control on calls to mobiles' and are explained in detail at http://www.ofcom.org.uk/static/archive/oftel/publications/mobile/depr0901.htm.

recover the efficiently incurred costs of the existing 2G and 3G networks and hence undermine dynamic efficiency. As noted in paragraph A11.20, signalling that past investments in 2G and 3G assets can be ignored (at least until there has been an opportunity to recover efficiently incurred expenditure) risks undermining regulatory predictability for MCPs and may compromise future incentives to invest.

A11.42 Turning to the 2009 EC Recommendation, and the requirement for "*efficient technologies available in the timeframe considered by the model*", we note that as explained in paragraph A11.11 we consider that new technologies will be deployed only if they are capable of delivering the same services as existing technologies at the same or lower cost.

A11.43 Although BT refers to the adoption of LTE technology in China, the USA, South Korea and a number of other countries, we are not aware of any MCPs in Europe that have deployed a national 4G only network that is currently capable of conveying the total traffic volumes assumed in our modelling. Instead, MCPs that have or are deploying 4G networks are continuing to deploy and develop their 2G and 3G networks to provide both coverage and capacity for traffic. This is particularly the case for UK voice traffic because VoLTE technology has yet to be deployed by any of the four largest MCPs,[18] meaning that 2G and 3G technologies remain necessary to deliver voice traffic.

A11.44 In addition, we consider that it would be unreasonable to assume that an MCP in the UK would be able to reach the market share of our modelled average efficient MCP if it offered a 4G only network. This is because the current take-up of active 4G handsets is too low. In other words, an MCP is unlikely to be able to reach the market share we assume for our modelled MCP without deploying a 2G and 3G network.

A11.45 Reinforcing this point, we consider it relevant that industry expectations point to the continued existence of 2G and 3G networks over the next charge control period. The presence of 2G and 3G networks is necessary to serve customers with 2G and 3G handsets and to support international roaming customers who require access to 2G and 3G networks. In this vein, we note that other NRAs continue to model 2G and 3G technologies through the period of the next charge control, as shown in Table A11.1 above.

A11.46 For the above reasons, we do not consider it appropriate to model a 4G only network, and propose to include both 2G and 3G technologies in the 2014 MCT model.

A11.47 However, we recognise that in doing so care must be taken around the traffic volumes assumed to use the 2G and 3G networks, and the forecast voice and data migration from 2G/3G to 4G. In relation to network modelling it is also necessary to reflect the use of S-RAN technology and to appropriately capture its impact on 2G and 3G network costs. These issues are discussed further in the relevant sub-sections below.

Inclusion of 4G data technology

A11.48 Turning to 4G technology, we note that, in contrast to what was the case at the time of our March 2011 Statement, 4G data technology is proven in the UK and the four

[18] VoLTE technology is discussed in more detail further below.

largest MCPs currently provide data services over 4G networks. As a result, we propose to include 4G data technology in our modelling.

A11.49 We consider that the inclusion of 4G data services will appropriately reflect the forward-looking costs of mobile service provision and hence promote allocative efficiency without undermining incentives to invest. Given the increasing importance of data as a proportion of total mobile network traffic (a point we consider further in the traffic forecasts below) we consider it important to include 4G data from the point of view of appropriately capturing the effects of economies of scope in the provision of mobile services.

A11.50 We note that the 2009 EC Recommendation does not contain an explicit reference to the inclusion of 4G technology, but we nevertheless consider that its inclusion is consistent with that recommendation. The 2009 EC Recommendation explains that the cost model *"should be based on efficient technologies available in the timeframe considered by the model".* As we note in the previous paragraph, 4G data services are currently offered by all four largest MCPs, suggesting that 4G technology is an efficient technology to include in the 2014 MCT model. When the 2009 EC Recommendation was published, 4G technology was not proven, so it could not have been expected to feature as a reference technology for modelling the costs of MCT.

A11.51 In support of this position, we note that data services using 4G technology have been modelled in a number of other European countries, as shown in Table A11.1 above.

Inclusion of 4G voice (VoLTE) technology

A11.52 Based on our assessment of the available evidence we consider that 4G technology should be included in the model. However, the question of whether VoLTE technology should be included in the 2014 MCT model is more finely balanced than in the case of 4G data, and something about which we specifically welcome stakeholder views.

A11.53 As noted above, VoLTE is a nascent technology in the UK, raising the question of whether or not it should be included in our model. During a period of technology change, such as the transition from voice traffic using 2G and 3G networks to VoLTE, an alternative to modelling VoLTE networks as the MEA is to adopt an anchor pricing approach.

A11.54 Anchor pricing involves charges being "anchored" to be no higher than the level that would prevail if there were no technological change. In this way customers (that is, wholesale purchasers of the regulated products) and ultimately consumers would be no worse off due to technological change. In the present case this would mean modelling a 2G, 3G, 4G network with VoLTE being excluded from the 2014 MCT model.[19]

A11.55 An anchor pricing approach, or the alternative of an approach based on identifying the MEA, is only ever implemented as a means to an end – the end being to cap charges in a way most likely to secure economic efficiency (i.e. allocative, productive and dynamic) and effective competition.

[19] The MTR would be derived using the blended costs of 2G and 3G MCT.

A11.56 The MEA approach seeks to set regulated prices reflective of the costs faced by an entrant if the SMP market were in fact contestable. The approach is most appropriate for those services or parts of the network where assets can be potentially replicated by entrants. The MEA approach fits well with the principle of effective competition, and fits well with dynamic and productive efficiency (because regulated rates are not based on incurred costs but modelled costs).

A11.57 However, the MEA approach does not always fit well with allocative efficiency. This is because the MEA approach will involve placing a value on all assets in the ground, and so even sunk assets will be valued on a replacement cost basis, even if they would not be replaced during the period of assessment (i.e. the control period) or even in the foreseeable future.[20]

A11.58 As noted above, none of the four largest MCPs currently operates VoLTE services, they are not discussed in the 2009 EC Recommendation, and have not been included in MCT models constructed by other European NRAs. However, as we note in paragraph A11.18 the evidence we have is consistent with VoLTE being included in the 2014 MCT model[21], and as such we consider it to be an "efficient technolog[y] available in the timeframe considered by the model", as envisaged in the 2009 EC Recommendation. Furthermore we note that no stakeholders have suggested to us that VoLTE should not be included in the 2014 MCT model.

A11.59 In support of this view we note that VoLTE has been deployed commercially in some countries, for example in South Korea, Hong Kong, and recently the USA.[22,23] We understand that some devices already in the market have the hardware capability to support VoLTE, which could be enabled through a software upgrade.[24] We expect that as VoLTE is rolled out by more networks, device manufacturers will release more VoLTE-enabled devices, or provide software upgrades for existing devices to enable VoLTE.

A11.60 For these reasons, we propose that VoLTE should be included in the 2014 MCT model, and the base case includes VoLTE services. The effect of excluding VoLTE is shown in our sensitivity analysis in Annex 16.

Summary of technology choice proposals

A11.61 As explained above we propose to model a hypothetical average efficient MCP, using a combination of 2G, 3G and 4G technologies, including VoLTE.

[20] What matters for economic efficiency is marginal costs, defined as the costs causally related to the output including the reduction in the productive capability of assets due to current consumption. (See Khan, 1993*, The Economics of Regulation: Principles and Institutions (5th printing),* The MIT Press, pp 71-73).

[21] [✂].

[22] TeleAnalysis reported in January that six Operators had already launched VoLTE with more operators trialling it or being in the process of deploying it. See http://www.teleanalysis.com/uncategorized/40-operators-in-different-stages-of-volte-deployment-4613.html.

[23] T-Mobile US announced that it has enabled VoLTE in Seattle (http://multimediacapsule.thomsonone.com/t-mobileusa/t-mobile-brings-voice-over-lte-to-seattle), while AT&T has enabled VoLTE in four US states (http://www.att.com/shop/wireless/services/hd-voice.html#fbid=BZJiq5qpZyX).

[24] For example, T-Mobile US customers using any of LG G Flex, Samsung Galaxy Note 3, or Samsung Galaxy Light can enable VoLTE by updating their devices on the latest software. See http://multimediacapsule.thomsonone.com/t-mobileusa/t-mobile-brings-voice-over-lte-to-seattle.

A11.62 We consider that this approach is consistent with our framework for technology choice, the approach adopted in previous MCT reviews, relevant technological developments since the last review, and the 2009 EC Recommendation.

Treatment of inflation

A11.63 As set out in Section 8, inflation is used as an input to the MCT charge control in two respects:

- First, to determine how the cap on charges is updated each year (e.g. in the form of a CPI+/-X charge control); and
- Second, when setting a charge control based on forecast costs, the cost inputs will typically be forecast to vary over time (and the cost of different inputs will vary in different ways – e.g. equipment operating costs may vary differently from equipment replacement costs).

A11.64 Section 8 explains that we considered the use of RPI and CPI inflation for the purposes of the charge control formula, and how we have taken account of stakeholder views on this topic. We consider that the CPI measure of inflation is preferable. In order to ensure consistency between this and the cost model we propose to also use CPI to deflate nominal costs, from which we then project the evolution of operating and capital cost price trends (including the WACC).

A11.65 We have derived a time series of CPI inflation from three sources:

11.65.1 CPI data are available from the ONS from 1997 onwards and are used for the years 1996/7 to 2012/13.[25]

11.65.2 For the period prior to 1996/7 we have estimated CPI using the average difference between the ONS data explained above and the inflation time series in the 2011 MCT model (over the period 1996/97 to 2012/13).[26]

11.65.3 For 2013/14 onwards we use the Bank of England CPI inflation target of 2% as a forecast of long run CPI inflation.[27]

A11.66 Consistent with this use of CPI inflation we propose to use an updated real WACC which is based on deflating the nominal WACC by CPI, as explained in Annex 14. This requires us to adjust the WACC values from earlier MCT models to CPI terms to produce a consistent time series which is used as a real discount rate.[28]

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[25] See Table 6b (D7G7) of the ONS Consumer Price Inflation Tables: See ONS, *Consumer Price Inflation – December 2013,* published 14 January 2014. http://www.ons.gov.uk/ons/rel/cpi/consumer-price-indices/december-2013/consumer-price-inflation-reference-tables.xls. We use April to April changes over the prior 12 months to derive data in financial years. We will update this to include data for 2013/14 when we publish the MCT model that accompanies our 2015 MCT review Statement.

[26] The average difference is 0.6 percentage points.

[27] See http://www.bankofengland.co.uk/monetarypolicy/Pages/framework/framework.aspx.

[28] The real discount rate in the 2011 MCT model took a different value in each of the years 1990/91 to 2000/01, and then changed with the construction of successive MCT models in 2003/4, 2006/7 and 2009/10. We adjust the old values of the WACC in each of these years using expected inflation at those times, meaning that it remains constant through each of the prior charge control periods. This is calculated as: $CPI\ real\ discount\ rate_t = \left[(1 + 2011\ MCT\ real\ discount\ rate_t) \times \frac{(1+2011\ MCT\ inflation_t)}{(1+CPI\ inflation_t)}\right] - 1$, where t refers to each of the years in which prior MCT models were updated, as explained above.

Summary of major changes to model

A11.67 The starting point for the 2014 MCT model was the 2011 MCT model. The changes we have made in developing the 2014 MCT model fall into the following three categories:

11.67.1 Those requiring updates purely to reflect the passage of time;

11.67.2 Those requiring modifications to existing model functionality; and

11.67.3 Those requiring the addition of new functionality.

A11.68 The major changes made under each of these headings are explained in the following sub-sections.

Updates to reflect the passage of time

A11.69 Input data and assumptions that require updating to reflect the passage of time include:

11.69.1 The use of updated traffic forecasts, which are explained in paragraphs A11.85 to A11.180 below;

11.69.2 The use of updated unit equipment capital and operating costs and cost trends, which are explained in Annex 12;

11.69.3 The use of an updated estimate of the WACC, which is explained in Annex 14.

Changes requiring modifications to existing model functionality

A11.70 The key changes since the 2011 MCT model that require modifications to existing functionality are:

11.70.1 The inclusion of additional (higher speed) HSPA developments;

11.70.2 The inclusion of additional (higher speed) backhaul developments;

11.70.3 The inclusion of upgrades to the core network in terms of MSS/MGW deployment and core transmission;

A11.71 These changes all affect the network module of the model, which is explained in detail in Annex 12.

Changes requiring the addition of new functionality

A11.72 The key changes since the 2011 MCT model that require the addition of new functionality are:

11.72.1 The inclusion of 4G network modelling;

11.72.2 The inclusion of VoLTE services;

11.72.3 The inclusion of Single-RAN (S-RAN) radio technology; and

11.72.4 Infrastructure sharing of active equipment (we only included passive equipment sharing in the 2011 MCT model).

A11.73 We have also considered whether it is necessary to include femtocells in the 2014 MCT model. As explained in Annex 12, Analysys Mason has tested whether this functionality is required in the model and, based on their analysis, we consider that its inclusion would not be proportionate.

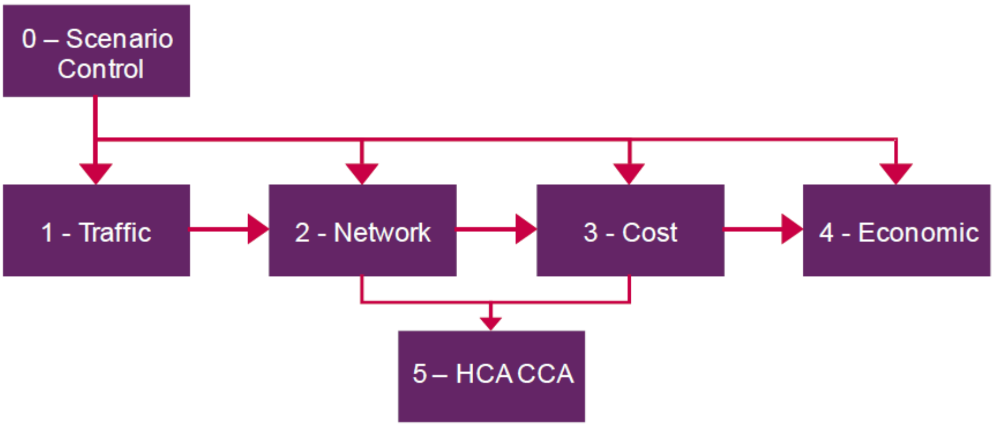
A11.74 Again, these changes all affect the network module of the model, which is explained in detail in Annex 12.

Model structure, calculation and outputs

Model structure

A11.75 The 2014 MCT model comprises six modules, each of which is a separate Excel workbook (a separate Excel file), as shown in Figure A11.1 below.

Figure A11.1: Structure of the 2014 MCT model



Source: Ofcom.

A11.76 The functions of these modules and the linkages between them are as follows:

- The **'Scenario Control'** module defines and allows the selection of the model scenarios and sensitivities. It also contains a summary of the key results.
- The **'Traffic'** module contains the service demand forecasts and network coverage assumptions.
- The **'Network'** module contains network dimensioning algorithms and forecasts the quantities of 2G, 3G and 4G network equipment required to provide network coverage and meet service demand ahead of time.
- The **'Cost'** module uses the calculated equipment quantities (as derived in the network module) and unit equipment prices to calculate network costs (both capital and operating) over time.

- The **‘Economic’** module calculates service costs from the forecast network costs, based on economic depreciation. The outputs of this module form the model results.

- The **‘HCA CCA’** module calculates the accounting cost of the network based on historic cost accounting (HCA) and current cost accounting (CCA) approaches. Outputs from this module are used for the purposes of model calibration only, as explained in Annex 13.

A11.77 The ‘Scenario control’, ‘Traffic’, ‘Economic’ and ‘HCA CCA’ modules have been developed by Ofcom. Each of these modules is explained in detail in their individual subsections below. Overviews are also provided for the ‘Network’ and ‘Cost’ modules, which have been developed by Analysys Mason. Full details of the network and cost modules are provided in an Analysys Mason report in Annex 12.

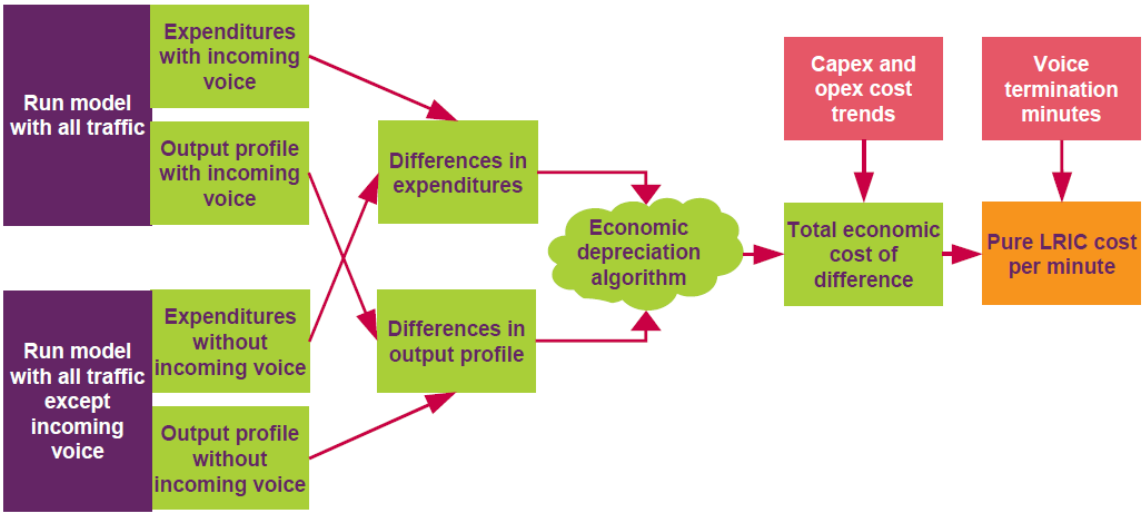
Model calculation

A11.78 The model calculates the LRIC of MCT using a decremental approach. Consistent with the 2009 EC Recommendation this involves considering MCT as a ‘final increment’ with no common costs (such as the common costs of a ‘coverage network’) being allocated to MCT.

A11.79 The incremental costs associated with MCT traffic are derived by first calculating the model outputs (service demand, asset volumes and cash flows for each network element) with MCT included and, second, with MCT traffic excluded. The incremental service demand, asset volumes and cash flows for each network element are then used as inputs to the economic depreciation (ED) algorithm. The outputs of this algorithm are combined with the network element usage factors to determine the LRIC of a minute of MCT.

A11.80 The calculation flow used to determine LRIC is shown in Figure A11.2 below (with MCT referred to as ‘incoming voice’ in the flow chart).

Figure A11.2: How the LRIC of MCT is calculated



Source: Ofcom.

Model outputs

A11.81 The outputs of the 2014 MCT cost model are unit costs (either LRIC or LRIC+) in each year for MCT. The model works in real terms using CPI inflation indexed to 2012/13 prices, and all outputs are stated on this basis.

Scenario control module

A11.82 The scenario control module contains the main parameters that affect the cost of MCT. These parameters then feed through to all other relevant modules.

A11.83 The *Scenario* worksheet in the module is constructed to allow the user to choose between different scenarios, with a macro enabling the calculation of either LRIC+ or LRIC results pertaining to these scenarios.

A11.84 The *Outputs* worksheet contains the most important results from the model.

Traffic module

Introduction

A11.85 The traffic module uses demand forecasts and network coverage assumptions to derive service traffic forecasts which are used in the Network module to dimension the 2G, 3G and 4G networks. This method is largely unchanged from the 2011 MCT model with the exception of the addition of 4G. This subsection describes in detail the data and assumptions used to produce the service demand forecasts in the 2014 MCT model.

Traffic forecasts

A11.86 There have been many changes in the mobile market since the 2011 MCT model was developed. The usage of services has differed from the forecasts in the 2011 MCT model, and 4G services have been introduced. Reflecting these developments all of the demand forecasts have been updated. The 2014 MCT model has the functionality to model the hypothetical network over the period to 2039/40; however we only include explicit traffic forecasts to Q4 2025/26 after which volumes are held constant.

A11.87 The model uses a forecast of subscriber numbers and forecasts of the demand for each modelled service per subscriber to derive total demand for each service. We have generated ‘High’, ‘Medium’ and ‘Low’ forecasts for each of the services listed in paragraph A11.89 below. These input forecasts are formulated with reference to:

- Historical data provided by the four largest MCPs (updated for the period Q2 2010/11 to Q2 2013/14);
- Forecast data provided by the four largest MCPs (up to Q4 2017 where possible);
- Third party reports, forecasts and other Ofcom work (used as cross checks); and
- Other relevant indicators in the absence of historical data such as for 4G services – e.g. 4G data usage caps on current retail tariffs provide a useful indicator as to potential limits on 4G data growth in the future.

A11.88 Some stakeholders also commented on the forecasts included in our draft MCT model published for the January 2014 workshop. These responses are summarised under the description of the relevant services, and in each case we provide a response making clear any changes we have made to our forecasts as a result.

A11.89 The traffic module produces the total demand over the modelled network for each of the following services:

i) 2G incoming, outgoing and on-net voice calls;

ii) 2G SMS[29] and MMS[30];

iii) 2G packet data;

iv) 3G incoming, outgoing and on-net voice calls;

v) 3G SMS and MMS;

vi) 3G handset packet data;

vii) 3G datacard[31] packet data;

viii) 4G incoming, outgoing and on-net voice calls;

ix) 4G SMS and MMS;

x) 4G handset packet data; and

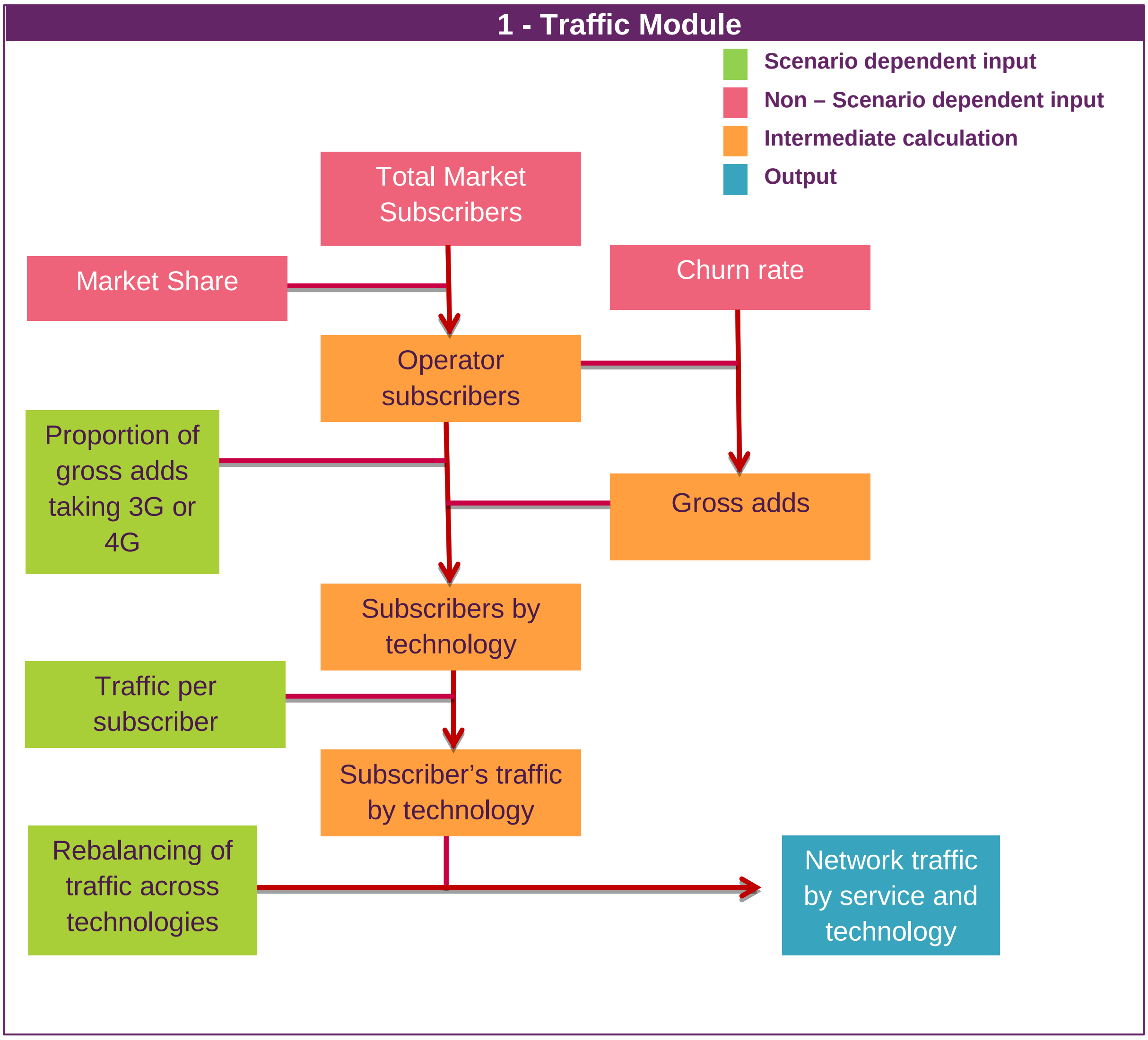
xi) 4G datacard packet data.

[29] By ‘SMS’ we refer to individual text messages sent or received using the Short Message Service.
[30] By ‘MMS’ we refer to individual messages with multimedia content sent or received using the Multimedia Messaging Service.
[31] Datacards includes all devices capable of transmitting and receiving data excluding handsets and Machine to Machine (M2M) devices.

Method for calculating traffic volumes

A11.90 An outline of the calculations contained in the Traffic module is shown in Figure A11.3 below.

Figure A11.3: Summary of Traffic Module calculations



Source: Ofcom

Subscriber numbers

A11.91 The starting point for the traffic forecasts is to forecast subscriber numbers. This is done separately for handset subscribers and datacard subscribers because we consider that these two groups of users have inherently different usage patterns.

A11.92 The forecast for the total number of mobile subscribers is based on a forecast of the UK population and SIM penetration, as explained below. Historic data are used to calculate a penetration rate for handsets and datacards individually; these are then forecast forward subject to a saturation point constraint. This total subscriber base is then translated into a defined number of subscribers for the modelled network using the assumed market share for the average efficient MCP.

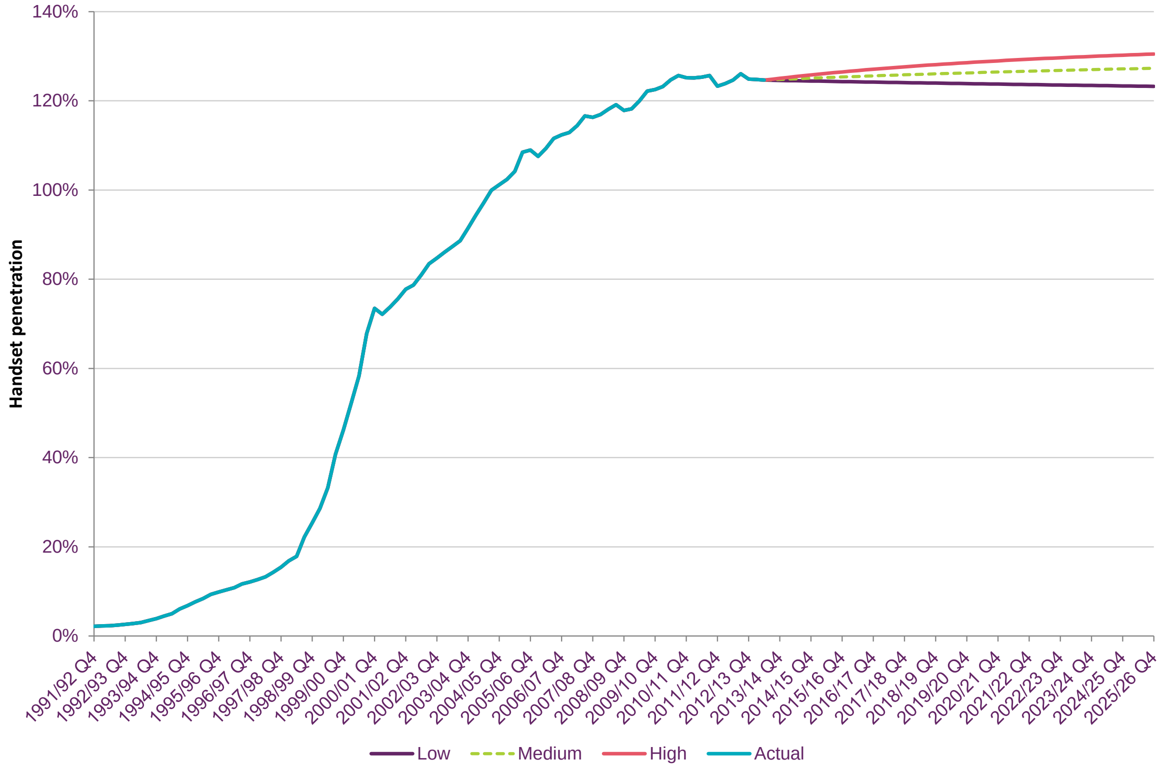
A11.93 In the 2014 MCT model we have updated the population figures used in the calculation of subscriber numbers. Previously we used data provided by the Economist Information Unit, however we now use historic and forecast population figures from ONS.[32] We note that the ONS forecasts slightly stronger growth than the data used in the 2011 MCT model. The effect of this change in the 2014 MCT model, using our medium handset penetration forecast, is to increase the total subscriber base by less than 1% in 2020/21.

SIM penetration

Handsets

A11.94 Handset SIM penetration has continued to grow over the period from 2010/11 to 2013/14 reaching almost 125%. Under our medium demand scenario we anticipate this growth will continue until a saturation point of 127% is reached in 2025/26. Our forecast under the high scenario is for stronger growth in penetration, reaching 130% by Q4 2025/26. Under our low demand scenario we forecast penetration to fall slightly to 123% by Q4 2025/26.

Figure A11.4: Mobile handset SIM penetration



Source: Ofcom 2014 MCT model.

Datacards

A11.95 At the time of the 2011 MCT review datacards were only available based on 3G technology, but are now readily available based on 4G technology. In the 2014

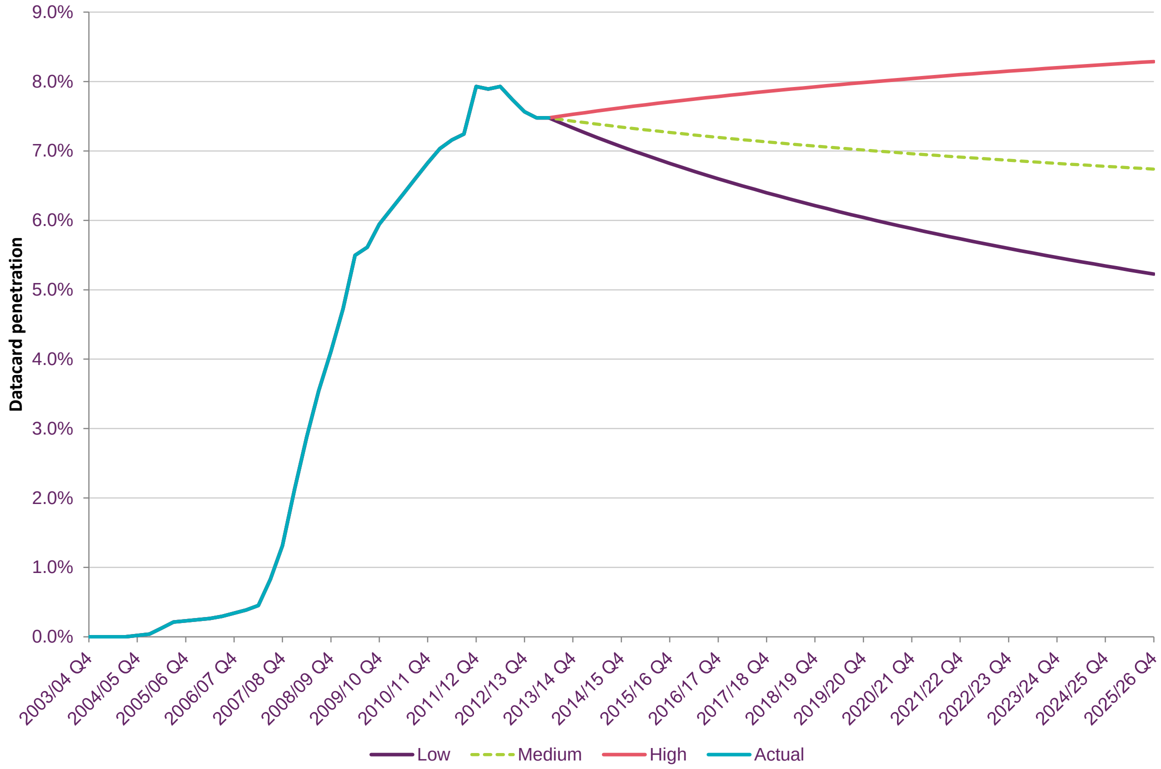
[32] ONS, *Summary: UK Population Projected to Reach 70 Million by Mid-2027*, released 26 October 2011. http://www.ons.gov.uk/ons/rel/npp/national-population-projections/2010-based-projections/sum-2010-based-national-population-projections.html

MCT model we therefore continue to forecast penetration of datacards, but in addition we now forecast the proportion of total datacards which are based on 3G technology or 4G technology.

A11.96 In the 2011 MCT model historical data showed growth in 3G datacards, and we forecast that this would continue with strong growth seeing penetration rates reaching around 27% by the end of 2020/21. We have now updated actual data for the period Q1 2010/11 to Q3 2013/14 which shows that growth slowed dramatically, with penetration rates levelling off at around 8%, and then dropping slightly. We consider that with the introduction of 4G technology some current datacard users may choose to use a 4G handset and tether this for their data needs, negating the need for a separate datacard.

A11.97 As a result, and as shown in Figure A11.5 below, our medium scenario forecasts datacard penetration to fall slightly, declining to just below 7% by 2025/26. Our low forecast is for a more significant drop, continuing at the same rate that has occurred over the past year. This results in a penetration rate of just above 5% in 2025/26. Our high scenario shows slight growth, reaching a similar level to that in 2010/11 by 2025/26. The growth shown in our high demand scenario is on the assumption that increasing demand for data heavy applications whilst on the move will increase uptake of datacards.

Figure A11.5: Datacard penetration



Source: Ofcom 2014 MCT model.

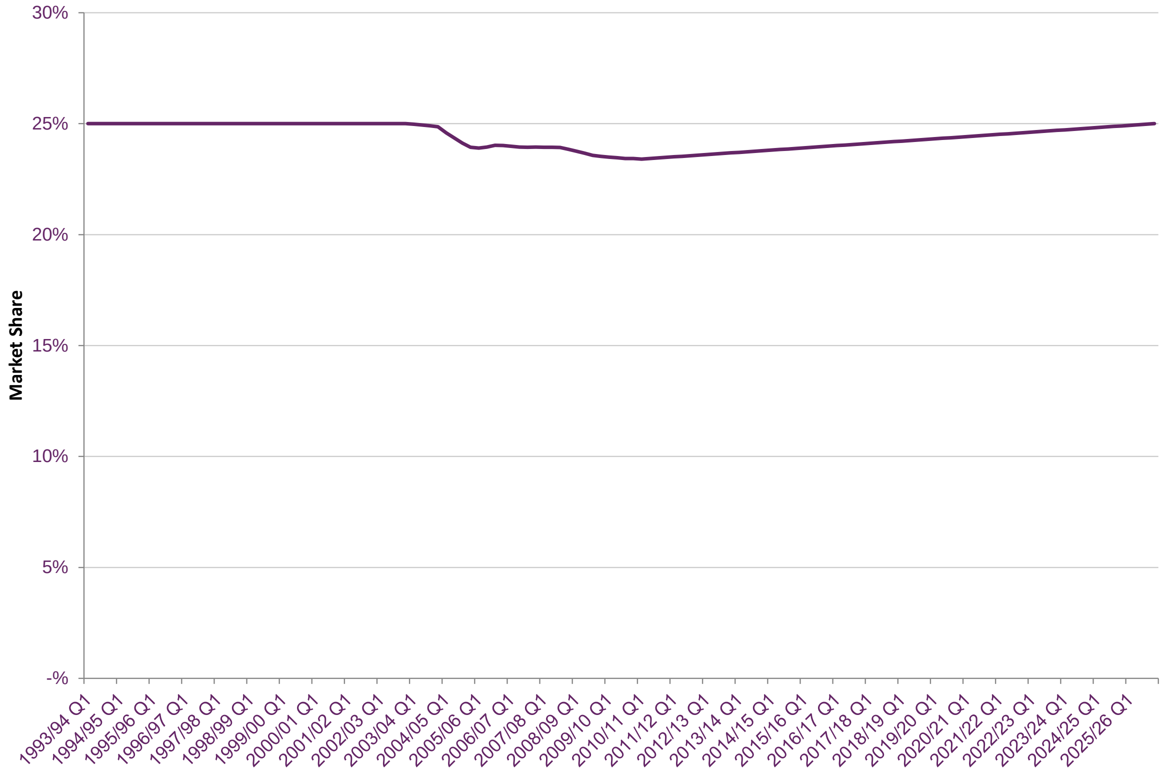
<u>Market share</u>

Handsets

A11.98 Our assumption for our modelled MCP's market share profile for handsets is identical to that used in the 2011 MCT model except we have adjusted the trend from the lowest point (in Q1 2010/11) to reach 25% by the end of 2025/26 rather than the end of 2020/21. This change is to reflect that the 25% market share is a long term assumption and should be reached by the end of the modelling period.

A11.99 Prior to 2003/04, market share is assumed to be 25% (corresponding to four players). Following the entry of a 3G only operator in 2003/04 market share begins to trend downwards towards 20% in the long run (corresponding to five players). However, due to the merger (via a joint venture) between Orange and T-Mobile we considered it appropriate to truncate this evolution and move back towards a 25% long run market share (corresponding to four players). Accordingly, from Q1 2010/11 onwards market share increases back towards 25% by the end of 2025/26. This is shown below in Figure A11.6.

Figure A11.6: Handset market share evolution



Source: Ofcom 2014 MCT model.

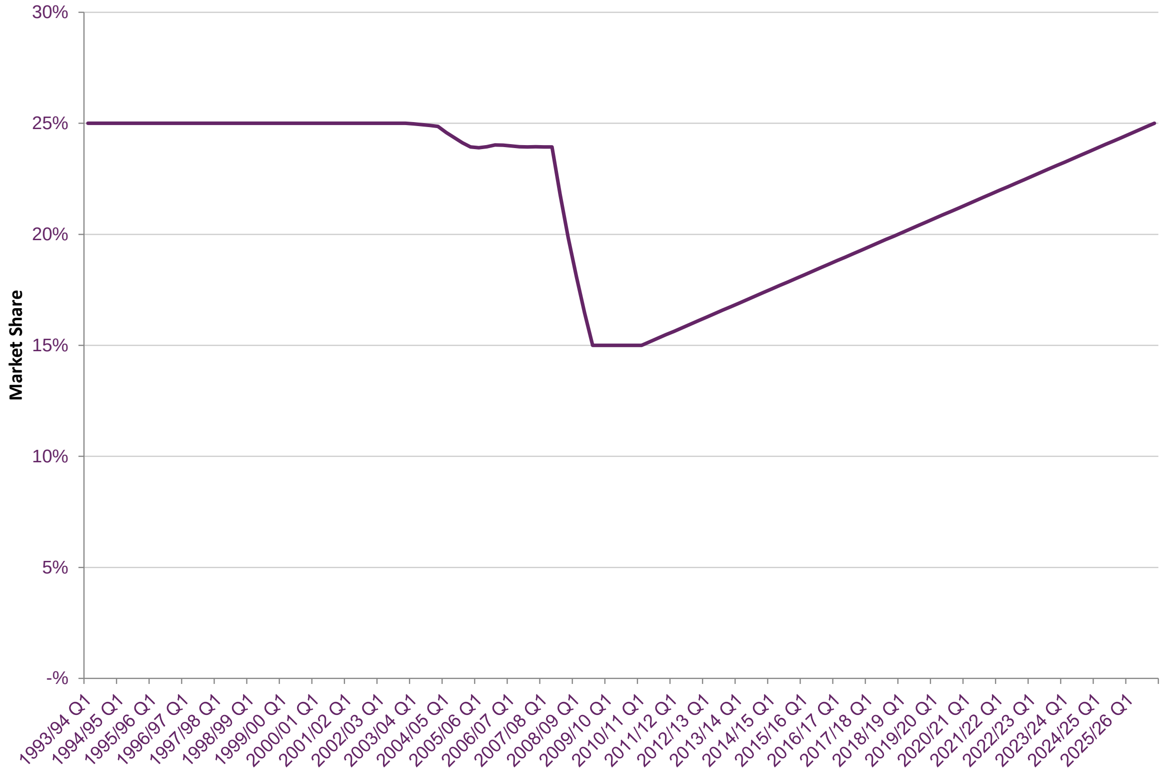
Datacards

A11.100 Following the appeal of the March 2011 Statement, we used a different market share assumption for datacards than that used for handsets in the revised charge controls currently applicable to March 2015.[33] This was to reflect the fact that H3G had a much greater share of the datacard market than the other MNOs and therefore data traffic accounted for a larger proportion of total traffic for H3G than for the 2G/3G MCPs.

[33] The CC determined that Ofcom should assume a different market share for datacards and handsets in the 2011 MCT model. Full CC Determination available athttp://www.catribunal.org.uk/files/1.1180-83_MCT_Determination_Excised_090212.pdf See the response to reference question 3, paragraphs 4.138 – 4.144.

A11.101 In the 2014 MCT model the datacard market share is set at the same level as the handset market share until 2007/08 Q3. From this point onwards, the datacard market share gradually decreased to 15% by 2008/09 Q3, remaining constant at 15% until 2010/11 Q1. Thereafter it increases gradually to reach 25% by 2025/26. The datacard market share evolution is shown in Figure A11.7 below.

Figure A11.7: Datacard market share evolution



Source: Ofcom 2014 MCT model.

Stakeholder responses to the October 2013 workshop

A11.102 EE suggested that Ofcom should as a starting point use a market share assumption of 20% in its model (in accordance with the 2009 EC Recommendation).[34] H3G commented that it was important to adopt a market share that is comparable to the top down information used as part of the calibration of the model.[35]

Ofcom response

A11.103 We do not agree with using a 20% market share given that this would not reflect the number of large national MCPs currently competing in the market. Therefore, we have taken the same approach as in the 2011 MCT model.

[34] EE response to October 2013 workshop, http://stakeholders.ofcom.org.uk/binaries/telecoms/policy/mobile/EE_MCT_Market_Review.pdf.
[35] H3G response to October 2013 workshop, http://stakeholders.ofcom.org.uk/binaries/telecoms/policy/mobile/Threes_Response_to_Ofcom_MCT_market_review_workshop.pdf.

A11.104 In response to H3G's comments on market share, our approach to calibration is explained in Annex 13 and takes account of a number of factors including market share.

Handset migration

A11.105 The rate of migration from 2G-only to 3G-enabled handsets has been revised significantly since the 2011 MCT model due to the introduction of 4G handsets. In the 2011 MCT model, we assumed that the proportion of new handsets that are 3G enabled would reach 80% by 2020/21, up from 54% in Q4 2009/10.

A11.106 However, 4G tariffs bundled with 4G-enabled handsets began to become available in 2012.[36] Therefore, in the 2014 MCT model we have revised our forecasts for 3G handsets downwards, and forecast growth in the take-up of 4G-enabled handsets[37]. We now expect that the proportion of new handsets that are 3G-enabled (but not 4G enabled) to reach a peak of 76% by the end of 2013/14, with the proportion of new handsets which are 4G-enabled growing to a peak of 95% by 2020/21. These changes are shown in Figure A11.8 below.

A11.107 The calculation of the number of new handsets requires an assumption of the market (average) rate of subscriber churn. This parameter changes slightly over time, but is relatively stable around 40% per annum[38]. This dictates the pool of subscribers which obtain a new handset in each quarter, and therefore the transition of subscribers from 2G to 3G, 3G to 4G and 2G to 4G[39]. The evolution of subscriber churn has been updated for the period 2010 – 2013 and then remains constant through to 2025/26.

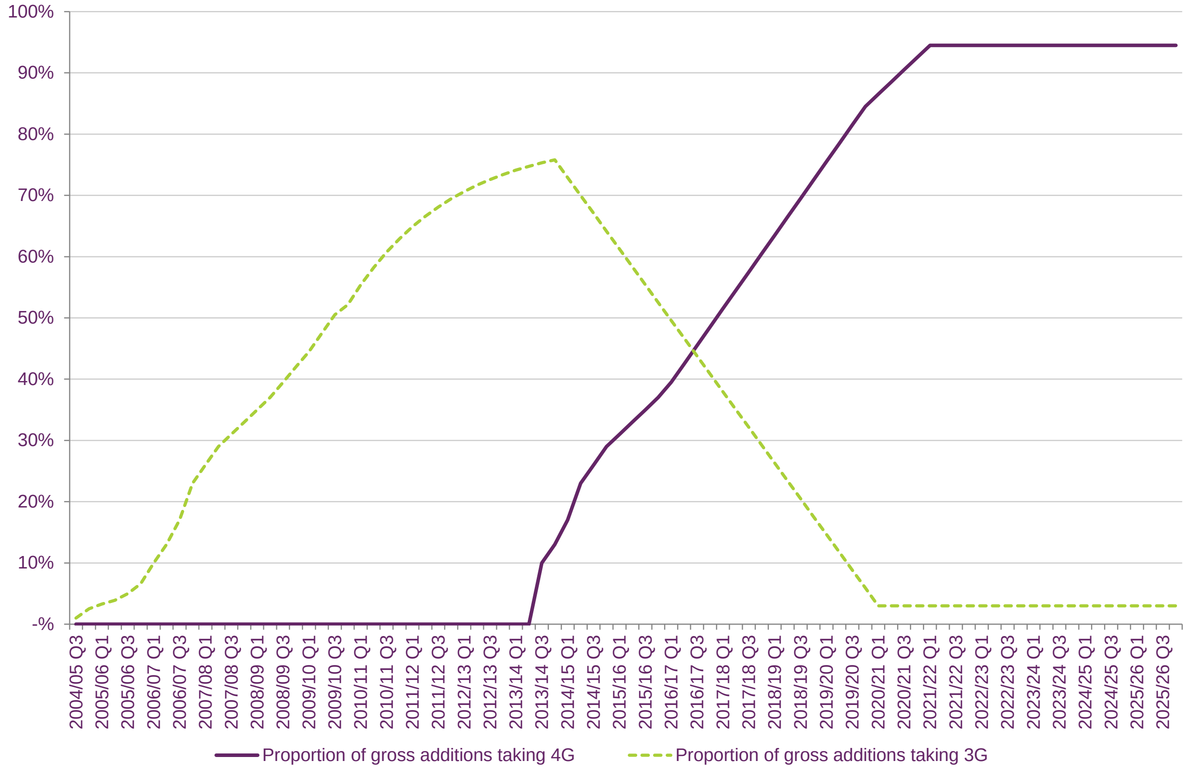
[36] EE launched its 4G network and tariffs on 30 October 2012 in 11 cities across the UK, http://www.theguardian.com/technology/2012/oct/29/ee-launches-uk-4g-mobile-network

[37] Any subscriber with a 4G enabled device will also be able to access services over 3G. Additionally in the case of handsets, any subscriber with a 4G or 3G enabled handset will also be able to access services over 2G).

[38] Source: Ofcom Market Intelligence

[39] We do not hold data on handset churn rates so we use subscriber churn as a proxy. Subscriber churn does not include those subscribers who purchase a new handset without changing contract, which other things being equal would lead to a higher churn rate. However there is also an opposing effect which is not taken into account – subscribers who take out new contracts but keep their existing handset. As a result of these opposing effects on handset churn, we consider subscriber churn provides a suitable proxy.

Figure A11.8: Forecast migration to 3G-enabled and 4G-enabled handsets



Source: Ofcom 2014 MCT model

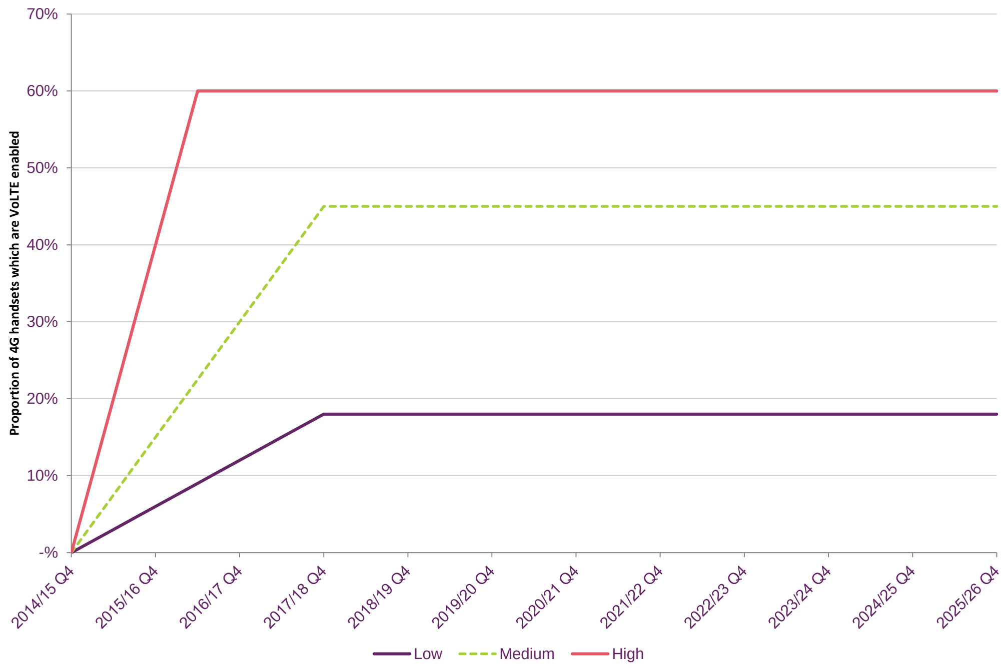
VoLTE enabled handsets

A11.108 The 4G-enabled handsets referred to above are those which are 4G data enabled but do not necessarily support VoLTE. Currently, VoLTE is supported by a small subset of the 4G data enabled handsets.[40] We expect that the percentage of VoLTE-enabled 4G handsets will increase once MCPs roll out a VoLTE service. In the 2014 MCT model we have reflected this by including a parameter for the take-up of VoLTE enabled handsets. The effect of this parameter (when it is set to less than 100%) is for voice traffic originated on a 4G enabled device which does not support VoLTE to be routed over the 3G network, therefore appearing as a 3G voice call in our model.

A11.109 The 2014 MCT model includes a low, medium and high scenario for the proportion of 4G devices which are VoLTE enabled. Our medium forecast predicts that 45% of 4G handsets will support VoLTE by the end of 2017/18, after this point it remains constant at 45%. Our high scenario predicts a faster take-up of VoLTE enabled handsets, with 60% of 4G handsets being VoLTE enabled by Q1 2016/17. Our low scenario predicts significantly lower take-up of VoLTE enabled handsets, with less than 20% of 4G handsets supporting VoLTE by the end of 2017/18.

[40] The Global mobile Suppliers Association (GSA) reports that less than 10% of the 4G handsets support VoLTE. (http://www.gsacom.com/downloads/pdf/GSA_lte_ecosystem_report_190314.php4)

Figure A11.9: Proportion of 4G handsets which are VoLTE enabled



Source: Ofcom 2014 MCT model

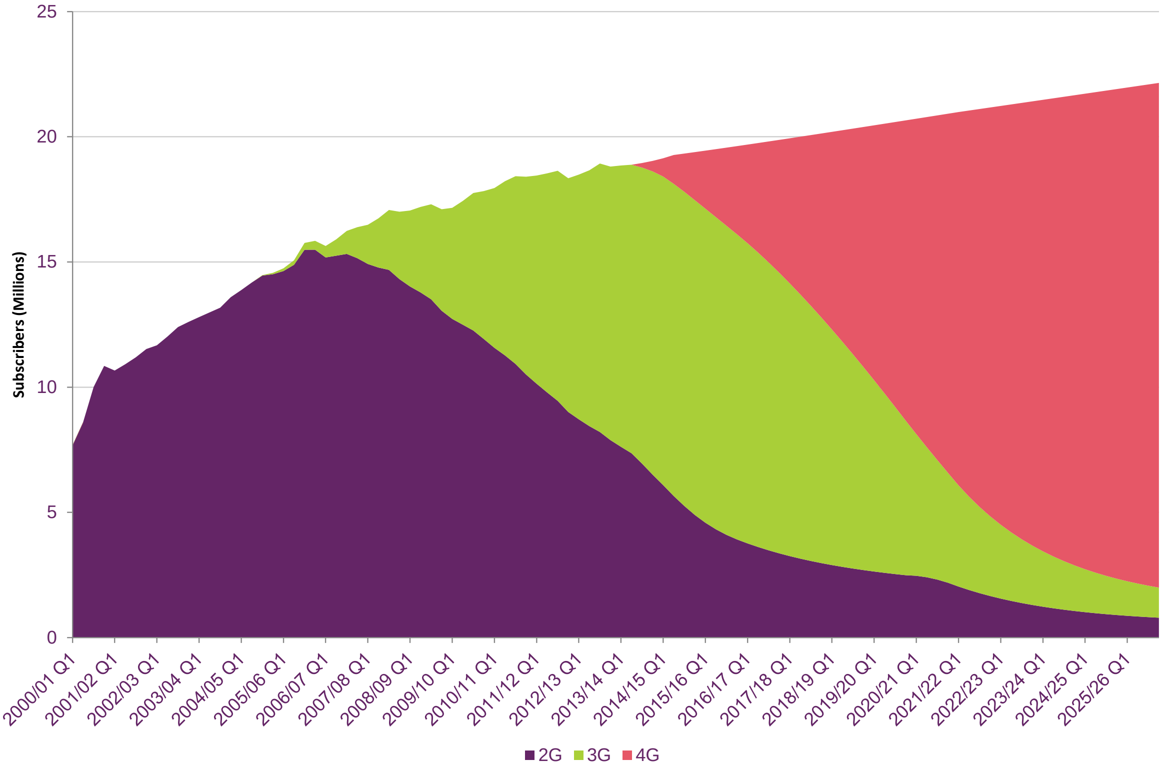
<u>Datacard migration</u>

A11.110 We have modelled the migration of datacard users from 3G to 4G technology in a relatively simple way – we have assumed a transition period where we have forecast the proportion of datacards which are either 3G or 4G enabled. We consider it would not be appropriate to model migration between the two technologies in the same way as we have done with handsets because we have concerns over whether historical churn data are likely to be reliable indicators of future churn rates. We believe that datacard churn is likely to be low relative to handsets, with most users changing their datacard in response to the availability of a new technology. Given there has not been a prior period of technology change for datacards, we do not consider there is any robust basis to inform future churn rates.

<u>Total subscribers of handset based services</u>

A11.111 Using the input parameters discussed above the model calculates the number of subscribers of the average efficient MCP. It also categorises these as a 2G subscriber, a 3G subscriber or a 4G subscriber. The total subscribers of the average efficient MCP under the medium demand scenarios are shown in Figure A11.10 below.

Figure A11.10: Modelled handset subscribers by technology



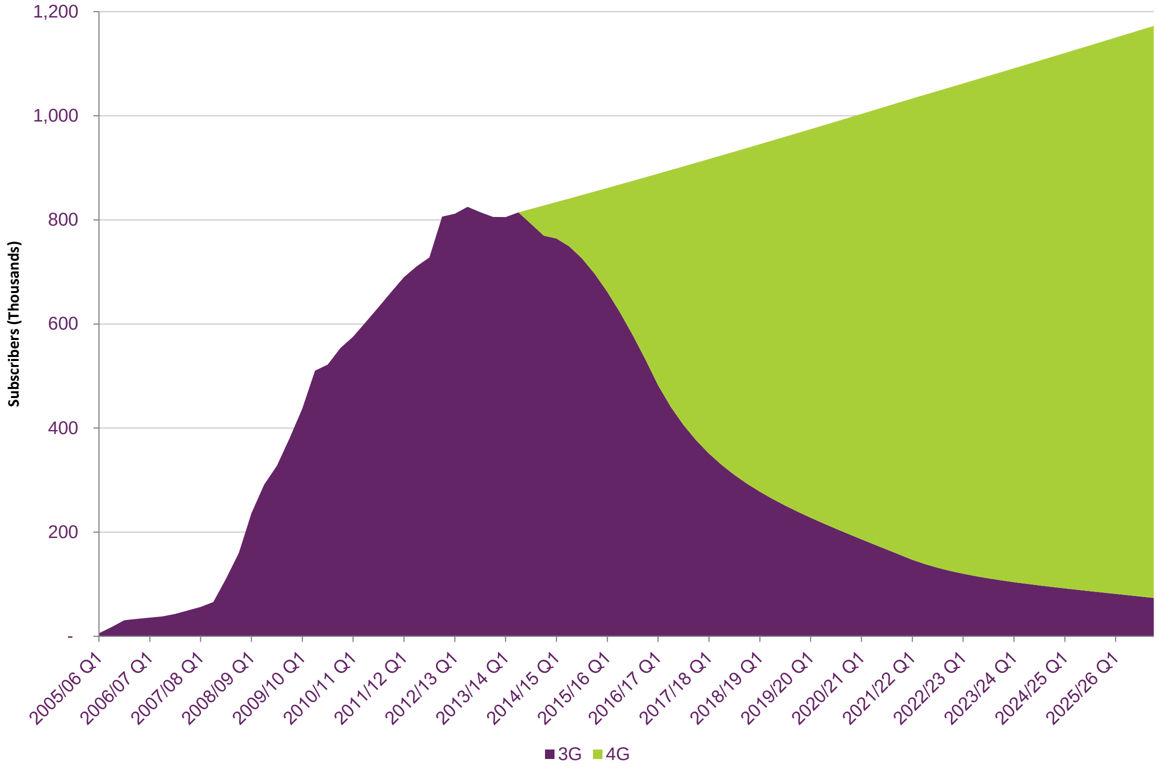
Source: Ofcom 2014 MCT model.

Total subscribers of datacard services

A11.112 Using the input parameters relevant for datacards discussed above, the model calculates the number of subscribers for the average efficient MCP. These are categorised as either a 3G or a 4G subscriber.[41] The datacard subscriber base under our medium datacard penetration scenario is shown in Figure A11.11 below.

[41] A 4G datacard subscriber is able to use both the 4G and 3G network.

Figure A11.11: Modelled datacard subscribers by technology



Source: Ofcom 2014 MCT model.

Outgoing voice usage per subscriber

A11.113 Having established subscriber numbers we next estimate outgoing voice, messaging and data service volumes on a per subscriber basis. For voice and messaging services our forecasts are the same across technologies, but our forecasts of data volumes vary by technology, with higher data forecasts for 4G than 3G, and in turn for 3G than 2G. The approaches used in each case are explained below.

A11.114 We note that all of our forecasts for voice, messaging and data usage are demand forecasts. In reality, due to handset capability, network coverage and any deliberate re-routing of traffic by MCPs, the actual traffic carried over the network may differ from the demand forecasts. We have captured this by ‘rebalancing’ the total demand taking into account these factors. This is discussed in more detail in paragraphs A11.173 to A11.176 below.

<u>Voice services</u>

A11.115 In the 2011 MCT model we forecast voice minutes per subscriber to continue to increase at a moderate growth rate throughout the period 2010/11 - 2012/13, thereafter they were expected to remain fairly level at around 165 minutes per month per subscriber. The updated actual data for the period 2010/11 – 2013/14 shows that voice minutes per subscriber have remained relatively flat at the 2010/11 levels, increasing only slightly to 140 minutes per month per subscriber. This is closer to our low forecast in the 2011 MCT model in which we forecast that voice minutes per subscriber would reach 145 minutes per month by 2013/14 and then remain constant.

A11.116 We expect that a number of key factors will influence how voice usage changes in the future, in particular we have identified the following:

- Increasing availability of larger inclusive call packages, including unlimited voice bundles. This would be expected to increase voice usage (other things being equal);
- Potential substitution from fixed call origination to mobile call origination;[42]
- Increasing use of OTT voice services and VoWiFi. This would be expected to reduce the amount of identifiable voice traffic passing over the network (other things being equal); and
- Increasing use of other forms of communication (e.g. social networks, text based messaging). This would be expected to reduce voice usage (other things being equal).

A11.117 Our medium scenario forecast predicts that voice usage will grow slowly. This is based on the assumption that the effect of larger voice bundles and potential substitution from fixed to mobile calls increases usage for the average subscriber to such an extent as to dominate the effects of the other two factors. The medium scenario forecasts voice minutes per subscriber to grow modestly to reach 146 minutes per month by 2025/26.

A11.118 Our high scenario forecasts voice minutes per subscriber to reach 162 minutes per month by 2025/26. This is based on the assumption that usage increases due to unlimited voice bundles, and that very little traditional voice migrates to OTT or other communications methods.

A11.119 In contrast to both the medium and high scenarios, our low scenario forecasts a decline in the average minutes of usage per month – falling to 126 minutes by 2025/26. This would be explained by increasing use of OTT and other forms of communications dominating any effect from unlimited traditional voice bundles. These three voice traffic scenarios are shown in Figure A11.12 below.

A11.120 We are aware of a discrepancy between the data provided in response to our section 135 information request (and used for the cost modelling) and the data published in Ofcom's latest telecoms data tables[43]. In particular, there is a difference between the historic voice usage shown in Figure A11.12 and that shown in Figure A9.11 in Annex 9 which is based on the latest telecoms data tables.

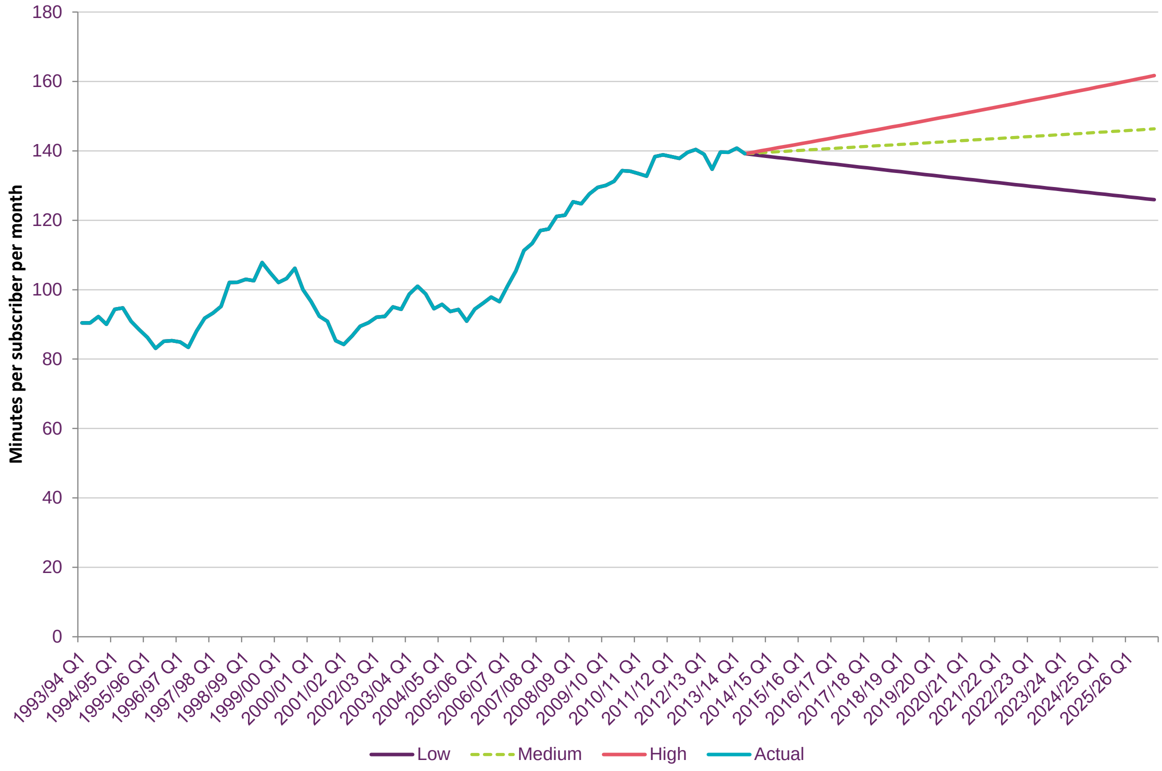
A11.121 We have investigated this with the largest MCPs who responded to our section 135 information request and it appears that the discrepancy is due to some of them omitting MVNO call minutes and subscribers from their total network minutes and total subscribers as requested. As a consequence the total call minutes reported in the 2014 MCT model in our base case are approximately 15% lower than those reported in the latest telecoms data tables.

[42] As noted in paragraph 3.42 of the 2013 FNMR Statement, mobile calls now account for more than half of total originated call minutes showing increasing substitution to mobile. However we also found that the level of mobile-only households was fairly stable, and most consumers have access to both mobile and fixed methods of communication.

[43] Ofcom Telecommunications Market Data Update Q4 2013 available at: http://stakeholders.ofcom.org.uk/market-data-research/market-data/communications-market-reports/tables/q4-2013/

A11.122 We plan to investigate this discrepancy before our statement is published. In the meantime, we have considered whether the apparently missing voice call origination data would affect the model outputs and we have conducted a test on the model to check how the outputs change should we increase voice call minutes to the levels suggested by the telecoms data tables. We have found that there is not a material effect on the LRIC outputs.[44]

Figure A11.12: Voice minutes per subscriber per month



Source: Ofcom 2014 MCT model.

Incoming and on-net voice usage

A11.123 The calculations explained in the preceding subsections forecast ‘outgoing’ traffic as the total of outgoing traffic to other networks (mobile and fixed) and on-net traffic. In order to derive the forecasts of incoming, outgoing (off-net) and on-net traffic required in the model further calculations are necessary.

A11.124 In order to split the outgoing traffic forecasts between traffic to other networks and on-net traffic we simply use an estimate of on-net traffic as a proportion of outgoing traffic. We have updated our estimates of this parameter using the evidence gathered from the four largest MCPs under our statutory powers, using historical

[44] We have performed this test by including additional ‘very low’ and ‘very high’ voice traffic scenarios in the model. These mirror the historical data until 2010/11, from which point onwards the ‘very low’ scenario reduces voice minutes per subscriber per month by 15%, and the ‘very high’ scenario increases them by the same amount. The impact of this on the LRIC results of the model sits within the range created by our voice usage sensitivity in Annex 16.

data for the past and using a traffic distribution to forecast this parameter in the future.[45]

A11.125 In order to calculate incoming voice traffic from our estimates of outgoing traffic we use an estimate of incoming traffic from other networks as a proportion of outgoing traffic. Again, we have updated our estimates of this parameter using the evidence gathered from the four largest MCPs under our statutory powers, using historical data for the past and using a traffic distribution to forecast this parameter in the future.[46] We have also conducted a cross check with Ofcom's 2013 FNMR model.[47]

A11.126 As a result we adjusted the ratio of fixed to mobile calls parameter to make it vary over time. Previously this was held constant, however to ensure consistency with the 2013 FNMR model this parameter now declines over time resulting in fewer fixed to mobile call minutes over the period 2011/12 to 2025/26. Whilst it is still difficult to compare directly between the two models due to differences in assumed market shares and included call types, we are confident that the fixed to mobile calls in each model are broadly consistent.

Comparisons across Europe

A11.127 In addition to basing our forecasts on historical trends and expectations of future behaviour, we have also compared our forecasts to a range of forecasts in other European countries. These comparisons show that our long term forecast for voice call usage sits comfortably within the range, and is of a similar trend to those forecasts across Europe.

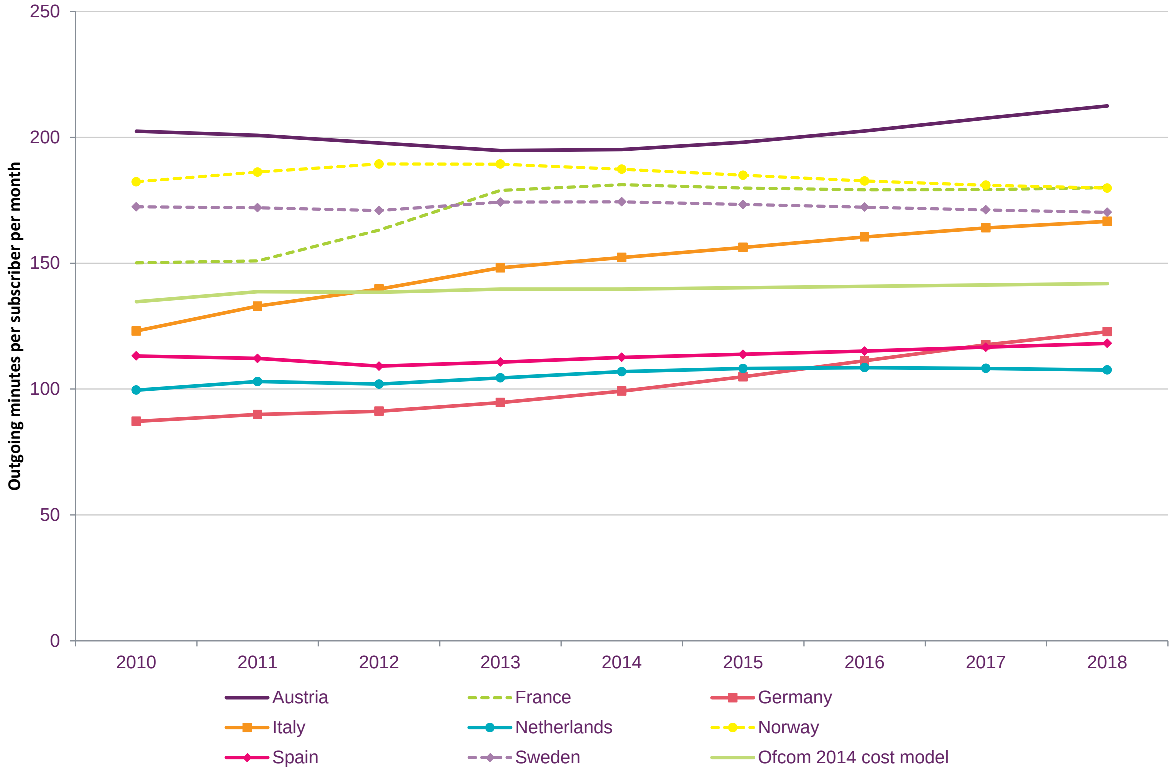
[45] Forecasts have been calculated from 2013/14 Q4, using the methodology from the 2011 MCT model. The proportion of on-net to outgoing traffic is calculated as forecasted traffic from own mobile network (relative to total mobile traffic) divided by total outgoing traffic (including traffic from fixed lines, other mobile networks and own mobile network).

[46] The proportion of incoming to outgoing traffic is shown by the following formula. .$\frac{incoming}{outgoing} = \frac{(Total\ fixed\ traffic * ratio\ of\ fixed\ to\ mobile\ calls) + (Traffic\ from\ other\ mobile\ network * ratio\ of\ offnet\ mobile\ to\ mobile\ calls)}{Total\ outgoing\ traffic}$

Incoming traffic is calculated as the traffic originating from the fixed network plus the traffic originating from other mobile networks. On-net traffic has been considered separately in A11.45.This is then divided by total outgoing traffic.

[47] http://www.ofcom.org.uk/static/models/ncc-model-13.zip.

Figure A11.13: Comparisons of monthly outgoing voice minutes per subscriber



Source: Western Europe telecoms market: interim forecast update 2013–2018, Analysys Mason

Stakeholder responses to the January 2014 workshop

A11.128 Following the January 2014 stakeholder workshop BT raised concerns over the proportion of incoming minutes from fixed lines that was assumed in the draft MCT model.[48]

Ofcom response

A11.129 In the draft MCT model the parameters affecting fixed to mobile calls had not yet been updated. These have now been updated and we have introduced a time variant element to the ratio of fixed to mobile calls parameter. The effect of this was to reduce fixed to mobile call minutes, ensuring consistency with the 2013 FNMR model. This is discussed in more detail in paragraph A11.125 above.

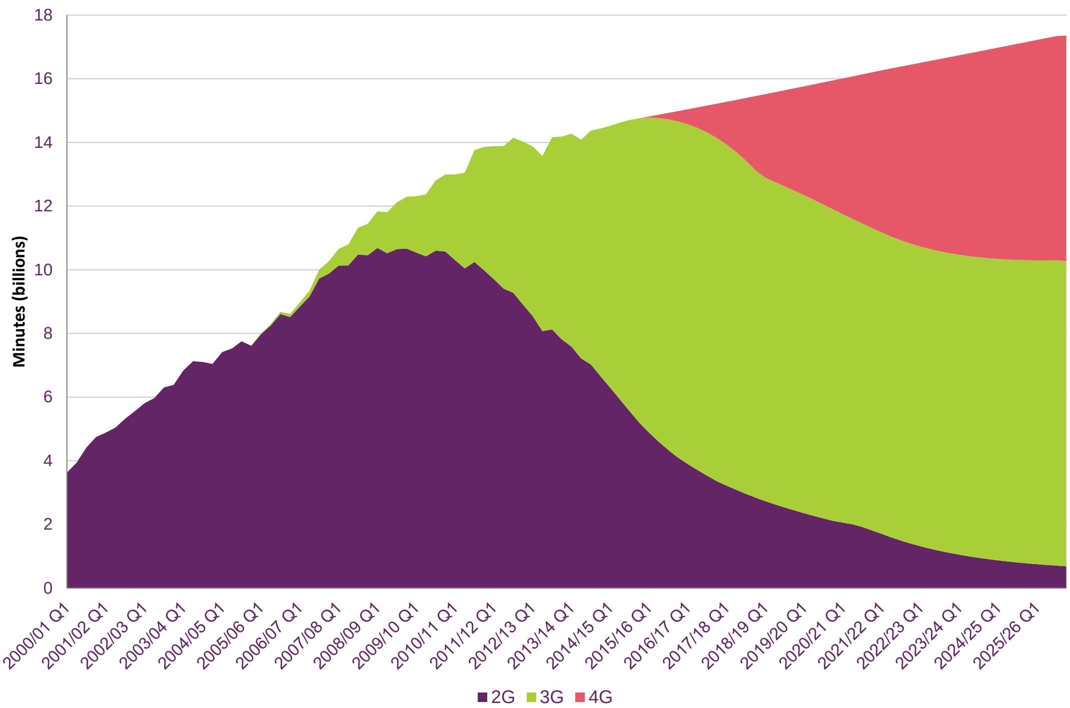
Voice traffic over different technologies

A11.130 The above input forecasts on a per subscriber basis are then used to calculate total voice minutes carried by the hypothetical MCP, categorised by technology. Figure A11.14 below shows the evolution of total call leg minutes[49] over time under our medium demand scenario, and split by technology.

[48] BT response to January 2014 workshop, http://stakeholders.ofcom.org.uk/binaries/telecoms/policy/mobile/bt-appendix-2014.pdf.

[49] Total call legs include incoming, outgoing and two times on-net call leg minutes.

Figure A11.14: Total call leg minutes per quarter by technology[50]



Source: Ofcom 2014 MCT model

Stakeholder comments to the January 2014 workshop

A11.131 EE considered that the forecasts for voice presented in the draft MCT model were not implausible, but that they were high relative to an appropriately conservative forecast given what it saw as the risks of regulating MTRs at the LRIC. It also made reference to Ofcom's Telecommunications Market Data Update for Q2 2013 which showed average call minutes per subscriber having fallen in the year to Q2 2013, suggesting the forecasts in the draft MCT model were also high relative to current trends in actual traffic.

A11.132 EE also noted that mobile markets are in a period of transition and there was increasing substitution of traditional voice by alternatives such as OTT services. It therefore considered that the flipside of some of the rise in data usage forecast by Ofcom is the fall in traditional calls as people shift communication via smartphone apps. It presented a table of data showing how traditional voice minutes had fallen in other countries in recent years. It also included supporting evidence that voice is predicted to decline in future in the form of third party forecasts.[51]

A11.133 EE commented that VoLTE will be a feature of the UK mobile market over the new charge control period but with only gradual take-up (a fraction of overall 4G take-up). EE made reference to a report from Nokia which forecast 10% of all LTE subscribers globally to be VoLTE enabled by the end of 2016. It also stated that VoLTE was one of a possible range of technologies relevant to supporting improvements in voice services over the next MCT price control, with other technologies including VoWiFi also being relevant.

[50] The values presented in this Figure are post rebalancing - see paragraphs A11.173 to A11.176 for an explanation of rebalancing in the 2014 MCT model.
[51] EE response to January 2014 workshop, http://stakeholders.ofcom.org.uk/binaries/telecoms/policy/mobile/EE-2014.pdf.

Ofcom response

A11.134 We note that the telecoms data tables have been revised since the version EE refers to; with the latest version (Updated for Q4 2013) showing voice has actually increased marginally between 2012 and 2013.[52] We have set out the reasoning behind the trend in our forecast of voice minutes per subscriber in paragraphs A11.112 to A11.127. This was considered in the context of various trends in the market which may affect voice usage, notably the increasing availability of unlimited call bundles, and use of OTT voice applications. As noted above, we have taken the view under our medium demand scenario that any effect of switching to OTT voice, which would tend to reduce traditional voice usage, is likely to be dominated by growth in traditional voice usage stemming from increased availability of inclusive call bundles and potentially substitution from fixed line call origination. We have also included low and high voice sensitivities which reflect different assumptions of the impact of OTT applications and unlimited call bundles on traditional voice.

A11.135 As discussed in paragraphs A11.110 to A11.111 above, we have added an additional parameter affecting VoLTE to the 2014 MCT model which was not present in the draft model released for the January 2014 workshop. This parameter reduces the number of 4G handsets which are VoLTE enabled, and therefore reduces the number of voice minute carried over VoLTE. After these changes we are confident that our forecasts for future voice usage are reasonable and based upon both historic trends and plausible assumptions of potential future changes in consumer behaviour.

Messaging services

A11.136 In the 2011 MCT model we forecast that the rate of growth in total messages (SMS+MMS) in recent years would slow down over time, with total messages per subscriber per month reaching 140 by the end of 2020/21. The updated actual figures in the 2014 MCT model show that messaging initially grew, reaching almost 160 messages per subscriber per month by 2011/12 Q1. However after this it declined to 143 messages per subscriber per month by Q3 2013/14.

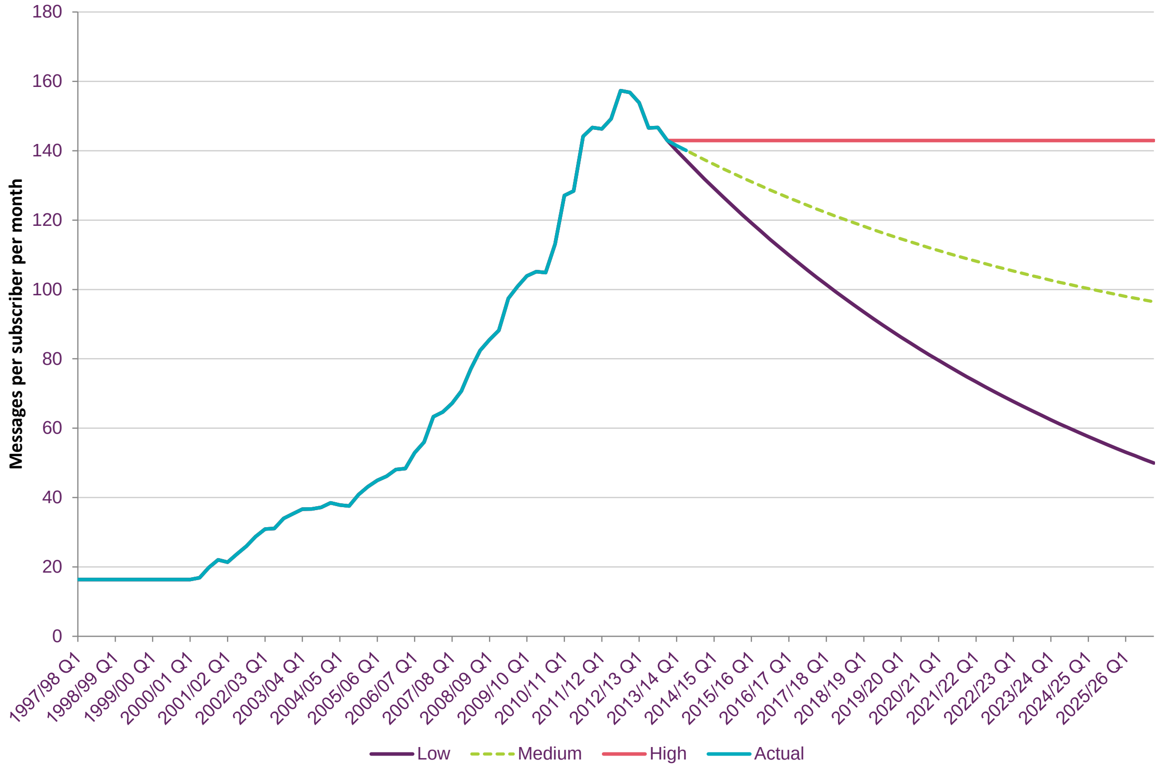
A11.137 Our forecasts for messaging services have been revised significantly from those in the 2011 MCT model. Our forecasts for the 2014 MCT model predict either a decline in the volume of messages per subscriber (medium and low scenarios) or that volumes per subscriber are maintained at the current level (high scenario). Specifically the medium scenario forecasts a decline to 96 messages per subscriber per month by 2025/26. The forecast decline is driven predominantly by an assumed increase in OTT messaging services such as iMessage, BBM and WhatsApp, but also as a result of a change in the way people choose to communicate – with social networks seen as an alternative medium to traditional SMS/MMS messaging.

A11.138 Our high forecast assumes that the current level of messages sent per subscriber per month remains constant at the current level of 143 through to 2025/26, and our low forecast assumes a significant decline to around 50 messages per subscriber per month by 2025/26. The three forecast scenarios are shown in Figure A11.15 below.

[52] The total volume of outgoing calls shown in the Q4 2013 update of the data tables are shown in Figure A9.10 of Annex 9.

A11.139 The input forecasts we use are for the combined total of SMS/MMS messages per subscriber. However, the 2014 MCT model uses an assumption of the proportion of total messages which are MMS and SMS to calculate separate output values for total SMS and total MMS messages. This has been revised in the 2014 MCT model to reflect the differing trends in historic SMS and MMS messaging and we forecast them to remain flat at the current levels. As of 2013/14 Q2 0.43% of 2G messages were MMS, and 0.58% of 3G messages were MMS. We have forecast the proportion of 4G messages which are MMS to be the same as that for 3G.

Figure A11.15: Forecasts for outgoing messages per subscriber per month



Source: Ofcom 2014 MCT model

Stakeholder comments to the January 2014 workshop

A11.140 As with voice, EE considered that Ofcom's forecast for SMS was not implausible, but was high relative to an appropriately conservative forecast given what it saw as the risks of setting MTRs at LRIC. It also referred to Ofcom's Q2 2013 update of the telecoms data tables which show that messages per subscriber have fallen from the same quarter of last year, suggesting this indicated Ofcom's forecasts are high relative to the current trend in actual traffic.[53]

A11.141 EE cited the increasing use of OTT services and trends experienced in other countries as reasons as to why Ofcom's forecasts for messaging were high. EE suggested that we should forecast an annual fall of 27% in text messages per subscriber to be consistent with recent UK data.

Ofcom response

[53] EE response to January 2014 workshop http://stakeholders.ofcom.org.uk/binaries/telecoms/policy/mobile/EE-2014.pdf

A11.142 We agree with EE that OTT messaging applications are likely to have a significant impact on future messaging volumes; however we consider that our current forecasts capture this to varying degrees in our low and medium demand scenarios. We believe that a 27% annual decline in messages per subscriber throughout our forecasting period would be excessive leaving very little traditional messaging by the end of 2025/26. We note that whilst OTT messaging applications have their advantages, there are still circumstances where traditional messaging would prevail, for instance in areas without 3G/4G coverage. It is also likely that a messaging user is indifferent between OTT and traditional SMS in terms of price per message as many mobile contracts now include unlimited SMS bundles. This removes one of the original incentives for subscribers to switch to OTT messaging applications.

A11.143 Overall we consider that our forecasts reflect the changes in usage behaviour identified by EE. We also note that the 2014 MCT model includes high, medium and low demand scenarios for sensitivity testing.

Data services

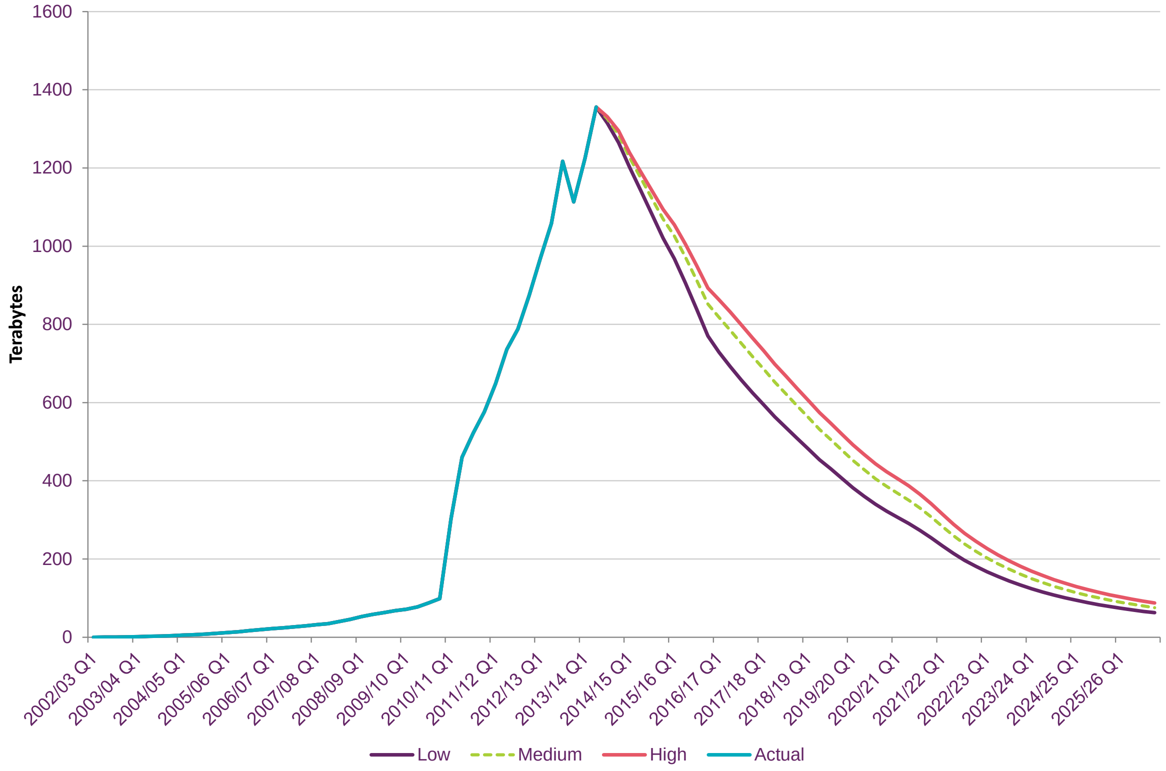
2G Data

A11.144 In the 2011 MCT model, 2G data was historically very low, and our forecasts were for this to continue, with fairly strong percentage growth, but the absolute total remaining small. Total data usage on handsets has grown rapidly in the period since 2010/11, and 2G data is no exception despite the relatively low speeds attainable with GPRS over GSM.[54] However, it is unclear exactly how much of this 2G data was originated on 2G handsets, and how much is fall back from 3G/4G handsets outside of 3G/4G coverage. As a result we have presented total 2G data rather than 2G data per subscriber.

A11.145 In response to the significant increase in 2G data usage since 2010/11, we have revised our forecasts upwards. Figure A11.16 below shows the significant increase in total 2G data to Q2 2013/14, and our expectation that it will now fall beyond this point. This is due to a fall in 2G only subscribers, a decline in data usage per 2G only subscriber and also a reduction in fall back from 3G/4G subscribers as coverage improves on those networks. Under our medium scenario we forecast total 2G data will fall from a peak of almost 1400TB to less than 100TB by the end of 2025/26.

[54] General Packet Radio Service (GPRS) is a packet oriented mobile data service on the 2G and 3G cellular communication systems.

Figure A11.16: Forecasts for total 2G handset data (TB)



Source: Ofcom 2014 MCT model.

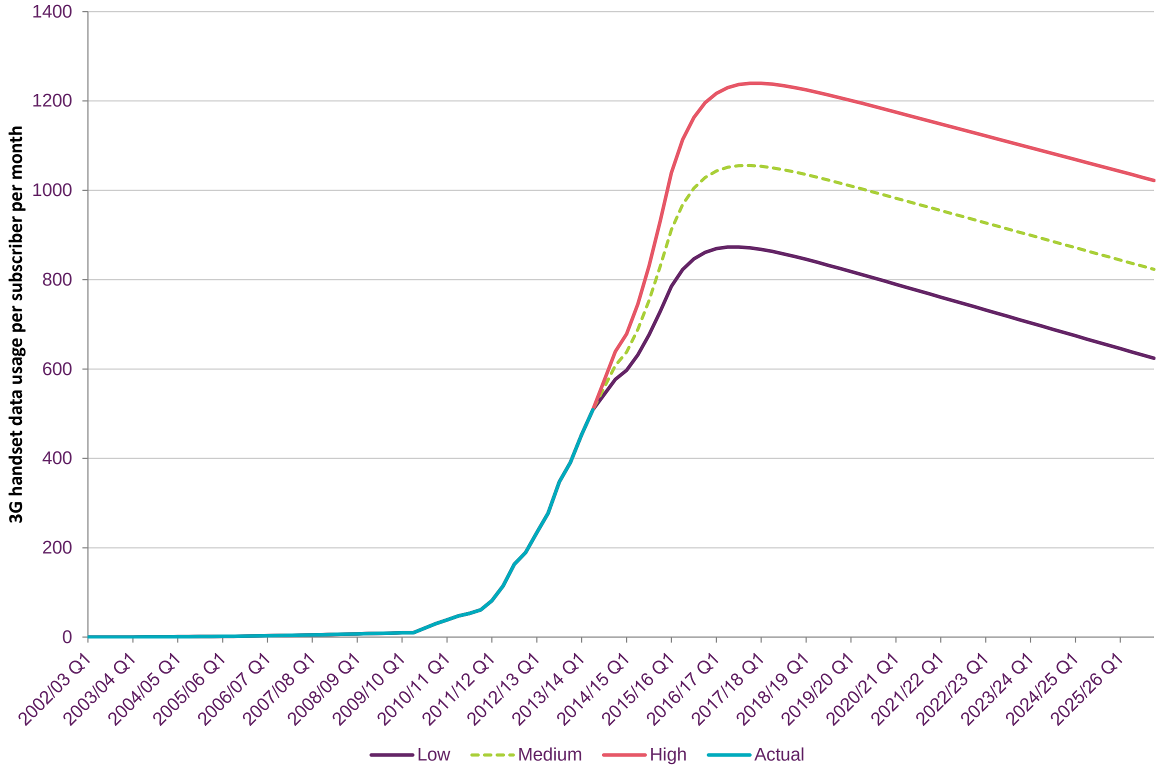
<u>3G handset data</u>

A11.146 The information provided in response to our formal information requests from the four largest MCPs does not provide us with a precise split of handset-based data traffic carried over 3G handsets. However, it does provide us with information on the amount of data usage by technology (across all devices), and the proportion of total data produced by handsets and datacards individually. By combining this information we have estimated the amount of data traffic carried for 3G handsets (and datacards).

A11.147 3G data usage has increased significantly in the period since 2010/11 to a level much higher than we forecast in the 2011 MCT model. In 2011 our medium forecast was for 3G data usage to grow to around 40MB per subscriber per month in 2012/13, and reaching about 100MB per subscriber per month by 2020/21. As a result of the much more rapid growth actually experienced, we have revised all our provisional forecasts upwards.

A11.148 In the 2014 MCT model, under all demand scenarios we forecast that 3G data will continue to grow to the end of 2015/16 and then begin to decline after this date. This date is around the time that 4G coverage is expected to exceed 98% and after 2015/16 we expect that many users will migrate to 4G enabled handsets. Our medium scenario forecasts 3G data per subscriber per month to peak around 1,050MB in Q4 2015/16, falling to around 800MB by Q4 2025/26. Under our high and low forecasts the peak of data is expected to reach 1,250MB and 850MB per subscriber per month respectively, and then falling to around 1,000MB and 600MB per subscriber per month respectively by 2025/26. The forecasts under each demand scenario are shown in Figure A11.17 below.

Figure A11.17: Forecasts for monthly 3G handset data usage per subscriber (MB)



Source: Ofcom 2014 MCT model.

<u>4G handset data</u>

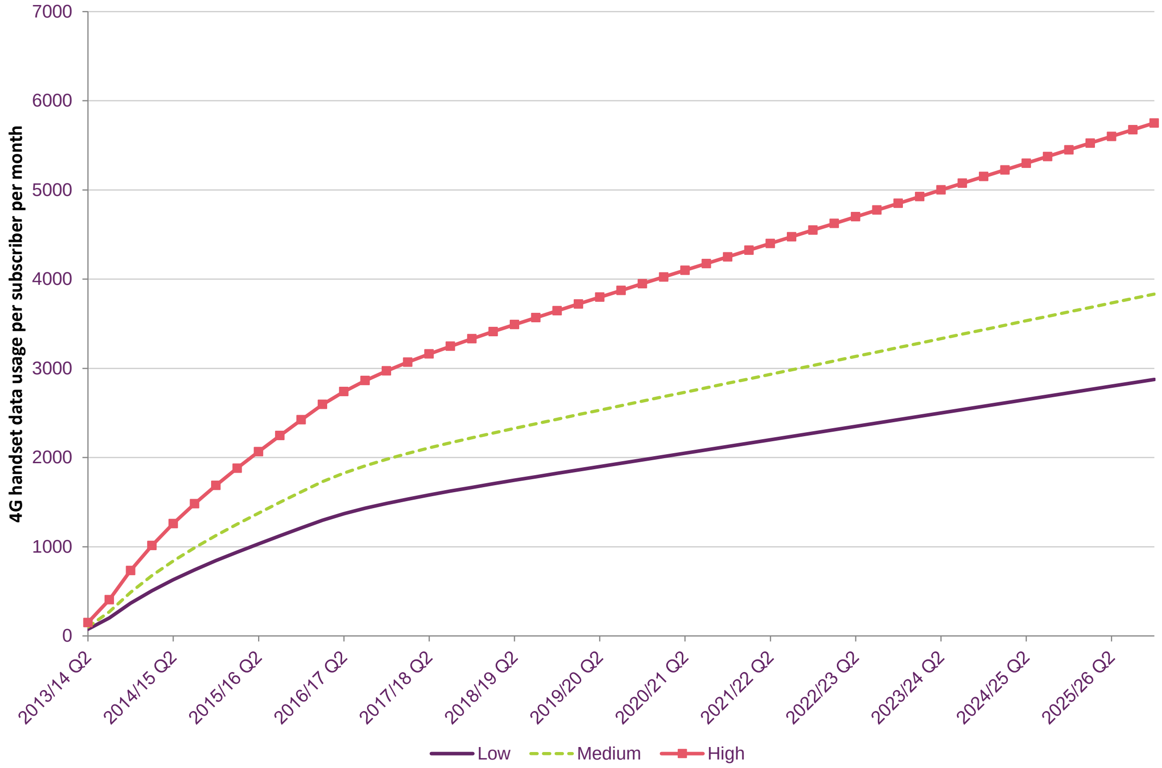
A11.149 As 4G services have only become available relatively recently we have limited historical data on which to base our forecasts[55]. As a result we have chosen to use other indicators and then cross checked our results with external sources. Our primary indicator is the usage cap on currently available 4G handset tariffs. On average MCPs have tended to offer 3 tariffs with usage caps of around 3GB, 5GB and 8GB. These have provided the basis for our forecasts through to 2025/26.

A11.150 We note that these are the maximum data allowance per month, and therefore are likely to be considerably in excess of the average usage per subscriber per month. Therefore we forecast 4G data to grow to levels of around 3GB, 4GB and 6GB per subscriber per month under the low, medium and high demand scenarios respectively. We anticipate the rate of growth will be highest in the first few years after 4G rollout as the early adopters of 4G are likely to be those with the heaviest usage patterns.

A11.151 We have compared our forecasts against the very limited historic data we have for 4G data and are confident they are broadly consistent. In addition we have cross checked our total data forecasts (which are increasingly dictated by trends in 4G usage) against third party sources. These comparisons are discussed below in paragraphs A11.159 to A11.172.

[55] We have not presented the limited data we do hold on 4G services for reasons of confidentiality.

Figure A11.18: Forecasts for monthly 4G handset data usage per subscriber (MB)



Source: Ofcom 2014 MCT model.

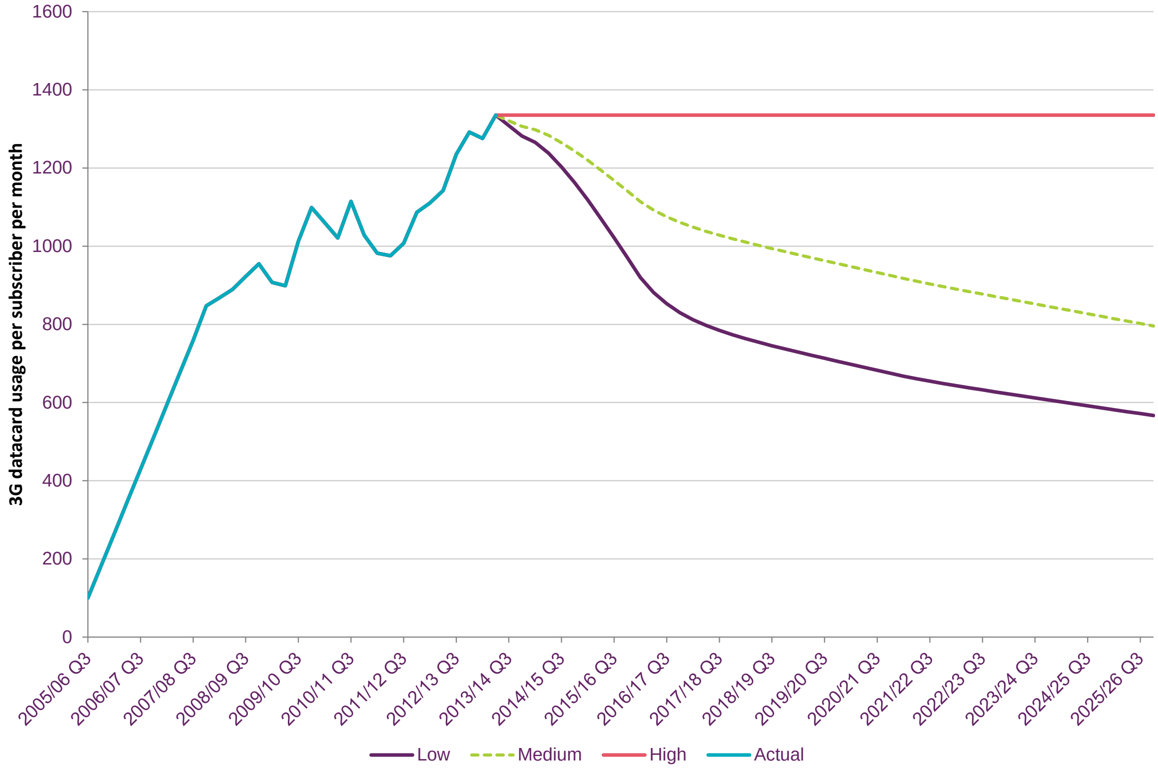
<u>3G datacard usage</u>

A11.152 As discussed above, in the 2011 MCT model datacards were only available using 3G technology. 4G datacards are now available and hence we expect that these will be adopted over time, with the heaviest users migrating to 4G soonest. We therefore believe that 3G datacard usage per subscriber will fall over time.

A11.153 In the 2011 MCT model we forecast monthly usage of datacards to fall slightly to around 1,000MB per subscriber per month by 2020/21. Our latest historic data shows that usage has actually increased much more than forecast, and has now reached around 1,350MB per subscriber per month in 2013/14. However, despite this greater than forecast rate of growth in usage, we expect that usage per 3G subscriber will fall over time due to users migrating to 4G based datacards.

A11.154 Our revised forecasts under the medium and low demand scenarios anticipate the greatest decline will occur between 2013/14 and 2016/17 as the heaviest data users switch from 3G to 4G technology. The decline is expected to continue after this time but at a steadier rate. We forecast that usage per subscriber per month will fall to around 800MB and 580MB in the medium and low demand scenarios respectively. Our high demand forecast is that current usage will remain flat at about 1,350MB per subscriber per month through to the end of 2025/26.

Figure A11.19: Forecasts for monthly 3G datacard usage per subscriber (MB)



Source: Ofcom 2014 MCT model.

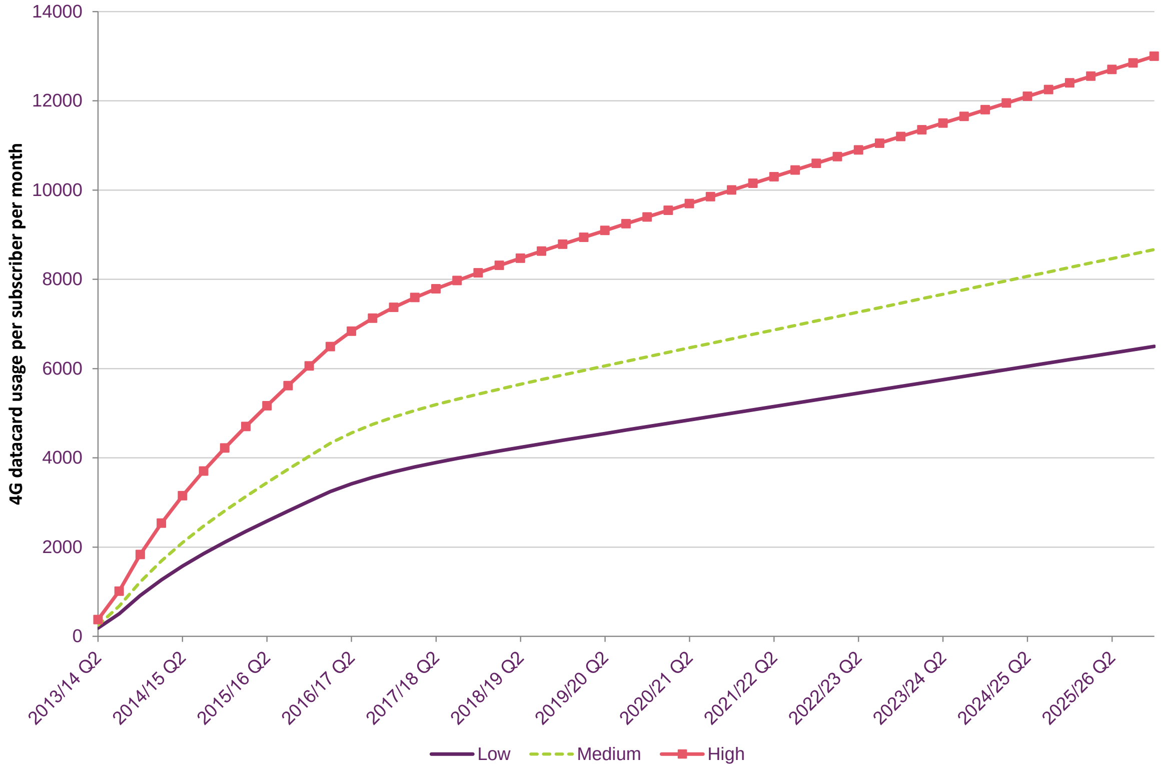
<u>4G datacard usage</u>

A11.155 As noted above 4G services have only been launched relatively recently, so we have very little historical data on which to base our forecasts. As a result we have chosen to use other indicators and then cross checked our results with external sources. Our primary indicator is the usage cap on currently available 4G datacard tariffs. On average MCPs have tended to offer three tariffs with usage caps of around 8GB, 15GB and 20GB. These have provided the basis for our forecasts through to 2025/26.

A11.156 We note that these are the maximum data allowance per month, and therefore are likely to be considerably in excess of the average usage per subscriber per month. Therefore we forecast 4G data to grow to levels of around 6.5GB, 8.5GB and 13GB per subscriber per month under the low, medium and high demand scenarios respectively by 2025/26. We anticipate the rate of growth will be highest in the first few years after 4G rollout as the early adopters of 4G are likely to be those with the heaviest usage patterns.

A11.157 Given the lack of historic data available for 4G services we have cross checked our total data forecasts (which are increasingly dictated by trends in 4G usage) against third party sources. These comparisons are discussed below in paragraphs A11.159 to A11.172.

Figure A11.20: Forecasts for monthly 4G datacard usage per subscriber (MB)

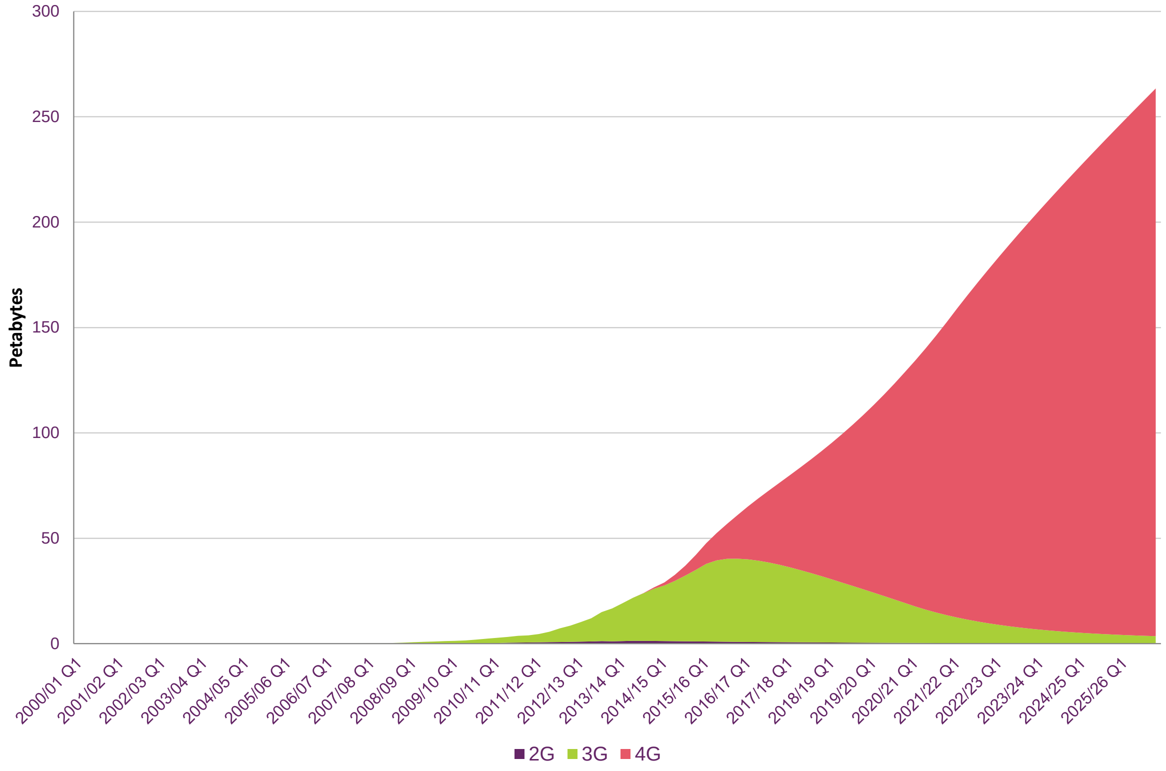


Source: Ofcom 2014 MCT model

Total data traffic split by technology

A11.158 The above input forecasts on a per subscriber basis are then used to calculate total data carried over the hypothetical network, categorised by technology. Figure A11.21 below shows the evolution of total data over time under our medium demand scenario, split by technology.

Figure A11.21: Total data split by technology



Source: Ofcom 2014 MCT model

Comparison of forecast total data in the 2014 MCT model and third party forecasts

A11.159 We have cross checked our data forecasts externally to ensure we are consistent with the direction and approximate magnitudes predicted by third party sources. In particular we have compared our forecasts to those produced by Analysys Mason and Real Wireless.

'Cost/benefit analysis of a 700MHz allocation to mobile' report by Analysys Mason – May 2014

Analysys Mason model (2012-2035)

A11.160 This report by Analysys Mason compares their own model with that of Real Wireless; both include forecasts of data traffic for the UK market. Analysis Mason forecasts that usage per month for smartphone users' rise from 692MB to 6,000MB over the period 2012-2035, and mobile broadband usage rises from 5,047MB to 30,000MB over the same period.[56] As we do not explicitly distinguish between smartphone usage and other handset usage, we would expect our figures for an average handset user to be lower than those for a smartphone user.

[56] 'Cost/benefit analysis of a 700MHz allocation to mobile', Analysys Mason, May 2014: http://stakeholders.ofcom.org.uk/binaries/consultations/700MHz/annexes/benefits_700MHz.pdf

A11.161 Our forecast for total data usage on an average handset is about 3500MB per month by the end of 2025/26.[57] This is in line with the direction and approximate levels presented in Analysys Mason's forecasts. Our forecast for an average datacard user is about 8200MB per month by the end of 2025/26, which is also directionally consistent with Analysys Mason, although may fall short of their predictions by 2035.

A11.162 Closer analysis of the Analysys Mason data shows that handset data per subscriber is forecast to grow with a CAGR of 39% between 2013 and 2018, and mobile broadband device data usage per subscriber to grow with a CAGR of 33% over the same period. These are both above the CAGR evident in our own forecasts for data over each device type. Specifically our forecasts show a predicted CAGR of 36% in handset data usage per subscriber and 27% in datacard usage per subscriber over the same period. We consider the Analysys Mason forecasts are broadly consistent with our own, although we recognise that our growth rates over this period are a little lower.

Real Wireless model (2012-2030)

A11.163 The Real Wireless model also presented in this report forecasts that usage per subscriber per month for an average handset device rises from 100MB to 1,273MB over the period 2013-2030, and mobile broadband device usage rises from 1,465MB to 17,236MB over the same period. Again whilst this is not directly comparable to our own forecasts due to differences in our definitions of device type, we see that our forecasts are directionally consistent. We predict average handset usage per subscriber to reach about 3,500MB by the end of 2025/26, which is greater than the level evident in the Real Wireless forecasts. However, in contrast we predict datacard usage per subscriber to reach around 8,200MB by the end of 2025/26 which is lower than the Real Wireless forecasts.

A11.164 Analysis of the underlying trend in the Real Wireless forecasts shows that they expect a CAGR of around 16% for both handset and mobile broadband device usage per subscriber over the period 2012-2030. We are unable to compare directly to these figures as we only forecast up until the end of 2025/26. However, comparing the CAGR in our forecasts from 2012 – 2025 to those from Real Wireless for the period 2012-2030, we can see they are directionally consistent and within a reasonable range.

A11.165 Our current forecasts assume a CAGR of 27% and 16% for handset and datacard usage per subscriber respectively over the period 2012 – 2025. We note that it's highly likely the five year period 2025 - 2030 covered by the Real Wireless forecasts but not by our own explicit forecasts would exhibit lower rates of growth relative to prior years. This would tend to reduce the overall CAGR for the period, and provides a possible reason as to why the Real Wireless growth rate falls below our forecast growth rates.

'Wireless network traffic worldwide: forecasts and analysis 2013–2018' report by Analysys Mason – October 2013

[57] This figure is for an average handset user irrespective of technology. The average is weighted by the number of subscribers using a particular technology to account for the differences in usage patterns.

A11.166 In addition to the forecasts of usage per subscriber we note that Analysys Mason previously published another report which forecast a CAGR for total data. This report suggested total data usage in developed markets would grow with a CAGR of 39.6% over the period 2013-2018. This figure rises to 44.5% when considering worldwide data growth[58]. This is consistent with our forecasts which predict total data usage will grow with a CAGR of 38.7% over the period 2013-2018[59].

A11.167 This comparison with third party forecasts shows our forecasts are broadly consistent in direction of change, and within a reasonable range of the magnitude of change predicted by external sources.

Stakeholder responses to the January 2014 workshop

A11.168 EE considered that the total data forecasts in Ofcom's draft MCT model were too high – specifically that the annual growth rate was high, and also that it expected the rate of growth to slow sooner than Ofcom had forecast, particularly given what it saw as the importance for Ofcom's forecast to be conservative. It noted that while data usage at low levels serves vital communication needs (messaging and email), at higher levels it is often less time critical and Wi-Fi is an increasing substitute. In addition, EE considered that the wider deployment of femtocells will act to slow the growth of data carried over mobile networks. EE also said that customers who take up 4G phones later tend to be lighter data users.[60]

A11.169 [✂]

A11.170 [✂] EE noted that Analysys Mason had forecast in October 2013 a compound annual growth rate of 34% for Western Europe over 2012-2018, compared to Ofcom's 43% over the same period.

Ofcom response

A11.171 As discussed above, our forecasts for data usage per subscriber are based on historic trends, future expectations, and then cross checked against external sources. The comparisons we have made with Analysys Mason and Real Wireless forecasts show we are within a reasonable range of these forecasts for total data usage.

A11.172 We have calculated the CAGR for our forecasts and compared it to the most recent Analysys Mason figures for the period 2013-2018 (after Analysys Mason revised its forecasts upwards), and we consider that there is broad consistency between them. Including 2012 inflates the Ofcom CAGR due to 4G data only beginning in 2013/14 and thus forecasting from 2012 involves starting from a lower base of usage (and hence growth needs to be higher to reach the same end of period level). The numbers we present in the comparison section above are from 2013 and reflect both our most recent forecasts, and the most recent forecasts from Analysys Mason.

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[58] 'Wireless network traffic worldwide: forecasts and analysis 2013–2018', Analysys Mason, October 2013.
[59] Our forecast CAGR for total data is greater than the CAGR for handset and datacard usage per subscriber because population, and therefore total subscribers, are also increasing over time.
[60] EE response to January 2014 workshop, http://stakeholders.ofcom.org.uk/binaries/telecoms/policy/mobile/EE-2014.pdf .

Traffic 'rebalancing'

A11.173 Traffic rebalancing refers to the reallocation of some of the forecast traffic demand between network technologies as a result of two factors:

- lack of network coverage; and
- deliberate 'network traffic management'.

A11.174 The traffic rebalancing calculations in the 2014 MCT model are based on those in the 2011 MCT model, but the calculations have been extended to account for 4G traffic, and also simplified.[61]

A11.175 In developing the 2014 MCT model we sought evidence from MCPs via our statutory information gathering powers regarding their approach to traffic rebalancing. Based on the evidence received, the rebalancing calculations in the 2014 MCT model are performed in five steps:

- Step 1: we take account of a lack of 2G network coverage. 2G traffic in geotypes without 2G coverage is shifted to geotypes which have coverage, leaving the total volume of 2G traffic unchanged.
- Step 2: we then take account of lack of 3G network coverage. Any 3G traffic (including voice, SMS and data) which cannot be carried on the network due to a lack of 3G coverage is rebalanced onto the 2G network.
- Step 3: a proportion of 3G voice traffic is also deliberately carried onto the 2G network (i.e. is not only carried on the 2G network due to 3G network traffic management).[62]
- Step 4: where there is a lack of 4G coverage, voice traffic is, if possible, carried on the 3G network. If the 3G network is unable to carry the voice traffic it is further rebalanced onto the 2G network.
- Step 5: where there is a lack of 3G and 4G coverage, MMS and data traffic are rebalanced onto the 2G and 3G network respectively. However, not all of the traffic is assumed to be rebalanced.[63]

A11.176 There is no deliberate fall back of 4G traffic (i.e. 4G traffic is only carried on 3G, or ultimately 2G, due to coverage constraints, not for deliberate network management reasons).

[61] The 'on-net calls adjustment', which was included in the 2011 MCT model, has been removed. This adjustment added considerably to the volume of the calculations, particularly with the addition of 4G traffic, but did not have a material impact on the results. We tested the removal of the 'on-net calls adjustment' in the 2011 MCT model, which lead to a 1% decline in the LRIC result. We also tested the draft MCT model (again for a 2G/3G operator as the inclusion of the 'on-net calls adjustment' for the 4G network proved to be extremely complex and would have added considerably to the volume of rebalancing calculations) and found that it lead to a 2% decline in the LRIC result.

[62] The proportion of 3G voice traffic deliberately rebalanced declines from 40% in 2009/10 Q4 to 0% in 2020/21Q4, as in the 2011 MCT model.

[63] For MMS traffic downgrading factors of 50% are applied, therefore 50% of MMS which cannot be carried on the first network is rebalanced and the remaining 50% is lost. For data traffic 75% downgrading factors are applied, therefore 75% of the traffic which cannot be carried on the first network is rebalanced and the remaining 25% of traffic is lost.

Geotypes and network coverage

A11.177 'Geotypes' are a means of mapping different geographical segments of the UK according to the likely density of traffic and building clutter that is experienced in those segments.[64] These factors have a direct influence on the number of sites that are required to provide (a) network coverage; and (b) sufficient network capacity to carry all of the traffic in the busy hour.

A11.178 The geotype definitions used in the model capture these geographical factors, and are defined on the basis of population density (as a proxy for variations in traffic density and building clutter). The 2014 MCT model includes a total of nine geotypes, which is unchanged from the 2011 MCT model.

A11.179 The proportion of the UK within each geotype has been estimated using geographical analysis of the postal sector areas in the UK. Demand is then distributed by geotype. The distribution of population, area and traffic by geotype is provided in Table A11.2 below. This is unchanged from the 2011 MCT model.

Table A11.2: Distribution of population, area and traffic by geotype

Geotype	Minimum population density (per km^2)	% of population	% of area	% of traffic
Urban	7,959	6.0%	0.1%	12.8%
Suburban 1	3,119	30.0%	1.6%	59.0%
Suburban 2	782	32.8%	4.8%	14.0%
Rural 1	112	21.2%	19.4%	5.9%
Rural 2	47	7.0%	23.3%	1.7%
Rural 3	25	2.0%	13.7%	0.4%
Rural 4	0	1.0%	37.0%	0.2%
Highways	n/a	n/a	n/a	3.0%
Railways	n/a	n/a	n/a	3.0%

Source: Analysys Mason.

A11.180 As shown in Table A11.3 below, we assume that in the long term (by 2025/26) 2G coverage of 98.4% of population, 3G coverage of 97.5% of population and 4G coverage of 98.2% of population is appropriate for the hypothetical average efficient operator. These assumptions are based on analysis of the area and population coverage information provided to us in responses to our formal information requests.

[64] For example, city centres with high traffic density and high building clutter, which compares to rural areas with low traffic density and low building clutter.

Table A11.3: Population coverage assumptions by technology 2025/26

Geotype	2G	3G	4G
Urban	100.0%	100.0%	100.0%
Suburban 1	100.0%	100.0%	100.0%
Suburban 2	100.0%	100.0%	100.0%
Rural 1	100.0%	99.0%	100.0%
Rural 2	97.5%	93.0%	90.3%
Rural 3	97.0%	97.0%	80.0%
Rural 4	61.0%	76.3%	80.0%
Highways	100.0%	92.5%	100.0%
Railways	100.0%	92.5%	100.0%
Overall	**99.4%**	**99.0%**	**98.7%**

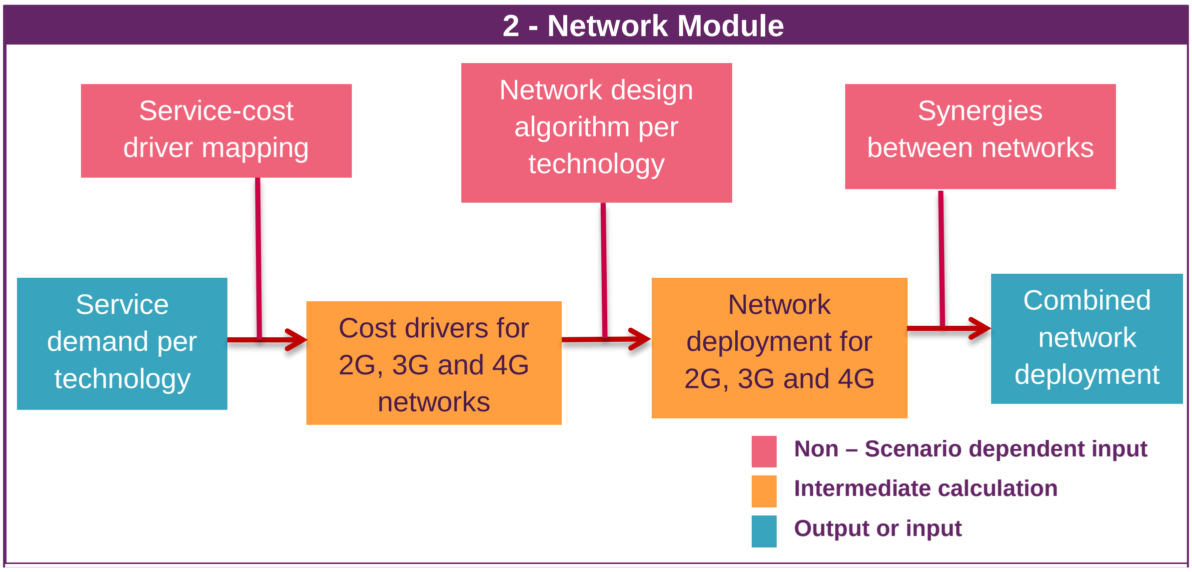
Source: Analysys Mason, Ofcom.

Network module

A11.181 The network module takes the forecast levels of service demand and coverage per geotype derived in the Traffic module and uses them in calculating the quantities of each type of 2G, 3G and 4G network equipment necessary to meet these requirements. This process, which also involves the use of telecommunications engineering algorithms is known as 'dimensioning', and has been completed by Analysys Mason.

A11.182 Full details of the Network module can be found in the Analysys Mason report in Annex 12, and are summarised below. The flow of the calculations in the network module is illustrated in Figure A11.22 below.

Figure A11.22: Summary of Network Module calculations



Source: Ofcom.

A11.183 The network module is where many of the modifications requiring new functionality or upgrades relative to the 2011 MCT model arise (see paragraph A11.72 above). The changes have been incorporated in a flexible manner, such that the impact of individual changes, such as the deployment of 4G and the use of S-RAN can easily be seen in the model.

Cost drivers

A11.184 In order to dimension the modelled 2G, 3G and 4G networks on the basis of cost causation relationships, the MCT model first converts the demand for each service under the selected input scenario into a number of specific cost drivers, each of which drives the deployment of certain network elements. A common measure of traffic output is required so that demand from multiple services can be aggregated appropriately. Traffic for each service is therefore converted into voice equivalent busy-hour Mbit/s. A matrix of routing factors is then applied to map the services onto a full set of network cost drivers.

Network dimensioning

A11.185 A number of technical parameters are required in order to establish quantifiable relationships between cost drivers and network deployment. The three key parameters which affect the dimensioning of the modelled 2G, 3G and 4G networks are:

- the cell radii;
- traffic demand per cell; and
- equipment capacities (including the radio, backhaul, backbone and core networks).

A11.186 To derive a realistic assessment of the cost structures for our average efficient MCP, we have used a bottom-up approach that calculates the quantities of each type of network elements required. These assets are dimensioned in the model according to the cost drivers discussed previously, either directly or indirectly (in the latter case for assets that are dimensioned on the basis of other asset quantities).

A11.187 The general approach taken for dimensioning the modelled 2G, 3G and 4G networks is the same as in the 2011 MCT model (although the inclusion of a 4G network is a new addition). Under this approach the radio network is dimensioned for coverage and capacity requirements in each geotype.

Spectrum holdings

A11.188 A key factor in determining the cell radii are the assumptions made relating to the spectrum bandwidth and the spectrum holdings of the modelled MCP. The 2011 MCT model included modelling of spectrum in the following bands:

- 1800MHz spectrum, which was used for 2G technology; and
- 2.1GHz spectrum, which was used for 3G technology.

A11.189 For the 2014 MCT model we considered these bands as a starting point but, given the inclusion of 4G technology in the model, we have also had to consider what spectrum band(s) and holdings should be used to support that technology.

A11.190 In the 2014 MCT model we propose the following spectrum holdings for our modelled MCP.

Table A11.4: Proposed spectrum holdings for our modelled MCP

<table>
<tr><th>Band</th><th colspan="2">Holding (paired MHz)</th><th>Technology</th></tr>
<tr><td>800MHz</td><td colspan="2">10</td><td>4G</td></tr>
<tr><td>900MHz</td><td colspan="2">0</td><td>n/a</td></tr>
<tr><td rowspan="2">1800MHz</td><td rowspan="2">30</td><td>20</td><td>2G</td></tr>
<tr><td>10</td><td>4G[65]</td></tr>
<tr><td>2.1GHz</td><td colspan="2">10, increasing to 15 in 2012/13</td><td>3G</td></tr>
<tr><td>2.6GHz</td><td colspan="2">10</td><td>4G</td></tr>
</table>

A11.191 A detailed explanation of our proposals relating to spectrum holdings used in the 2014 MCT model, including our response to comments made by stakeholders regarding the spectrum assumptions used in our draft MCT model published in January 2014, is provided in Annex 15.[66]

[65] Following refarming assumed in 2012/13, see Annex 15.
[66] We also note that the model includes options to exclude each of 800MHz, 1800MHz, and 2.6GHz spectrum from the 4G network. We have tested these scenarios and found that they have only a limited impact on the results.

2G and 3G network design

A11.192 We are proposing to make revisions to the 2G/3G network design to reflect developments since the March 2011 Statement. The revisions made are described in Annex 12 and include:

- changes made to the HSPA part of the 3G network to accommodate improvements in HSPA technology;
- changes to the backhaul design with the addition of further high-speed backhaul options;
- changes to transmission to the core network ('hub to core');
- changes to transmission within the core network; and
- changes to network parameters used to dimension the 2G and 3G network that reflect the passage of time since the development of the 2011 MCT model.

4G network design

A11.193 We are proposing to make additions to the network design to accommodate 4G infrastructure. The additions made to accommodate 4G infrastructure are described in Annex 12 and include:

- The design of the 4G radio network, including:
  - Radio coverage requirements;
  - Cell capacity and carrier overlays;[67]
  - Backhaul requirements;
  - Site requirements
- The design of the 4G core network; and
- The design of the VoLTE network.

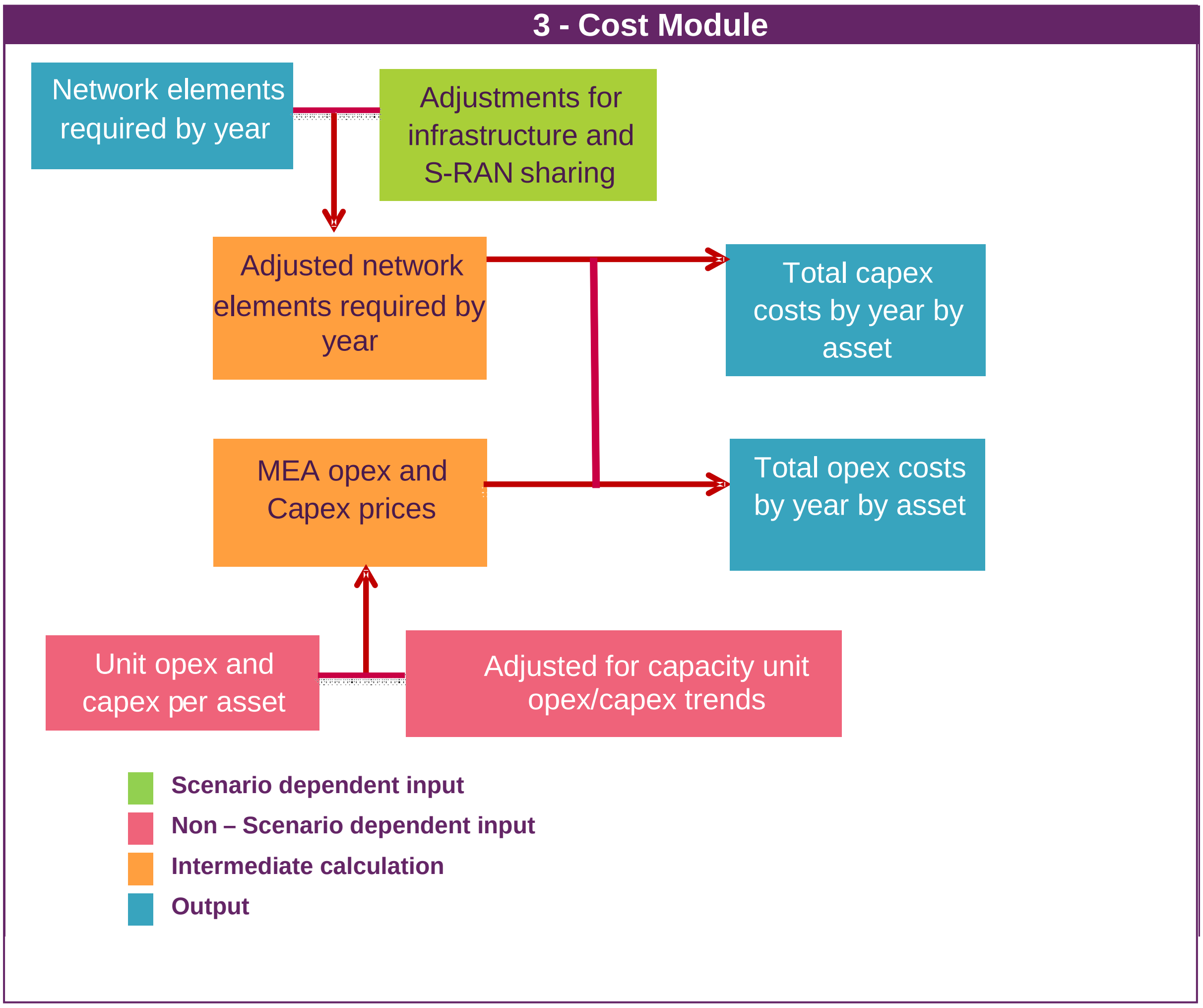
Cost module

A11.194 Using the equipment quantities calculated in the network module as inputs, the cost module forecasts the total cash flows (i.e. investment and operating costs) that would be incurred in each year to purchase, renew, maintain and decommission the required number of each type of network element. This process allows us to calculate the costs that would be incurred by an average efficient MCP.

A11.195 The cost module of the model has been developed by Analysys Mason, and is explained fully in Annex 12. A summary of the workings of the module is shown in Figure A11.23 and explained below.

[67] Carrier overlay refers to the deployment of additional spectrum (radio carriers) in the same cell to increase the total capacity of the cell.

Figure A11.23: Summary of Cost Module calculations



Source: Ofcom.

A11.196 These calculations are based on a Modern Equivalent Asset (MEA) approach, which takes into account changes in the investment and maintenance costs associated with each asset type as well as technological developments that improve asset productivity. For example, an asset which is expected to halve in price and double in effective capacity over a given period of time would have an MEA investment price at the end of the period equal to a quarter of the original price. This approach accords with that of the 2011 MCT model.

A11.197 In addition to updates to unit costs and cost trends to reflect the passage of time, the cost module has also been used to incorporate changes in MCPs network design relating to:

- Single-RAN (S-RAN) technology; and
- The impact of infrastructure sharing.

<u>S-RAN</u>

A11.198 The 2011 MCT model assumed that 2G BTSs and 3G NodeBs remained as separate network elements in the radio network. Since 2011, equipment vendors have designed ‘combined’ base stations that provide 2G, 3G and 4G functionality (or a combination of 2G, 3G and 4G functionality). This combined equipment is referred to as single-RAN equipment or S-RAN, and we have gathered evidence from MCPs that indicates that the use of S-RAN is becoming widespread.

A11.199 Deploying S-RAN equipment has the potential to reduce costs when compared to deploying separate 2G BTSs, 3G NodeBs and 4G eNodeBs. We consider that an average efficient MCP with a 2G, 3G, 4G network configuration would deploy S-RAN technology within the timeframe of our modelling period. Therefore, we propose that S-RAN deployment should be included in the 2014 MCT model.

A11.200 In the draft MCT model, we included our approach to capturing the impact of S-RAN through adjusting cost trends of affected assets.

Stakeholder responses to the January 2014 workshop

A11.201 BT argued that the model attempted to capture new technology through simple cost adjustments when a more fundamental change to the model logic was required.[68]

A11.202 BT argued under our approach the cost of S-RAN is based on the amalgamation of 2G, 3G and 4G equipment and that the cost of S-RAN equipment is then allocated to each of the different technologies. The drawback of this approach is that it includes the much higher costs of 2G equipment in the very early days of mobile networks. BT argued that this gives an exaggerated cost of 2G capability compared to 4G and when the model is applied it allocates this overestimated 2G cost to the 4G elements. At the very least, Ofcom should ensure that these forward looking costs are calibrated to the actual costs which MCPs are now achieving.

A11.203 BT noted that the reason that the industry is moving to multimode equipment is to allow the efficient migration of traffic between technologies. As a result the equipment itself will be of a similar cost (there might be separate charges for software licence fees) irrespective of the technology used and the available capacity would be split between the 2G, 3G and 4G requirements on the same site.

A11.204 BT argued that to carry out an assessment of the impact appropriately, the effect of S-RAN should be included in the Network module, installing only the required number of multi-mode devices on site to support the total demand, at a cost in line with the current price of 4G equipment.

A11.205 EE noted that the draft MCT model assumed that S-RANs replace single 2G, 3G and 4G RAN equipment from 2013/14. [✂] More generally, EE believes that its experience represents an efficient path of asset deployment over time given the timing of technology availability and spectrum assignments.[69]

A11.206 [✂]

A11.207 H3G noted that such an S-RAN solution is only possible when the technologies are provided by the same equipment vendor.[70] [✂].

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[68] BT response to January 2014 workshop, http://stakeholders.ofcom.org.uk/binaries/telecoms/policy/mobile/bt-2014.pdf.
[69] EE response to January 2014 workshop, http://stakeholders.ofcom.org.uk/binaries/telecoms/policy/mobile/EE-2014.pdf.
[70] H3G response to January 2014 workshop, http://stakeholders.ofcom.org.uk/binaries/telecoms/policy/mobile/Three.pdf.

A11.208 H3G noted that sourcing equipment from different vendors can result in cost savings, relative to single vendor sourcing. If the model is to assume S-RAN deployment, it is important that it does not also assume unit costs that can only be achieved through multi-vendor sourcing.

Ofcom response

A11.209 We have considered two options to modelling the impact of S-RAN:

i) By defining new ‘combined base station’ assets, which are deployed as replacements for existing base stations over a defined period of time; or

ii) Making adjustments to the cost trends of individual 2G, 3G and 4G base station assets and the costs allocated to these network elements to capture the impact of S-RAN.

A11.210 We consider that (i) would be a significant exercise, since a new S-RAN design would require a large number of new network design inputs, which would need to be parameterised, as well as matching cost inputs.

A11.211 We consider that (ii) is a less detailed approach to modelling S-RAN than (i) since it requires less information regarding the costs of S-RAN equipment. Although we recognise that (ii) is a modelling simplification, we consider that it provides an acceptable and proportionate means of capturing the deployment of S-RAN equipment.

A11.212 Notwithstanding the above, we accept that the approach used in the draft MCT model did not adequately reflect the multi-mode nature of S-RAN. In our testing of the draft MCT model we found that as traffic migrated from 2G and 3G to 4G, 2G and 3G RAN equipment became underutilised and costs per unit of 3G traffic increased. However, since S-RAN is technology neutral, the spare capacity (as a result of traffic migrating from 2G and 3G) should have been able to be used by 4G traffic. Therefore, we have sought to capture this effect by assuming that the costs of the S-RAN equipment are redistributed among the 2G, 3G and 4G assets based on the proportions of radio traffic carried.[71] As such, where the 2G, 3G, or 4G assets have a higher proportion of radio traffic they will be assigned a higher proportion of the cost of the S-RAN. This thereby allows annual cost trend adjustments to be made as the mix of 2G/3G/4G traffic change over time.[72]

A11.213 In the 2014 MCT model, we assume that S-RAN will become available for use in 2013/14 and that the existing radio equipment is completely replaced with S-RAN equipment over three years. We recognise that this will not be representative of all MCPs but consider that it is a reasonable assumption based on the evidence we have gathered.

A11.214 In our base case, we also assume that all network technologies will be upgraded to use a combined 2G+3G+4G S-RAN i.e. other combinations of S-RAN, say, 3G+4G only are not modelled.

[71] In addition to the traffic related allocation, each technology is assigned a small fixed element of the S-RAN cost.

[72] Note that, as explained further in paragraph A11.233 below, the equipment cost trends that feed into the economic depreciation calculations exclude the effect of the redistribution of cost of S-RAN equipment.

Infrastructure sharing

A11.215 The 2011 MCT model allowed for the sharing of passive infrastructure (sites only). However, since the development of the 2011 MCT model, MCPs have extended infrastructure sharing to also include active infrastructure (radio equipment and backhaul).

A11.216 Based on the evidence gathered we consider that it is appropriate to extend infrastructure sharing to include active infrastructure. We included active infrastructure sharing in the draft MCT model.

Stakeholder responses to the January 2014 workshop

A11.217 BT noted that the draft MCT model appeared to be insensitive to assumptions around the use of shared infrastructure between MCPs. It noted that a 50% discount is applied to the cost of equipment in a shared infrastructure scenario but this is then cancelled out by an assumption that the capacity of this equipment must be doubled (and the assumption is made that the cost is therefore doubled), effectively negating the benefit of shared infrastructure.[73]

A11.218 EE noted that Ofcom was still developing its approach to modelling active infrastructure sharing. However, it considered that the approach taken in the draft MCT model to implement active RAN sharing (i.e. applying a 50% capex share adjustment) may need further refinement to better reflect the commercial models in relation to 4G networks (which in important respects entail less network sharing than under historic agreements).[74]

A11.219 [✂]

A11.220 [✂]

A11.221 [✂]

A11.222 [✂]

A11.223 In summary, EE argued that infrastructure sharing should not be assumed to simply halve the costs incurred by each operator and that further investigation of opex was needed.

Ofcom response

A11.224 Although we had sought to capture the impact of infrastructure sharing in the draft MCT model (through adjusting cost trends in the cost module), we had not been able to fully work through the approach at that time. This resulted in our draft MCT model being insensitive to our assumptions around infrastructure sharing.

A11.225 In the 2014 MCT model, we have adapted the approach to implementing infrastructure sharing from that in the draft MCT model. The changes made to the 2014 MCT model avoid the problem that was identified in the draft MCT model of

[73] BT response to January 2014 workshop, http://stakeholders.ofcom.org.uk/binaries/telecoms/policy/mobile/bt-2014.pdf.
[74] EE response to January 2014 workshop, http://stakeholders.ofcom.org.uk/binaries/telecoms/policy/mobile/EE-2014.pdf.

reduced costs from infrastructure sharing being negated by the doubling of capacity in the network as traffic doubles.

A11.226 The calculations to implement infrastructure sharing are found in both the cost module and network module. At a high level, our approach increases the traffic on the modelled network to include that from a second operator sharing the infrastructure. However, we then identify only those costs that the modelled operator would pay for its own traffic, and then recover those costs over the modelled operator's own traffic using the existing routing factor table.

A11.227 We have gathered evidence from the four largest MCPs regarding their infrastructure sharing arrangements. This evidence indicates that MCPs have chosen to share infrastructure in different ways. Therefore, the assumptions we use in our modelling can never be reflective of the infrastructure sharing adopted by all MCPs. Nevertheless, we consider that the evidence gathered from these MCPs provides support to our assumption of that a hypothetical efficient MCP could implement infrastructure sharing in relation to 2G, 3G and 4G technologies.

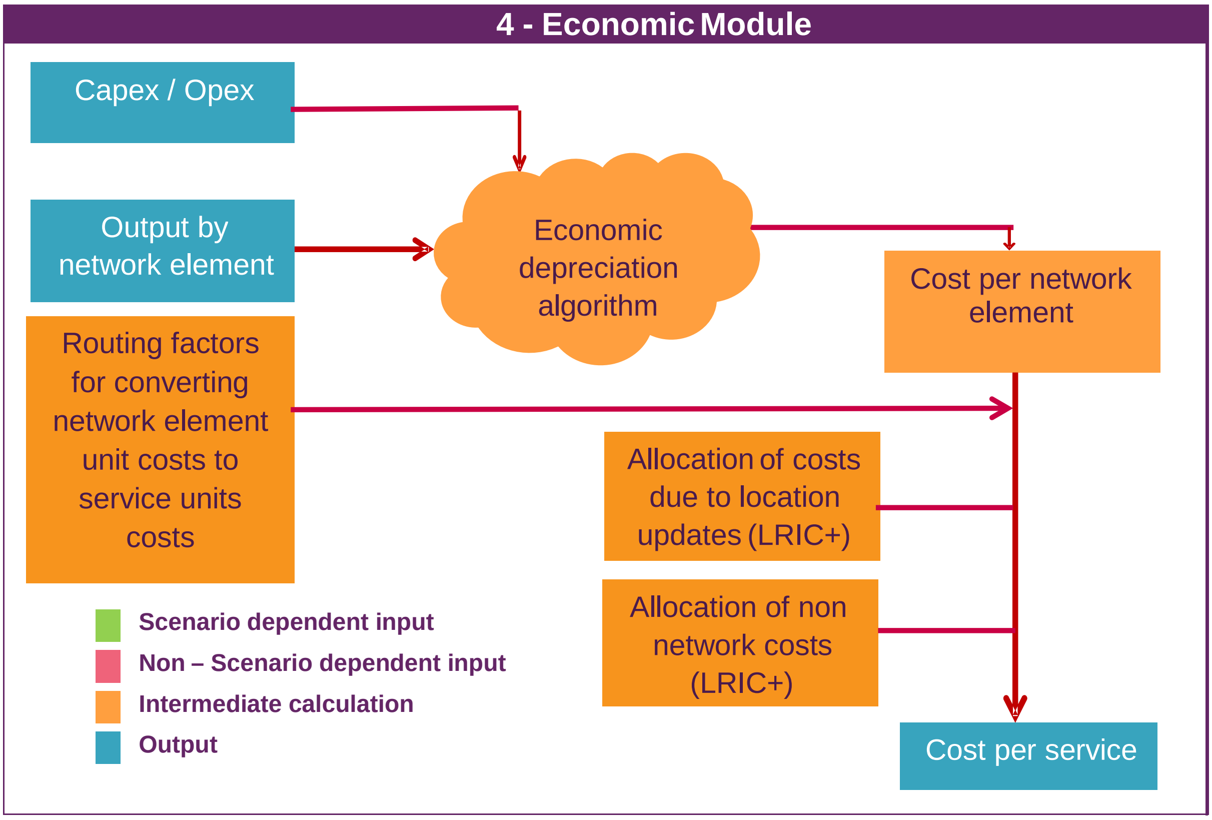
A11.228 A detailed description of our infrastructure sharing assumptions is provided in Annex 12.

Economic module

A11.229 Once the yearly capex and opex of the hypothetical efficient MCP have been calculated in the cost module of the model, we must determine how these costs are recovered over time. This is done in the economic module.

A11.230 The economic module implements economic depreciation to calculate a cost per unit of output, in each year, for every asset in the model. These costs per unit of output for each asset are then used to estimate the unit service cost for each service modelled using service routing factors. An overview of the calculation flow in the economic module is shown in Figure A11.24 below.

Figure A11.24: Summary of Economic Module calculations



Source: Ofcom.

Use of economic depreciation

A11.231 We use economic depreciation instead of accounting approaches to depreciation because we consider that it better reflects the forward looking economic value of an asset and hence better mimics the outcome of a competitive market. Furthermore, using economic depreciation is consistent with the 2009 EC Recommendation which states that "the recommended approach for asset depreciation is economic depreciation wherever feasible."[75]

A11.232 Consistent with our MCT models since 2005 (including the 2011 MCT model), we use a form of economic depreciation known as Original Economic Depreciation ('Original ED').[76] We consider Original ED to be a better depreciation approach to other forms of economic depreciation because it better mimics the outcomes that would be seen in a competitive market. We note that the Original ED approach to economic depreciation has been supported by the CC each time it has been appealed, most recently in the 2012 CC Determination.

[75] 2009 EC Recommendation, point 7.
[76] Economic depreciation was also used by Oftel in 2001 in relation to its Review of the Charge Control on calls to mobile, http://www.ofcom.org.uk/static/archive/oftel/publications/mobile/ctm0901.pdf and http://www.ofcom.org.uk/static/archive/oftel/publications/mobile/depr0901.htm.

How economic depreciation works

A11.233 Economic depreciation matches the cost of equipment to its actual and forecast use over the long-term. Consequently, there is relatively little depreciation in years when utilisation is low and relatively high depreciation in years of full, or almost full, equipment utilisation.

A11.234 An alternative way to characterise economic depreciation is as a cash flow analysis to answer the question: what time series of prices, consistent with trends in the underlying costs of production and given forecast traffic, yield an expected present value equal to the capital and operating cash flows from building and running the network?

A11.235 In order to answer this question, the economic module performs the following calculation in three stages:

- **Stage 1**: A constant unit cost is calculated as if the final year utilisation and input costs applied over the entire lifetime of the network.
- **Stage 2**: A second component is added to recover the additional costs caused by earlier under-utilisation of the network compared to the final year level.[77] This step is also applied as a constant unit price for all years.
- **Stage 3**: A third component is added to recover the remaining unrecovered (or over-recovered) costs due to input costs, including the WACC, being above (or below) the final year level. The shape of this component is determined by the arithmetic difference between the in-year and final-year input costs,[78] and is therefore zero in the final year (or any year that shares the same level of input costs and WACC as the final year). More costs are recovered in years when asset prices and the WACC are higher than the final year.

A11.236 The Original ED algorithm used in the 2011 MCT model included a 'fix' that prevented unit costs for network elements from being negative. The 'fix' was applied through an iterative element to the final stage of the ED algorithm that shifted the cost profile weighting factor upwards until no unit costs for the output of that element were negative. The 'fix' was introduced by Ofcom because although negative unit costs can be a legitimate output of the economic depreciation calculations given certain inputs, it was considered to be counter-intuitive.

A11.237 However, in the 2012 CC Determination[79] the CC indicated that the 'fix' was unnecessary. Therefore, we have chosen to remove the 'fix' from the 2014 MCT model.

A11.238 As mentioned in footnote 72, the cost trends used in the Economic module exclude the impacts of the redistribution of S-RAN costs amongst the 2G, 3G and 4G

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[77] If utilisation is falling over time then this could be a negative value.
[78] The 'input costs' for a particular year are the asset price (or operating cost) for that given year and the WACC. The arithmetic difference between in-year and final year input costs is given by: (Asset price$_t$ x WACC$_t$) – (Asset price$_n$ x WACC$_n$). Where (t) is the current year and (n) is the final year.
[79] See paragraphs 3.502-3.503 of the 2012 CC Determination, http://www.catribunal.org.uk/files/1.1180-83_MCT_Determination_Excised_090212.pdf

assets. The reason for this is that the approach reflects a modelling simplification to capture the efficiencies associated with equipment sharing between MCPs rather than changes in the replacement costs of individual pieces of network equipment faced by MCPs, and as a result should not be used in determining the optimal path of cost recovery.

A11.239 As set out in Figure A11.23, the ED algorithm allows us to calculate the yearly unit cost for each network element. The network element output cost is then multiplied by the routing factors which thereby converts the network element unit costs to the service unit costs i.e. the cost of MCT per minute.[80]

[80] We have made two refinements to the Economic module in order to ensure consistent cost recovery when calculating LRIC. The first ensures that the costs of switch sites that are incremental to MCT are allocated solely to MCT (rather than allocated between voice and data traffic as they are under LRIC+). The second allocates costs using service volumes and routing factors rather than decremental element output.

Annex 12

Analysys Mason report

This report is published separately.

Annex 13

Calibration of the 2014 MCT model

Introduction

A13.1 Cost models can be constructed in both ‘top-down’ and ‘bottom-up’ forms. In a top-down approach, relationships between outputs and costs are estimated from historical accounting information, and costs are projected forward on the basis of service volume forecasts and some predetermined cost volume relationships. In a bottom-up approach (as described in Annex 11), the components that comprise the network costs are identified at a more granular level. Asset volume drivers are then defined to determine the quantity of each of the network components required for a given level of forecast network output. These network components then have costs assigned to them.

A13.2 In this market review, as in previous market reviews, we are using a hybrid modelling approach as described in the 2009 EC Recommendation.[81] This approach aims to capture the strengths of both top-down and bottom-up approaches. The model has been developed as a bottom-up cost model with a view to establishing the unit cost benchmarks for MCT of an average efficient MCP, rather than MCP-specific unit cost benchmarks. However, it has also been calibrated by adjusting unit cost levels and cost causality relationships of different cost components, to ensure the model is reasonably in line with the actual costs incurred by the 2G/3G/4G MCPs (i.e. excluding H3G) in historical years.

A13.3 The purpose of this annex is to describe the method which has been used to calibrate the model based on assets counts and accounting data, and to summarise the results of the calibration (to the extent possible having regard the confidentiality of the data provided by the four largest MCPs).

A13.4 All the results presented in Section 7, Annex 11 and Annex 16 take into account the calibration of the model to an average efficient 2G/3G/4G MCP.

Proposals in the October 2013 and January 2014 Workshops

A13.5 Previous versions of the MCT model have been calibrated with reference to two different types of high-level benchmarks obtained from information provided by the MCPs in response to formal information requests:

- counts of different types of network equipment (e.g. cell sites, MSCs); and
- accounting costs based on data from the MCPs’ management accounts.

A13.6 At our October 2013 and January 2014 workshops we noted that calibration would be an important part of the modelling process for the 2015 MCT review. Our preliminary proposal at the workshops was that we would take a similar approach to that which had been used in previous calibrations of the MCT model. However, we

[81] See point 3 and recital 9 of the 2009 EC Recommendation.

indicated that there would be less focus on using the Net Book Value (NBV) as part of the calibration.[82]

Stakeholder comments to the October 2013 workshop

A13.7 H3G considered that it would be important for Ofcom to carry out a careful analysis of its bottom-up unit equipment costs before carrying out its top-down calibration.[83]

A13.8 EE noted Ofcom's preliminary view that it would focus on aligning the model with actual GBVs of the MCPs. EE stated that this would be in line with the conclusions on the CC in the appeals relating to the last market review. However, EE said that in focusing on the GBV element of the calibration it will be important not to take the CC conclusions out of context. EE noted that the CC stressed that for its purposes the timeliness of implementation was an important consideration but also noted at paragraph 7.228 of the 2012 CC Determination that in an "ideal world a proper reconciliation between the bottom-up and top-down data would be carried out and this reconciliation would involve a reassessment of the data or the methodology underlying Ofcom's decision".

A13.9 EE considered that it was important to undertake a sensible and appropriate calibration process as a bottom up model is unlikely to capture all of the relevant costs. A priori, this is likely to be an important issue this time around given the technological and market changes. All of the mobile networks are currently in a state of significant change, which makes it more likely that there will be cost changes which a bottom up model focused on voice services will not be able to capture. As such reconciling top down and bottom up information will be important.

A13.10 However, before the detailed structure of the bottom up model was known, EE considered it was too early to comment in detail on the appropriate approach to calibration.[84]

Ofcom response and proposed approach to calibration

A13.11 We have undertaken a thorough calibration of the 2014 MCT model, within the limits of the information that the MCPs have been able to provide. As proposed in the October 2013 and January 2014 workshops, we have calibrated the 2014 MCT model using network equipment counts and top-down accounting information.

A13.12 For the financial calibration, we consider that GBV is a more appropriate calibration benchmark than in-year capital expenditure or the NBV. Although NBV can act as a useful cross-check during the calibration process (and was used in the calibration of the 2011 MCT model), we consider that its usefulness is limited given the information is sensitive to the differences and changes to the depreciation approaches used by the 2G/3G/4G MCPs and is more sensitive than GBV to fluctuations in capex in each year.

[82] Slide 30, http://stakeholders.ofcom.org.uk/binaries/consultations/mobilecallterm/MCT_slides.pdf.
[83] H3G response to October 2013 workshop, http://stakeholders.ofcom.org.uk/binaries/telecoms/policy/mobile/Threes_Response_to_Ofcom_MCT_market_review_workshop.pdf
[84] EE response to October 2013 workshop, http://stakeholders.ofcom.org.uk/binaries/telecoms/policy/mobile/EE_MCT_Market_Review.pdf

A13.13 Network operating costs are likely to fluctuate less than capital costs on a year-to-year basis as these represent costs of on-going network maintenance and asset operation, which are relatively stable. However, we recognise that there are still likely to be year-in-year fluctuations in these cost benchmarks which are not explainable solely by the parameters and network dimensioning rules within the 2014 MCT model.

A13.14 We have therefore used evidence obtained in relation to asset counts, GBV and network operating costs as the primary metrics for our calibration exercise.

A13.15 Since the calibration data collected from the MCPs are historical data, they relate to a period before some of the latest technological developments included in the 2014 MCT model were actually implemented. In particular, S-RAN assets were introduced as recently as 2013 and hence the effects of their deployment will not be fully reflected in the calibration data which cover the period to Q3 2013. As a result we have undertaken our calibration exercise excluding S-RAN deployment.[85]

Data collection process

A13.16 Data to inform the calibration exercise formed an important part of our information requests to the four largest MCPs using our powers under Section 135 of the Communications Act 2003, as described in Annex 11. We requested actual equipment inventories from MCPs for the period Q3 2010 to Q3 2013 and projections of future inventories of equipment. Turning to accounting cost data, we requested information from each of the four largest MCPs for network GBV, NBV and network operating costs for the period 2009/10 to 2013/14.

A13.17 For network equipment counts none of the four largest MCPs was able to provide us with all of the information requested, but in relation to certain particularly significant asset types, such as site counts, all four largest MCPs provided useful information. Where information requested has not been provided we have estimated asset counts, given the trends in the data available to us.

A13.18 The process of calibration using accounting cost information has been more difficult than for the asset counts. This is partly because requesting accounting information and comparing it to intermediate outputs of the model is complicated by different classifications and definitions of types of costs, both between the individual MCPs and between the MCPs and the model. Furthermore, we found a lack of consistency between the accounting information provided in response to the section 135 information request dated 8 November 2013 and the accounting information provided for the 2011 MCT model.

A13.19 Our comparison of accounting data showed that for [✂] there appeared to be a significant downward step change between the four years of data provided for the 2011 MCT model, and the four years of data provided for the 2014 MCT model. This step change was beyond the fluctuations in data that we would reasonably expect to occur between data gathering exercises.

A13.20 Where the information provided in response to the section 135 information request was incomplete or where there were inconsistencies between the information provided and that provided for the 2011 MCT review, we sought clarifications from each of the largest MCPs via a series of follow-up questions. In relation to the

[85] This is scenario 6 in the 2014 MCT model.

financial information, in particular, [✂] were unable to provide a detailed and comprehensive explanation of the discrepancies with the information provided for the 2011 MCT review.

A13.21 In the absence of accounting information that is consistent with that provided for the purposes of the 2011 MCT model, and in particular in the absence of persuasive and comprehensive evidence as to the reasons for the discrepancies, we have taken an alternative approach to using the financial information provided by [✂].

A13.22 In these cases we have used the accounting information provided by the 2G/3G/4G MCPs[86] to calculate the absolute change in GBV over the period 2010 to 2013. We have then applied these changes to the corresponding GBV levels from the final year of calibration data from the 2011 MCT review to provide an extrapolated set of GBV values.[87] These extrapolated GBV values have been used instead of section 135 information request GBV data for [✂].

A13.23 We have used the same extrapolation approach for operating costs in the 2014 MCT model for [✂] for the same reasons.[88]

A13.24 We consider this approach to be reasonable, because of the inconsistencies in the latest data received from [✂] and the fact that we have not been provided with reconciliation to the data used in the 2011 MCT review that we consider to be satisfactory.

A13.25 We anticipate requesting further accounting data and explanation from the MCPs in relation to this in order to understand this discrepancy.

Model inputs adjusted as part of the calibration

A13.26 To calibrate the model we have adjusted certain bottom-up input parameters to achieve asset counts and costs (GBV and network operating costs) consistent with the top-down information obtained from each of the four largest MCPs, while the bottom-up parameters remain within the range of the available bottom-up information from each of the four largest MCPs.

A13.27 Where the same input parameters are used in both the 2011 MCT model and the 2014 MCT model, our starting point for these inputs is the values in the 2011 MCT model. Some of these parameters have subsequently been adjusted to take account of bottom-up evidence provided by MCPs.

A13.28 We have then adjusted the following model input parameters such that a high-level asset count and cost outputs (specifically GBV and network operating costs) for the modelled average efficient MCP are in line with the top-down evidence that we have collected:

i) Parameters adjusted for the asset count and financial calibration:

- unit capacities of network elements;

[86] The accounting information was provided in response to the section 135 information request dated 8 November 2013 (and information received from the four largest MCPs following our clarification process).
[87] Since the two sets of accounting data did not overlap it was necessary for us to derive both the 2010 and 2011 values using the difference between the 2011 and 2010 section 135 data.
[88] [✂]

- minimum asset deployments;
- asset utilisation factors;
- the proportion of cell sites which are shared between 2G, 3G and 4G networks;
- NodeB processing parameters;
- the percentage of traffic in the busy hour; and
- GPRS data rate.

ii) Parameters adjusted for the financial calibration only (GBV and opex):

- MEA investment costs per unit of equipment over time; and
- MEA operating costs per unit of equipment over time.

Results of the 2014 MCT model calibration

A13.29 The aim of the asset count and financial calibration exercise was to ensure the high level outputs from the model are consistent with MCP data. There have been considerable changes in the mobile industry over the calibration period. As a result, we recognise that some data provided by MCPs may not represent a network under normal conditions.

A13.30 For instance, reconciliation of network assets after two networks merge can cause top-down accounting cost data to reduce. Specifically, we observe that [✂]. We would not wish to inadvertently capture this effect in our calibration.

A13.31 Similarly we recognise that the asset counts and network costs evident in the MCP data will depend, in part, on the MCPs' market shares. We have borne this in mind when considering the calibration of the 2014 MCT model.

A13.32 We consider the model well calibrated if the model results fall with the minimum and maximum values provided by the MCPs and follow a similar trend to the MCP data. We also consider how well the model outputs match the average of the MCP data.

Asset count calibration

A13.33 The general principle we applied was that the count of the most important assets (e.g. cell sites) should be close to the average count of the 2G/3G/4G MCPs,[89] and always between the minimum and maximum values seen across all four largest MCPs. We adopted a broadly similar approach as in the calibration of the 2011 MCT model and we consider that averaged data is more likely to give reliable estimates of the overall industry figures rather than those that reflect specific MCP strategies.

[89] Note that although we have used data from the 2G/3G/4G MCPs, the 2014 MCT model only includes 4G services from Q3 2013/14. As a result no 4G assets are included in the asset count calibration.

A13.34 Table A13.1 below shows the counts of key network equipment in the model compared to the average MCP benchmark after completing the calibration of the 2014 MCT model. This is shown on a randomised average basis for the 2G/3G/4G MCPs. Each asset count has also been randomised by a different randomisation factor.[90]

Table A13.1: Comparison of asset count of key network equipment between model output and 2G/3G/4G randomised MCP data in 2012/13

Asset type	% difference between 2014 MCT model and average MCP data[91]	2G/3G/4G MCP average	2G/3G/4G randomised MCP average	2014 MCT Model
2G macrocell equipment	✂	✂	**10,361**	**10,928**
2G micro and picocell equipment	✂	✂	2,706	2,134
3G macrocell equipment	✂	✂	**11,707**	**11,531**
3G micro and picocell equipment	✂	✂	1,842	829
Total macro sites	✂	✂	**12,051**	**14,832**
Total micro and pico sites	✂	✂	2,961	3,339
TRXs	✂	✂	**184,091**	**102,816**
BSCs	✂	✂	225	132
3G carriers	✂	✂	**72,179**	**64,985**
RNCs	✂	✂	133	123
2G/3G MSC server	✂	✂	**24**	**23**
2G/3G MGW	✂	✂	44	32
SMSC	✂	✂	**13**	**3**
HLR	✂	✂	29	9
SGSN	✂	✂	**11**	**8**
GGSN	✂	✂	8	8

Source: Ofcom analysis of section 135 responses and 2014 MCT model.

A13.35 In addition to Table A13.1 the figures below compare the 2G/3G/4G MCP averages for key assets against the model outputs over the period 2010/11 to 2013/14. As above, where randomised results are shown these include a random factor of +-20% in order to maintain confidentially.

[90] The 2G/3G/4G MCP average has been randomised by +-20% in order to maintain the confidentially of the section 135 responses.
[91] [✂]

A13.36 Figure A13.1 shows a comparison of 2G cell equipment between a 2G/3G/4G MCP average and the 2014 MCT model outputs for Q2 in the years 2010/11, 2011/12, 2012/13 and 2013/14.

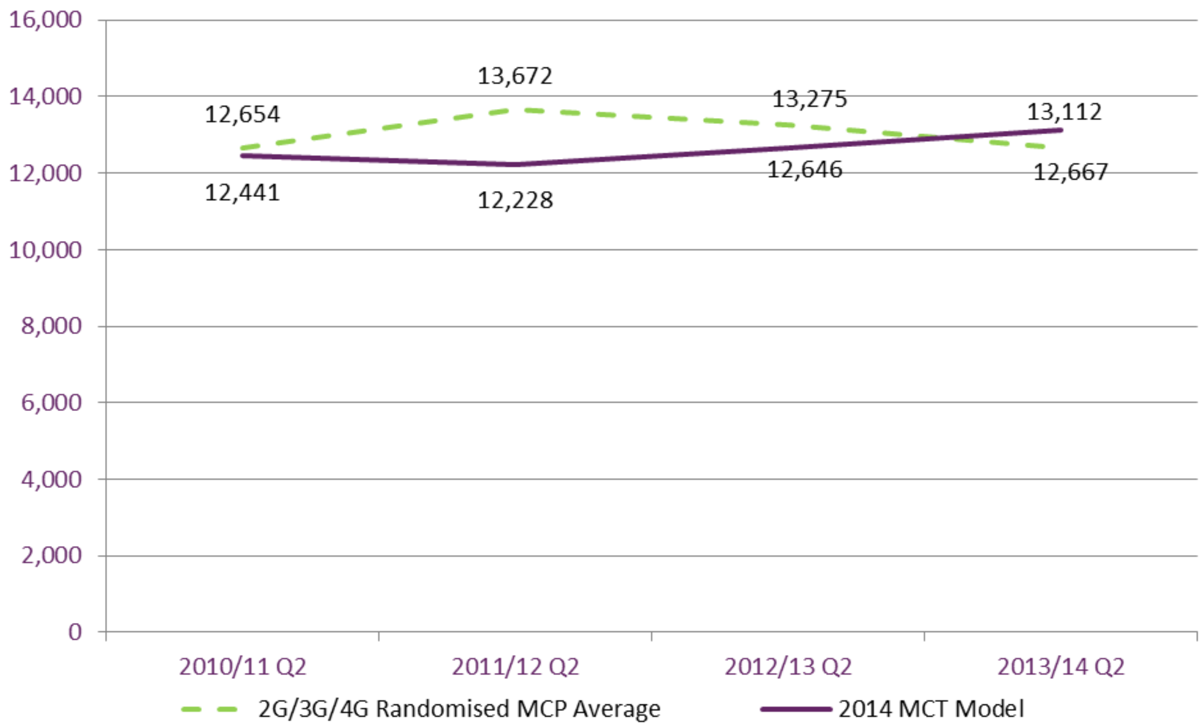
Figure A13.1: Comparison of total 2G cell equipment between model output and 2G/3G/4G MCP data

[✂]

Source: Ofcom analysis of section 135 responses and 2014 MCT model.

A13.37 Figure A13.2 below shows a comparison of 2G equipment between a 2G/3G/4G randomised MCP average and the 2014 MCT model outputs for Q2 in the years 2010/11, 2011/12, 2012/13 and 2013/14.

Figure A13.2: Comparison of total 2G cell equipment between model output and 2G/3G/4G randomised MCP data



Source: Ofcom analysis of section 135 responses and 2014 MCT model.

A13.38 Figure A13.3 below shows a comparison of 3G equipment between a 2G/3G/4G MCP average and the 2014 MCT model outputs for Q2 in the years 2010/11, 2011/12, 2012/13 and 2013/14.

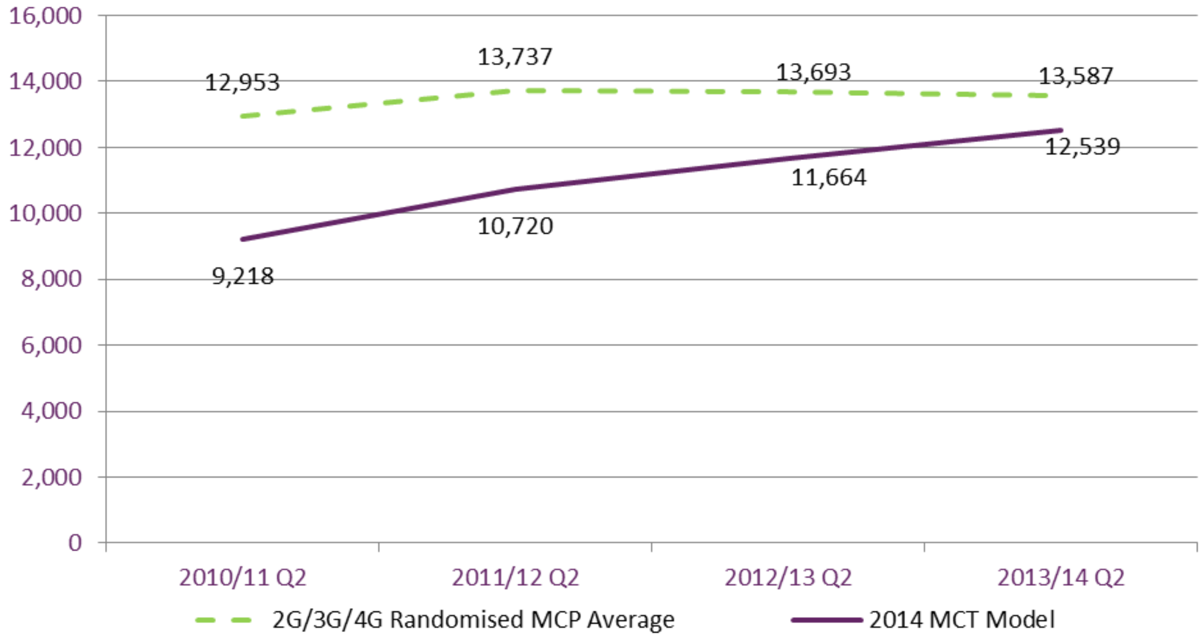
Figure A13.3: Comparison of total 3G cell equipment between model output and 2G/3G/4G MCP data

[✂]

Source: Ofcom analysis of section 135 responses and 2014 MCT model.

A13.39 Figure A13.4 below shows a comparison of 3G equipment between a 2G/3G/4G randomised MCP average and the 2014 MCT model outputs for Q2 in the years 2010/11, 2011/12, 2012/13 and 2013/14.

Figure A13.4: Comparison of total 3G cell equipment between model output and 2G/3G/4G randomised MCP data



Source: Ofcom analysis of section 135 responses and 2014 MCT model.

A13.40 Figure A13.5 below shows a comparison of total macro sites between a 2G/3G/4G MCP average and the 2014 MCT model outputs for Q2 in the years 2010/11, 2011/12, 2012/13 and 2013/14.

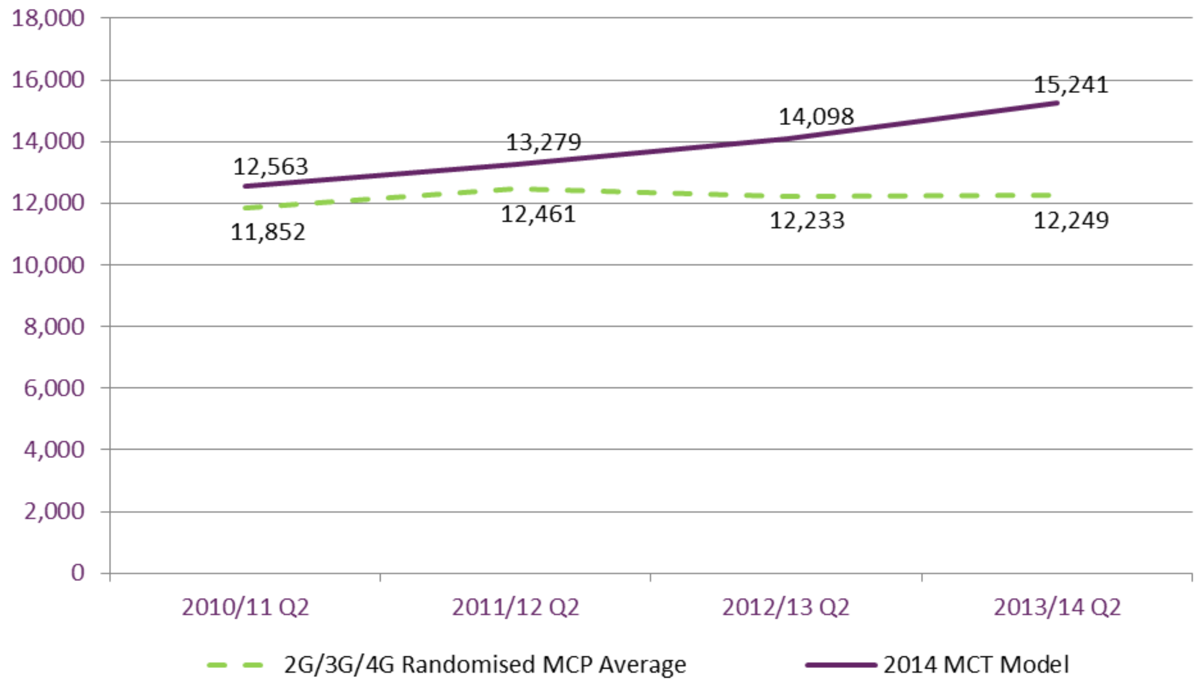
Figure A13.5: Comparison of total macro sites between model output and 2G/3G/4G MCP data

[✂]

Source: Ofcom analysis of section 135 responses and 2014 MCT model.

A13.41 Figure A13.6 below shows a comparison of total macro sites between a 2G/3G/4G randomised MCP average and the 2014 MCT model outputs for Q2 in the years 2010/11, 2011/12, 2012/13 and 2013/14.

Figure A13.6: Comparison of total macro sites between model output and 2G/3G/4G randomised MCP data



Source: Ofcom analysis of section 135 responses and 2014 MCT model.

A13.42 Figure A13.7 below shows a comparison of total macro, micro and pico sites between a 2G/3G/4G MCP average and the 2014 MCT model outputs for Q2 in the years 2010/11, 2011/12, 2012/13 and 2013/14.

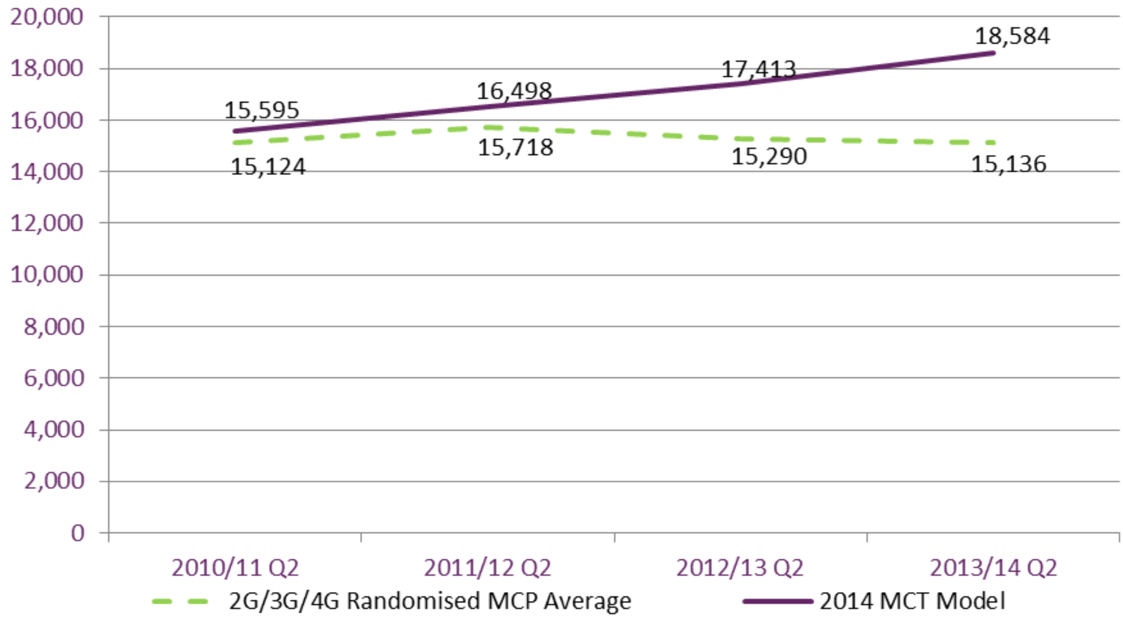
Figure A13.7: Comparison of total macro, micro and pico sites between model output and 2G/3G/4G MCP data

[✂]

Source: Ofcom analysis of section 135 responses and 2014 MCT model.

A13.43 Figure A13.8 below shows a comparison of total macro, micro and pico sites between a 2G/3G/4G randomised MCP average and the 2014 MCT model outputs for Q2 in the years 2010/11, 2011/12, 2012/13 and 2013/14.

Figure A13.8: Comparison of total macro, micro and pico sites between model output and 2G/3G/4G randomised MCP data



Source: Ofcom analysis of section 135 responses and 2014 MCT model.

Cost calibration

A13.44 The aim of the cost calibration exercise is to adjust the model inputs so that the level of GBV and operating costs produced in the model are broadly consistent with the average MCP data.

A13.45 The model has been calibrated so that the GBV and operating cost outputs for 2010, 2011, 2012 and 2013 were as close as possible to the average of the 2G/3G/4G MCPs and at least always between the minimum and maximum values seen across all of the MCPs.

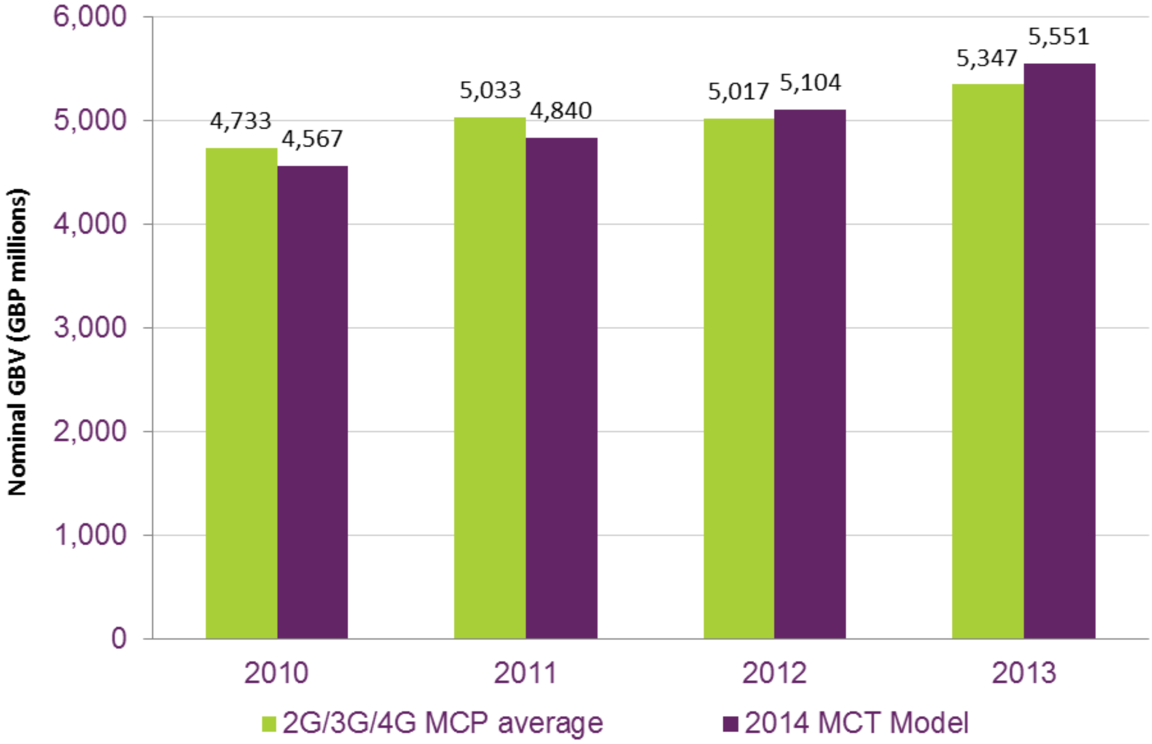
A13.46 In addition to adjusting the network dimensioning parameters, we also performed a general uplift to historic asset price trends in order to bring the GBV into calibration. Where we found a difference between the 2014 MCT model financial outputs and the MCP data, we first examined whether any of the bottom-up network build parameters should be adjusted. Once we were satisfied that the network build part of the model was well calibrated, we made a general uplift to asset price trends in order to bring the 2014 MCT model into calibration. This uplift is similar to the approach used in the 2012 CC determination.[92] The advantage of a general uplift to asset prices is that it maintains the structure of relative asset prices and cost volume relationships that have been determined from the bottom-up data.[93]

A13.47 Figure A13.9 below shows the GBVs outputs from the 2014 MCT model and the projected (and non-randomised) average of GBVs from the 2G/3G/4G MCPs.

[92] See 2012 Competition Commission Determination on the March 2011 Statement, Paragraph 7.271. http://www.catribunal.org.uk/files/1.1180-83_MCT_Determination_Excised_090212.pdf

[93] The uplifts to the asset price trends are 25% in each year from 2008/09 to 2011/12.

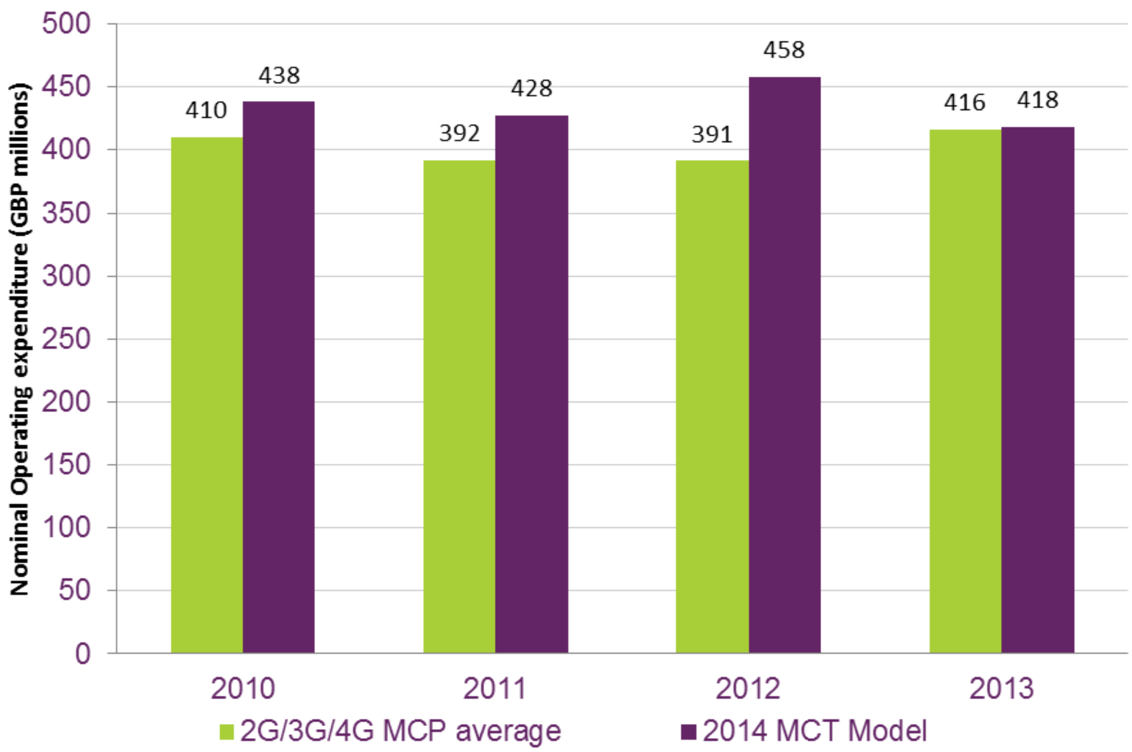
Figure A13.9: GBV comparison between the 2014 MCT model output and adjusted 2G/3G/4G MCP data



Source: Ofcom adjusted section 135 responses and 2014 MCT model.

A13.48 Figure A13.10 shows the opex outputs from the 2014 MCT model and the projected (and non-randomised) average of opex values from the 2G/3G/4G MCPs.

Figure A13.10: Opex comparison between the 2014 MCT model output and 2G/3G/4G MCP data



Source: Ofcom adjusted section 135 responses and 2014 MCT model.

A13.49 In summary, having considered stakeholder responses and refined key input parameters, we consider the 2014 MCT model to be well calibrated to an average efficient 2G/3G/4G MCP.

Annex 14

Cost of capital

Introduction

A14.1 In this annex we set out our estimate of the weighted average cost of capital (WACC) for an average efficient MCP. This WACC is used as the discount rate in the 2014 MCT model (which is a discounted cash flow model) used to set the proposed MCT charge control.

A14.2 We have an established framework for estimating the WACC which has been used in previous charge controls (including the 2011 MCT review) and which closely reflects that adopted by other UK regulators. We attach weight to the objective of promoting regulatory predictability by ensuring a consistent regulatory approach over appropriate periods, provided that we are satisfied that the circumstances of a specific case do not warrant us taking a different approach.

Summary of our proposals

A14.3 For this consultation we propose to use a pre-tax real WACC for an average efficient UK MCP of 6.9%. This WACC estimate is in real terms with respect to CPI inflation, consistent with the use of CPI as the inflation index in the 2014 MCT model.

A14.4 A number of the parameters used in this WACC calculation are the same as those used in the WACC calculation published in the 2014 Fixed Access Market Review Draft Statement (2014 FAMR Draft Statement) in relation to LLU and WLR.[94] This is because these parameters relate to market-wide factors rather than company-specific factors. The main differences between the WACC calculation presented here and that in the 2014 FAMR Draft Statement relate to the asset beta and debt premium assumed for an average efficient MCP, the forward looking gearing rate used to calculate an equity beta and used as a weighting in the WACC calculation, and the RPI inflation used to calculate a nominal WACC. In recognition that some of these parameters could change between now and our Final Statement for this market review, in our sensitivity analysis we have used a range for the pre-tax real WACC for an efficient UK MCP of 5.9% to 7.9% (see Annex 16 of this consultation).

A14.5 Our consultation estimates of the WACC for a UK MCP are shown in Table A14.1 alongside the WACC estimates used in the March 2011 Statement.

[94] Fixed access market reviews: wholesale local access, wholesale fixed analogue exchange lines, ISDN2 and ISDN30 – Volume 2: LLU and WLR Charge Controls, 20 May 2014 http://stakeholders.ofcom.org.uk/binaries/telecoms/ga/fixed-access-market-reviews-2014/draftstatement/volume2.pdf

Table A14.1: WACC estimate for an average efficient MCP

WACC component	March 2011 (Statement)	June 2014 (Consultation)
Real risk-free rate (RPI)	1.5%	1.3%
RPI inflation	2.5%	3.3%
Nominal risk-free rate	4.0%	4.6%
Equity Risk Premium	5%	5%
Debt beta	0.10	0.10
Asset beta	0.56	0.54
Gearing (forward looking)	30%	27%
Equity Beta	0.76	0.70
Cost of equity (post-tax)	7.8%	8.2%
Debt premium	1.5%	1.2%
Corporate tax rate	24%	20%
Cost of debt (pre-tax)	5.5%	5.8%
WACC (pre-tax nominal)	8.9%	9.0%
WACC (pre-tax real) (RPI deflation)	6.2%	5.5%
WACC (pre-tax real) (CPI deflation)		6.9%

Note: Real WACC with respect to RPI is calculated by deflating the nominal WACC by forecast RPI. Real WACC with respect to CPI is calculated by deflating the nominal WACC by forecast CPI.

How we calculate and use the cost of capital

A14.6 Companies have two basic ways of obtaining funding, through debt or equity. By knowing the proportion of each type of funding, and estimating the cost of each, we can estimate the WACC.

A14.7 The model that we have consistently used for estimating the cost of equity is the Capital Asset Pricing Model (CAPM), which the Competition Commission (CC) has previously found to be the most robust way for a regulator to measure the returns required by shareholders.[95] We propose to continue to use CAPM to estimate the WACC. We consider that it remains the most appropriate method for estimating the cost of capital for regulatory purposes and we place weight on taking a consistent approach to estimating the cost of equity within the WACC over time.

The Capital Asset Pricing Model (CAPM)

A14.8 The pre-tax nominal WACC is derived as follows:

$$WACC = \frac{Ke * (1 - g)}{1 - t} + Kd * g$$

[95] Paragraph 13.19, page 13-4, Competition Commission, *Northern Ireland Electricity Limited price determination*, *A reference under Article 15 of the Electricity (Northern Ireland) Order 1992,* 26 March 2014 ('the 2014 NIE Final Determination'). https://assets.digital.cabinet-office.gov.uk/media/535a5768ed915d0fdb000003/NIE_Final_determination.pdf

- Where Ke = the cost of equity which is given by reference to the risk-free rate (Rf), the expected return on the equity market as a whole over the risk-free rate (i.e. the equity risk premium, or ERP) and the perceived riskiness of the asset in question (β) such that:

$$Ke = Rf + ERP * \beta$$

- Kd = the cost of debt, which is given by reference to the risk-free rate and the debt premium of the firm, dp, such that:

$$Kd = Rf + dp$$

- t is the corporate tax rate; and

- g = gearing (debt funding as a proportion of total debt and equity funding).

A14.9 The pre-tax real WACC is obtained using the following formula: ((1+pre-tax nominal WACC)/(1+forecast inflation rate))-1. Since we are calculating a pre-tax real WACC with respect to CPI, the forecast inflation used in this formula is CPI inflation.

Key parameters

A14.10 There are a number of parameters that we have to estimate in order to calculate the overall WACC for an average efficient MCP.

A14.11 Some of these parameters reflect market-wide factors that affect all firms. We recently considered these market-wide factors as part of the 2014 FAMR Draft Statement. For the purposes of this consultation we have adopted the same values for these market-wide parameters as in the 2014 FAMR Draft Statement given that the documents have been published around the same time. Specifically, we assume:

14.11.1 **Real risk-free rate (RFR) of 1.3%:** In the 2014 FAMR Draft Statement we decided to leave the real RFR unchanged from the 1.3% used in the 2013 BCMR Statement[96]. We noted that spot rates on RPI-linked gilts remained negative but had started to increase and that forward rates on index-linked gilts were positive and increasing. We considered we should be cautious about interpreting the evidence since a number of temporary distortions may be affecting the data. Combined with our RPI inflation forecast for this consultation of 3.3% (see next sub-section), the nominal RFR is 4.6%.

14.11.2 **Equity risk premium (ERP) of 5.0%:** In the 2014 FAMR Draft Statement we decided to leave the ERP unchanged from the 5% used in the 2013 BCMR Statement.[97] We put most weight on the historical premium of equities over government bonds. Using data from the 2014 Sourcebook[98], this suggested that an ERP of 5% was reasonable. Similarly, an estimate of 5% was consistent with recent survey evidence and the range used by the CC in its 2014 NIE Final Determination.[99]

[96] Paragraph A14.51, 2014 FAMR Draft Statement.
[97] Paragraph A14.137, 2014 FAMR Draft Statement.
[98] Credit Suisse Global Investment Returns Sourcebook 2014 (2014 Sourcebook).
[99] See footnote 95 for link.

14.11.3 **Corporate tax rate of 20%**: In the Budget of April 2013, the UK Government announced its intention to reduce the corporate tax rate from 23% to 21% for 2014/15 and to 20% for 2015/16.[100] We propose to use a corporate tax rate of 20% since this represents the best estimate of what the tax rate will be on a long-run, forward-looking basis. This is consistent with the 20% tax rate used in the 2014 FAMR Draft Statement.[101]

A14.12 For the 2015 MCT Statement we will review whether these market-wide parameters remain appropriate in the light of more recent market data.

A14.13 The following sections of this annex consider the remaining parameters for the WACC calculation, specifically: inflation, asset beta, debt beta, gearing and the debt premium.

Inflation

A14.14 For the purposes of the proposed MCT charge control we need to estimate a pre-tax real WACC appropriate to use as the discount rate in a long-run discounted cash flow model.

A14.15 The discounted cash flow model is a real terms model with respect to CPI. Given the long-run horizon of this discounted cash flow model, we propose to use a long-run forecast for the CPI inflation rate. We have therefore used the Bank of England's target CPI inflation rate of 2% in our calculation of the real (CPI-deflated) WACC.

A14.16 However, we still need a long run estimate of RPI inflation as well as CPI inflation. The reason for this is that our estimate of the real RFR used to calculate the WACC is informed by RPI-linked gilts. Combining the real RFR (defined by reference to RPI-linked gilts) with a forecast for RPI inflation enables us to calculate a nominal risk-free rate on a consistent basis and, from this, a nominal WACC. This nominal WACC can then be translated into a real WACC with respect to CPI, by deflating it by forecast CPI.

A14.17 The RPI assumption used should be appropriate for the long-run nature of the discounted cash flow model (which forecasts to 2039/40, with perpetuity values thereafter). We propose to estimate a long-run RPI rate by adding the Bank of England's long-run estimated difference between RPI and CPI to the Bank of England's CPI target of 2%. In its 2014 Inflation Report the Bank of England published a 'long run' estimate of the wedge between RPI and CPI of 1.3%.[102] This implies an RPI forecast of around 3.3% based on long-run expectations. This is the RPI rate we propose to use in our WACC calculation.

A14.18 We note that our RPI assumption of 3.3% differs slightly from the 3.2% rate used in the 2014 FAMR Draft Statement, which was concerned with forecasting out to 2016/17. Given the long-run nature of the 2014 MCT model we consider that we should use the best available long-run estimate of RPI consistent with the long-run CPI estimate of 2%.

[100] Corporation tax rates available here: http://www.hmrc.gov.uk/rates/corp.htm
[101] Paragraph A14.141, 2014 FAMR Draft Statement.
[102] Page 34, Bank of England, *Inflation Report,* February 2014.
http://www.bankofengland.co.uk/publications/Documents/inflationreport/2014/ir14feb.pdf.

Equity beta

A14.19 A company's equity beta measures the returns to shareholders relative to returns from the equity market as a whole.

A14.20 Our aim is to estimate an appropriate equity beta for an average efficient MCP. Doing this is not straightforward since while the parent companies of the four largest UK MCPs[103] are all listed on stock exchanges, the UK businesses themselves are not separately listed. Nevertheless, we can use the betas of these companies, and other similar companies, as an input to our estimate of an equity beta for an average efficient MCP.

A14.21 We propose to derive an equity beta by estimating the following:

- First, an asset beta for an average efficient MCP. The asset beta is the beta of a firm assuming no gearing, i.e. zero debt funding. It can be used to assess the systematic risk of a company irrespective of the capital structure.

- Second, a forward-looking gearing for an average efficient MCP. This forward looking gearing rate is used to re-lever the asset beta in order to derive an equity beta.

Asset beta

A14.22 Our approach to estimating the asset beta is to start with evidence on asset betas that most closely resembles the company or companies we are trying to regulate. We would then move away from these estimates if alternative evidence suggests there are strong reasons to do so.[104] In order to estimate an asset beta for an average efficient MCP we place most weight on evidence of asset betas from companies that actually have UK mobile operations.

A14.23 However, the parent companies of the four largest UK MCPs are not pure play mobile operators; they often also have fixed-line or other telecoms operations. We have therefore considered evidence from comparator companies in other countries to judge whether an adjustment to the asset betas of UK MCPs is appropriate. In particular, the evidence used has been chosen to give as much information as possible about whether the mobile and non-mobile operations of UK MCPs are likely to have different asset betas.

A14.24 In order to help us carry out this analysis we commissioned a report from the Brattle Group (Brattle). Brattle's report can be found in Annex 17. Brattle calculated asset betas for the following groups of listed companies:

- European parent companies of UK MCPs;

- US mobile and fixed line operators;

[103] Vodafone, Telefonica (O2), Orange (EE), Deutsche Telekom (EE) and Hutchison Whampoa (H3G).

[104] For example, when calculating the Openreach asset beta in the 2014 FAMR Draft Statement, we started with the BT Group asset beta and then considered evidence from benchmark companies in deciding how to disaggregate the BT Group asset beta into an asset beta for Openreach and an asset beta for the Rest of BT.

- EU mobile and fixed line operators; and
- UK utilities.

A14.25 Brattle estimated asset betas by first calculating the equity betas for these listed companies, based on regression analysis of the observed equity returns relative to a chosen equity index using data up to the end of 31 January 2014. Brattle calculated both one-year and two-year daily equity betas against a range of market indices, e.g. FTSE All Share and FTSE All World.

A14.26 Asset betas are then calculated using the following formula:

$$\beta\ asset = Gearing * \beta\ debt + (1 - Gearing) * \ \beta\ equity$$

A14.27 Brattle calculated asset betas by de-levering the observed equity betas using an average gearing ratio consistent with the time period for estimating the equity beta. For example, a two-year equity beta was de-levered to an asset beta using the average two-year gearing in the same period. Brattle calculated the asset betas assuming a debt beta of zero and 0.1.[105]

A14.28 Our analysis is based on the two-year asset betas calculated by Brattle assuming a debt beta of 0.1. In previous WACC calculations we have generally placed most weight on the two-year beta because we consider that it provides the most appropriate balance between a short enough estimation period to remain relevant whilst having enough data points to be sufficiently statistically robust. We have considered asset betas calculated using a debt beta of 0.1 since this is consistent with our proposals in paragraphs A14.55 to A14.61 below.

European parent companies of UK MCPs

A14.29 The European parent companies of the UK MCPs considered by Brattle were: Vodafone, Telefónica (O2), Orange and Deutsche Telekom (who each own 50% of EE).[106] In this annex we refer to these four parent companies as the UK MCPs. The UK MCPs share a number of common characteristics; they are all telecoms operators, they generate a significant proportion of their revenue, profitability and value in Europe, and they have a mix of fixed and mobile businesses.

A14.30 For each of the UK MCPs, Table A14.2 shows Brattle's estimates of the asset beta alongside the proportion of total revenue that relates to mobile operations and the market capitalisation of the parent companies. The table shows that of the UK MCPs, Vodafone derives the overwhelming majority (89%) of its revenue from mobile operations and its asset beta is currently the highest. The asset beta estimates based on the FTSE-All Share are similar to those based on the FTSE All World.

[105] Brattle also ran a number of statistical tests to ensure that the equity beta estimates were sufficiently robust. These included tests for trading illiquidity and time distortions, and tests to ensure that the equity beta estimates satisfy the standard conditions underlying ordinary least squares regression.

[106] We did not ask Brattle to consider Hutchison Whampoa, the owner of H3G, as it is a diversified conglomerate operating across a number of sectors including retail, ports and telecoms. Beta estimates for Hutchison Whampoa are therefore unlikely to convey useful information about an average efficient MCP.

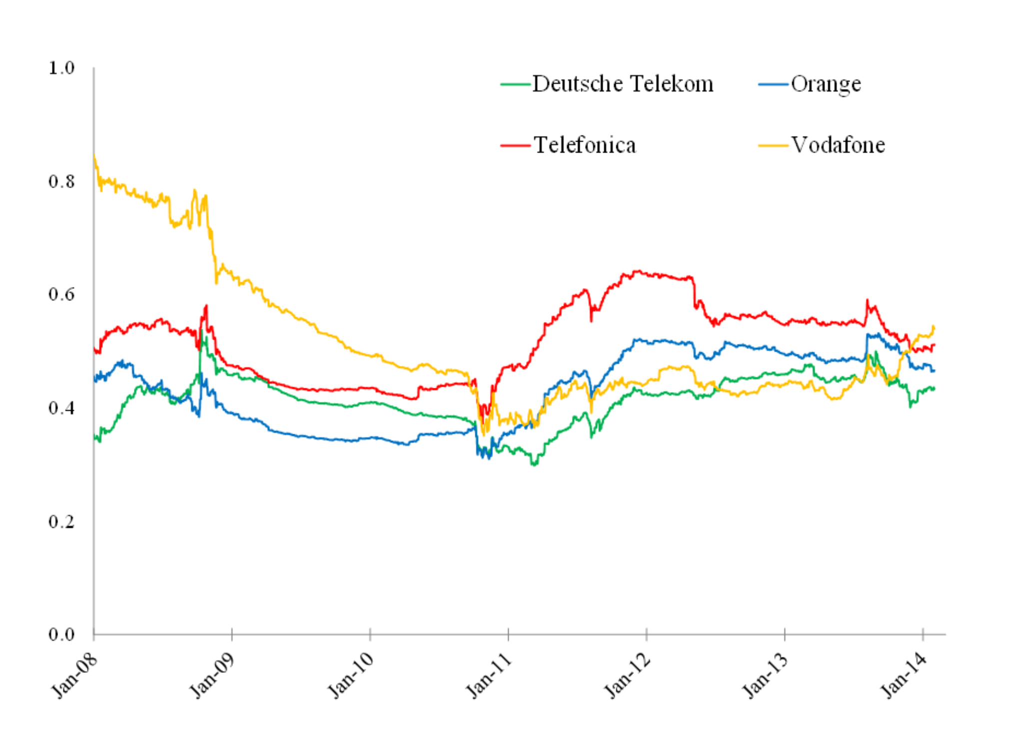
Table A14.2: Asset betas for the UK MCPs

	Asset beta (All share)	Asset beta (All World)	Mobile revenue %	Market Cap £bn
Vodafone	0.56	0.54	89%	110
Telefónica	0.49	0.51	67%	52
Orange	0.43	0.47	52%	24
Deutsche Telekom	0.42	0.43	50%	53
Average	0.48	0.49	65%	

Note: Asset beta estimates based on two year equity betas with a debt beta of 0.1. Market capitalisation as at 31 January 2014. Mobile revenue data relates to 2013 results and was provided by Brattle. Note that Deutsche Telekom does not separately report its revenue from mobile operations; the figure shown is Brattle's estimate from its report.

A14.31 Figure A14.1 shows the rolling two-year asset betas for the UK MCPs against the FTSE All World. The chart shows that the asset betas have been relatively stable in the last couple of years, although Vodafone's asset beta has been rising in the last few months while those of the other UK MCPs have fallen a little. Over the last two years the two-year asset betas have ranged between 0.4 and 0.6. Vodafone's two-year asset beta is currently the highest of the UK MCPs, as it was in the period up to the end of 2010.

Figure A14.1: Two-year rolling asset betas against the FTSE All World for the UK MCPs



Source: Brattle

US mobile and fixed line companies

A14.32 Brattle calculated asset betas for three pure play fixed line US telecommunications companies (Century Link, Frontier and Windstream) and six companies whose operations were principally in mobile (AT&T, Verizon, Sprint, Leap, T-Mobile and US Cellular).

A14.33 Table A14.3 summarises the asset beta estimates calculated by Brattle. The table shows that asset betas for US mobile operators are currently all higher than those for US fixed line operators. Based on the All World index, the average asset beta for the US mobile operators considered by Brattle is 0.53 compared to an average of 0.34 for US fixed line operators. A similar difference is observed when the S&P500 index is used.

Table A14.3: Asset betas for US telecommunications companies

	Asset beta (S&P500)	Asset beta (All World)	Mobile revenue %	Market cap £bn
US mobile operators				
T-Mobile	0.65	0.69	100%	24
US Cellular	0.59	0.58	100%	4
Leap	0.40	0.41	100%	1
Sprint	0.64	0.64	90%	33
Verizon	0.45	0.41	67%	137
AT&T	0.51	0.45	54%	174
Average	**0.54**	**0.53**		
US fixed line operators				
Century Link	0.39	0.37	-	17
Frontier	0.32	0.29	-	5
Windstream	0.36	0.36	-	4
Average	**0.36**	**0.34**		

Note: Asset beta estimates based on two year equity betas with debt beta of 0.1. Mobile revenue data relates to 2013 results and was provided by Brattle. Market capitalisation as at 31 January 2014.

EU mobile and fixed line operators

A14.34 Brattle calculated asset betas for seven EU telecommunications companies that have mobile operations to varying degrees. Brattle segregated these companies into ‘EU mobile’ companies that derived more than two-thirds of revenues from mobile operations and ‘EU diversified’ companies for which mobile operations represent a smaller part of the business.

A14.35 Table A14.4 summarises the asset beta estimates calculated by Brattle.

Table A14.4: Asset betas for EU mobile operators

	Asset beta (All Europe)	Asset beta (All world)	Mobile revenue %	Market Cap £bn
EU mobile operators				
Mobistar	0.48	0.47	87%	1
KPN	0.32	0.33	75%	12
Tele2	0.59	0.69	72%	4
Telenor	0.56	0.57	78%	23
Average	**0.49**	**0.51**		

EU diversified operators				
Telecom Italia	0.39	0.36	24%	15
Belgacom	0.45	0.45	16%	7
Sonaecom	0.42	0.43	64%	1
Average	**0.42**	**0.41**		

Asset beta estimates based on two year equity betas with debt beta of 0.1. Mobile revenue data relates to 2013 results and was provided by Brattle. Market capitalisation as at 31 January 2014.

A14.36 While the average asset beta for EU mobile operators is slightly higher than the average for the diversified operators, the asset betas for KPN (which is 75% mobile) and Mobistar (87% mobile) are similar to those of the EU diversified operators, based on both the All Europe and All World indices. We note that KPN was the subject of a takeover bid from America Movil during the period of estimation though this does not appear to have affected its asset betas, which have remained relatively low throughout the period.[107]

A14.37 Unlike the evidence from US comparators, the EU evidence does not so clearly suggest that asset betas for mobile operators will be larger than those for other telecoms operators. However, the distinction between those companies which can be categorised as mobile companies and those that are not mobile companies is less clear for the EU telcoms sample than is the case for the US telcoms sample. For example, the US fixed line operators considered by Brattle don't have any mobile operations, but the EU "diversified operators" derive 16% to 64% of revenues from mobile operations.[108]

UK utility companies

A14.38 The UK utility companies can provide a useful reference since we would expect the asset beta for a utility company to be lower than that for an average efficient MCP (i.e. utility companies are likely to be associated with lower systematic risk). While demand for mobile services is fairly robust, it is unlikely to be as stable as for the products provided by pure utility operators (e.g. water, electricity, and gas) which are regarded as 'essentials' by consumers. Also, the regulatory framework in utilities such as water involves a "duty to finance". No such duty exists for Ofcom in relation to UK MCPs, which further implies that the provision of mobile services is likely to be more risky than utilities.

A14.39 The asset betas calculated by Brattle are consistent with this view. Asset betas for UK utility companies considered by Brattle ranged from 0.26 to 0.41, with an

[107] Based on data provided by Brattle, KPN's two-year asset beta against the All World has been between 0.28 and 0.38 in the last two years (assuming a debt beta of 0.1). See Figure 20 in the Brattle report.

[108] We note that the average asset betas would not change by much if Sonaecom was classified as a mobile operator in Table A14.4. For example, the All World EU mobile operator average would be 0.50 against an EU diversified operator average of 0.41. Our observations on KPN and Mobistar would continue to apply.

average of 0.34 measured against the FTSE All World index and from 0.28 to 0.46 with an average of 0.35 based on the FTSE All Share index.[109]

Proposal on asset beta

A14.40 In its report. Brattle concluded that the best current two-year asset beta estimates for the UK MCPs were between 0.43 and 0.54. This range was based on the All World index (see Table A14.2).[110] Brattle said it used the asset betas calculated against the All World index because "*i) none of the companies represents a significant % of the All-World index by market capitalization, ii) all four companies pull substantial investment from all corners of the globe, and iii) all four companies have significant operations spread across the globe*".[111] Our asset beta ranges for an average efficient MCP in this section are presented with reference to the All World index.

A14.41 Brattle recommends an asset beta range for an average efficient UK MCP of 0.40 to 0.60. It says that this range is "is consistent with the asset betas of the parent companies of the UK MNOs themselves, with particular weighting towards the estimated asset beta ranges for Vodafone and Telefónica as the two parent companies with the greatest overall focus on mobile operations. The recommended range reflects the statistical uncertainty inherent in our two-year asset beta estimates…[and] is consistent with both US and European telecom companies displaying a significant mobile focus".[112] Brattle adds that "*seven of 11 companies, where wireless accounts for more than two thirds of revenues, display two-year betas against the FTSE All-World above 0.5*".[113]

A14.42 The evidence above, in particular from the US comparators in Table A14.3, suggests that asset betas for companies predominantly engaged in mobile activities are likely to be higher than for companies with more of a focus on fixed line operations. This indicates that the asset beta for an average efficient MCP is likely to be higher than the asset betas for UK telecoms companies with significant fixed line operations.

A14.43 In the 2014 FAMR Draft Statement we estimated Openreach's asset beta at 0.50.[114] Openreach's asset beta was 0.50 whether measured against the All Share or All World indices since the BT Group asset beta on which it is based was identical for both indices.[115] We would expect an average efficient UK MCP to be exposed to higher systematic risk than Openreach based on both the evidence from the US telcoms operators considered above and the fact that Openreach is a stable

[109] In its report for the 2014 FAMR Draft Statement Brattle's asset beta estimates for utility companies ranged from 0.27 to 0.46 and averaged 0.34, based on the All Share index. The very small differences between the asset beta estimates for utility companies presented here reflects the more up to date sample used in the latest Brattle report (which considers data up to the end of January 2014 compared to data to the end of December 2013 in the 2014 FAMR Draft Statement). This small difference would not affect our conclusions in either the 2014 FAMR Draft Statement or this consultation.
[110] Table A14.2 shows that asset betas calculated against the All Share index were almost identical, with an average asset beta of 0.48.
[111] Page 31, Brattle report.
[112] Page 32, Brattle report.
[113] Brattle report, page 32.
[114] Table A14.1 of the 2014 FAMR Draft Statement.
[115] See Table 2 on page 16 of the April 2014 Brattle report which shows that the BT Group asset beta was 0.72 against both the All Share and All World when a debt beta of 0.1 was used.

regulated wholesale provider of fixed line telecommunications. We would therefore expect the asset beta of an average efficient UK MCP to be greater than 0.50. Combined with Brattle's recommendation, we consider that the asset beta of an average efficient UK MCP would be between 0.50 and 0.60.

A14.44 Further, we consider that an asset beta close to the middle of this 0.50 to 0.60 range is likely to be appropriate. This is because an asset beta around the mid-point is consistent with either placing weight on the current Vodafone asset beta of 0.54, or on the likely outcome of disaggregating the asset beta for the UK MCPs, as we explain below.

A14.45 The average asset beta of the UK MCPs is 0.49 (against the All World index), with average revenue from mobile operations in 2013 of around 65%.[116] The evidence suggests that the mobile operations would have a higher asset beta than the non-mobile telecoms operations. If we had robust estimates of the economic value of the mobile and non-mobile parts of the UK MCP businesses it might be possible to decompose their asset betas in order to estimate a mobile only asset beta.[117] However, the mobile operations are not listed separately from the non-mobile operations. For the UK MCPs the only metric we have been able to identify in order to separate mobile and non-mobile operations is revenue.[118] In the 2014 FAMR Draft Statement we said that revenue was not an appropriate measure to decompose asset betas since it did not capture the costs of each parts of the business.[119] However, to illustrate the potential impact, if the average asset beta of 0.49 for the parent companies of UK MCPs (against the All Share index) was disaggregated using a 65% weighting for the mobile business (based on the average proportion of total revenue that relates to mobile) and assuming that the non-mobile asset beta would be 65% of the mobile asset beta[120], then the resulting mobile-only asset beta would be around 0.55, which is the mid-point of the 0.5-0.6 range noted above.[121]

A14.46 However, the calculation above is only illustrative, whereas we do have a specific asset beta for Vodafone, which has a predominantly mobile oriented business (i.e. 89% of revenue). Vodafone was also the UK MCP on which we placed most weight in the March 2011 Statement.[122] We therefore consider its asset beta is a reasonable proxy for an average efficient UK MCP and so propose to use an asset beta of 0.54.

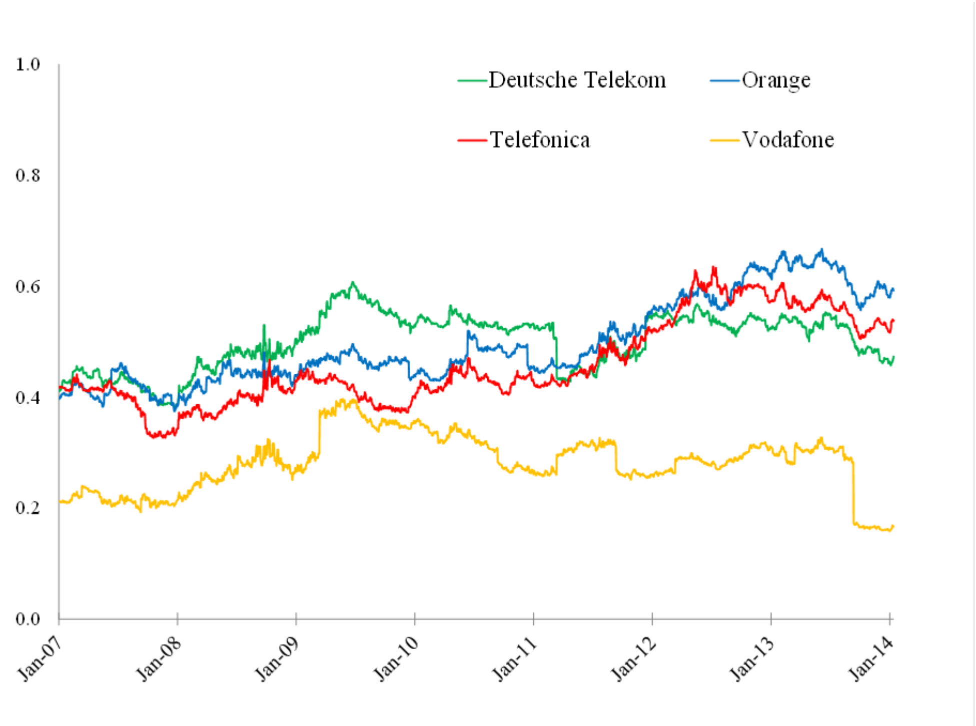
[116] This is the average of the mobile revenue percentages shown in Table A14.2.
[117] In paragraph A14.279 of the 2014 FAMR Draft Statement we said that "*from a theoretical perspective, the weights [used when decomposing an asset beta] should reflect the economic value of each part of the business*".
[118] The annual reports of the UK MCPs split out EBITDA on a country by country basis but not by line of business (e.g. mobile versus fixed line operations).
[119] Paragraph A14.283. 2014 FAMR Draft Statement.
[120] The figure of 65% is derived using the data on US comparators from Table A14.3. Against the S&P500 index the fixed line operators have an average asset beta of 0.36 which is 67% of the mobile operators' average asset beta of 0.54. Against the All World index the same ratio is 64%. The average of these two ratios is 65%.
[121] The same result is derived if the absolute difference between the average asset betas for US comparators is used from Table A14.3 rather than the percentage difference between the asset betas.
[122] In the March 2011 Statement we assumed an asset beta of 0.56 for an average efficient MCP, which was based on recent estimations at that time for Vodafone's asset beta (against the All Share index). See paragraph A8.129 of the March 2011 Statement.

Forward looking gearing

A14.47 A forward looking gearing rate is used to re-lever the asset beta into an equity beta. Figure A14.2 shows the gearing levels, as calculated by Brattle, for the UK MCPs.

A14.48 As with its previous reports for Ofcom, Brattle calculates gearing by first calculating working capital. If working capital is positive, gearing is calculated by reference to long term debt only. If working capital is negative, gearing is calculated by reference to long and short term debt.[123]

Figure A14.2: Gearing of parent companies of UK MCPs



Source: Brattle.

A14.49 The chart shows that Vodafone's gearing has consistently been the lowest of the UK MCPs and has been around 30% for most of the last three years. In relation to the fall in Vodafone's gearing to around 17% towards the end of 2013 Brattle notes that "*at the end of 2013 Vodafone was preparing to sell Verizon and the related fixed asset was transferred to current assets as 'current assets held for sale'. Following the working capital screen, short term debt is no longer included in the leverage calculations which results in a drop in leverage for the third quarter of 2013*."[124]

A14.50 Gearing levels for the other UK MCPs have been higher than Vodafone's and in the last two years have typically ranged from 45% to 65%. However, these UK MCPs have substantial regulated fixed-line operations, making them somewhat less reliable comparators than Vodafone for ascertaining the likely gearing of an average

[123] Brattle report, page 16.
[124] Brattle report, page 16.

efficient ‘pure play’ MCP since Vodafone’s operations are largely mobile.[125] Consequently, we would expect an average efficient UK MCP to have a gearing level closer to Vodafone’s.

A14.51 In the March 2011 Statement we assumed a forward looking gearing rate of 30% which was based on Vodafone’s observed gearing level over the two years prior to that statement. The average gearing over the last two years for Vodafone is 27%. Given that our asset beta assumption for an average efficient MCP is the same as Vodafone’s asset beta, we consider it would be consistent to base the gearing level on Vodafone’s gearing since this is the level of gearing that we observe for a company with the same level of systematic risk as we propose for our modelled average efficient MCP.

A14.52 We have used a forward-looking gearing rate of 27%, equal to Vodafone’s average gearing over the last two years.[126] We have not put significant weight on Vodafone’s low gearing towards the end of 2013 because this reflects the sale of its stake in Verizon.

A14.53 In any case, the overall WACC calculation is not very sensitive to the assumed forward looking gearing assumption. Indeed, assuming other parameters were held constant, the pre-tax real WACC would continue to be 6.9% for all forward looking gearing levels between 16% and 32%.[127]

Proposal on equity beta

A14.54 Combining our asset beta estimate of 0.54, our forward looking gearing estimate of 27% and our debt beta estimate of 0.1 (see next section) we derive a forward looking equity beta for an average efficient MCP of 0.70. This is calculated using the following formula:

$$\beta equity = \frac{\beta asset - \beta \text{debt} * Gearing}{1 - Gearing}$$

Debt beta

A14.55 The debt beta is intended to measure the covariance of the return on debt to the return on the market. The debt beta is used to de-lever the equity beta in order to estimate the asset beta and, subsequently, to re-lever the asset beta to derive a forward looking equity beta.

A14.56 There are significant practical difficulties in estimating debt betas robustly.[128] The CC has previously noted when trying to estimate debt betas:

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[125] While Vodafone does have some fixed line operations (for example it acquired Cable & Wireless Worldwide in July 2012 and TelstraClear in October 2012), its operations mostly relate to mobile. Table A14.2 shows that in 2013 89% of Vodafone’s revenue came from mobile operations.
[126] This is also the gearing rate used by Brattle to de-lever Vodafone’s 2-year equity beta to calculate a 2-year asset beta.
[127] One reason for the relatively small effect of leverage on the WACC is the relatively low corporate tax rate of 20%.
[128] It is technically possible to calculate a beta of debt where the debt is traded by using the CAPM formula. However, equity values fluctuate more than the value of debt; therefore the correlation between debt returns and market returns is weak.

> "the regression-based approach was hampered by poor data quality and models with poor statistical properties."[129]

A14.57 We have therefore considered other sources of evidence such as academic texts and previous CC determinations:

- Brealey, Myers and Allen in their textbook *Principles of Corporate Finance* estimate that debt betas of large firms are in the range of 0 to 0.2[130]; and
- the CC, in its Heathrow and Gatwick review used a point estimate of 0.1 where the debt premium was 1.4 to 1.7%.

A14.58 In the March 2011 Statement, we used a debt premium of 0.1.[131] In the 2014 FAMR Draft Statement we also used a debt beta of 0.1 alongside a debt premium range for BT of 1.0% - 1.5%.

A14.59 In paragraphs A14.62 to A14.72 we propose to use a debt premium range for an average efficient MCP of 1.0% - 1.6%. This is similar to the range we used for BT in the 2014 FAMR Draft Statement (i.e. 1.0% - 1.5%).

A14.60 In light of the above, we consider it appropriate to assume the same debt beta as we used in our recent analysis of the WACC for BT and in our analysis of the WACC for an average efficient MCP in the March 2011 Statement, i.e. a debt beta of 0.1.

A14.61 We note that the overall WACC calculation is not very sensitive to the assumed debt beta. For example, assuming other parameters were held constant, a debt beta of 0.15 rather than 0.1 would reduce the pre-tax real WACC by 0.1 percentage points from 6.9% to 6.8%[132].

Debt premium

A14.62 In estimating the cost of debt for an average efficient MCP, we require two inputs:

14.62.1 The nominal RFR (which we estimated at 4.6% earlier in this annex); and

14.62.2 The debt premium.

A14.63 The debt premium represents the extra return that investors require as a reward for investing in debt rather than a risk-free asset.

A14.64 We have estimated a debt premium for an average efficient MCP by considering the observed yields on sterling denominated debt for each of the parent companies of the UK MCPs, over and above benchmark UK government gilt yields. We consider that recent estimates of the yield on debt for these companies are a good proxy for the efficiently incurred forward looking cost of debt to be included in the WACC estimate. For the purposes of determining a range for the debt premium we have

[129] See paragraph 7, Page L34, C*ompetition Commission report: Stansted Airport Ltd - Q5 price control review*, 'Appendix L: Cost of Capital', 23 October 2008. http://www.caa.co.uk/docs/5/ergdocs/ccstanstedl.pdf

[130] Page 436, Brealey, Myers and Allen, 2013, *Principles of Corporate Finance, 11th Edition*.

[131] See paragraph A8.96

[132] Using the formula in paragraph A14.54, increasing the debt beta from 0.1 to 0.15 would decrease our forward looking equity beta from 0.70 to 0.68. In turn this would reduce the cost of equity and WACC by 0.1 percentage points.

considered debt premium data over the last twelve months so as not to give undue weight to a particular observation that may not be typical.

A14.65 We have considered the sterling denominated debt of each UK MCP with both short-term and long-term maturity dates. Table A14.5 lists the debt we have considered alongside the average, minimum and maximum spread of this debt in the last 12 months over nominal UK government gilts. The credit rating of each company is included in brackets after the company name.

Table A14.5: Spread of sterling denominated debt over UK government gilts for European parents of UK MCPs

Maturity date	Years to maturity	12 month average	12 month min	12 month max	Current (April 2014)
Vodafone (A-)					
2017	3	1.0%	0.9%	1.2%	0.9%
2018	4	1.1%	0.9%	1.2%	0.9%
2025	11	1.1%	1.0%	1.3%	1.2%
2032	18	1.1%	1.0%	1.4%	1.2%
Deutsche Telekom (BBB+)					
2019	5	1.1%	1.0%	1.3%	1.0%
2022	8	1.1%	1.0%	1.3%	1.1%
2028	14	1.2%	1.1%	1.5%	1.2%
2030	16	1.2%	1.0%	1.4%	1.1%
Orange (BBB+)					
2016	2	0.9%	0.8%	1.3%	0.8%
2017	3	1.3%	1.1%	1.5%	1.2%
2020	6	1.4%	1.2%	1.7%	1.2%
2025	11	1.4%	1.2%	1.7%	1.3%
2028	14	1.5%	1.3%	1.7%	1.4%
2034	20	1.5%	1.2%	1.8%	1.4%
2050	36	1.5%	1.2%	1.7%	1.4%
Telefónica (BBB)					
2018	4	1.9%	1.1%	2.7%	1.1%
2020	6	2.2%	1.4%	3.2%	1.4%
2022	8	2.3%	1.6%	3.2%	1.6%
2026	12	2.3%	1.6%	3.1%	1.6%
2029	15	2.3%	1.6%	3.2%	1.6%

Source: Bloomberg, Ofcom analysis. Company credit rating is the long term credit rating of the company and reflects the Bloomberg composite rating which takes into account the ratings of Moody's, S&P and Fitch. Note that a rating of BBB- or higher indicates an investment grade bond.

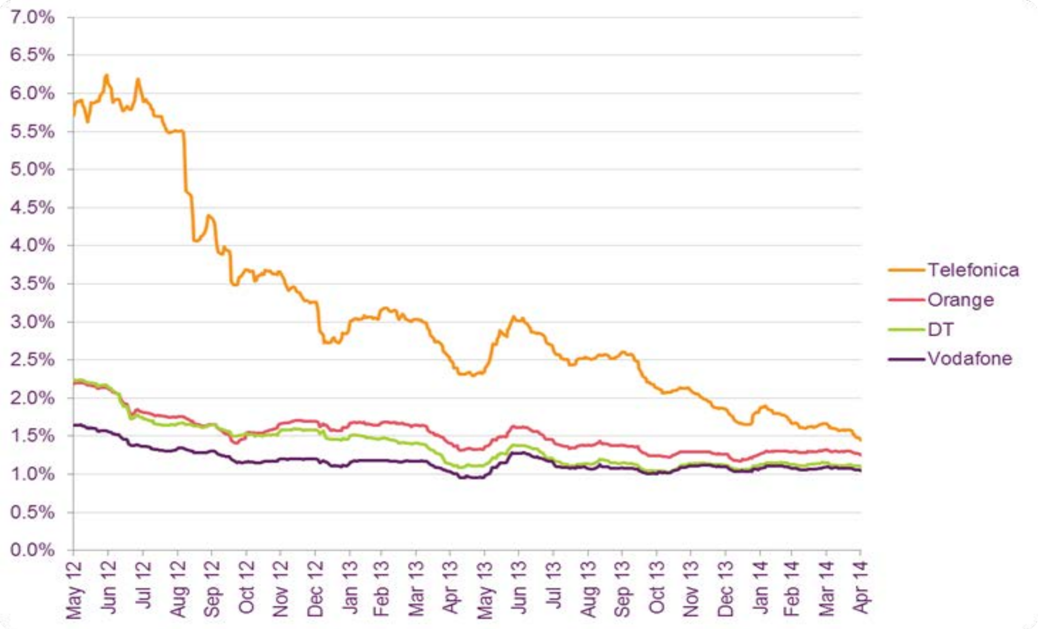
A14.66 Longer term debt typically has a higher yield and spread than shorter term debt. While the outstanding debt of the UK MCPs has different maturities, the average maturity is typically around ten years. For the purposes of deriving a range for the debt premium of an average efficient MCP we have taken into account the spreads on both shorter and longer term debt since an average efficient MCP would be expected to raise debt of varying maturities when considering its future financing requirements. Table A14.6 shows the average, minimum and maximum debt premium for each of the UK MCPs taking into account all of the sterling-denominated debt in issue. (The minima and maxima shown are therefore the average minima and average maxima averaged over the maturities shown for each UK MCP.) Figure A14.3 charts the average spread over the last two years.

Table A14.6: Average spread of sterling denominated debt over UK government gilts for European parent companies of UK MCPs

	Average maturity (years)	12 month average	12 month min	12 month max	Current (April 2014)
Vodafone (A-)	9	1.1%	1.0%	1.3%	1.0%
Deutsche Telekom (BBB+)	11	1.1%	1.0%	1.4%	1.1%
Orange (BBB+)	13	1.3%	1.2%	1.6%	1.2%
Telefónica (BBB)	9	2.2%	1.5%	3.1%	1.5%

Source: Bloomberg, Ofcom analysis. The 12 month minimum and maximum spreads represent the average across all maturities, not the very highest or the very lowest spread (which will be maturity specific – typically for debt at each end of the maturity spectrum).

Figure A14.3: Average spread of sterling denominated debt over benchmark yields for European parents of UK MCPs



Source: Bloomberg, Ofcom analysis. Data to 30 April 2014.

A14.67 Taken together the chart and preceding table show that the average debt premium for Vodafone and Deutsche Telekom has been stable at around 1.1% for the last six months. The average debt premium for Orange is a little higher at closer to 1.3% and while this has been relatively stable in recent months it has been as high as 1.6% over the last year. Taking these three parent companies together, the average debt premium is 1.2% over the last 12 months.

A14.68 Until recent months, the average debt premium for Telefónica appears somewhat of an outlier compared to that for the UK MCPs. Nevertheless, Telefónica's average debt premium has reduced steadily over most of the last year (and more broadly since about July 2012) and appears to be converging to the upper end of the debt premium range seen for the other UK MCPs in the last year – the highest debt premium (when averaged overall all maturities in the last year) being for Orange at 1.6%. Telefónica currently stands at 1.5%, still somewhat above the latest debt premium for Orange (at 1.2%), Deutsche Telekom (1.1%) and Vodafone (1.0%).

A14.69 Based on this data, we consider that a reasonable range for the debt premium for an average efficient MCP is 1.0% - 1.6%. This range captures the average debt premium over the last 12 months for Vodafone, Deutsche Telekom and Orange (across all maturities) and is bounded by the minimum and maximum debt premia (averaged across all maturities) for these companies over the last year. A range of 1.0% to 1.6% also encompasses the level to which Telefónica's average debt premium has converged from its historically high level.

A14.70 In our analysis of the asset beta and gearing for an average efficient MCP we placed particular weight on the data for Vodafone. Given this, it is reasonable to closely consider the debt premium of Vodafone, since Vodafone's relatively low gearing, compared to the other UK MCPs, may be one reason why its debt premium is also relatively low. Placing weight on Vodafone would imply a debt premium closer to the lower end of the 1.0% to 1.6% range, since over the last year Vodafone's average debt premium (across all maturities) has been between 1.0% and 1.3%, with an average of 1.1%.[133]

A14.71 Following our earlier analysis, we might also place less weight on Telefónica's debt premium since it appears to be an outlier compared to the others, and place more weight on the average of the other three UK MCPs. The average debt premium of the other three UK MCPs is 1.2% over the last year.

A14.72 In light of the above, we consider that a debt premium slightly below the mid-point of the 1% to 1.6% range is appropriate. We have therefore used a debt premium of 1.2% for our base case.[134]

Proposed WACC estimate

A14.73 Table A14.7 sets out our proposed WACC estimate for an average efficient MCP. The pre-tax nominal rate (deflated by CPI) of 6.9% is used in the MCT cost model from 2013/14 onwards. As explained in Annex 11, prior to that we have used the CPI adjusted real WACC consistent with previously determined values of the WACC for an average efficient MCP.

[133] In the March 2011 Statement, we used a value for the debt premium (1.5%) which was consistent with the debt premium on Vodafone's medium-term debt at the time. We also noted that this was possibly conservative (i.e. on the upside), given recent issues Vodafone had made of dollar denominated debt. See paragraph A8.151 of the March 2011 Statement.

[134] We note that, holding other parameters constant, the pre-tax real WACC would be 6.9% for all debt premium estimates between 1.08% and 1.45%.

Table A14.7: WACC estimates for an average efficient MCP applicable from 2013/14

	June 2014 (Consultation)
WACC (pre-tax nominal)	9.0%
WACC (pre-tax real) (RPI deflation)	5.5%
WACC (pre-tax real) (CPI deflation)	6.9%

Source: Ofcom analysis

Annex 15

Other modelling issues

Introduction

A15.1 This annex explains the reasoning underlying our proposals on a number of other modelling issues in the 2014 MCT model. These issues are as follows and are addressed in turn in the following sub-sections:

- Spectrum bands, allocations and valuation;
- Administrative costs; and
- HLR update costs.

A15.2 Consistent with the approach taken in the 2011 MCT review, we do not consider that spectrum, administrative and HLR update costs would arise in the provision of MCT viewed as the final traffic increment. Therefore, these costs do not have a direct impact on the LRIC results of the model that we propose to use in setting the charge control. Nevertheless, we have sought information on these costs for the purposes of determining the LRIC+ of MCT.

Spectrum

Spectrum bands

A15.3 The 2011 MCT model included modelling of spectrum in the following bands:

- 1800MHz spectrum, which was used for 2G technology; and
- 2.1GHz spectrum, which was used for 3G technology.

A15.4 In the 2014 MCT model, we considered these bands as a starting point and also considered what spectrum band(s) we should include in the model to support 4G technology.

A15.5 Ofcom's 4G auction of 800MHz and 2.6GHz spectrum concluded in February 2013[135] and since then these bands have been used to provide 4G services, along with refarmed 1800MHz spectrum. As a result, we propose to include the following spectrum bands in the 2014 MCT model:

- 800MHz spectrum, which is used for 4G technology;
- 1800MHz spectrum, which is used for 2G and 4G technologies;
- 2.1GHz spectrum, which was used for 3G technology; and
- 2.6GHz spectrum, which is used for 4G technology.

[135] See http://media.ofcom.org.uk/2013/02/20/ofcom-announces-winners-of-the-4g-mobile-auction/.

A15.6 These bands are the same as those we included in the draft MCT model that was published in January 2014 and discussed during our January 2014 stakeholder workshop.[136] We did not receive any comments on the bands that we had included.

A15.7 Our proposals do not include the use of 900MHz spectrum and, consistent with the March 2007 and March 2011 Statements, we assume that the average efficient MCP uses 1800MHz spectrum to provide 2G services. For the purposes of our LRIC+ calculations we are interested in the economic value of the average efficient MCP's stock of 1800MHz spectrum on a forward-looking basis. In the past we have observed that 1800MHz spectrum may be advantageous in terms of providing capacity, whereas 900MHz spectrum is beneficial from the point of view of providing coverage. [137] However, given the introduction of market mechanisms for the valuation of 900MHz and 1800MHz spectrum and tradable licences we would expect any difference between the costs of offering services using the different spectrum bands to have reduced. As a result we consider it reasonable to continue to model 2G services using 1800MHz spectrum and do not model 900MHz spectrum.

Spectrum holdings

Initial considerations on spectrum holdings

A15.8 For each of the bands noted in paragraph A15.5 the next step is to consider appropriate holdings. In the draft MCT model we proposed the holdings shown in Table A15.1 below.

Table A15.1: Spectrum holdings proposed in the draft MCT model (paired, MHz)

	Holding (paired MHz)	% of MCP total
800MHz	10	33%
900MHz	0	0%
1800MHz	30	42%
2.1GHz	10	17%
2.6GHz	10	14%
Total holding	**60**	**23%**

Source: Ofcom, January 2014

A15.9 The starting point for these holdings was the 1800MHz and 2.1GHz holdings included in the 2011 MCT model, which we maintained, and the addition of 2 x 10MHz of each of 800MHz and 2.6GHz spectrum.

A15.10 To ensure that the assumptions made in the draft MCT model were reasonable, we performed a number of cross-checks, in relation to the following:

[136] See slide 23 of the presentation.
[137] See paragraphs 9.96 to 9.98 of our March 2007 Statement, and paragraph 9.75 of our April 2010 Consultation.

- The 4G auction 'reserved portfolios' (as shown in Table A15.2 below) in order to ensure that our assumed spectrum holdings would be likely to be sufficient for our MCP to be a credible competitor);[138]

Table A15.2: 4G auction 'reserved portfolios' (paired, MHz)

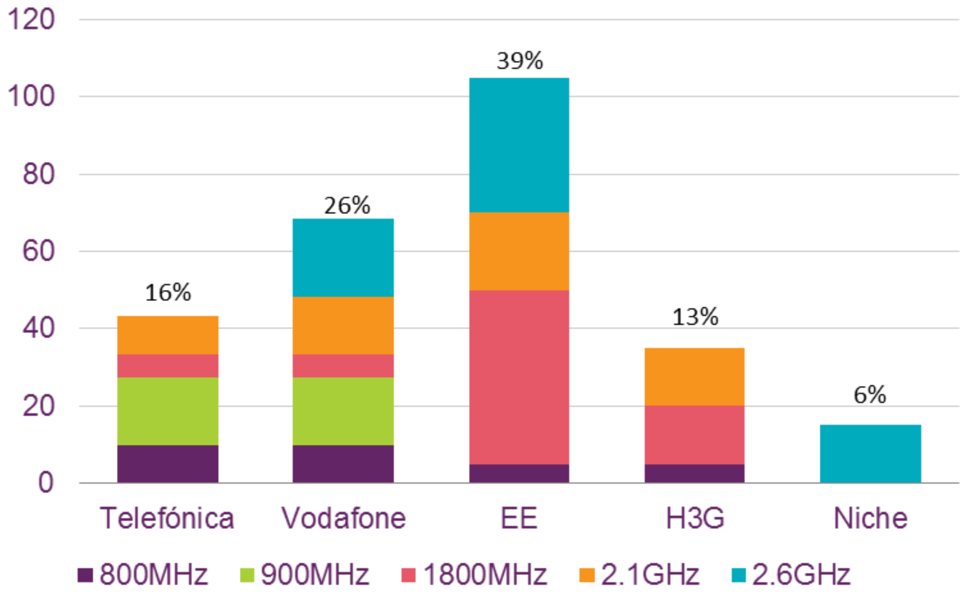
	Portfolio 1	Portfolio 2	Portfolio 3	Portfolio 4
800MHz	15	10	5	0
1800MHz	0	0	15	15
2.6GHz	0	10	0	20

Source: Paragraph 4.311 of Ofcom's 800 and 2.6 Award Statement.

- The 4G auction 'safeguard caps' of 27.5MHz of sub-1GHz spectrum and 105MHz overall, in order to ensure that our assumed spectrum holdings did not exceed the 'safeguard caps' used in the 4G auction;[139]

- The actual holdings of the four largest MCPs (since one auction lot of 800MHz spectrum in the 4G auction came with a coverage obligation), as shown in Figure A15.1 below.[140]

Figure A15.1: MCP spectrum holdings (paired MHz)



Source: Ofcom.

[138] See paragraphs 1.16, 4.7 and 4.25 of Ofcom, *Assessment of future mobile competition and award of 800 MHz and 2.6 GHz*, statement, 24 July 2012. http://stakeholders.ofcom.org.uk/binaries/consultations/award-800mhz/statement/statement.pdf.
[139] Ibid, paragraph 4.313.
[140] Ibid, paragraph 1.22.

Initial considerations on spectrum refarming

A15.11 The use of 1800MHz spectrum for 4G services requires it to be refarmed from 2G use. Following our decisions to allow variations to existing 900MHz and 1800MHz licences in 2011[141] and to existing 900MHz, 1800MHz and 2100MHz licences in 2013[142], spectrum previously used to provide 2G services has been used for:

- 4G services, in the case of 1800MHz spectrum;[143] and
- 3G services, in the case of 900MHz spectrum.[144]

A15.12 Having considered the holdings of our modelled operator and the UK experiences of refarming, we considered it appropriate to assume that 2 x 10MHz of the modelled 1800MHz holding of 2 x 30MHz was refarmed for 4G use in the draft MCT model. We assumed that this refarming took place in 2012/13 and was hence available to the modelled operator for its 4G network roll-out. This is consistent with the timing of Ofcom's decision to allow EE to refarm its 1800MHz spectrum, which took effect in September 2012.[145]

Stakeholder responses to the January 2014 industry workshop

A15.13 Following our January 2014 workshop we received comments on the subject of spectrum holdings from BT. In relation to 3G spectrum, BT argued that an allocation of 2 x 10MHz, corresponding to two 3G "radio carriers", was too little and that at least three carriers should be assumed from 2011 onwards.[146]

A15.14 Turning to spectrum for 4G use BT thought our allowance of 2 x 30 MHz of 4G spectrum (comprising 2 x 10MHz of 800MHz, 2 x 10MHz of 1800MHz, and 2 x 10MHz of 2.6GHz spectrum) was "*a reasonable median position of the operators after the auction*", but that further refarming and the potential acquisition of further spectrum for 4G use should also be taken into account.[147]

Proposals on spectrum holdings and refarming

A15.15 Addressing 3G spectrum first, we agree with BT's observation that "*no UK operator is currently running a 3G network with only two 3G carriers*".[148] We also agree that it would be better for us to more accurately reflect the quantities of spectrum that are being used to provide 3G services. As a result, we propose to increase the

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[141] See Ofcom, Statement on variation of 900 MHz and 1800 MHz Wireless Telegraphy Act licences, statement, 6 January 2011. http://stakeholders.ofcom.org.uk/binaries/consultations/900-1800mhz-wireless-telegraphy/statement/Statement.pdf.
[142] See Ofcom, Statement on the Requests for Variation of 900 MHz, 1800 MHz and 2100 MHz Mobile Licences, statement, 9 July 2013. http://stakeholders.ofcom.org.uk/binaries/consultations/variation-900-1800-2100/statement/statement.pdf.
[143] See https://explore.ee.co.uk/our-company/newsroom/ee-doubling-4g-network-speeds-and-pushing-the-pace-of-uk-mobile-innovation.
[144] See, for example, http://news.o2.co.uk/?press-release=o2-first-to-switch-on-new-superfast-3g-900mhz-network.
[145] See http://stakeholders.ofcom.org.uk/consultations/variation-1800mhz-lte-wimax/statement.
[146] BT response, p7 http://stakeholders.ofcom.org.uk/binaries/telecoms/policy/mobile/bt-2014.pdf
[147] BT response, p7, http://stakeholders.ofcom.org.uk/binaries/telecoms/policy/mobile/bt-2014.pdf.
[148] BT response, p7, http://stakeholders.ofcom.org.uk/binaries/telecoms/policy/mobile/bt-2014.pdf .

allocation of 2.1GHz spectrum in the 2014 MCT model from 2 x 10MHz to 2 x 15 MHz of 2.1GHz spectrum.

A15.16 Not all of the UK operators hold 2 x 15 MHz of 2.1GHz spectrum, but 900MHz and 1800MHz spectrum was liberalised for 3G use in our January 2011 Statement.[149] As noted above 900MHz spectrum has been used for 3G services by Telefónica since March 2011,[150] and subsequently also by Vodafone.[151] We propose to assume that our modelled operator gained a third 3G carrier (an additional 2 x 5 MHz of 2.1GHz spectrum) in 2012/13.

A15.17 We have also considered the inclusion of further refarming of spectrum for 4G use in the MCT model. However, in the face of considerable uncertainty as to the details of what spectrum might be refarmed in the future and the timing of any refarming we consider this unduly speculative.

A15.18 We have not included any modelling of future acquisitions of spectrum in the 2014 MCT model on the same grounds. Although Ofcom is currently planning future spectrum awards, including spectrum that could be used for 4G services, we consider that there is too much uncertainty surrounding the timing and use of this spectrum to allow robust modelling of its use.

A15.19 Based on the above our proposed spectrum holding and uses are set out in Table A15.3 below.

Table A15.3: Proposed spectrum holdings, uses and carrier sizes

Band	Holding (paired MHz)		Technology	Modelled carrier size (paired MHz)
800MHz	10		4G	5
900MHz	0		n/a	n/a
1800MHz	30	20	2G	0.2
		10	4G[152]	5
2.1GHz	10, increasing to 15 in 2012/13		3G	5
2.6GHz	10		4G	5

Source: Ofcom, 2014 MCT model.

A15.20 We have performed the same cross-checks on these holdings as we did to the holdings we proposed in the January 2014 stakeholder workshop (see paragraph A15.10 above) and consider them to be reasonable. Specifically we have ensured that the allocation exceeds at least one of the 4G auction ‘reserved portfolios’ (specifically portoflios 2 and 3 in Table A15.2) but falls within the ‘safeguard caps’. Consideration has also been given to the four largest MCPs’ actual holdings as a cross-check.

[149] See footnote 141.
[150] See http://news.o2.co.uk/?press-release=o2-first-to-switch-on-new-superfast-3g-900mhz-network.
[151] See http://blog.vodafone.co.uk/2013/11/05/vodafone-4g-signal-and-frequencies-explained/.
[152] Following refarming in 2012/13, see paragraph A15.11.

Spectrum valuation

A15.21 The valuation of spectrum holdings influences the LRIC+ outputs of the 2014 MCT model but does not affect the LRIC outputs.

A15.22 As we explained in the March 2011 Statement, although LRIC could in principle include some contribution to spectrum costs, the modelling implementation means that it is not necessary to include an explicit estimate of spectrum costs.[153]

A15.23 The reason LRIC could (in principle) include some contribution to spectrum is that if termination volumes were zero, then an MCP might be able to avoid having to purchase (or, equivalently, if considering a traffic decrement, reducing) its current spectrum holdings. For a given amount of spectrum, more capacity can be provided by increasing the size of the network (i.e. increasing the number of base stations and/or traffic-handling capacity at base stations). Alternatively, for a given size of network (i.e. a fixed number of base stations), more capacity can be provided if more spectrum is deployed.

A15.24 However, at the margin, the willingness to pay for additional spectrum required to deliver a given amount of traffic would be no more than the network costs otherwise required (i.e. if network equipment rather than spectrum were used to provide the additional capacity). As our 2014 MCT model calculates the LRIC for MCT based on the network costs with and without termination volumes, it explicitly measures the avoided network costs for the traffic increment in question (i.e. MCT provided to other CPs). Viewed in this way, changes in spectrum value should not affect the LRIC of MCT.

A15.25 Our approach in valuing the spectrum holdings of the average efficient MCP is to reflect the forward-looking economic value (i.e. opportunity cost) of the spectrum. In doing so we draw on the latest available evidence for the market value of spectrum.

Initial considerations on spectrum valuation

A15.26 For the draft MCT model we drew on spectrum valuation information in Ofcom's recent consultation on Annual Licence Fees (ALF) for 900 MHz and 1800 MHz spectrum (the 'ALF Consultation')[154] and reflected the manner in which the licences for different spectrum bands are paid for. We explained that work was ongoing in relation to this issue.

Stakeholder responses to the January 2014 industry workshop

A15.27 In relation to spectrum valuation we received responses to our proposals at the January 2014 workshop from EE and from BT. EE commented that it was necessary to consider how the ALF proposals should best be reflected in the model.[155] BT noted that any information drawn from Ofcom's ALF project would

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[153] See paragraphs A9.7 to A9.9 of the March 2011 Statement.

[154] Ofcom, *Annual licence fees for 900 MHz and 1800 MHz spectrum*, consultation, 10 October 2013. http://stakeholders.ofcom.org.uk/binaries/consultations/900-1800-mhz-fees/summary/900-1800-fees.pdf.

[155] See EE's response, p 15, http://stakeholders.ofcom.org.uk/binaries/telecoms/policy/mobile/EE-2014.pdf.

require updating as this work progresses, and that care was necessary in relation to inflation and the timing of the fees.[156]

Consultation proposals for 800MHz and 2.6GHz spectrum valuations

A15.28 Both 800MHz and 2.6GHz spectrum were included in Ofcom's 4G auction, which concluded in February 2013. As a result, we have recent market evidence on the value of holdings in these spectrum bands and propose to use these estimates in the 2014 MCT model.

A15.29 Based on the Linear Reference Pricing (LRP) analysis of auction data by DotEcon, 800MHz spectrum was estimated to have a value of £29.9m per MHz. The corresponding value for 2.6GHz spectrum was found to be £5m per MHz.[157] These valuations are doubled to find the value per paired MHz as used in the 2014 MCT model.

A15.30 The 4G auction required payment for spectrum acquired by 21 February 2013 so we propose to treat payments for 800MHz and 2.6GHz spectrum as one-off capital expenditures incurred in 2012/13. Since 2012/13 is the base year for costs in the 2014 MCT model, no adjustment is necessary to account for inflation. The figures explained above mean that a holding of 2 x 10 MHz of 800 MHz spectrum has a value of £598m and a holding of 2 x 10 MHz of 2.6GHz spectrum has a value of £100m (both in 2012/13 prices).[158]

A15.31 We do not propose to make a gestation adjustment for this spectrum, reflecting the speed with which it has been used to deploy 4G services. However, it is necessary to consider the value of this spectrum from 2033 onwards (i.e. after the initial period of 20 years), also in light of the licence conditions requiring the licensees to pay the relevant fees as prescribed by Ofcom from 2033.[159] For the purposes of the 2014 MCT model, we assume a capitalised value based on the auction prices paid in 2012/13 as a proxy. This future payment is discounted back to 2012/13 and added to the initial outlay to produce 2012/13 total capital expenditures of £755m in relation to the 800MHz spectrum and £126m for the 2.6GHz spectrum (both in 2012/13 prices).

Proposals for 2.1GHz spectrum valuation

A15.32 The valuation of 2.1GHz spectrum is not as straightforward as for 800MHz and 2.6GHz because there is no recent direct market evidence of its value and the ALF Consultation does not seek to value it. However, the ALF Consultation does contain information that can be used in order to derive an estimate of the forward-looking economic value of 2.1GHz spectrum, as explained below.

A15.33 We propose to treat 2.1GHz spectrum payments as two lump sums:

[156] See BT's response, p 10, http://stakeholders.ofcom.org.uk/binaries/telecoms/policy/mobile/bt-2014.pdf.
[157] See paragraphs 4.20 and 4.25 of the ALF Consultation.
[158] Calculated as 29.9 x 2 x 10 = £598m and 5 x 2 x 10 = £100m respectively.
[159] See paragraph 8 of the Template Spectrum Access 800 MHz/1800 MHz/2.6 GHz licence in Ofcom, *The award of 800 MHz and 2.6 GHz spectrum – Annexes, Information Memorandum*, 24 July 2012. http://stakeholders.ofcom.org.uk/binaries/consultations/award-800mhz/statement/IM2.pdf.

15.33.1 The first being incurred in 2004/5, relating to 2 x 10MHz of 2.1GHz spectrum and based on adjustment to the 2004/5 valuation used in the 2011 MCT model; and

15.33.2 A second incurred in 2012/13, relating to the 2 x 15MHz of 2.1GHz spectrum assumed to be held from that point onwards and based on more recent evidence of spectrum values.

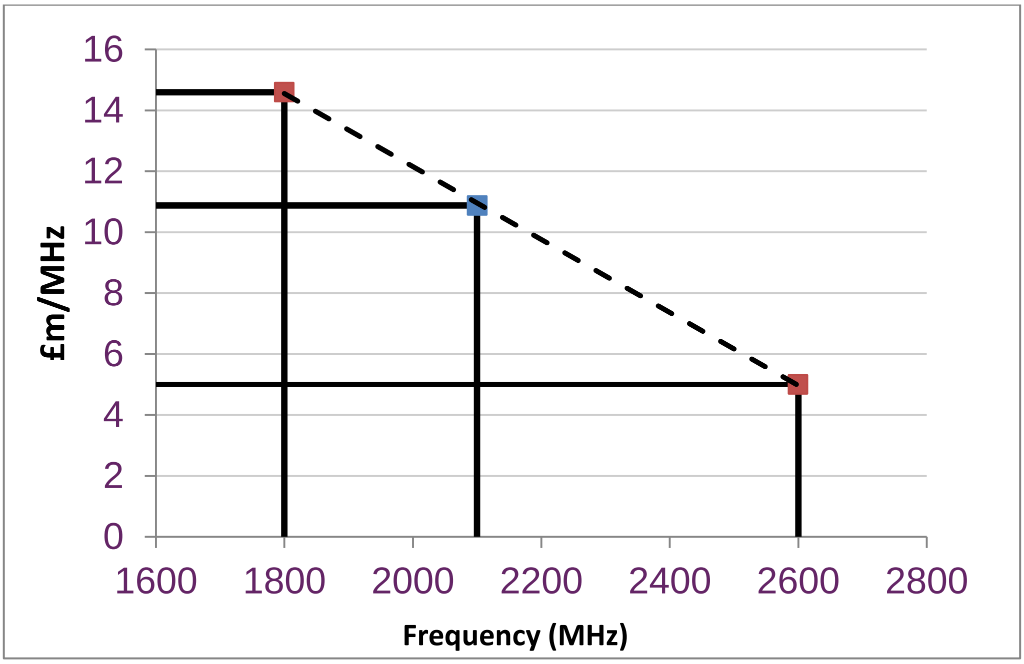
A15.34 The starting point for the first lump sum is the 2.1GHz spectrum value of £451m (2008/9 prices) used in the 2011 MCT model. This was incurred in 2004/5 in relation to the 16 year period to 2021/22.[160] In order for us to apply a second lump sum reflecting an updated valuation in 2012/13 it is necessary to adjust the lump sum incurred in 2004/5 in order to avoid double counting.

A15.35 Having first adjusted from 2004/5 to 2012/13 prices, we account for the change in the assumed length of time for which the 2004/5 lump sum applies by first annuitizing the 2004/5 lump sum using a discount rate of the WACC over the 16 year period for which the lump sum was assumed to apply in the 2011 MCT model[161], and then discounting the annual amounts over the eight year period to which we now assume the lump sum relates. This produces a revised lump sum for 2 x 10 MHz of 2.1GHz spectrum of £313m (in 2012/13 prices), which is assumed to be incurred in 2004/5. The capital expenditure assumed to have been incurred in 2004/5 is therefore lower than in the 2011 MCT model. However, this is supplemented by a second lump sum incurred in 2012/13, as explained below.

A15.36 The starting point for the second lump sum is a linear interpolation between the 2.6GHz spectrum valuation of £5m per MHz (2012/13 prices) explained above and the ALF Consultation ‘best estimate’ of the value of 1800MHz spectrum.[162] This ‘best estimate’ for 1800MHz spectrum was £15m per MHz in 2013/14 prices, or £14.7m per MHz in 2012/13 prices. This produces a valuation for 2.1GHz spectrum of £11.07m per MHz, as shown in Figure A15.2 below.

[160] See footnotes 268 and 270 of the March 2011 Statement.
[161] Calculated as a geometric mean of the WACC forecast in the 2011 MCT model for the licence duration.
[162] The ALF Consultation explains that the ‘best estimate’ of the value of 1800MHz spectrum takes into consideration the sums bid in the 4G auction, prices paid in other spectrum auctions abroad and the technical and commercial characteristics of the spectrum bands.

Figure A15.2: Linear interpolation of 2.1GHz valuation



Source: Ofcom.

A15.37 The estimate explained in paragraph A15.36 implies that the modelled operator's 2012/13 holding of 2 x 15MHz of 2.1GHz spectrum has a valuation of £332m. The value of this spectrum beyond 2022 (also in light of the licence conditions requiring the licensees to pay the relevant fees as prescribed by Ofcom from 2022) is accounted for in the same way as that described for 800MHz and 2.6GHz spectrum above, namely that a capitalised value is included and discounted back from 2022 to 2012/13. This produces a second lump sum of £419m to be incurred in 2012/13 (in 2012/13 prices).[163]

Initial considerations on 1800MHz spectrum valuation

A15.38 As was the case in the 2011 MCT model our approach to valuing 1800MHz spectrum differs from those explained above because the fees paid for it are made on an annual basis rather than as a lump sum. However, our aim of reflecting the forward-looking opportunity cost of the spectrum is unchanged.

A15.39 For 1800MHz spectrum we propose to update the approach used in the 2011 MCT model by appending the historical stream of opex with updated assumptions derived from the proposals in the ALF Consultation (both appropriately adjusted to be expressed in 2012/13 prices).

A15.40 The ALF Consultation proposes an annual payment of £1.19m per MHz per year for 1800MHz spectrum (2013/14 prices). We are still considering responses to the ALF Consultation (including consideration of the level and timing of the introduction of the new ALF rates). However, for the purpose of this MCT consultation we have used the proposed annual payment as we consider it is the best available source of

[163] Discounting this 2012/13 lump sum of £419m back to 2004/5 (using the 2014 MCT model WACC) and adding it to the 2004/5 lump sum of £313m gives a total valuation in 2004/5 of £515m (2012/13 prices). By coincidence, this is very close to the 2004/5 valuation included in the 2011 MCT model, once it is adjusted to 2012/13 prices.

information as to the market value of 1800MHz spectrum at this time. If the figure for the annual payment is modified following the ALF Consultation we will change our assumption in the MCT model accordingly.

A15.41 Specifically we adjust the £1.19m per MHz per year to 2012/13 prices to assume an annual payment of £1.17m per MHz per year, or £70m per year for the modelled operator's allocation of 2 x 30MHz.[164] We assume this valuation from 2013/14, consistent with the date of publication of the ALF Consultation.

A15.42 The final element of the 1800MHz calculation is to allocate part of this cost to 4G services, once 2 x 10MHz of the modelled operator's total holding of 2 x 30MHz is refarmed for 4G use. As explained in paragraph A15.12 we assume that re-farming occurs in 2012/13 and from this point onwards one third of the annual payment for 1800MHz spectrum is allocated to 4G services, the remainder is recovered from 2G services.[165]

Summary of proposals on spectrum valuation

A15.43 Based on the analysis above our proposals on the valuation of the spectrum for the 2014 MCT model are shown in Table A15.4 below.

[164] We note that the ALF calculations are based on post-tax modelling, and so use a post-tax WACC when discounting and a Tax Adjustment Factor, or TAF (see paragraph 5.62 of the ALF Consultation for an explanation). In essence, the TAF adjusts for the fact that the tax treatment of ALFs is more favourable than that for a lump sum licence payment, and hence the ALFs should be uplifted so as to leave the MCP in the same position as if it had paid a lump sum.) Tax on inputs (such as labour) is typically captured in the cost inputs used for charge controls, not least because they are reflected in the regulated firm's incremental cash flows. As a result we do not consider it necessary to adjust for this in drawing on the ALF calculations for the purposes of MCT modelling.
[165] As a result of this assumption, the valuation of 1800MHz spectrum used for 4G services in 2012/13 is based on the valuation from the 2011 MCT model before the revised valuation applies from 2013/14.

Table A15.4: Spectrum valuation summary

	Methodology	Treatment in model	Valuation (2012/13 prices)
800MHz	LRP analysis of 4G auction bid data	Lump sum in 2012/13	£755m, incurred in 2012/13
900MHz	n/a	n/a	n/a
1800MHz	Valuation consistent with 2011 MCT Model, then updated from 2013/14	Annual fee	Historical figures to 2012/13, £70m per annum thereafter and split between 2G and 4G
2.1GHz	Adjusted historical valuation from 2004/5, then interpolate between 1800MHz and 2.6GHz from 2012/13	Lump sum in 2004/5, second lump sum in 2012/13	£313m incurred in 2004/5 and £419m in 2012/13
2.6GHz	LRP analysis of 4G auction bid data	Lump sum in 2012/13	£126m, incurred in 2012/13

Source: Ofcom.

Administrative costs

A15.44 In addition to network costs, other non-network costs are included in the 2014 MCT model in the form of administrative costs.

A15.45 However, consistent with the approach in the 2011 MCT review, administrative costs are considered common costs that are not sensitive to termination traffic. Therefore, the LRIC of MCT does not include an allowance for administrative costs.

A15.46 Nevertheless, under LRIC+ administrative costs have, in the past, been attributed to MCT and therefore we have outlined how these have been estimated in the 2014 MCT model in determining LRIC+ outputs.

A15.47 In the 2011 MCT model, non-network costs were classified as follows:

- Customer acquisition, retention and service costs (CARs): comprising advertising and marketing, discounts and incentives, customer care, billing and bad debts;
- Administrative costs: comprising general overheads; and
- Other costs: costs not relating to the running of the UK network nor either of the above two categories.[166]

A15.48 Accordingly we have sought the relevant accounting cost information from the four largest MCPs and this is summarised in Table A15.5 below.

[166] For the purposes of our LRIC+ calculations we apply the same methodology as that used in the 2011 MCT model. 'Other costs' are not considered as part of network costs and are not recoverable form network services. They are also not considered as part of 'retail' costs for the purposes of allocating administrative costs between network and retail, which we recognise may conservatively overstate the administrative cost mark-up for LRIC+.

Table A15.5: Average non-network costs

	Costs (£m, calendar year 2013)
CARs	1,526
Other	939
Administrative	543
Total	3,008

Source: Ofcom analysis based on information provided by the four largest MCPs in response to formal information requests.

A15.49 Of the three categories of non-network costs shown in Table A15.4 above, we only include a contribution to administrative costs under LRIC+. This is consistent with the March 2011 Statement.[167] Administrative costs include the overheads for non-network depreciation (IT, furniture and office equipment), property costs, human resources, finance and legal costs, and IT overheads.

A15.50 Table A15.6 below sets out our approach to estimating the share of total administrative costs that are allocated to network activities under LRIC+. This table has been created using accounting information for 2013, which is the latest available.[168]

[167] See paragraph 9.78.
[168] In Table A15.5 the second column shows the calculation methodology and the third column contains the data and the results.

Table A15.6: Allocation of administrative costs to network activities

	Calculation	Costs (£m, calendar year 2013)
Network depreciation	A	277
3G and 4G licence amortisation	B	232
Network opex	C	357
NBV of network assets	D	1,401
NBV of 3G and 4G licences	E	2,313
Cost of capital[169]	F	9.0%
Cost of capital on network assets and licences	G=(E+D) x F	336
Total annual network costs	H=A+B+C+G	1,202
Annual CARS costs	I	1,526
Annual costs of "Other" activities	J	939
Annual costs of Admin activities	K	543
NBV of non-network assets	L	688
Cost of capital on non-network assets	M=L x F	62
Cost of capital on non-network assets attributable to CARS (Retail)	N=M x I/(I+J+K)	32
Total CARS (Retail) costs	O=I+N	1,557
Cost of capital on non-network costs attributable to Admin	P=M x K/(I+J+K)	11
Total Admin costs	Q=K+P	554
Total Network and Retail costs	R=H+O	2,759
% Network costs	S=H/R	44%
Administrative costs allocated to network activities	T=S x Q	241

Source: Ofcom analysis based on information provided by the four largest MCPs in response to formal information requests. Data are averages of responses for 2G/3G/4G operators, where available and consistent with evidence underlying the 2011 MCT model.

A15.51 As shown in the final row of Table A15.6 we estimate that £241m in calendar year 2013 prices (£245m in 2012/13 prices) should be allocated to network activities as a share of administrative costs for the average efficient operator under LRIC+.

A15.52 The total administrative cost allocated to network activities is allocated to network services (e.g. incoming calls, outgoing calls and data) in proportion to their respective shares of network traffic costs. The ppm mark-up for administrative costs in the LRIC+ of MCT in 2017/18 is estimated by dividing the termination share of

[169] Pre-tax nominal based on the pre-tax real WACC of 6.9% explained in Annex 14 and assuming 2% inflation.

these network traffic costs (in £m) by the number of minutes terminating in that year. For 2017/18 the administrative cost contributes 0.10ppm (in 2012/13 prices) to the LRIC+ of MCT.

A15.53 As in the 2011 MCT model and earlier models we assume that administrative costs remain constant in real terms over the charge control period. As explained in the March 2011 Statement[170] we accept that administrative costs may not necessarily remain fixed over time, but as a modelling simplification (and since we do not propose to set MTRs on the basis if LRIC+) we include administrative costs in constant real £m terms over time.

HLR update costs

A15.54 The HLR (Home Location Register) updates identify the location of subscribers on the network in order to efficiently route mobile services, including incoming voice calls, to them. In the 2014 MCT model, as in the 2011 MCT model, we propose that HLR update costs are driven by the number of subscribers. As such, we consider that the increment of off-net termination traffic would not cause additional HLR update costs and therefore we propose that HLR update costs should not be included in the LRIC of MCT. However, HLR update costs would be included in the LRIC+ of MCT.

A15.55 To determine the LRIC+ of MCT, the costs of HLR updates are allocated to incoming services based on the proportion of incoming legs attributable to that service. This is added as a mark-up after the model has allocated the other network costs via routing factors.

A15.56 In the 2011 MCT model, for 2014/15 the HLR update costs contributed 0.01ppm (2008/09 prices) to the LRIC+ of MCT. In the 2014 MCT model, HLR update costs contribute 0.01ppm to the LRIC+ of MCT for 2017/18 (2012/13 prices).

[170] See paragraphs A9.91 to A9.98.

Annex 16

Model outputs and sensitivities

Introduction

A16.1 We have used the 2014 MCT model to calculate the unit cost of MCT using a LRIC cost standard in order to inform the charge control calculations. The model is explained in Section 7 and details of the methodology, inputs and assumptions are provided in Annexes 11 to 17.

A16.2 This annex summarises the results of the model under a base case scenario and also under a range of alternative scenarios in order to provide a sensitivity analysis. We also construct high and low scenarios that show the range for the proposed benchmark efficient unit costs of MCT.

A16.3 This annex is structured as follows:

- we first describe the assumptions and inputs used in the base case scenario, and then present the corresponding base case results (the unit costs of incoming 2G, 3G and 4G voice calls);
- we then compare the model results against LRIC+ results and the results of the 2011 MCT model as a cross-check for historic cost recovery;
- we examine the sensitivity of the results to changes in demand assumptions;
- we test the sensitivity of the model outputs to changes in the bottom-up network build assumptions;
- we then test the model for changes in the real pre-tax WACC; and
- finally we combine the various scenarios to create high cost and low cost scenarios.

A16.4 As explained in Annex 11, all of the results of the model are presented in real terms, expressed in 2012/13 prices.

Model base case

A16.5 The base case scenario of the 2014 MCT model uses the following key assumptions and inputs:[171]

- an average efficient national MCP deploying 2G, 3G and 4G networks, including VoLTE services;
- our medium subscriber and traffic forecasts (as described in Annex 11);
- a long-term market share of 25%;

[171] A full list of the assumptions used in the base case can be found on the 'Scenario' sheet of the 'Scenario Control' module of the model.

- infrastructure sharing (both passive and active);
- use of Single-RAN (i.e. S-RAN) technology;
- the spectrum allocations explained in Annex 15;
- the HSPA and backhaul upgrades as explained in Annex 12; and
- a real (CPI deflated) pre-tax WACC of 6.9%, as explained in Annex 14.

Results

A16.6 The base case LRIC unit costs of 2G, 3G, 4G and blended MCT are shown in Figure A16.1 below. In 2017/18 the LRIC of MCT is 0.60 ppm for 2G, 0.48 ppm for 3G and 0.26 ppm for 4G. The blended LRIC of MCT in 2017/18 is 0.48 ppm.

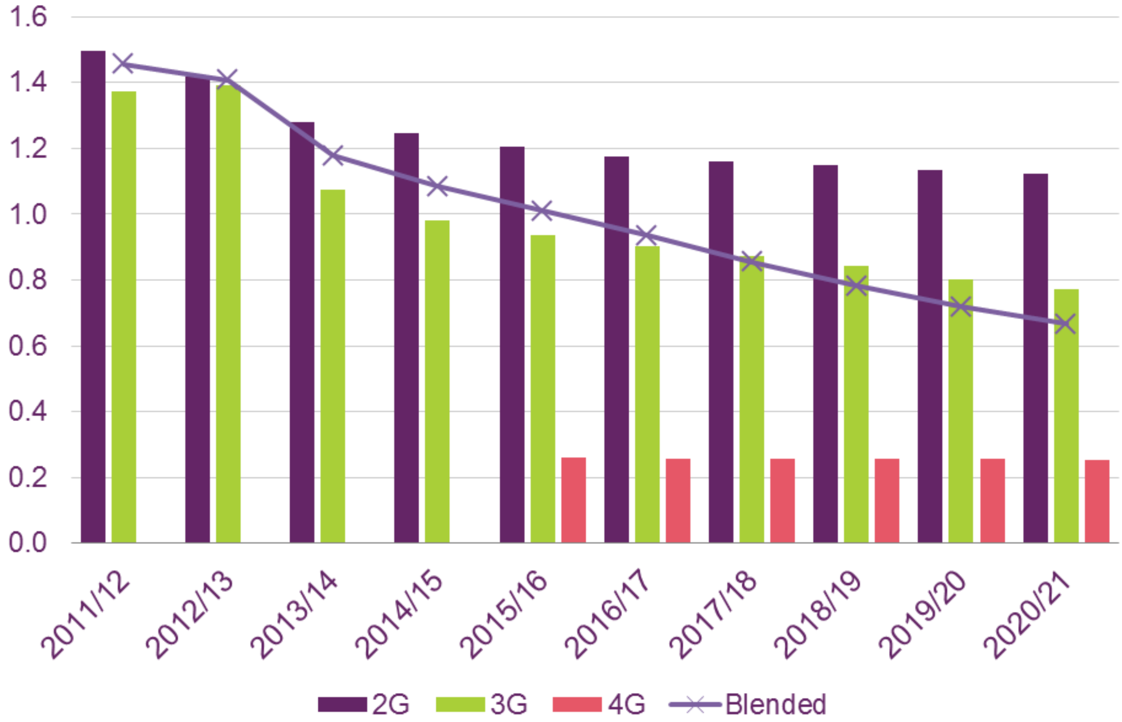
Figure A16.1: LRIC of MCT (ppm, real 2012/13 prices)

Source: Ofcom 2014 MCT model.

A16.7 Figure A16.1 shows that the blended unit cost of MCT is declining over time. This is due to declining costs of 2G and 3G MCT over the period, and the introduction of 4G MCT (i.e. VoLTE) into the blended average from 2015/16, which has a lower unit cost than 2G or 3G MCT.

A16.8 As explained in Section 7 and Annex 11, the model is also capable of calculating LRIC+ results. The base case LRIC+ unit costs of 2G, 3G, 4G and blended MCT are shown in Figure A16.2 below. In 2017/18 the LRIC+ of MCT is 1.16 ppm for 2G, 0.87 ppm for 3G and 0.26 ppm for 4G. The blended LRIC+ of MCT in 2017/18 is 0.86 ppm.

Figure A16.2: LRIC+ of MCT (ppm, real 2012/13 prices)



Source: Ofcom 2014 MCT model.

Comparison of 4G LRIC and LRIC+

A16.9 These results show that the LRIC and LRIC+ of 4G MCT are very similar, and the LRIC+ is only slightly higher than the LRIC. We have investigated this result and found that it is driven by macrocell site deployments, in conjunction with a modelling assumption that the number of cell sites cannot decrease over time (the 'non-decreasing sites adjustment').

A16.10 We assume that the modelled number of sites cannot decrease over time in order to avoid a situation in which the 2G and 3G site requirements fall in the short term (as a result of reductions in 2G and 3G traffic) only to increase again in the longer term as a result of 4G network deployments. We do not consider the profile of site deployments in the absence of this assumption to be reasonable.

A16.11 A consequence of this assumption is that the termination increment includes cell sites that are permanently avoided, meaning that the costs of replacing and maintaining these sites are incremental to termination for the remainder of the modelled period.[172] Even after these costs are discounted this results in considerably higher additional avoided expenditure compared to the case in which the 'non-decreasing sites adjustment' is not made, and these costs are allocated to MCT.

A16.12 This effect, in combination with the fact that site costs are the dominant component of the LRIC of 4G MCT, is sufficient to produce the result that the LRIC of 4G MCT is only slightly lower than the LRIC+. We consider that the question of whether the

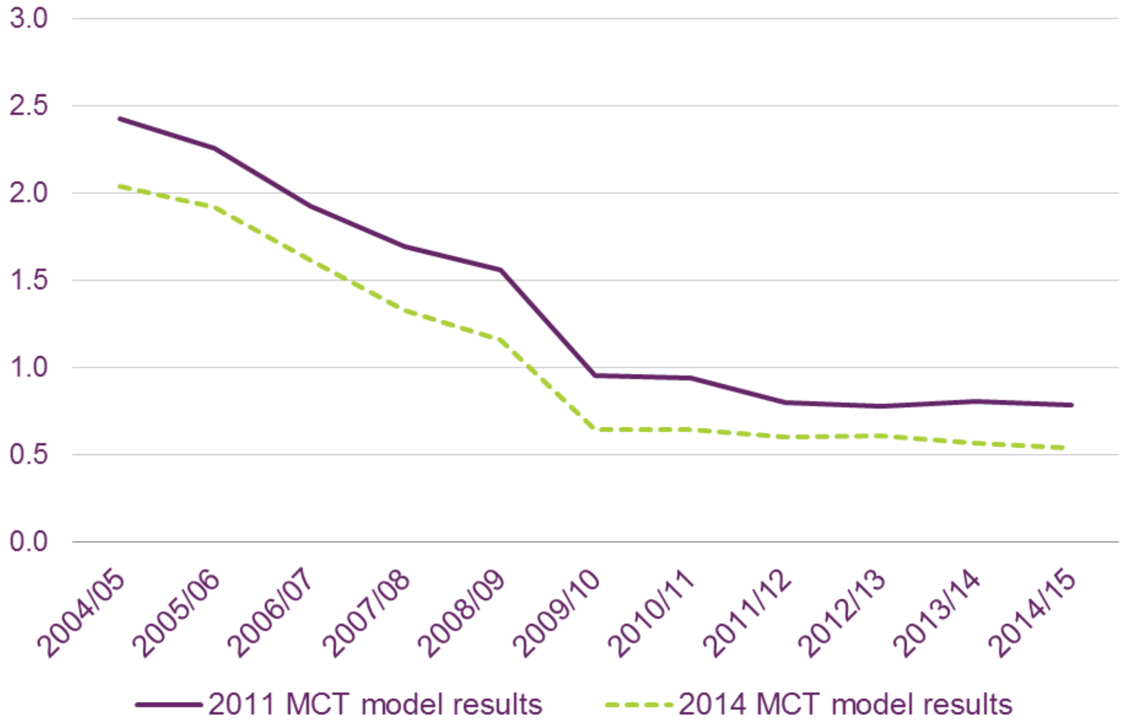
[172] Without the 'non-decreasing site adjustment' cell sites are only temporarily avoided and therefore the avoided expenditure from the termination increment is lower, resulting in the 4G LRIC being lower than the 4G LRIC+.

LRIC+ of 4G MCT is too low could be investigated further, however since we propose to set MTRs using the LRIC outputs of the model do not consider this to be a sensible use of our resources.

Comparison of results between the 2014 and 2011 MCT models

A16.13 A comparison of the blended LRIC results from the 2014 and 2011 MCT models is shown in Figure A16.3 below. This shows that the blended LRIC results of the 2014 MCT model lie below their equivalents from the 2011 MCT model throughout the period shown. This is the result of the updated demand forecasts showing greater traffic volumes, lower equipment prices and, towards the end of the period, the introduction of lower cost technologies such as 4G.

Figure A16.3: Blended LRIC of MCT from 2014 and 2011 MCT models (ppm, real 2012/13 prices)



Source: Ofcom 2011 MCT model, 2014 MCT model and Ofcom calculations.

Sensitivity analysis: Demand assumptions

A16.14 In order to test the 2014 MCT model we have performed sensitivity analysis to explore the impact of varying assumptions on the model results. For the demand assumptions we have used the low and high estimates explained in Annex 11 for each of:

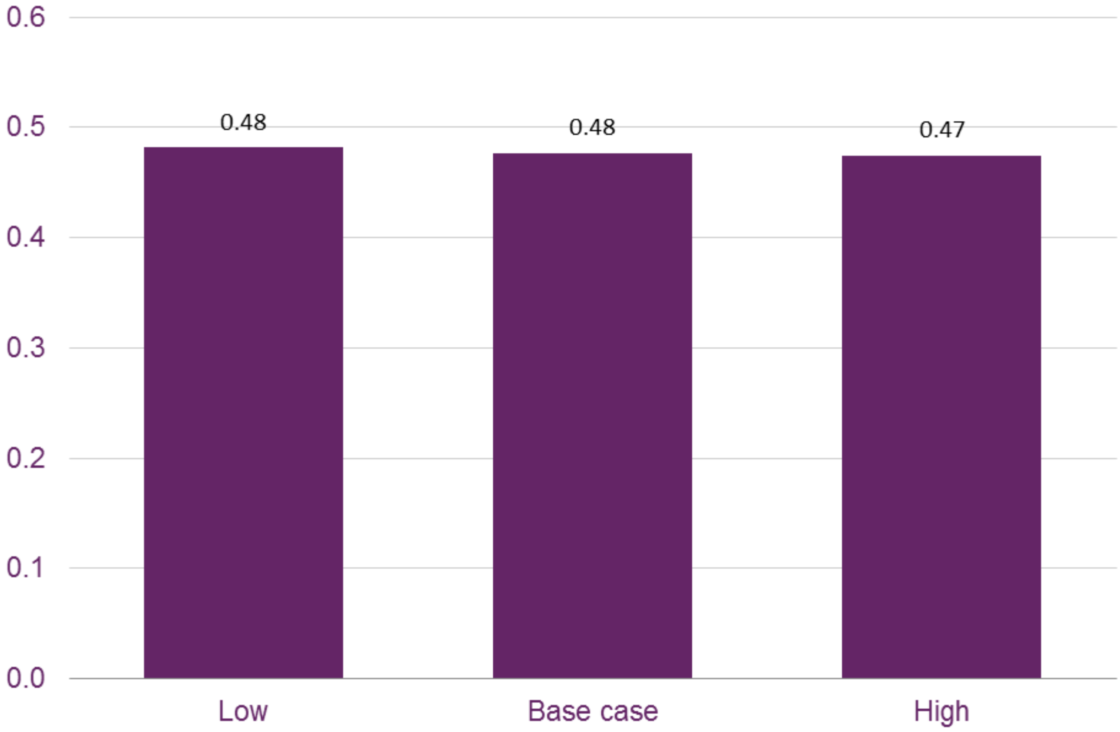
- **Handset penetration:** the percentage of the population using mobile voice services;
- **Voice usage:** the minutes of use per subscriber;
- **Data usage:** the data usage per subscriber; and
- **VoLTE handset availability:** the share of 4G handsets that are VoLTE enabled.

A16.15 These changes are first made on an individual basis and presented in the following sub-sections in comparison to the results in the model base case. We then merge the changes in the main demand parameters to create combined high and low demand scenarios.

Handset penetration

A16.16 The impact of varying our handset penetration assumption on the blended LRIC of MCT in 2017/18 is shown in Figure A16.4 below. Compared to the base case blended LRIC in 2017/18 of 0.48 ppm, a lower level of handset penetration leads to a marginally higher result (although this is not visible when the cost model results are reported to two decimal places in Figure A16.4) and higher handset penetration to a lower result of 0.47 ppm.

Figure A16.4: Sensitivity analysis of handset penetration (ppm, 2012/13 prices)

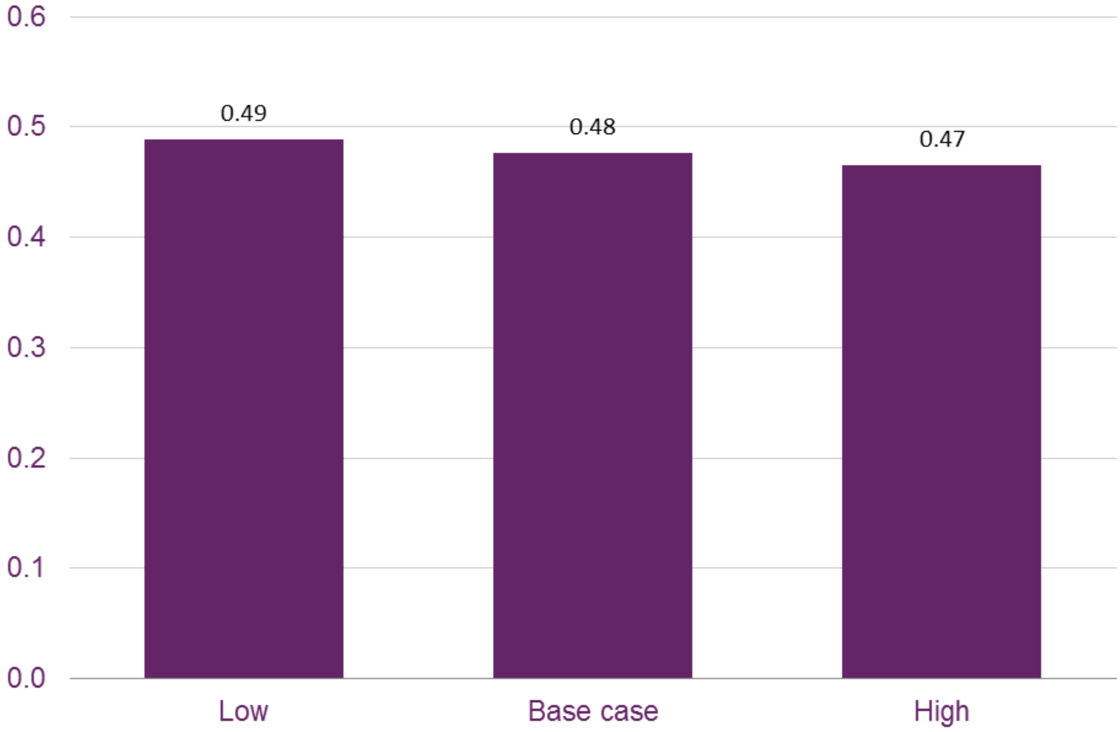


Source: Ofcom 2014 MCT model.

Voice usage

A16.17 The impact of varying voice usage assumptions on the blended LRIC of MCT is shown in Figure A16.5 below. Compared to the base case blended LRIC in 2017/18 of 0.48 ppm, a lower voice usage assumption leads to a blended LRIC of 0.49 ppm and higher voice usage to a lower result of 0.47 ppm.

Figure A16.5: Sensitivity analysis of voice usage (ppm, 2012/13 prices)

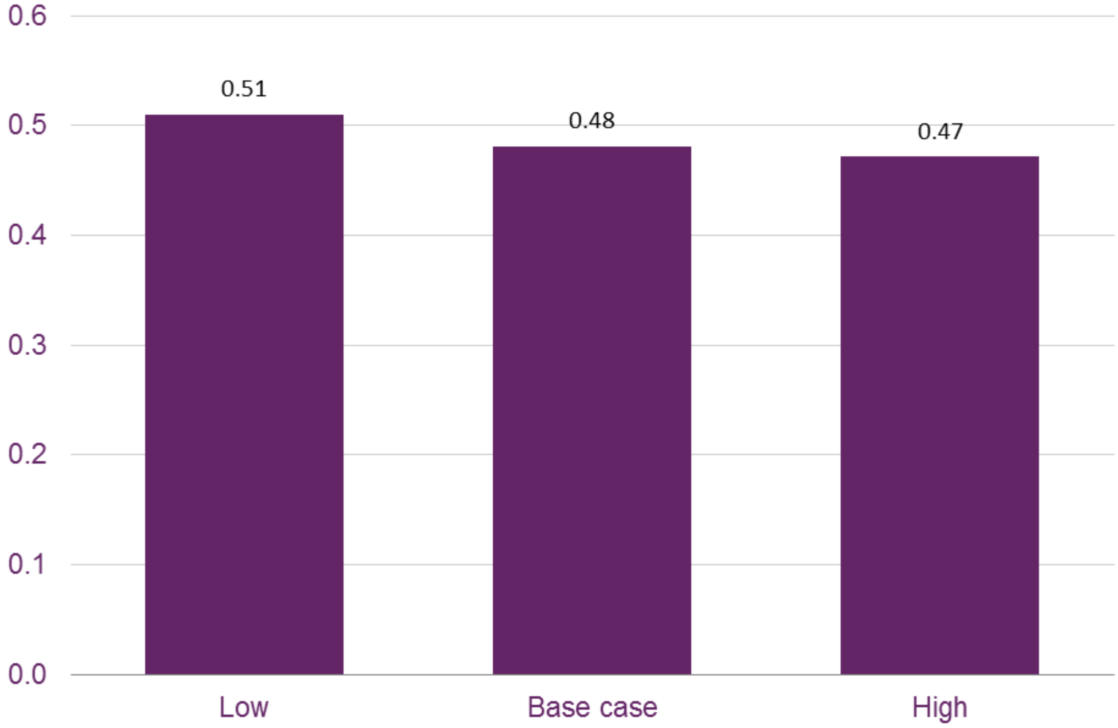


Source: Ofcom 2014 MCT model.

Data usage

A16.18 The impact of varying data usage assumptions on the LRIC of MCT is shown in Figure A16.6 below. Compared to the base case blended LRIC in 2017/18 of 0.48 ppm, a lower data usage assumption leads to a blended LRIC of 0.51 ppm and higher data usage to a lower result of 0.47 ppm.

Figure A16.6: Sensitivity analysis of data usage



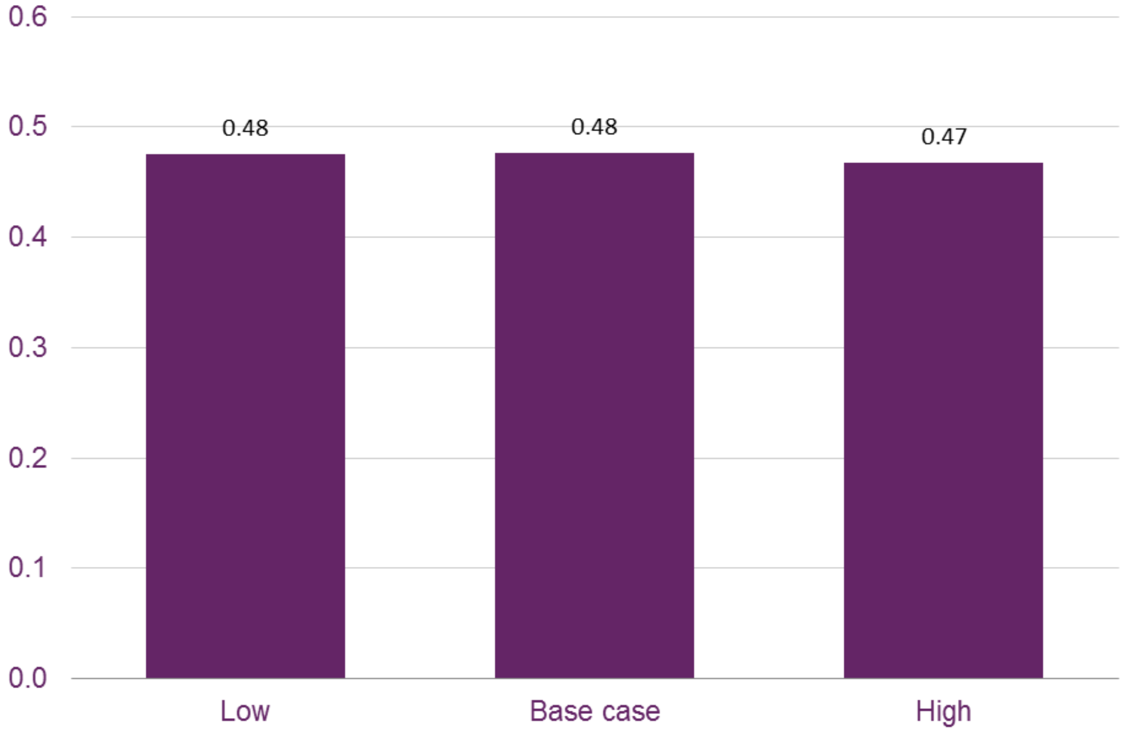
Source: Ofcom 2014 MCT model.

VoLTE handset availability

A16.19 The impact of varying our VoLTE handset availability assumption on the LRIC of MCT is shown in Figure A16.7 below. Compared to the base case result of 0.48 ppm, lower VoLTE handset availability leads to a marginally lower result (although this is not visible when the cost model results are reported to two decimal places in Figure A16.7) [173], and higher VoLTE handset availability leads to a lower blended LRIC of MCT of 0.47 ppm.

[173] As noted in our sensitivity analysis of the 2011 MCT model (see footnote 312 of the 2011 MCT Statement), small fluctuations in the LRIC results are possible as a result of modularity effects. Modularity effects occur because when a new asset is purchased it may not be fully utilised immediately. If assets are underutilised, when we introduce an increment of traffic the spare capacity will be used before any additional costs are incurred. If assets are fully utilised then adding incremental traffic will give rise to costs immediately.

Figure A16.7: Sensitivity analysis of VoLTE handset availability



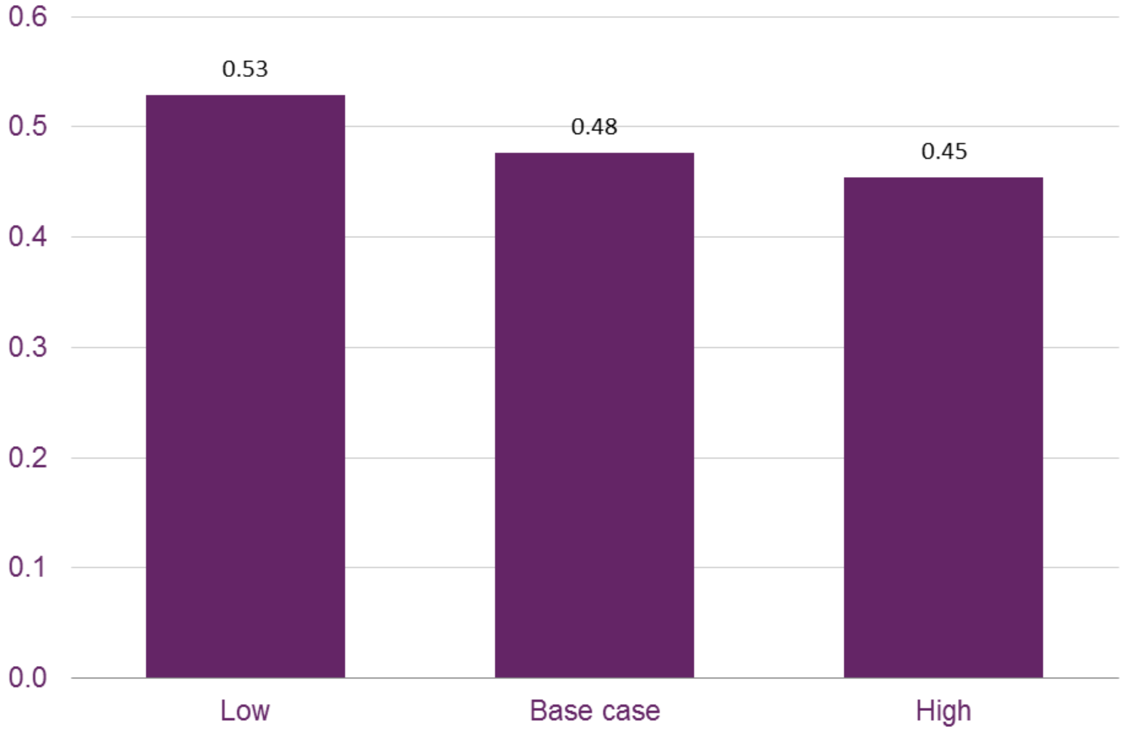
Source: Ofcom 2014 MCT model.

Combined demand scenarios

A16.20 The impact of varying the demand parameters explained above in a combined manner is shown in Figure A16.8 below. This shows that the impact of our combined low demand forecasts on the blended LRIC of MCT is to increase it from the base case value of 0.48 ppm to 0.53 ppm. The corresponding combined high demand forecasts reduce the results to 0.45 ppm.

A16.21 As was found in the sensitivity analysis of the 2011 MCT model, the LRIC of MCT is relatively insensitive to changes in demand forecasts.

Figure A16.8: Sensitivity analysis of combined low and high demand forecasts



Source: Ofcom 2014 MCT model.

Sensitivity analysis: technology, WACC and other assumptions

A16.22 We next test the sensitivity of the model results to non-demand assumptions and inputs, as follows:

- **Exclude 4G:** we exclude the deployment of the 4G network from the model;
- **Exclude VoLTE:** we exclude VoLTE (4G voice) services from the model, but retain 4G data services;
- **Exclude infrastructure sharing:** we exclude the active infrastructure sharing assumptions in the model;
- **Exclude S-RAN deployment:** we exclude the use of S-RAN equipment in the model;
- **WACC:** we vary the value of the WACC ± 1 percentage point around the central estimate of 6.9% (pre-tax real); and
- **Cost trends**: we vary the cost trend adjustment used for calibration in Annex 13.

A16.23 As before, these changes are first made on an individual basis and presented in the following sub-sections in comparison to the results in the model base case. We then combine these sensitivities with the demand sensitivities to create combined scenarios.

Exclude 4G

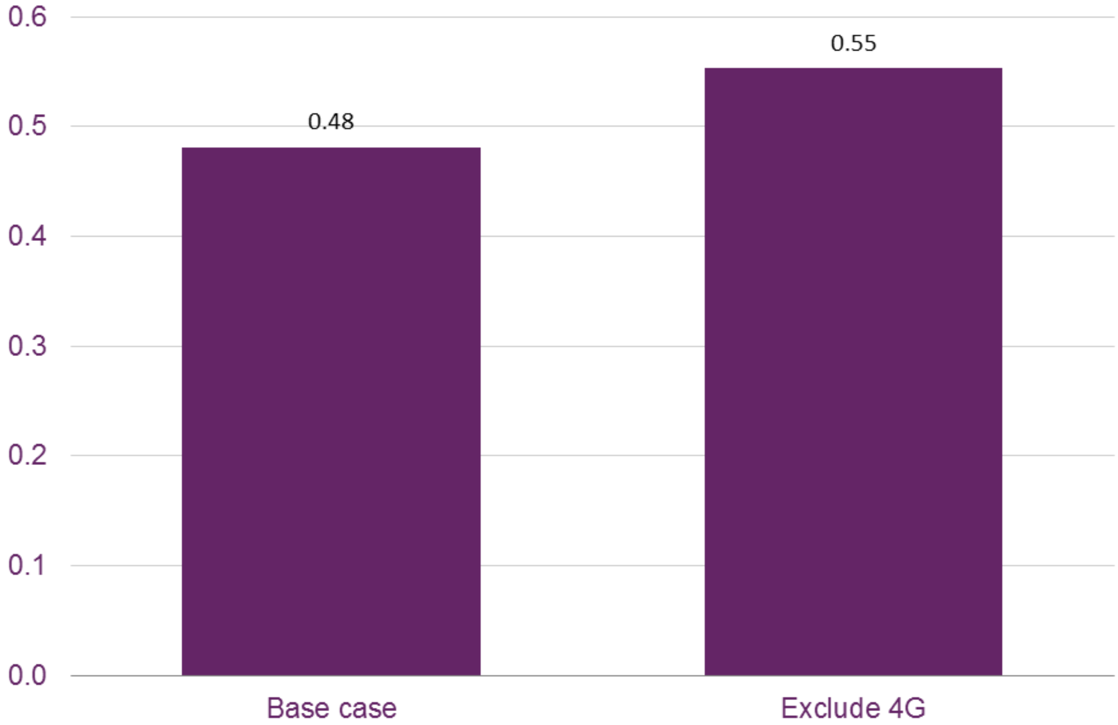
A16.24 The impact of excluding the 4G network on the blended LRIC of MCT in 2017/18 is shown in Figure A16.9 below. Compared to the base case blended LRIC in 2017/18 of 0.48, excluding the 4G network leads to a blended (2G/3G) LRIC of 0.55 ppm.

A16.25 This result is higher than that in the base case for two reasons:

- Excluding the 4G network means that 4G data is not modelled, and nor is voice (VoLTE) included in the blended MTR. Since 4G voice has lower unit costs than 2G and 3G MCT this leads to a higher blended result than in the base case.

- Excluding the 4G network leads to modest increases in both the 2G and 3G LRIC of MCT. This is because more 2G and 3G equipment is necessary to carry the same level of MCT traffic.

Figure A16.9: Sensitivity analysis of excluding 4G (ppm, 2012/13 prices)



Source: Ofcom 2014 MCT model.

Exclude VoLTE

A16.26 The impact of excluding VoLTE on the blended LRIC of MCT is shown in Figure A16.10 below. Compared to the base case blended LRIC in 2017/18 of 0.48 ppm (2012/13 prices), excluding VoLTE leads to a slight increase in the blended LRIC of MCT (although this is not visible when the cost model results are reported to two decimal places in Figure A16.10).

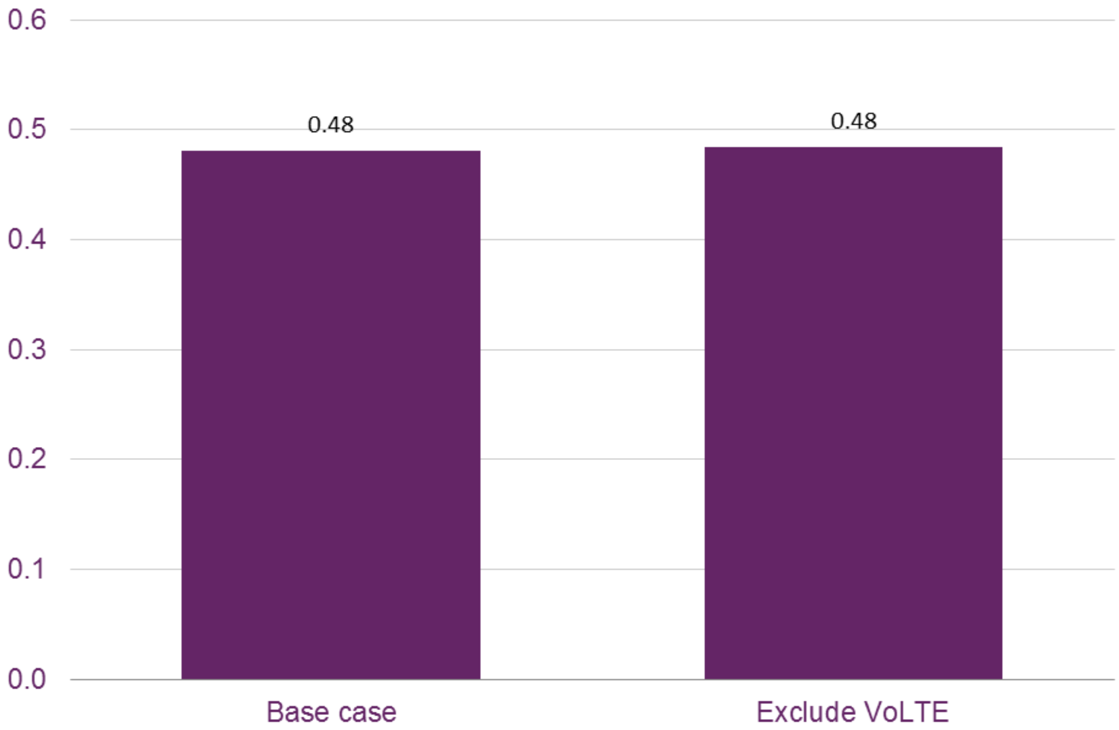
A16.27 Excluding VoLTE has two offsetting effects on the components of the blended LRIC:

- 4G MCT has lower unit costs than 2G and 3G MCT so excluding 4G MCT increases the blended LRIC.

- Excluding 4G leads to reductions in both the 2G and 3G unit LRIC of MCT because the presence of a 4G data network means that there is spare capacity on the 2G and 3G networks for voice traffic, resulting in lower unit costs. This reduces the blended result.

A16.28 The net impact of these two effects is to leave the blended LRIC of MCT only slightly higher with VoLTE excluded.

Figure A16.10: Sensitivity analysis of excluding VoLTE (ppm, 2012/13 prices)

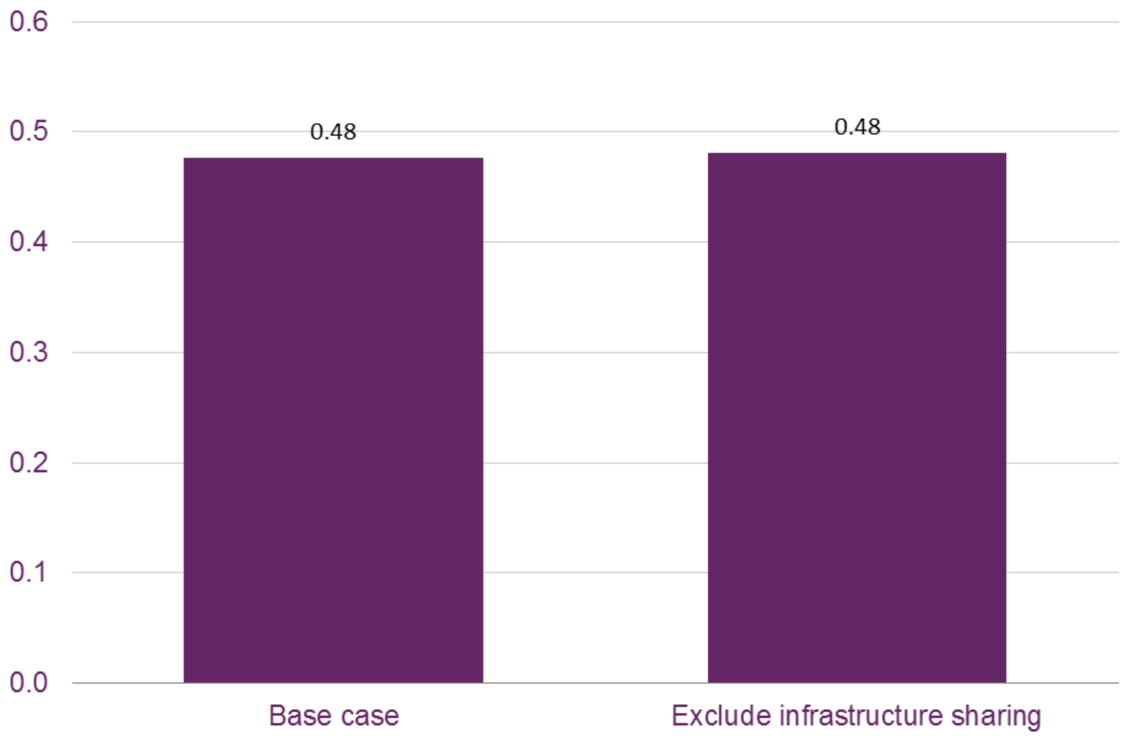


Source: Ofcom 2014 MCT model.

Exclude infrastructure sharing

A16.29 The impact of excluding infrastructure sharing on the LRIC of MCT is shown in Figure A16.11 below. This shows that compared to the base case blended LRIC in 2017/18 of 0.48 ppm (2012/13 prices), excluding infrastructure sharing leads to an increase in the blended LRIC of MCT (although this is not visible when the cost model results are reported to two decimal places in Figure A16.11).

Figure A16.11: Sensitivity analysis of excluding infrastructure sharing

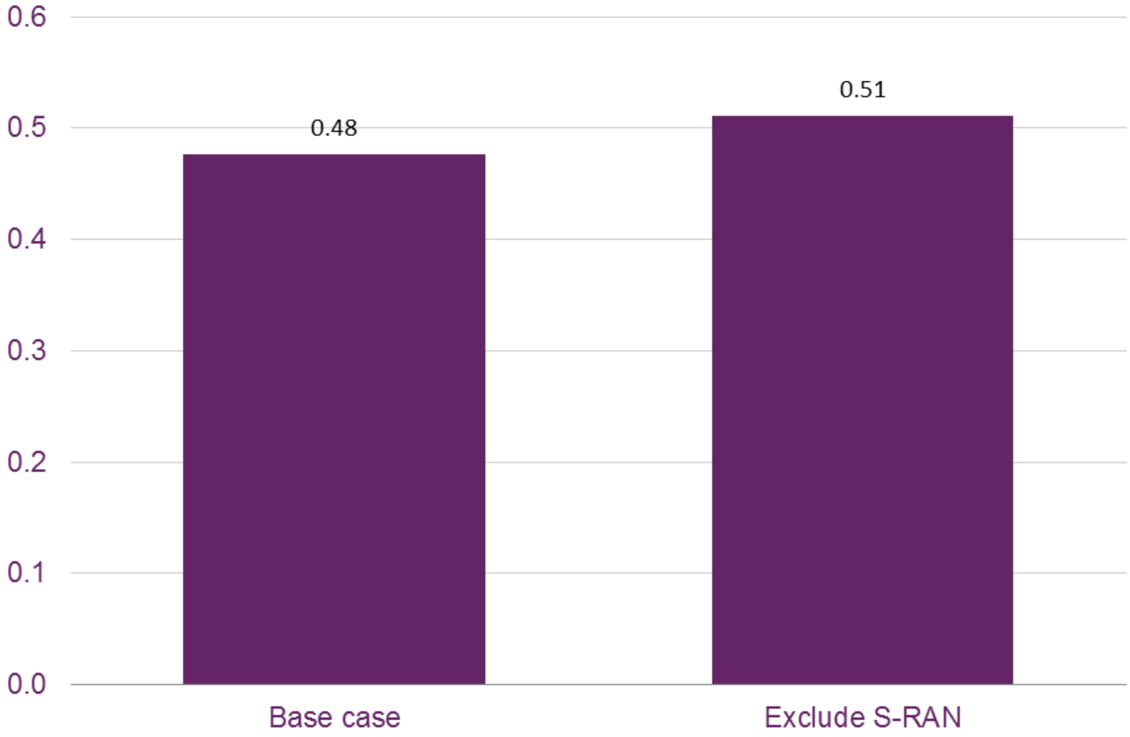


Source: Ofcom 2014 MCT model.

Exclude S-RAN deployment

A16.30 The impact of excluding S-RAN deployment on the LRIC of MCT is shown in Figure A16.12 below. Compared to the base case blended LRIC result of 0.48 ppm, excluding S-RAN equipment increases the blended LRIC to 0.51 ppm in 2017/18.

Figure A16.12: Sensitivity analysis of excluding S-RAN deployment



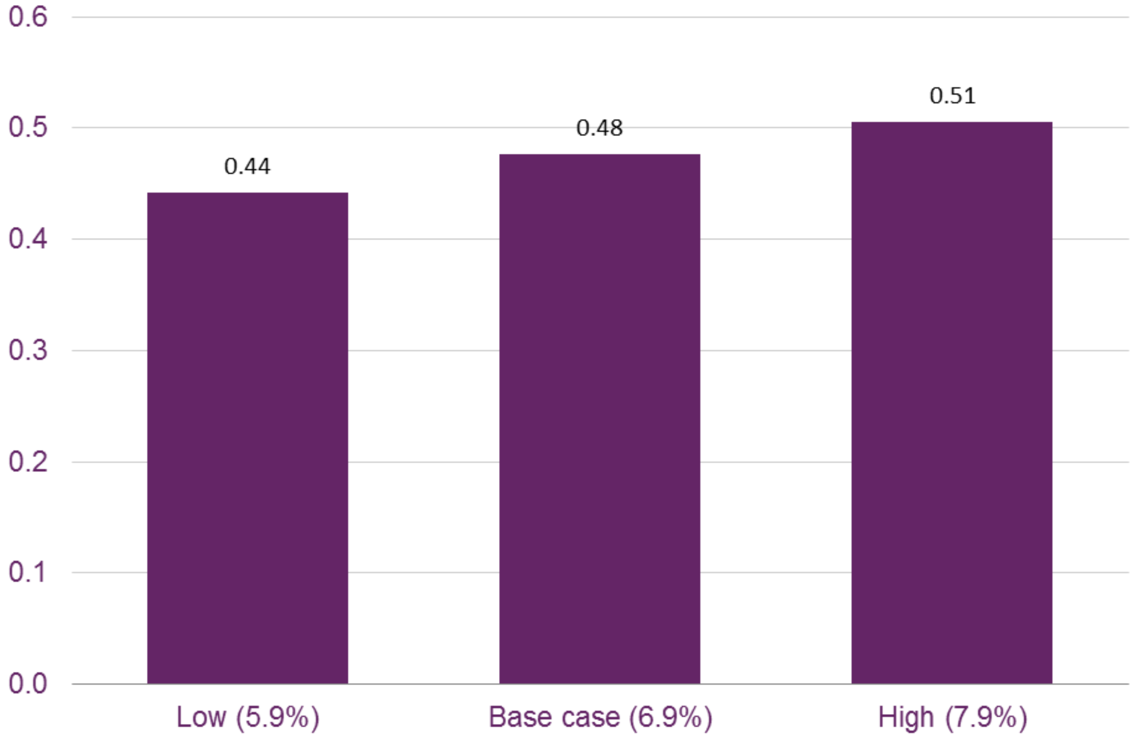
Source: Ofcom 2014 MCT model.

WACC

A16.31 The impact on the blended LRIC results of varying the WACC is shown in Figure A16.13 below. Relative to the base case blended LRIC of 0.48 ppm, which uses a WACC of 6.9% (as explained in Annex 14), our low WACC assumption (5.9%) leads to a blended LRIC of 0.44 ppm, and the high WACC assumption (7.9%) produces a blended LRIC of 0.51 ppm.[174]

[174] We note that in testing the sensitivity of the results to changes in this parameter we have introduced the high and low WACC scenarios from 2009/10 (the point in time at which the WACC was changed in the 2011 MCT model). The reason for this is that the CPI-discounted real WACC in the 2014 MCT model for the period from 2006/7 to 2008/9 is 12.37% and that for 2009/10 to 2012/13 is 6.7%. As a result, were we not to make the WACC sensitivity change from 2009/10 onwards we would have a WACC time series that falls from 12.37% to 6.7% in 2009/10 only to increase again to our high WACC scenario of 7.9% in 2013/14. Fluctuations such as this in the WACC can give rise to anomalous results.

Figure A16.13: Sensitivity analysis of changing the WACC

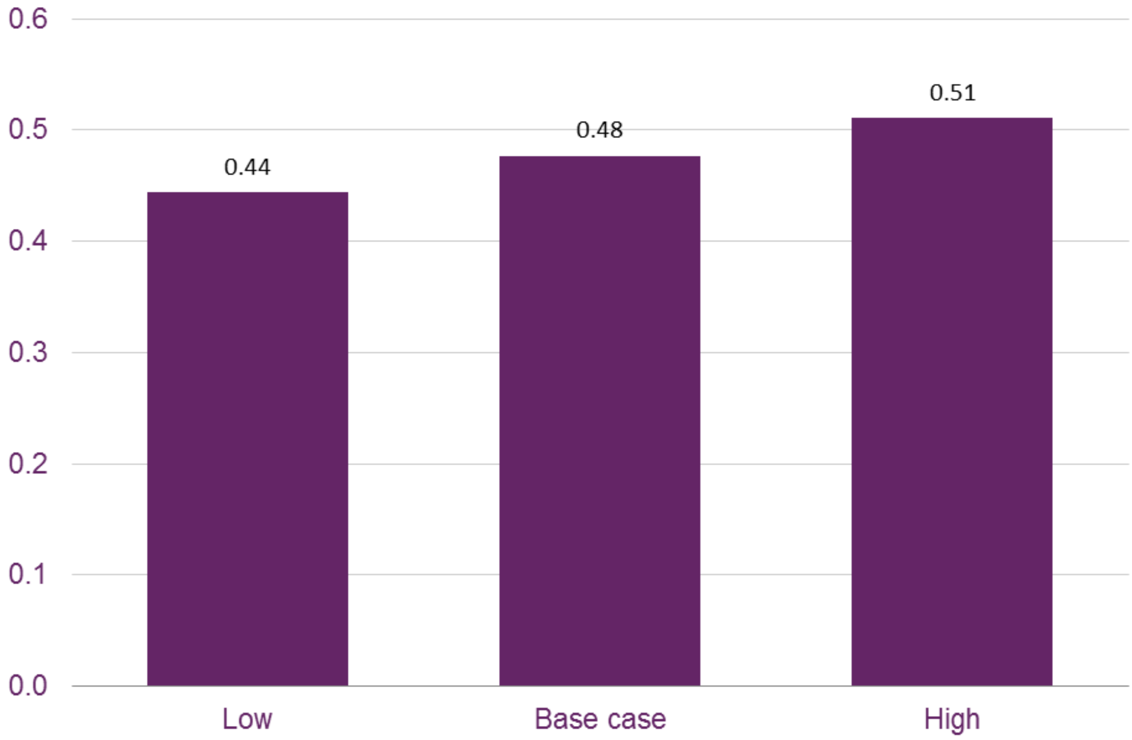


Source: Ofcom 2014 MCT model.

Investment cost trends

A16.32 The impact on the blended LRIC results of varying the investment cost trends (as explained in Annex 15) is shown in Figure A16.14 below. In the low case we remove five percentage points from the general uplift applied to the investment cost trends in each year between 2008/9 and 2011/12, and in the high case we add five percentage points in each year. Compared to the base case result of 0.48 ppm, the low case result is 0.44 ppm and the high case is 0.51 ppm.

Figure A16.14: Sensitivity analysis of changing price trends



Source: Ofcom 2014 MCT model.

Base, high and low scenario: Summary of outputs

A16.33 In order to show the sensitivity of the 2014 MCT model to further combinations of parameter changes we use the sensitivities explained above to create overall high cost and low unit cost scenarios for the LRIC of MCT. The composition of these combined scenarios is shown in Table A16.1 below.

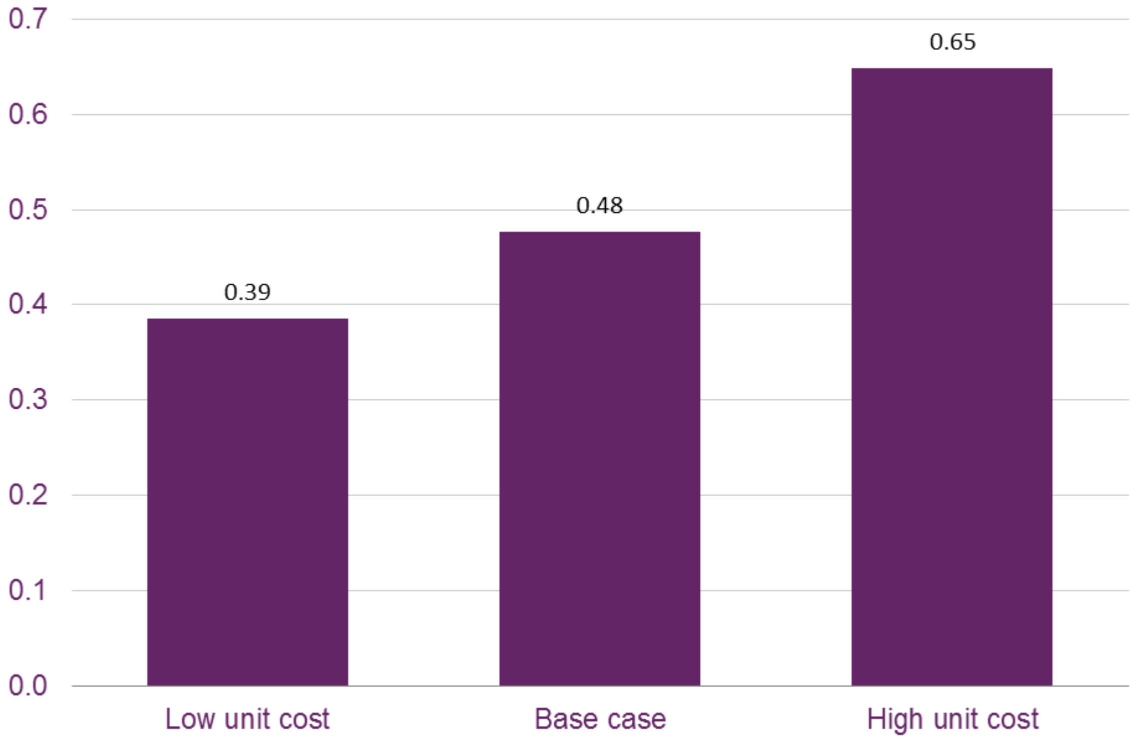
Table A16.1: Assumptions used in the base case, high cost and low unit cost scenarios

	Low unit cost scenario	Base case	High unit cost scenario
Demand	High	Medium	Low
WACC	5.9%	6.9%	7.9%
VoLTE handsets	High	Medium	Low
S-RAN	Included	Included	Excluded
Infrastructure sharing	Included	Included	Excluded
Cost trends	Low	Medium	High

Source: Ofcom.

A16.34 The resulting LRIC unit costs under these combined scenarios are shown in Figure A16.9 below.

Figure A16.9: Sensitivity analysis for combined low and high cost scenarios



Source: Ofcom 2014 MCT model.

A16.35 Figure A16.9 shows that compared to our base case result of 0.48 ppm, the combined low unit cost scenario LRIC of MCT is 0.39 ppm and the combined high unit cost scenario LRIC of MCT is 0.65 ppm.

Annex 17

Brattle report

This report is published separately.