Annex 9

Competition and Delay to Liberalisation Modelling

Introduction

A9.1 This annex describes our quantitative modelling of the impact of different options for liberalisation on the economic welfare generated by the provision of high quality mobile broadband.

A9.2 The first section concerns impacts resulting from changes in the intensity of competition. These affect allocative efficiency and are modelled using a calibrated version of the Cournot model.

A9.3 The second section concerns welfare impacts due to a delay in liberalisation causing a delay to the launch of services.

A9.4 For each type of welfare effect this Annex provides:

- An overview of the methodology used to quantify competition effects and a discussion of how and why the methodology has changed since the September 2007 Consultation.
- A description of our present approach to the modelling
- The key results and sensitivities from the model.

Welfare impacts due to changes in the intensity of competition

Overview of methodology previously used and relevant changes

A9.5 In the September 2007 Consultation, we estimated the benefits of intervention in liberalising 900MHz spectrum - over a twenty year period - to be £1.1bn. These benefits were measured against the counterfactual[1] that there would be a reduction in competitive intensity in the provision of mobile broadband services if the spectrum were liberalised in the hands of the incumbents. In the counterfactual we assumed that one of the current five players would exit the mobile market as a whole, and assumed that intervention to provide wider access to 900MHz would prevent exit. We used a Cournot model to estimate the benefits of increased competitive intensity.

A9.6 However, we acknowledged that the impact of a change in competitive intensity might not be as extreme as this. The assumption that the 2100MHz only operators would not match (at least not fully) the quality provided by the 900MHz incumbents, underlay the counterfactual. We also acknowledged, however, that it was possible that 2100MHz only operators would match quality.

[1] A counterfactual is a baseline which allows us to measure the impact of changing policy. In this case it describes how the market would continue to develop if we simply liberalised spectrum in the hands of the incumbents.

A9.7 A number of things have changed since then:

- The possibility of a longer term remedy means that the time period and consequently the scale of the potential benefits of intervention has now changed;
- We are using different market demand scenarios to assess cost differences between frequencies. Since these are a major driver of whether we need to consider alternative options for liberalising 2G spectrum, we also need to consider how this affects our assessment of the costs and benefits of different methods of liberalisation; and
- There are now more projections, though they are still few, for mobile data revenues. Hence our present analysis of the potential benefits of liberalisation is able to evaluate the impact on narrower market segments.

A9.8 We now consider three possible outcomes based on the size of the cost difference:

- Low significance in which no operator finds it profitable to roll out UMTS900
- Medium significance in which there are two variants;
    - All 2100MHz operators can afford to match
    - Only RAN shared 2100MHz operators can afford to match
- High significance in which no 2100MHz operators can afford to match

A9.9 Competition effects never arise in the low outcome as the cost difference is so small that the cost advantage of using 900MHz is lower than the costs of clearance. In this outcome the 900MHz operators do not roll out UMTS900 and neither do the 2100MHz operators so no competition problems arise.

A9.10 Competition effects may arise in the medium and high significance outcomes if the policy option changes the number of operators with access to 900MHz spectrum, either directly through acquiring spectrum or indirectly through RAN sharing.

A9.11 Where the competition benefits due to wider access to 900MHz are relevant, the working hypothesis is that only operators with 900MHz spectrum could compete in providing high quality mobile broadband services in the interim period, recognising that this is an imperfect measure for the reasons described above.

A9.12 There may also be a negative welfare effect if mandated release causes a delay to liberalisation which results in foregone benefits from high quality mobile broadband services.

Views concerning our use of Cournot model to estimate welfare effects

A9.13 Vodafone commented on our use of the Cournot model to estimate the impact of changes in market structure on welfare in its response to the September 2007 Consultation.

A9.14 Vodafone considered that it was inappropriate to use the Cournot model as a proxy for competition in the mobile market because of some of the model's assumptions:

that services are homogenous and that firms choose what level of capacity to supply in order to compete, rather than choose what price to sell their services. Moreover, Vodafone said that because we had chosen a model that axiomatically assumed that entry would increase competition in mobile markets, we had not provided evidence to support that view.

A9.15 We addressed a similar issue in our Statement on the award of 2.6GHz in April 2008, and the arguments are equally relevant here. There is a solid theoretical and regulatory foundation for considering that entry will increase competition[2]. Moreover, the majority of oligopoly models commonly used in analysing competition and merger issues in oligopoly also predict this result.

A9.16 We consider that it is reasonable to use the Cournot model to estimate the plausible range of welfare impacts from changes in the market structure for mobile broadband. The Cournot model is a stylised model, but it is very tractable. The advantage of using it in this situation is that it produces similar results to other (less tractable) models of imperfect competition which describe mobile service provision well. Firstly, Kreps and Scheinkman[3] show that the outcome of the standard Cournot model (where firms decide only what quantity to supply) is equivalent to Cournot model with a two-stage decision process. First firms first commit to the capacity they aim to provide over their networks and then they compete in prices. Secondly, a 'Bertrand' model of oligopoly (in which firms compete on price) with product differentiation, may describe competition in mobile well. It also produces outcomes similar to the standard Cournot model and it is extensively used in merger simulation for anti-trust cases.

Competition modelling

A9.17 This section outlines the model we have used to quantify welfare effects from changes in the intensity of competition.

Timescales for estimating benefits

A9.18 In Annex 12 we note that the relevant time period over which we should assess competition effects is the interim period. This begins when liberalised 900MHz spectrum is available and enough handsets have permeated the market so that the 900MHz operator can offer a high quality broadband service to consumers who are sensitive to changes in quality. The interim period ends at the point at which 2100MHz operators can use acquired 800MHz spectrum to provide high quality mobile broadband services to the same segment of the market. In our base case we have assumed that this period is between 2012 and 2014. The timing assumptions are discussed in further detail in Annex 12.

A9.19 The advantage of the 900MHz operator could persist beyond the interim period if there are significant first mover advantages. This would be the case if for example the 2100MHz operator by not matching suffered from reputational inertia. Reputational inertia would occur if the 2100 MHz operator obtained a reputation for lower quality from its provision of services through 2100 MHz spectrum in the interim period which persisted even where following the interim period it provided

[2] For example the Competition Commission guidelines on merger references. See also an empirical study, H. Koski and T. Kretschmer, "Entry, standards and competition: firm strategies and the diffusion of mobile telephony" Review of Industrial organisation 2004

[3] D. Kreps, J. Scheinkman: Quantity Pre-Commitment and Bertrand Competition Yield Cournot Outcomes, Bell Journal of Economics, 1983

higher quality services through lower frequency spectrum. The 2100MHz operator would be less likely to face reputation inertia in a fast growing market.

A9.20 We have tested the sensitivity of our results to the duration of the interim period by using the lower estimate of 2 years and the upper estimate of 4 years of the likely duration of competition effects from Annex 12.

Dimensioning the affected market segment

A9.21 If the outcome is that some or all of the 2100MHz operators do not match, then the mode of liberalisation could have an impact on competition in the mobile market. In the previous consultation we said that one extreme effect of cost difference could be exit from the total UK mobile market entirely and we quantified this effect. However, clearly a range of less extreme impacts on competitive intensity could occur, and we acknowledged this.

A9.22 We have now focused on those customers who may be sensitive to differences in mobile broadband quality and the associated revenues. The associated revenues would include mobile broadband and other mobile services (eg. voice, SMS) for those customers who always bundle their mobile services, and mobile broadband only for those customers who view the purchasing decisions as separable.

A9.23 We have therefore dimensioned the market segment with reference to the overall UK market. In the base case, we have assumed that the revenues sensitive to changes in quality - and so forming the size of the affected market segment – is 25% of total UK mobile market revenues, and that the associated number of subscribers is consistent with this. The low and high cases assume 15% and 35% respectively in revenue terms.These parameters dimension the affected market segment for the calibration of the Cournot model.

A9.24 We have explored the sensitivity of our modelling results to these dimensioning assumptions and these are illustrated below.

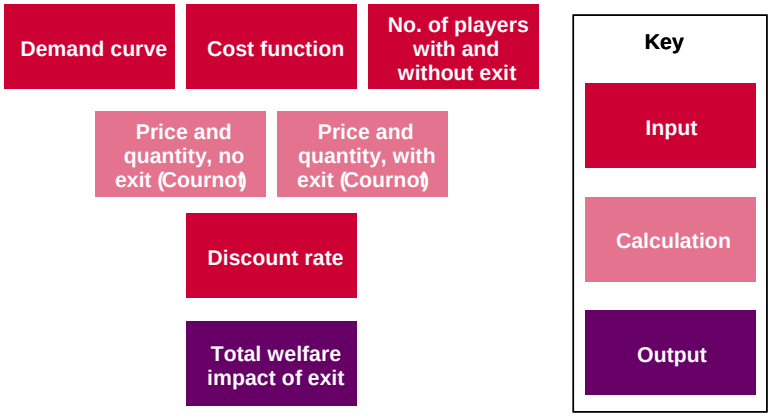
Model specification

A9.25 We have implemented the Cournot oligopoly model structure used in the September 2007 Consultation to quantify the welfare implications of changing the number of players in a market.

A9.26 At a high level the model compares the producer and consumer surplus across two scenarios; a factual and a counterfactual. The counterfactual describes the market structure which results from liberalisation in the hands of the incumbents and access to 900MHz spectrum limited to the current holders, and the factual describes how the market structure changes over time as a result of intervention to provide wider access to 900MHz. The purpose of the model is to establish the difference in welfare between these two cases. The base case period modelled is the interim period of 3 years.

A9.27 Figure 1 illustrates this high level structure.

Figure 1: Flow diagram for oligopoly competition model



A9.28 The price and quantity variables in the model are annual ARPU (average revenue per user) and subscriber volumes for the relevant mobile market. The market modelled is the affected segment of the UK mobile market with subscriber volumes and ARPU values forecast for the next 20 years.

A9.29 The forecast of mobile data ARPU and subscribers are based on Analysys Mason forecasts of total UK mobile service revenues from data and non-data services. As noted above, in the base case the total revenues in the affected market segment are assumed to be approximately 25% of the UK mobile market.

A9.30 The Analysys forecasts cover the period 2007 to 2013. In order to forecast beyond 2013 we have taken as a starting point the Analysys forecast for 2013 and forecast this forward by assuming a constant annual growth rate equal to the forecast rate of real GDP growth of 2% per annum. This approach assumes that the size of the mobile data market in relation to the wider economy stays roughly constant from 2013 to 2028.

A9.31 The first stage of the modelling is a calibration exercise which calculates the parameters of the assumed linear demand curve $P=a-bQ$ and the symmetric marginal cost.

- Given the forecast price and output for the first year, and the assumed elasticity the model calculates the slope of the demand curve *a* and the choke price *b* by considering a small (0.1%) change in price.
- The model calibration uses the parameters *a*, *b* and the number of firms *n* to calculate the average marginal cost required to produce the Cournot equilibrium price and output values equal to the forecast price and output.[4]

A9.32 The second stage of the modelling is to calculate a base line development of the demand curve parameters *a* and *b*, and the average marginal cost.

- In the first year these variables take the values produced in the first stage of the modelling.

[4] This approach derives the marginal cost assumption that is consistent with the forecast price and output in the base line market development with 5 players as the equilibrium outcome under Cournot competition. An alternative approach would be to specify the marginal cost and derive the equilibrium price and quantity with Cournot competition. We have adopted the former approach using the Analysys Mason forecasts of ARPU and subscribers.

- From the second year onwards *a* and *b* are a function of inflation and the price of substitutes, and the price and quantity forecast. The marginal cost is calculated by solving for the Cournot equilibrium.

A9.33 The third stage is to establish a Cournot equilibrium in every year of the relevant period for both the factual (i.e. the outcome of the policy option) and the counterfactual (commercial outcome if we liberalise in the hands of the incumbents). The inputs for this computation are the number of firms in the market, the demand curve and the average marginal cost (the parameters of which are calculated in the earlier stages). The outputs of this stage of the model are the price and output. Using price, quantity, the demand curve, and marginal cost we can obtain the values of consumer and producer surplus that we are ultimately interested in.

A9.34 Looking more closely at the inputs required for the equilibrium to be established it is clear that the number of firms in the market in any given year is an input and will be the only input variable that is different between the factual and counterfactual.[5] While it might be argued that a further difference between the factual and the counterfactual would be due to cost differences (either fixed or marginal costs), the analysis abstracts from such differences in order to simplify the analysis.[6]

A9.35 Having specified all the inputs, the consumer and producer welfare produced in each year of the 20 year NPV period are calculated for each scenario, and discounted back (at the real social discount rate of 3.5%) to 2008 values. The difference between the discounted welfare values of the factual and counterfactual is then the welfare implication of the difference in number of players between the two scenarios.

Key results and sensitivities

A9.36 This section sets out our estimates of the welfare effects of a change in competitive intensity. This situation would occur under the counterfactual that 2100MHz operators do not match.

A9.37 Given our dimensioning of the affected market segment, we consider the welfare effects of a change in competitive intensity by considering the difference between a 2 player market and a market with a higher number of players. The working hypothesis here is that only firms with access to 900MHz spectrum would be able to competitively provide mobile broadband services included in the revenues in the affected market segment.

A9.38 The base case is that the welfare effect of an increase in competition on the affected segment should be modelled as the difference between a 2 player market and a larger number of players over the interim period only. In the base case we made the following assumptions:

- Linear demand curve

[5] This makes the assumption that the demand conditions in the market and costs are independent of the number of players. While it is possible to envisage scenarios in which that isn't the case (for example where the take-up of 3G services is materially affected by the number of players promoting those services), such effects are uncertain and would add to the complexity of the modelling.

[6] For example, with more operators (ie the factual) industry fixed costs will be higher; however, this is dealt with in the next section. By contrast, it might be argued that marginal costs per operator would be lower in the factual if more than the incumbent 900MHz operators have access to this spectrum. Clearly, the welfare consequences of these two effects would offset each other to some extent.

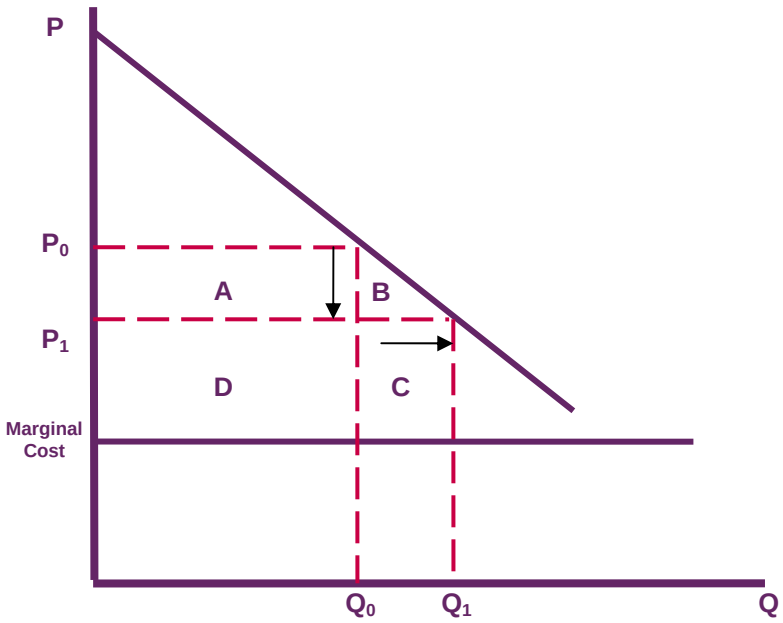
- Entry of a number of operators over the interim period 2012-2014 (3 years);
- Elasticity of demand of -1.0;
- A real social discount rate of 3.5%;
- Marginal cost is determined as described above; and
- Real price of substitutes falling by 1% from 2012 onwards.
- Revenues in the affected market segment grow at 2% per year in real terms i.e. equal to the rate of real GDP growth

A9.39 We now describe a change in competitive intensity from 2 players to 3 players to highlight the size of welfare effects involved.

A9.40 The entry of one operator increases the number of players in the affected market segment from 2 to 3 and decreases the market price by 8% and increases the number of subscribers by 12.5%, resulting in an increase in consumer welfare (area A+B in figure 2) of £1 billion in 2008 values.

A9.41 The entry of one operator changes total producer surplus from area A+D to D+C in figure 2 due to increased subscriber volumes but reduced price. We estimated that total producer surplus is decreased by around £575million in 2008 values.

Figure 2: Welfare Gains from the entry of one operator



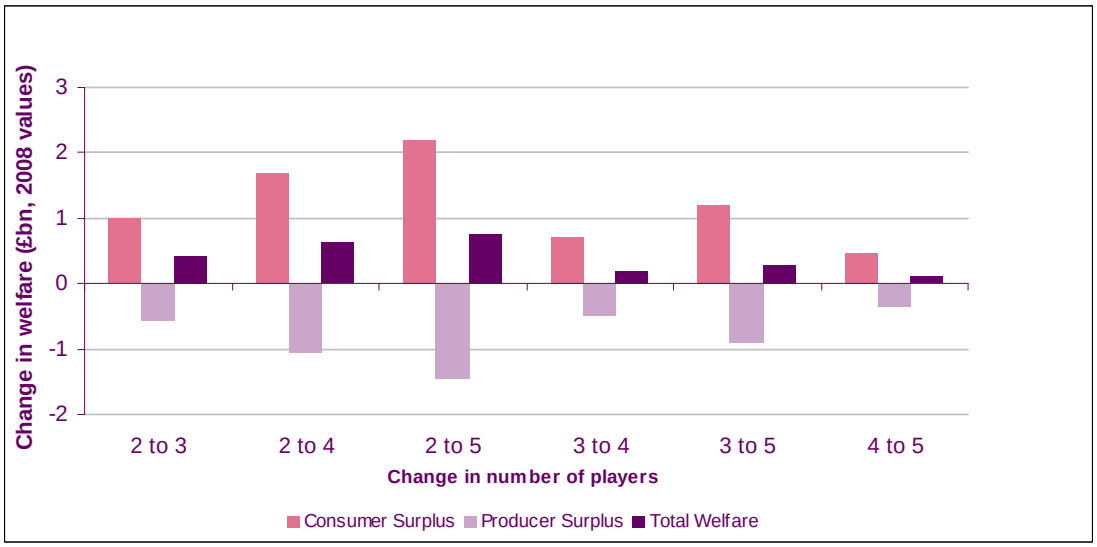
A9.42 This yields a total welfare gain of around £425 million in 2008 values.

A9.43 We also quantified a greater change in competitive intensity from 2 to 4 players and 2 to 5 players. The former reflects the counterfactual that two networks in a network sharing agreement obtain 900MHz spectrum, and the latter represents the

counterfactual that three networks in a network sharing agreement obtain 900MHz spectrum. Figure 3 below shows the welfare effects associated with 1, 2 and 3 new entrants over the interim period. The first bar shows the change in consumer welfare, the second shows the impact on producer surplus, and the third shows the net effect on total welfare. As the number of players increases consumers benefit from lower prices, while firms make less profit.

A9.44 Our assessment of the benefits of liberalisation has also considered the case where a 1 block release enabled a sixth operator to enter the mobile broadband market in 2015, ie. following the interim period. Such an additional player could increase competitive intensity over the period to 2027, compared to a situation with five players. Our Cournot modelling suggests that the additional net welfare benefit could be in the order of £190 million over this period.

Figure 3: Welfare gain from change in market structure, looking at the affected market segment only

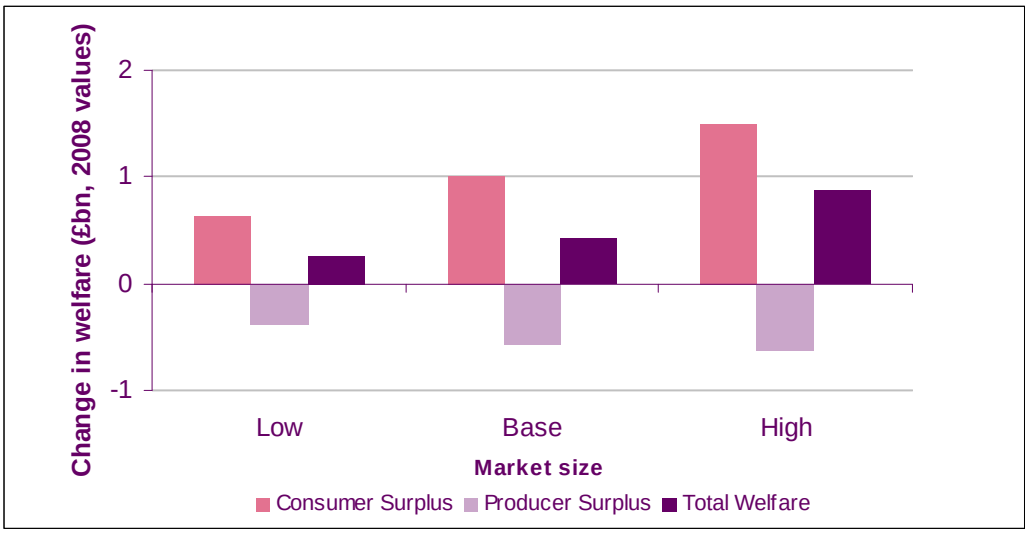


A9.45 Our welfare change estimates are among other things sensitive to the estimated price changes resulting from the Cournot model. In the cases above, the Cournot model gives a price reduction as a result of an increase in the number of players from 2 to 3 as 8%, with price reductions of 13% and 16% resulting from increases in the number of players from 2 to 4 and 2 to 5 respectively. These estimates are clearly subject to a degree of uncertainty, and to the extent that price changes might in practice tend to exceed (or be less than) those predicted by the Cournot model, our estimate of welfare change will be too low (or too high)[7].

[7] Some evidence available from other industries indicate the extent of price reductions which have sometimes occurred following deregulation and entry into a market. The nominal cost of international phone calls following deregulation of and new entry into the UK telecoms market for example fell around 12% per annum over the period 1994 to 2002. Between 1997 and 2003, the average nominal price of the lowest priced carrier's for a selection of European international airfares fell by around 10% per annum following deregulation and new entry into the budget airline industry. One study of US price competition in the market for antiinfective pharmaceutical products found that market prices fell by around 50% following entry of the second and third players. There are relatively few robust studies of entry and price effects, and these numbers are clearly not conclusive. We nevertheless note that they give some indication of the order of magnitude of price effects that might be seen following entry, and in general they comfortably exceed the price reductions given by our Cournot modelling.

A9.46 As discussed above we have considered a range of inputs to dimension the affected market segment. We have used low, base and high inputs of the affected market segment revenues which represent 15%, 25% and 35% of the total UK mobile market, respectively. Figure 4 below illustrates the sensitivity of the welfare change estimates to the size of the affected market segment.

Figure 4: Sensitivity to dimensions of the affected market segment



A9.47 We have considered a range of changes in competitive intensity, which may arise under certain scenarios. These are illustrated in table 2 of Annex 7.

A9.48 Our range for estimated welfare changes is bounded by our assumptions concerning the size of the affected market segment. In our interpretation of the results in section 7 we also take account of the potential for other sources of variation, such as the size of the percentage price changes caused by a change in the number of players, by recognising the considerable uncertainty over the size of the competition benefits.

A9.49 The central results above use the conservative forecast that total mobile revenues will grow in real terms at 2%, which is equal to the forecast real GDP growth rate from 2013 onwards.

A9.50 It is important to note that the effect of flexing this parameter is small as we have used the Analysys Mason forecasts for the period up to and including 2013 so this parameter only affects the potential magnitude of welfare effects in remaining years of the interim period, which is 2014 only in the base case and 2014 and 2015 in the high case.

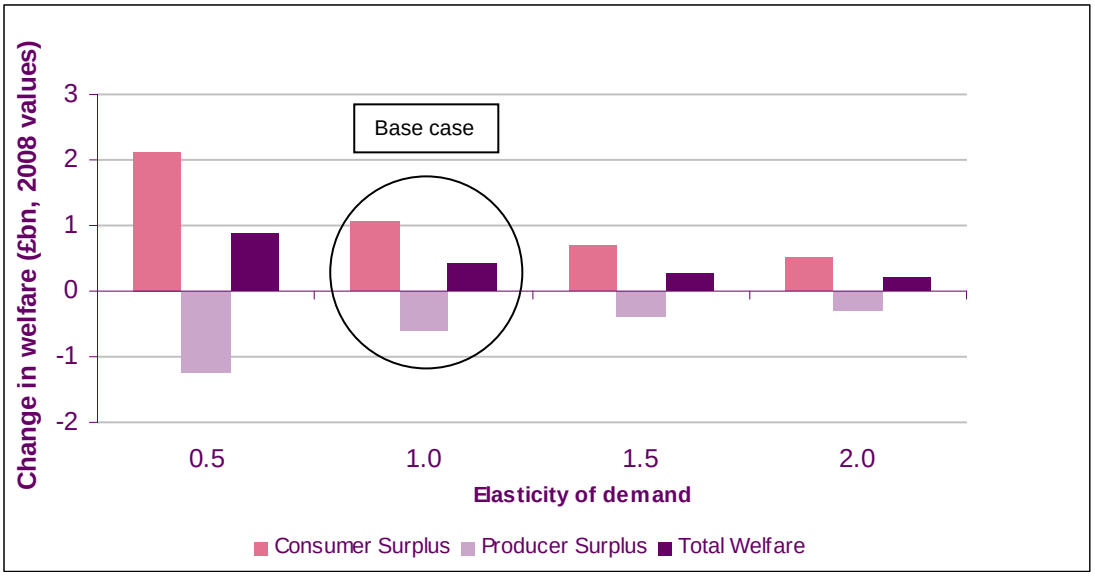
A9.51 Hence we have explored the sensitivity of the results using our high estimate of the length of the interim period, that is 4 years rather than 3, to highlight the effect of changing the revenue growth parameter. All other assumptions apart from the revenue growth are set at the base case values. The effect of assuming different growth rates are set illustrated in table 1 below.

Table 1: Sensitivity to revenue growth

	NPV in 2008 values (£millions)		
Revenue growth beyond 2013	**Consumer Surplus**	**Producer Surplus**	**Total Welfare**
0%	1,420	-840	580
2%[8]	1,410	-830	580
5%	1,400	-820	580
10%	1,380	-810	570

A9.52 The model allows us to show the welfare effects under a range of different assumptions of demand elasticities. This is illustrated in figure 5 below for the base case of an increase in the number of players from 2 to 3.

Figure 5: Sensitivity to Elasticity assumptions



A9.53 If operators which hold 900MHz spectrum benefit from first mover advantages such as acquiring a reputation of providing a higher quality network, the effects on competition persist beyond the interim period.

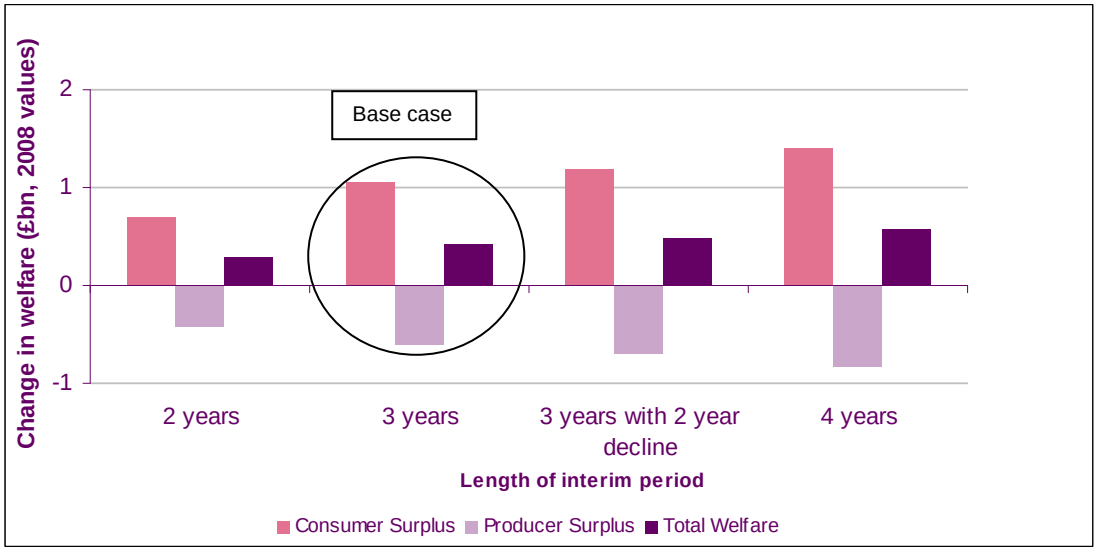
[8] This is our baseline revenue growth assumption

A9.54 The model can accommodate changes in the length of the period over which competitive effects are felt. We have explored the sensitivity of our central results to this parameter by considering four alternative periods:

- Two years of competition effects over the period 2012-2013.
- Three years of full competition effects 2012-2014, the base case.
- Three years of full competition effects 2012-2014 with a diminution in competition effects to zero over a 2 year period 2015-2016. This is modelled by assuming the number of players in the counterfactual approaches 5 over time, and taking the Cournot equilibrium values for price and quantity.
- Four years of full competition effects from 2011 to 2014.

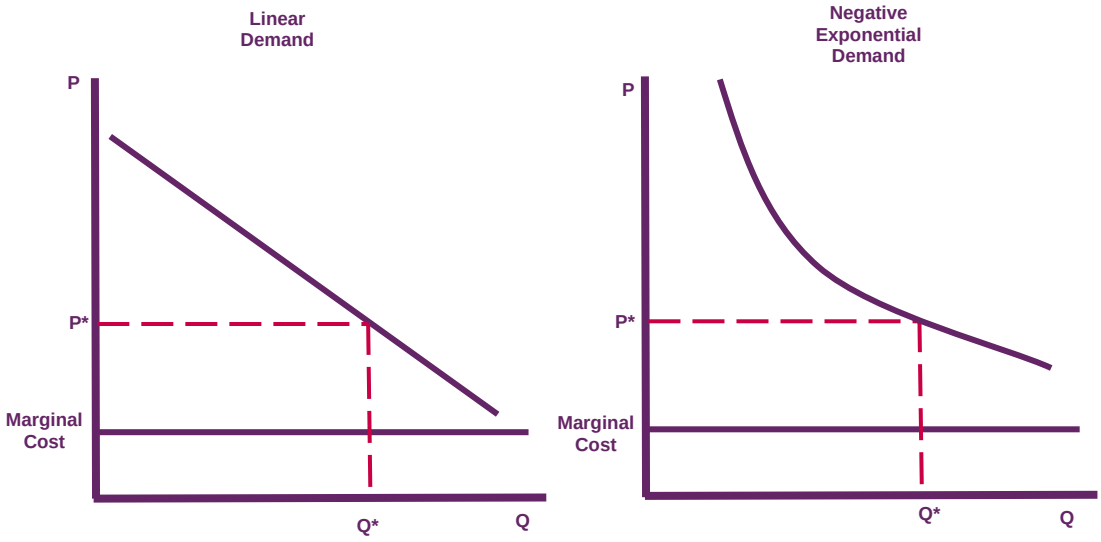
A9.55 The effects of flexing the assumption about the length of the period of reduced competitive intensity are illustrated in figure 6 below for the case of 2 to 3 players.

Figure 6: Sensitivity to duration of competition effects



A9.56 We have also explored the degree to which the base case results are sensitive to the assumptions made about the shape of the demand curve. Specifically, in the base case we assumed that the demand curve is linear, which is illustrated on the left in figure 7 below. We have also modelled the case if the demand curve has a negative exponential functional form so that it is takes the form illustrated on the right in figure 7 below.

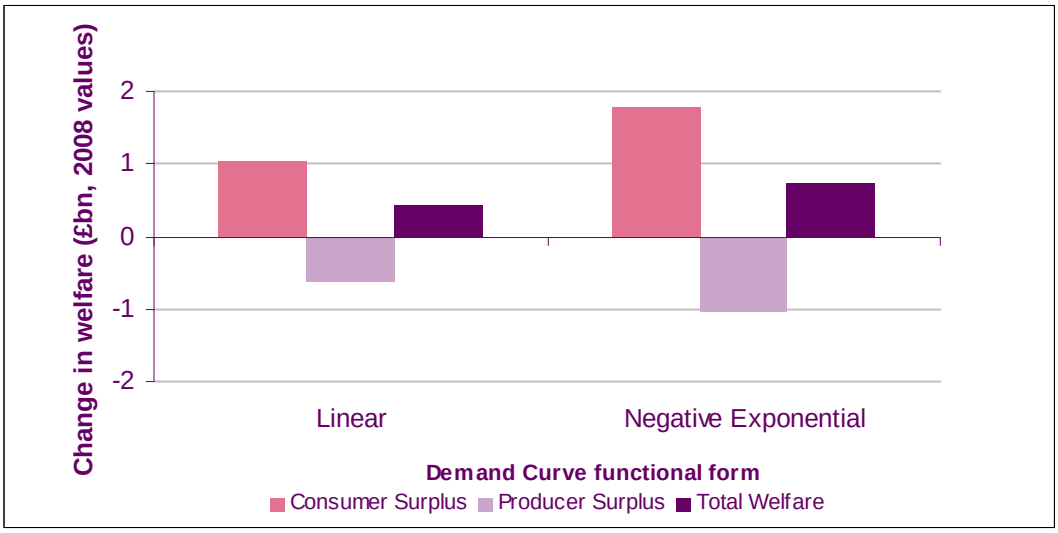
Figure 7: Demand Curve Functional Forms



A9.57 In the calibration stage of the modelling both demand forms pass through the points given by the forecasts of price and quantity, P* and Q*, but the implied marginal cost and total welfare differ depending on the assumption about the shape of the demand function.

A9.58 Changes in the number of players will have different effects on equilibrium prices and output depending on the assumed form for the demand curve. The effect of changing the demand curve form is illustrated in figure 8 below.

Figure 8: Sensitivity to shape of demand curve assumptions



A9.59 We have also estimated the impact on total welfare and consumer surplus of the any delay in the effects of more intense competition. Tables 2 and 3 set these out for the cases where the number of competitors might have increased from 2 to 3 and from 2 to 4 respectively. That is, for the 2 to 3 case, a one year delay in the impacts of enhanced competitive intensity reduces total welfare by around £150m and consumer surplus by around £350m. A delay that extended across the whole of the 3 year interim period would effectively eliminate enhancements from competition and associated benefits.

Table 2: Effect on delay to competition benefits where the number of competitors increases from 2 to 3

£million		2012	2013	2014	Total
Total welfare	Each year	150	140	135	425
	Cumulative effect	150	290	425	
Consumer surplus	Each year	350	340	320	1010
	Cumulative effect	350	690	1010	

Table 3: Effects on delay to competition benefits where the number of competitors increases from 2 to 4

£million		2012	2013	2014	Total
Total welfare	Each year	215	210	200	625
	Cumulative effect	215	425	625	
Consumer surplus	Each year	590	570	540	1700
	Cumulative effect	590	1160	1700	

Welfare impacts due to a delay to liberalisation

A9.60 As discussed in Annex 7, mandated release of 900MHz spectrum may cause a delay to liberalisation which will result in a cost to society due to foregone benefits of high quality mobile broadband over the delay period.

A9.61 We have estimated these effects using the innovation model which produces an indicative quantification of the likely size of the foregone benefits over the delay period.

Overview of methodology previously used and relevant changes

A9.62 Our 2007 consultation estimated the welfare implications of delay in the launch of major enhancements to cellular mobile services. Delays in innovation are indicative

of the type of dynamic efficiency loss which could result from a reduction in the level of competitive intensity in the UK mobile market. Hence we modelled a 20 year period from 2007/08, with 3G services having been launched four years before this in 2003/04, and "4G" services (ie. the future innovation) launched in 2014/2015. We assumed a delayed case where 4G services are launched one year later in 2015/2016, and that there is a period of 'catch up' after which 4G penetration reaches 100%. We assumed for the purposes of modelling a 'welfare uplift' of 25%; that is, we assumed that the economic value of 4G services was 25% over that for 3G services, and similarly for 3G over 2G. We took the value of consumer and producer surplus arising from public cellular mobile services from the 2002 Radiocommunications Agency (RA) and 2006 Europe Economics reports into the value of spectrum.

A9.63 In general we would expect that dynamic efficiency effects in terms of for example innovation will have a reasonably long time horizon, due to the lead times for research, development and investment in this market. Over this time horizon, dynamic efficiency effects would tend to be greater where competitive intensity tended to be greater. Consequently it would be appropriate to model the effects of any reduction in the benefits of innovation resulting from a sustained and long term reduction in competitive intensity, were there to be a significant risk of such a reduction occurring.

A9.64 Our present modelling is now focused on a shorter interim period during which competitive intensity may be reduced or influenced through our approach to liberalisation. Consequently we consider that any benefits from dynamic efficiency effects that may occur over the interim period are likely to be small if they occur at all and so we have chosen not to model these explicitly.

A9.65 We have however continued to recognise that welfare effects can result from any delay to liberalisation, and we have modelled these. We have made a number of changes to our previous model to allow us to capture these effects:

- We now assume that the delay in high quality mobile broadband services is likely to range from no delay in the low case, to 3 months in the base case and 6 months in the high case, reflecting our view of a plausible delay period caused by mandated spectrum release.

- We base our estimates of welfare using consistent figures for revenue, consumer and producer surplus as in the competition modelling described above, rather than on those from the RA and Europe Economics reports.

<u>Views concerning our estimate of welfare uplift</u>

A9.66 Vodafone suggested that we had overstated our estimates of the welfare effect because our assumptions about the 'welfare uplift' were too high. Vodafone suggested that in its view the evidence pointed more to a 10% uplift, comparing 3G and 2G.

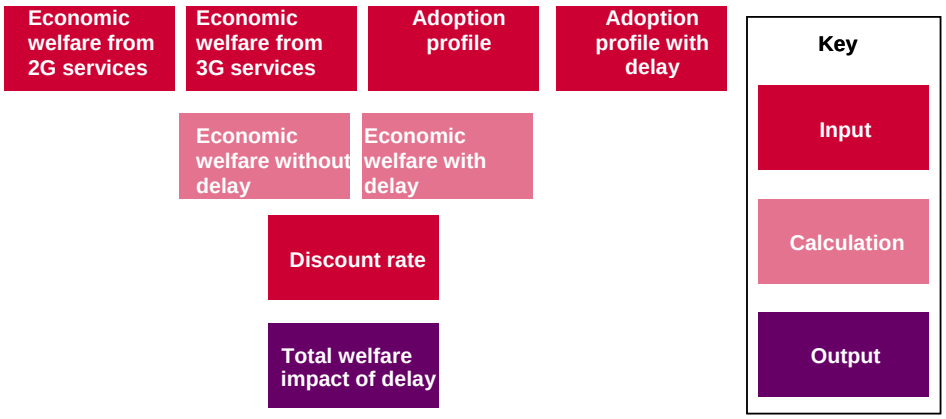
A9.67 We note that Vodafone's comparison of 3G versus 2G compares a mature service (2G) to one that is still developing (3G). We suggest that there is still a reasonable potential for growth in 3G ARPU, as mobile develops and that this could reasonably encompass a broader range for the assumed welfare uplift. We nevertheless acknowledge that our assumption is subject to a considerable degree of uncertainty, and we have reflected this by adopting a range of assumptions from 10% to 40% in order to illustrate the effects of this assumption.

Delay to liberalisation modelling

A9.68 Our model answers the question: what are the foregone innovation benefits due to a delay in the liberalisation of 900MHz spectrum?

A9.69 We employ a similar model as was used in the previous Consultation to investigate the welfare implications of delay in major enhancements to mobile broadband services, as in figure 9:

Figure 9: Delay to liberalisation model structure



A9.70 As before we model the flow of economic benefits over a 20 year period, this time starting from 2008. However now we model in the base case the delay in the introduction of high quality mobile broadband as three months rather than one year.

A9.71 We assume that the difference between the take up in the delayed scenario and that under the base case erodes over time. Hence the penetration of high quality mobile broadband services in the delayed scenario 'catches up' with the base case in 5 years.

Key assumptions

A9.72 We took the value of consumer and producer surplus given as a result of the welfare modelling of competition effects as our starting point. We believe that this is a more consistent approach, with competition and dynamic effects driven by the same underlying assumptions concerning the size of the modelled mobile market segment and demand.

A9.73 We assume that the total economic value of moderate 2100MHz mobile broadband services is a given percentage over and above the economic value generated by 2G services. Further we assume that "fast 900MHz" high quality mobile broadband services produce the same proportionate increase in economic value over and above moderate 2100MHz mobile broadband services. The size of this welfare uplift per user is uncertain and therefore we have considered a variety of proportions for the uplift.

A9.74 In order to identify the impact of the delay on consumer surplus we assume that producer surplus is a fixed percentage of economic value, and as such each innovation proportionately increases producer surplus.

A9.75 The flow of benefits over time is discounted at the real social discount rate of 3.5%, which is the standard Treasury rate for conducting cost-benefit analysis from society's perspective.

A9.76 Our base case for the timing of the launch of fast 900MHz services is 2012, as in the competition impacts model above.

A9.77 We quantify the effects assuming three different 'catch-up' periods of 3, 5, and 7 years. This is the number of years, following the delay, which it takes for the

penetration level in the delay case to rise and meet the penetration level in the base case.

A9.78 We assume the same migration profile from moderate 2100MHz services to fast 900MHz services as that from 2G to moderate 2100MHz services. We analyse the sensitivity of our results to this assumption below.

A9.79 For both the base case and delay case, we assume that the total addressable market in any given year is the same. The implicit assumption is that the innovation does not affect take-up of mobile services as a whole. This is a reasonable assumption given that the delay period is short.

Key results and sensitivities

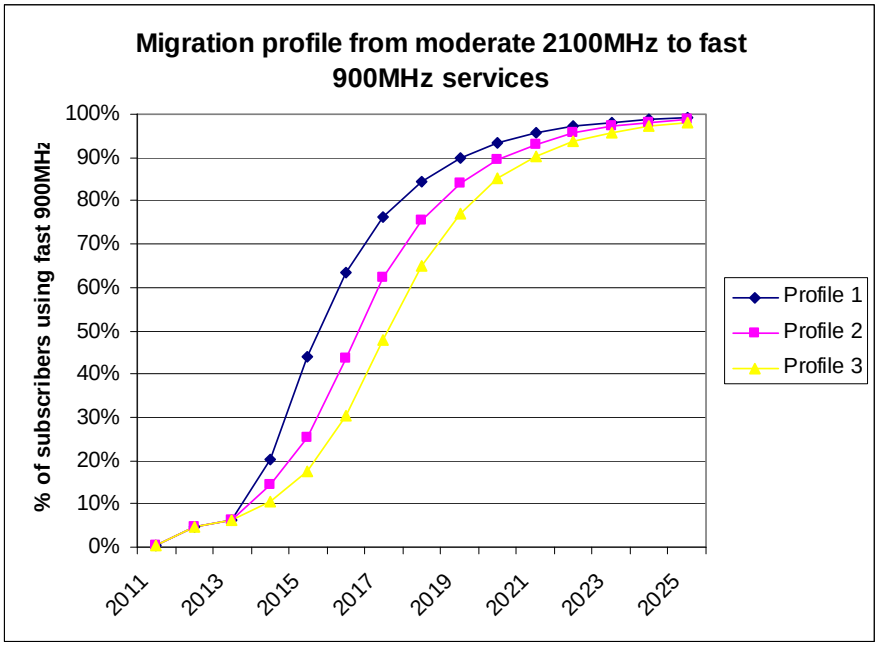
A9.80 Our base case is that the welfare effect of foregone benefits due to a delay in liberalisation compared to what otherwise would have been the case can be modelled as a three month delay in innovation with the following parameters:

- 25% uplift in welfare from each successive innovation;
- 5 year catch up period;
- a technology adoption profile as set out by the medium migration scenario;
- welfare per user as derived from the demand curve input module
- a real social discount rate of 3.5%.

A9.81 The total welfare loss from a delay to liberalisation is around £45million in 2008 values.

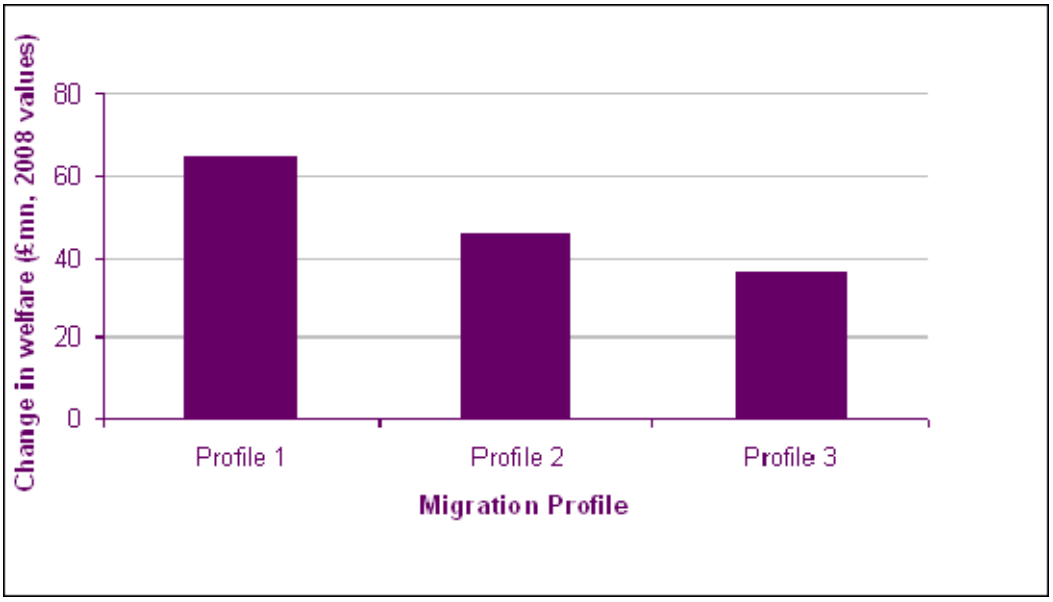
A9.82 We have used three scenarios to capture the migration of moderate 2100MHz customers to fast 900MHz services over time. Figure 10 below shows these rates over time.

Figure 10: Migration profiles



A9.83 The effect of the assumed migration profile on the cost of delay is illustrated in figure 11 below.

Figure 11: Sensitivity of innovation cost of delay to migration profile



A9.84 In our base case we have assumed that there is a 3 month delay to liberalisation due to mandated release. In our low case we assume no delay to liberalisation so the costs of delay are zero, whereas in our high case the delay is 6 months and the costs are therefore higher. Table 4 sets out our estimates.

Table 4: Sensitivity to assumed delay

NPV of welfare loss	Delay to liberalisation		
	Low (no delay)	Base (3 months)	High (6 months)
	£0m	£45m	£90m

A9.85 We also tested to what extent the results are sensitive to our assumptions about the economic welfare uplift from moderate 2100MHz to fast 900MHz services. The results are presented in table 5 below.

Table 5: Sensitivity to assumed uplift in economic value of innovation

NPV of welfare loss	Assumed uplift economic value			
	10%	25%	40%	50%
	£15m	£45m	£80m	£110m

A9.86 The base case assumes that the delayed migration to fast 900MHz services catches up with the base migration profile 5 years after the delay period. We have quantified the effects of assuming a shorter and longer catch up period, using our

baseline assumptions for the other parameters, below. Table 6 sets out our estimates.

Table 6: Sensitivity to assumed catch up period

NPV of welfare loss	Catch up period (years)		
	3	5	7
	£20m	£45m	£120m