NERA
ECONOMIC CONSULTING

Deriving ALFs from Lump-Sum Valuations – A Response to Ofcom's Third Consultation

Telefónica UK

15 April 2015

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Executive Summary

Telefónica UK has asked NERA to review Ofcom's revised proposal (dated 19 February 2015) for re-calculating the value of the annual licence fee ("ALF") paid for both the 900 MHz and 1800 MHz spectrum bands. This report reviews Ofcom's discount rate used for converting a lump-sum into annuities (ALFs); we do not comment on whether the lump-sum value correctly reflects the market value of licences for 900 MHz and 1800 MHz frequencies.

Ofcom seeks to convert its estimate of the lump-sum spectrum value into annuities using its discount rate while taking account of inflation and tax effects. Following the second consultation, Ofcom proposes the following revisions:

1. Ofcom moved away from a long-run estimate to a more current estimate of the cost of debt. This change in methodology accounts for the differences between the regulatory rate setting for capital cost allowances, which need to allow for continuous refinancing over the regulatory period, and the ALF rate setting, which is a "one-off" investment.
2. Ofcom used bonds with a shorter maturity to more closely match the duration of the ALF payment stream, which has a duration of about half of the license lifetime. Based on a shorter 12-month averaging period, a shorter reference bond maturity of 10 years and an inflation risk premium of 10 basis points, Ofcom calculates a cost of debt of 0.9% (real, post-tax).
3. Ofcom introduced a positive risk premium to account for risk-sharing. Ofcom and the MNOs can review the level of the ALF in case of "material misalignment". Although Ofcom considers the risk to the government to be symmetrical, Ofcom adds 1.1 percentage points to the cost of debt to compensate for the risk of future reviews.

Whilst the adjustments described in (1) and (2) are economically sound, Ofcom's risk premium to compensate for the alleged risk-sharing significantly biases the discount rate upwards.

Ofcom's approach to estimating the risk sharing premium generates implausible results

Compared to the risk premiums derived from corporate bonds with different credit ratings (i.e. different levels of risk), Ofcom's premium for risk sharing looks significantly too high.

MNOs are currently mostly rated in the "BBB" category. Bonds in this category trade on average 0.2 ppts higher than those in the next highest category (A) and 0.55 ppts higher than those in the category "AA".[1] Ofcom's risk premium of 1.1 ppts (post-tax) and 1.32 ppts (pre-tax) equates to more than twice the difference in credit risk of two whole rating categories (from BBB to AA). Ofcom's premium for risk sharing therefore reflects considerable risk, which does not appear plausible given that the mechanism is symmetric in nature.

[1] There are no liquid indices of GBP bonds in lower bands than BBB to compare to the BBB index.

Ofcom's approach builds on incorrect methodological foundations

Ofcom does not consider risk sharing within a methodologically sound framework. Ofcom argues that the government's share in the operating risk stems from the MNO's possibility to hand back the license or to renegotiate the ALFs. This is akin to the government granting a real option to the MNO to hand back the license. Widely established option pricing theory exists to price such real options. Ofcom's proposed risk-sharing formula fails to incorporate the specific payoff and valuation features associated with real options.

In addition, the government's right to renegotiate the ALF in favourable market conditions constitutes an option that has economic value and should therefore be deducted from the discount rate. The two effects offset each other to an extent. The net value of the two options may even be positive to the government. This is the case when revenues and profits are expected to increase over time.

Ofcom's estimate overstates the *current* cost of debt

Ofcom's use of a 12 months average as a measure of the *current* cost of debt lies significantly above truly short-run estimates of 1 month or 3 months averages, which are better proxies for the current cost of debt. In light of the above there is no reason for Ofcom to use a discount rate in excess of 0.9% (real, post-tax).

Correcting for errors in the cost of debt calculation significantly reduces annuities

Based on our discount factor of 0.9% (real, post-tax) and Ofcom's lump-sum value of spectrum (which is not part of our analysis and taken as given), we calculate that annuities for the 900 MHz and 1800 MHz bands reduce to GBP 1.32m per MHz of 900 MHz spectrum and to GBP 0.75m per MHz of 1800 MHz spectrum, respectively. Table 1.1 shows our results alongside Ofcom's ALF estimates based on a discount rate of 2.0% (real, post-tax).

Table 1.1
Ofcom and Corrected ALF Values (GBPm/MHz)

Spectrum	Ofcom	ALF using corrected discount rate
900 MHz	1.48	1.32
1800 MHz	0.84	0.75

Source: NERA analysis based on Ofcom data

1. Introduction

Telefónica UK has asked NERA to review Ofcom's revised proposal (dated 19 February 2015) for re-calculating the value of the annual licence fee ("ALF") for both the 900 MHz and 1800 MHz spectrum bands. This report reviews Ofcom's discount rate used for converting lump sum payments into annuities (ALFs); we do not comment on whether the lump-sum value correctly reflects the market value of licences for 900 MHz and 1800 MHz frequencies. This report is written for Telefónica UK to be included in its response to the Ofcom ALF consultation.

Since the first consultation in 2013, Ofcom has made a number of significant revisions to its methodology for estimating the discount rate used for transposing the lump-sum spectrum value into ALF payments over a 20 year period. Initially, Ofcom proposed to use the long-run WACC of an MNO. Following the first consultation, Ofcom recognised the debt-like character of the ALF from the point of view of the government and decided to replace the WACC with the cost of debt as the relevant discount rate.

Subsequent to further consultation, Ofcom further changed its methodology for calculating the discount rate. Most importantly, Ofcom abandoned its long-run approach and relied upon current market data. It also reduced the maturity of the reference bonds to match more closely the effective duration of the licence. Both changes reduced the cost of debt from initially 2.6% to 0.9% (real, post-tax). However, Ofcom also introduced an additional risk premium of 1.1% (post-tax) to account for the alleged degree of risk-sharing between the MNO and the government. The risk premium increases the discount rate to 2.0% (real, post-tax); more than doubling its pre-sharing estimate.

While Ofcom corrected several shortcomings in its proposed methodology, a number of inconsistencies remain. As a result, Ofcom's risk premium to compensate for the alleged risk-sharing significantly biases the discount rate upwards, which we demonstrate in the following sections:

- Section 2 summarises Ofcom's revised proposals for calculating the ALF;
- Section 3 demonstrates that Ofcom's risk-sharing premium overstates the government's risk exposure;
- Section 4 sets out why Ofcom's discount rate calculation already provides a degree of headroom even without the risk sharing premium; and
- Section 5 summarises the results and concludes on the corresponding ALF values.

The appendix provides more detail on how Ofcom should have used real option theory to correctly value the impact of risk sharing in a methodologically sound framework.

2. Ofcom's Revised Proposals for Calculating the ALF

2.1. Main Changes during the Consultation Process

Ofcom seeks to revise the ALF amounts paid for the existing 900 MHz and 1800MHz frequencies based on new information about the value of spectrum informed by the amounts paid in the UK 4G auction.

Initially, Ofcom proposed a discount rate of 4.2 per cent (real, post-tax), based on Ofcom's 2011 MCT determination. In its second consultation, Ofcom recognised that – from the government's point of view – the ALF bears close resemblance to a debt obligation. Consequently, Ofcom corrected its approach and used the cost of debt instead of the WACC. Ofcom also decided to adjust ALF payments using CPI instead of RPI inflation.

In its third consultation, Ofcom made two further major revisions to its methodology:

1. Ofcom significantly reduced the averaging period used to estimate the cost of debt, moving from a multi-year horizon to a 12-month period. This modification accounts for the differences between the allowed costs of capital in a regulatory rate setting, which need to allow for continuous refinancing over the regulatory period, and the ALF setting, which essentially is a one-off "investment".
2. Ofcom used shorter (10 year) maturity bonds to better match the effective duration of the lifetime of the license.[2] Based on these corrections, Ofcom arrives at a cost of debt of 0.9% (real, post-tax).[3]
3. Ofcom introduced a risk premium to account for the alleged risk-sharing between the Government and the MNO: Ofcom and the MNOs can review the level of the ALF in case of "material misalignment" – that is, the MNO can relinquish spectrum in adverse market conditions and Ofcom can adjust the ALF if spectrum increases in value. Although Ofcom considers the risk to the government to be symmetrical, Ofcom adds 1.1 percentage points to the cost of debt to compensate for the risk of future reviews.

The adjustments described in (1) and (2) above are economically sound as described in detail in our previous report. However, Ofcom's approach to calculating the "risk sharing" premium is substantially flawed, as we demonstrate in more detail below.

2.2. Background to Ofcom's Risk-sharing Mechanism

In this section we set out the background to Ofcom's estimate of the "risk sharing" premium. While the notion of risk sharing has been present throughout the consultation process, Ofcom has significantly changed its quantitative assessment as part of the third consultation. The evidence presented, however, lacks a methodological basis and is based on an incorrect framework and assumptions. Accordingly, the resulting estimate is implausible, as we demonstrate in more detail in section 3.

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[2] The ALF payment stream has a Macaulay duration of about half of the lifetime of the licence.

[3] The figure is also net of an inflation risk premium of 10 basis points, which Ofcom subtracts from the real cost of debt.

2.2.1. First Consultation (October 2013)

Ofcom argues that ALFs entail a number of risks relative to the lump-sum, which work in opposite directions. On balance, and due to the difficulty of quantifying any potential net effect, Ofcom concluded that it should not adjust the cost of debt as the appropriate discount rate:

> *"we note that there are differences between auctioned licences and 900MHz/1800MHz licences which could imply that the level of ALF for the latter should be either higher or lower than implied by in the annualisation of auction prices:*
>
> - *ALF payers have the **option** of handing back the licence and avoiding future ALFs (whereas purchasers of auctioned licences pay the lump sum fee upfront – entirely upfront in the case of the UK, but partially so for some other countries e.g. Ireland). H3G argued in their response to the Second Competition Assessment that this factor contributes to making 900 MHz spectrum more valuable than 800 MHz.*
> - *Licences of ALF payers include potential for licence revocation on 5 years' notice for spectrum management reasons whereas grounds for revocation are more limited for auctioned licences in the initial 20-year period.*
>
> *These considerations work in **opposing directions** (the first consideration could increase, and the second consideration could reduce, the value of the ALF licence relative to the auctioned licence). The effect of the first consideration could be the more relevant if the risk of licence revocation is considered low. But **because of the difficulties of quantification we have not sought to adjust ALFs for either potential effect**."*[4]

Ofcom acknowledges offsetting effects in the risk sharing between government and licensee. Ofcom explicitly mentions the "option" character associated with the ALF payment structure. We will consider the option feature further below for the purpose of a more rigorous calculation of a potential risk premium.

2.2.2. Second Consultation (August 2014)

In its August 2014 consultation, Ofcom argued that the appropriate discount rate for the ALF calculation depends on the relative risks borne by the government and the licensee. These risks refer to a potential change in license value over the 20-year period. Ofcom identified two polar cases for the allocation of risks and spelt out corresponding discount rates:

1. If the licensee alone bears the consequences of a decreasing economic value of the spectrum license, i.e. ALFs remain fixed over the 20-year period independent of changes in the value of spectrum. In this case, the ALF – from the government's point of view – most closely resembles a 20-year debt instrument. Hence, the cost of debt would be the appropriate discount rate.

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[4] Annual licence fees for 900 MHz and 1800 MHz spectrum: Oct. 2013 consultation, paragraphs 5.28-29.

2. If changes in the economic value of spectrum translate directly into changes of the ALF payments such that the government bears the risks, Ofcom considers that the appropriate discount rate is the MCT WACC, which through the asset beta takes account of the return variability.

Algebraically, the two polar cases are combined in the following risk sharing formula:

(1) $ALF\ discount\ rate = Debt\ rate + Government\ share\ of\ operating\ risk * (WACC - Debt\ rate)$

As in its first Consultation, Ofcom acknowledges again that it is impossible to determine the "$Government\ share\ of\ operating\ risk$" with any precision. Ofcom therefore opted for what it considered a conservative approach by concluding on the cost of debt as the appropriate discount rate.

Ofcom explicitly noted that there is no robust estimate for the government's share of operating risk and infers that a conservative regulatory approach suggests that the cost of debt is the appropriate discount rate:

> *"For the reasons set out above, we recognise that it is possible that the appropriate discount rate lies above the cost of debt. However, for the reasons set out in Section 1 we consider it appropriate to take a conservative approach when interpreting the evidence to derive ALFs. We therefore propose to use the cost of debt rate for the purposes of deriving ALFs…."*[5]

In the referenced section 1, Ofcom lists two main reasons for applying a conservative approach in setting the annual license fees: (i) asymmetry of risks related to either over- or underestimating the market value of the spectrum; and (ii) the possibility that the forward-looking market values today are lower than the auction values used to set the annual license fees owing to greater availability of mobile spectrum in the future.[6]

2.2.3. Third Consultation (February 2015)

In its latest consultation, Ofcom abandons its conservative approach from the October 2013 and August 2014 consultations. It calculates the discount rate as a weighted average of the cost of debt and the WACC, where the parameter "$Government\ share\ of\ operating\ risk$" is solely given by illustrative considerations.

Ofcom presents a number of simplified scenarios simulating the potential fallout for the government in case of a tariff adjustment halfway through the 20-year license period to illustrate the government's share of economic risks. Acknowledging substantial difficulties in estimating the true allocation of economic risks, Ofcom notes that:

> *"there is no clear way of quantifying the effect of the possibility of review taking place on the Government's share of risk and the consequent effect on an appropriate discount rate" (4.59),*

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5 Annual licence fees for 900 MHz and 1800 MHz spectrum: Aug. 2014 further consultation, paragraph 4.25

6 Annual licence fees for 900 MHz and 1800 MHz spectrum: Aug. 2014 further consultation, paragraph 1.34

and cautions against the inferences to be drawn from its stylised estimate emphasising that the *"the share of risk that should be incorporated in the discount rate is inevitably a matter of judgement rather than of fact."* (4.59) Based solely on regulatory judgement, Ofcom applies a value for the parameter "*Government share of operating risk*" of 25%, stating:

> *"We have not identified clear reasons to prefer any particular figure within this narrower range of 0% to 50%, given the complexity and uncertainty relevant to the analysis. The mid-point within this narrower range is 25%." (4.62)*

Despite Ofcom's acknowledgement of "*difficulties of quantification***"** (first consultation) and its proposal to use the cost of debt rate as the appropriate discount rate as a *"conservative approach"* (second consultation), Ofcom exercises "*regulatory judgement*" in its third consultation to set the value for the share of risk at 25%. The effect of this is that the discount rate increases by more than 100% relative to the cost of debt that Ofcom previously considered the appropriate discount rate.

3. Ofcom's Risk Sharing Analysis Lacks Methodological Foundation and Generates Implausible Results

3.1. Ofcom's Approach Generates an Implausibly Large Risk Premium

On the basis of the risk sharing Equation (1) shown in section 2.2.2, Ofcom calculates a premium of 1.1% (post-tax), more than double the rate before risk sharing drawing on the reasoning we set out in section 2.2. When accounting for the corporate tax rate, the risk sharing premium increases to 1.32%.

The disproportionate magnitude of the "risk sharing" premium becomes clear when comparing the premium Ofcom uses to the actual observed differences between corporate bond yields with different credit ratings as shown in Table 3.1.

Table 3.1
Corporate Bond Yields and Difference to BBB Spreads (Nominal, pre-tax)

Time Horizon	AA	A	BBB	Ofcom ALF
1 Month	3.06%	3.26%	3.58%	n/a
1 Year	3.82%	4.02%	4.37%	
Difference to BBB Spread (Bps) on a pre-tax basis				
1 Month	-52	-20	'--	+132
1 Year	-55	-20	'--	

Source: NERA analysis of iBoxx data. GBP-denominated corporate bonds with 10Y to 15Y maturity. Data cut-off: 25 March 2015.

Table 3.1 shows that the difference between AA rated bonds and BBB rated bonds (a difference of two full rating grades or six "notches") is just over 50 basis points (0.5 percentage points). Ofcom's implied risk sharing adjustment of 1.32 percentage points on a pre-tax basis is more than twice that level. When taking account of the fact that most MNOs are now rated in the BBB band[7], Ofcom's risk-sharing adjustment places the implied "credit risk" that the UK government supposedly allocates to the ALF well into sub-investment grade (or "junk") territory, which starts only one full rating grade below the MNOs' current rating.[8] As we show below, there is nothing to suggest that a rational investor would place such a significant premium on the risk sharing faced by the government, given that the mechanism is symmetric.

[7] According to latest Bloomberg figures, Vodafone is rated A- while Orange and Deutsche Telekom are rated BBB+ and Telefonica is rated BBB.

[8] Major data providers such as iBoxx and Bloomberg do not provide benchmark indices for sub-investment grade ratings.

3.2. Ofcom Overestimates the Discount Rate in the Upper Polar Case

One reason behind the implausible large risk sharing premium is Ofcom's use of the (long-run) MCT WACC for the calculation of the upper bound. As we set out in our response to the previous consultations there is a fundamental difference between (i) the situation faced by the government in the case at hand where the government essentially provides one-off "financing" to the MNOs and (ii) the case of regulated MNOs who have to be put into a position where they can attract new funds at any point during the regulatory period.[9] Ofcom has accepted this argument as part of the most recent consultation by calculating a current cost of debt – the lower polar case in Equation (1). It is inconsistent for Ofcom to recognise the "one-off nature" of the ALF transaction while using a long-run WACC. As Ofcom argues:

> *"the ALF annualisation exercise starts from a notional one-off transaction, Communications Providers (CPs) need to finance regular on-going capex programmes (which the WACC within a charge control has to support). (…)The costs of financing in the long run are therefore relevant in ensuring appropriate investment signals are sent through the charge control." (A10.11)*

There are no on-going capex programmes in the ALF case. Hence a current measure of the discount rate is appropriate, which the MCT WACC based on long-run estimates cannot fulfil.

Consequently, Annex 10, para A10.76 to A 10.79 does not present the appropriate current discount rate and therefore concludes on an inappropriately large risk sharing premium. The combination of a *current* cost of debt measure in the lower polar case with a *long-run estimate* in the upper polar case is inconsistent and leads to an upward biased discount rate in the current market environment as the fact that the government is taking on market risk is already reflected in the use of the WACC.

This finding is independent of Ofcom's argument about the comparability of the risk of spectrum and MNOs as a whole.[10] Below we illustrate the impact of using a short-term WACC instead of the MCT WACC. We draw on two polar cases for illustrating what a short-term WACC might look like assuming (i) constant total market returns (i.e. any change in the risk-free rate being offset directly by an inverse change in the equity risk premium [ERP]) and (ii) constant ERP in the face of current low real risk-free rates of around 0%.

The short-term WACC that Ofcom should have used in this case is around 0.5 to 1.0 percentage points lower than the long-run WACC that Ofcom uses for its MCT decision.[11]

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[9] NERA (17 September 2014): Deriving ALFs from Lump-Sum Valuations – A Response to Ofcom's Second Consultation, A Report for Telefónica UK; Chapter 4.

[10] Annual licence fees for 900 MHz and 1800 MHz spectrum - Provisional decision and further consultation, February 2015, para 4.27 to 4.29.

[11] These estimates of the short-term WACC should be seen as illustrative of the potential relative effect of moving to a short-run number. We have not independently assessed Ofcom's estimates of other parameters including beta and total market returns and our use of them should not be considered an active endorsement of their accuracy.

Table 3.2
Comparison of MCT WACC and short-term WACC

	MCT WACC	Short-term WACC constant TMR	Short-term WACC constant ERP
Implied Real TMR	6.3%	6.3%	5.3%
Real risk-free rate (RPI deflated)	1.0%	0.0%	0.0%
RPI inflation	3.3%	3.3%	3.3%
Nominal risk-free rate	4.3%	3.3%	3.3%
Equity risk premium	5.3%	6.3%	5.3%
Debt beta	0.10	0.10	0.10
Asset beta	0.60	0.60	0.60
Gearing	40.0%	40.0%	40.0%
Equity beta	0.93	0.93	0.93
Cost of equity (post-tax)	9.3%	9.2%	8.2%
Debt premium	1.1%	0.9%	0.9%
Corporate Tax Rate	20.0%	20.0%	20.0%
Cost of debt (pre-tax)	5.4%	4.2%	4.2%
CPI inflation	2.0%	2.0%	2.0%
WACC (pre-tax nominal)	9.1%	8.5%	7.9%
WACC (post-tax nominal)	**7.3%**	**6.8%**	**6.3%**
WACC (post-tax real; CPI deflated)	**5.2%**	**4.7%**	**4.2%**
Ofcom overestimation of short-term WACC		0.44%	0.98%

Source: NERA calculation on the basis of Ofcom`s Mobile call termination market review 2015-18 Draft Statement from 6 February 2015 and its assumption for CPI inflation of 2%. Implied real TMR in the "constant TMR case" is calculated as the sum of the MCT ERP and risk-free rate while in the "constant ERP" case it is calculated as the sum of the MCT ERP and the current risk-free rate, which we assume to be 0%. For the short-term cost of debt we use Ofcom's estimate of 0.9% from the third ALF consultation paper for illustrative purposes.

As Table 3.2 shows, a short-term WACC (real, post-tax) is up to around one percentage point lower than the MCT WACC used by Ofcom for calculating the risk sharing premium. Following the adjustment formula set out in Annex 10 of the consultation, the correct use of a short-term WACC would have reduced the risk sharing premium by between 11 and 25 basis points.

3.3. Risk-Sharing as a Real Options Problem

Ofcom likely further overstates the degree of risk-sharing by not considering the risk of revaluation within a methodologically sound framework. Ofcom's Equation (1) does not take account of the "real option" characteristics of license renegotiations and potential licence revocation. Ofcom, however, recognised the "option" feature of the risk of licence revocation in the first consultation.[12]

[12] Annual licence fees for 900 MHz and 1800 MHz spectrum: Oct. 2013 consultation, paragraphs 5.28.

Ofcom argues that the government's share in the operating risk stems from the licensee's possibility to hand back the license or to renegotiate the ALFs. The event of the MNO renegotiating the ALF in an adverse market environment is akin to the government granting an option to the MNO to hand back the license.

Widely established option pricing theory exists to price such real options. In analogy to option theory, the underlying security is the value of spectrum and the strike price is the present value of the remaining ALF payments before negotiation. By "exercising" the option, the MNO receives the present value of the remaining ALF payments, ensuring the MNO against downside risk. The cost of this "insurance" (the option value) is born by the government.

Ofcom's proposed risk-sharing formula fails to incorporate the specific payoff and valuation features associated with real options. We refer to real options theory to analyse the economic value of risk sharing. The appendix to this paper provides a framework and the calculation of the value of the option associated with the revocation of the licence.

The government's right to renegotiate the ALF in favourable market conditions constitutes an option as well and has economic value. This value would need to be deducted from the discount rate. The option value inherent in the contract in favour of the government and the option value the government grants to the MNO offset each other to a large extent.

Depending on the revenue profile of the license over time, the net value of the two options may even be positive to the government. This is the case when revenues and profits are expected to increase over time, which creates a "hold-up" problem where the government can increase ALFs towards the end of the 20-year period when the option of returning the license has become less attractive for MNOs.

3.4. The Theory of Risk Premiums for Government Investments

Ofcom's approach assumes that the government needs compensation for what is an a priori symmetric risk sharing scheme. The government's own manual on appraisal and discounting suggests that the required compensation is generally considered trivial within government. As the Green Book puts it:

> *"The fraction of income worth paying for certainty (C) is approximated by the expression:*
>
> $$C = - var(y) / 2y^*$$
>
> *where y is the net additional income resulting from the proposal, and y* is the total expected income or benefits (including the project income) of those impacted by the proposal.*
>
> *Given the size of national income relative to the scale of most individual projects, the cost of variability for projects that benefit the community as a whole is usually negligible."*[13]

As the ALF payments benefit the Treasury, y* (the national budget) is likely to be several orders of magnitude larger than the variability of the ALF payments, suggesting the government's required protection against variation in the ALF payments would be essentially zero under this approach.

3.5. Conclusion

Ofcom's approach to valuing the risk-sharing not only marks a significant departure from its original position but also draws on a highly stylised approach that lacks a sound methodological underpinning. It also makes a number of errors.

A simple comparison of the proposed premium to differences in the bond yields for corporate debt with different rating grades shows that the supposed increase in required compensation for relatively limited risk sharing is implausibly large. This is partly due to Ofcom's inconsistent approach of combining a long-run estimate for the upper polar case with a current measure for the lower polar case, and partly due to Ofcom's unjustified approach to assessing the probability of renegotiation.

Using a consistent short-run approach to both polar cases reduces the risk sharing premium by up to 25 bps. Considerations from real option theory and government budgeting theory suggest that it is far from clear that the government requires additional premium for risk sharing, given the symmetric nature of renegotiation risk and the comparatively small value relative to the size of the national budget.

[13] *HMT (2011): THE GREEN BOOK - Appraisal* and Evaluation in Central Government, p. 89.

4. Further Elements of Ofcom's Consultation Paper that Overstate the Government's Risk Exposure

In the latest consultation document, Ofcom recognised the "one-off" character of the ALF obligation by significantly shortening the averaging horizon used to determine the cost of debt. We welcome Ofcom's move towards a shorter averaging period. When using a short-term cost of debt, different averaging periods can be applied. Using a 1-year averaging period – as Ofcom currently does – generates a higher cost of debt than using shorter averaging periods like 3 months or 1 month. By choosing an averaging period towards the top end of the short-run approach, Ofcom already provides some leeway for risk-sharing although shorter averaging periods more closely reflects current market conditions.

4.1. Estimates of the Current Cost of Debt

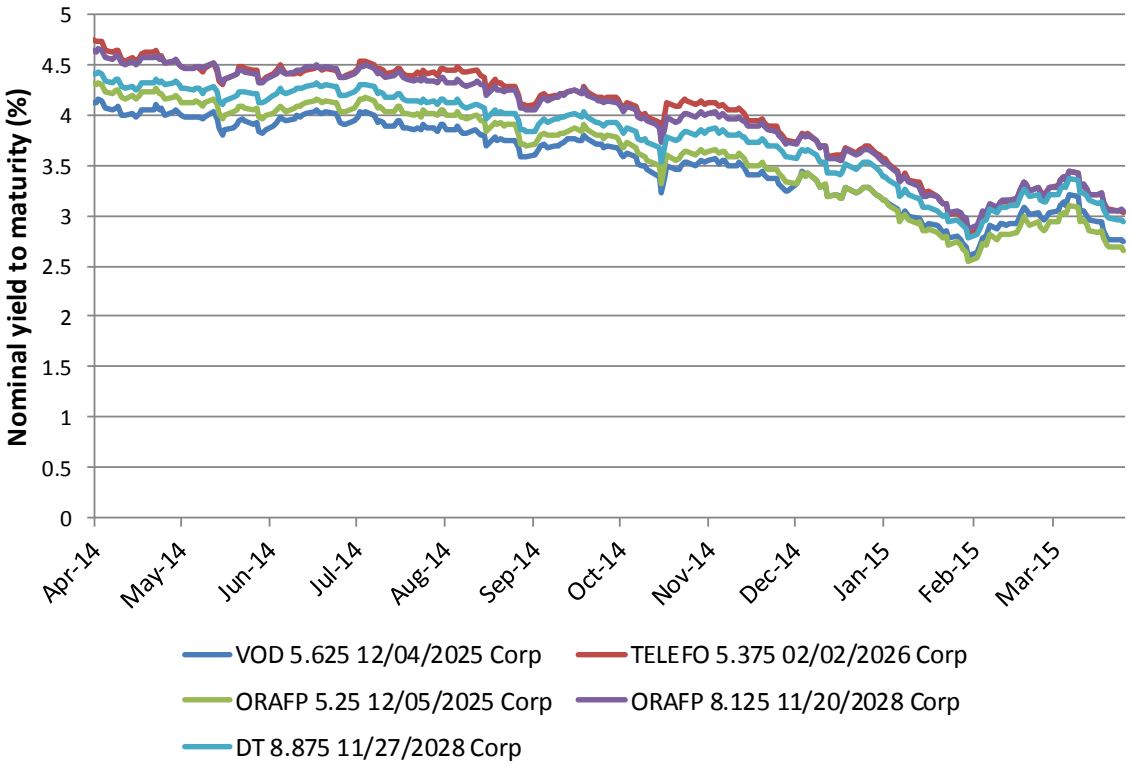
Given the conceptual background supporting the use of a current cost of debt estimate, it is relevant to identify the corresponding empirical cost of debt estimates. In line with Ofcom's approach, we calculate yields on bonds issued by the parent companies of UK mobile operators. Given that the ALF payments do not contain a bullet payment as is usually the case for coupon-paying bonds, the Macaulay duration relevant in the case of ALFs is around 10 years.[14] Ofcom applies the following criteria in the latest ALF consultation:

- issued in GBP currency; and
- maturity of around 10 years approximating a duration of 10Y with a bond with 10Y maturity.

A total of five bonds satisfy these criteria. Figure 4.1 shows the nominal yield to maturity over the last year for the selected bonds issued by UK mobile operators' parent companies. Our sample of bonds corresponds to the bonds that Ofcom selected to estimate the cost of debt.

[14] Annual licence fees for 900 MHz and 1800 MHz spectrum: Feb. 2015 further consultation, A10.21.

Figure 4.1
Nominal Yields on Selected UK Mobile Operators' Bonds



Source: NERA analysis of Bloomberg data

At 2.7% to 3.2%, nominal yields on the selected bonds were significantly lower over the most recent 1-month and 3-month periods than over the most recent 1-year horizon (3.6% to 4.0%) and the 1-year horizon that Ofcom used (3.8% to 4.1%).

Table 4.1
Nominal Yields on Selected UK Mobile Operators' Bonds

	Maturity (Y)	1M average YTM	3M average YTM	1Y average YTM
VOD 5.625 12/04/2025 Corp	10.7	2.7	3.0	3.6
TELEFO 5.375 02/02/2026 Corp	10.8	3.0	3.2	4.0
ORAFP 5.25 12/05/2025 Corp	10.7	2.7	2.9	3.6
ORAFP 8.125 11/20/2028 Corp	13.6	3.0	3.2	4.0
DT 8.875 11/27/2028 Corp	13.6	2.9	3.2	3.8
Average	**11.9**	**2.9**	**3.1**	**3.8**

Source: NERA analysis of Bloomberg data; cut-off date is 25 March 2015

The findings above suggest that a range of 2.9% to 3.8% is a reasonable estimate of the current cost of debt for a notional UK mobile-only operator. This is consistent with a real post-tax cost of debt between 0.5% and 1.2%, when using a long-run CPI inflation assumption of 2.3% (Table 4.2).

Table 4.2
Current Cost of Debt of a UK Mobile-Only Operator

	Low	High
Cost of Debt nominal, pre-tax	2.9%	3.8%
CPI Inflation	2.3%	2.3%
Cost of Debt real, pre-tax	0.6%	1.5%
Cost of Debt real, post-tax	**0.5%**	**1.2%**

Source: NERA analysis; real cost of debt is calculated from nominal using the Fisher formula; for CPI inflation we use the long-run forecast for the UK from the Consensus Forecasts 2014. Corporate tax rate is 20%.

In light of the above, Ofcom's choice of real, post-tax cost of debt before "risk sharing" already appear to contain a degree of "headroom" that will partly protect the UK government from the effects of any risk sharing.

4.2. Liquidity Risk

Ofcom rejected our claim for further reductions of the discount rate to remove any liquidity premium from the cost of debt. According to Ofcom, the government bears full liquidity risk because it cannot re-sell the ALF contract to a third party and, if anything, the illiquidity of the ALF contract would justify a higher premium over the cost of debt.[15]

Ofcom may have misunderstood our argument and, hence, we elaborate on our argument submitted: a liquidity premium is paid to *investors* to compensate them for lack of liquidity. The ALF contract, however, is constructed by the *government* to serve public purposes and, by construction, not meant for financial trading. Hence, from the perspective of the government, no compensation is required for a feature that contradicts the purpose of the ALF. This consideration was behind our estimate of the risks for which the government would require compensation.

4.3. Securitisation

Ofcom did not adopt our proposed one-notch rating uplift adjustment of the discount rate (corresponding to a proposed reduction of the discount rate of 10 to 12 basis points) to allow for greater security of the ALF contract compared to unsecured corporate debt. Ofcom considers the evidence submitted does not warrant any rating uplift:

> *"it is not clear what uplift (if any) would be afforded for security against a specific asset in isolation (although it seems likely to be less than the full notch suggested by NERA); and as Telefónica acknowledged, the value of any security is likely to be weaker due to correlation between default and spectrum value." (A10.37b and c)*

[15] Annual licence fees for 900 MHz and 1800 MHz spectrum: Feb. 2015 further consultation, A10.50.

At the same time, Ofcom acknowledges that structural enhancements, such as securitisation would likely merit some notch uplift according to Moody's Rating Methodology for Regulated Electric and Gas Networks:

> *"While securitisation is not specifically mentioned (in Moody's Rating Methodology for Regulated Electric and Gas Networks), it is likely that this would be considered such an enhancement." (A10.35)*

By not allowing for any uplift for securitisation despite acknowledging that the ALF structure would likely bring some benefits, Ofcom again includes a degree of "headroom" in its estimates.

5. NERA Estimate of Discount Factor and ALF Value

This section brings together the results derived above in order to obtain an aggregate estimate of the discount rate, based on which we can determine the value of the ALF payments.

5.1. Discount Rate

We conclude on the following features of an appropriate discount rate:

- The discount rate to be used for annuitisation is the short-run MNO cost of debt, corrected for a number of items that follow from the specific ALF setting and that have to be deducted from the debt premium: liquidity premium, securitisation and inflation risk.
- The case for applying a specific premium for "risk sharing" is weak; with Ofcom's own estimate implausibly large compared to the difference in bond yields across the risk (rating) spectrum and inflated by a method that lacks methodological foundation and draws on an incorrect upper polar case.

Our additional analysis in section 4 has shown that Ofcom's estimate of the pre-risk-sharing cost of debt of 0.9% is towards the high end of a plausible range based on latest data. In light of the above, there is no reason for Ofcom to use a discount rate in excess of 0.9%.

5.2. Calculation of ALF

For a given lump-sum of the spectrum value, we use the discount factor of 0.9% (real, post-tax) to derive the ALF for the 900 MHz and 1800 MHz bands, respectively. Table 5.1 compares Ofcom's estimation with the value we obtain by applying the corrected discount factor to Ofcom's lump-sum estimation. We note that this report only concerns the methodology used to convert the lump-sum value into an ALF annuity. It does not address the question of whether the lump-sum value correctly reflects the market value of licences for 900 MHz and 1800 MHz frequencies. We calculate that annuities for the 900 MHz and 1800 MHz bands amount to GBP 1.32m per MHz and GBP 0.75m per MHz respectively.

Table 5.1
Ofcom and Corrected ALF Values (GBPm/MHz)

Spectrum	Ofcom	ALF using corrected discount rate
900 MHz	GBP 1.48	GBP 1.32
1800 MHz	GBP 0.84	GBP 0.75

Source: NERA analysis based on Ofcom data

Appendix A. Valuing Risk Sharing Using Real Options

In this section we provide an overview of the theory of option pricing and how it applies in the context of ALF setting. We illustrate how Ofcom could have determined the value of risk sharing using real options.

A.1. Renegotiating ALFs as a Real Option Problem

In an earlier report, we set out that the ALF setting is akin to the government extending a loan to the MNOs.[16] Under the assumption that the MNOs can revoke (or renegotiate) the license, e.g. in adverse market conditions, makes this a "puttable" loan. Hence, the government not only provides the MNO a loan but also a put option, namely the right but not the obligation to revoke or renegotiate the license in case spectrum (i.e. the underlying security) has fallen significantly in value.[17] In analogy to option pricing theory, the MNO has the option to "sell" the spectrum to the government at a price equal to the present value of the remaining payments under the original ALF (the "strike price").

The put option can also be considered as an insurance against downside risk on behalf of the MNO and provided by the government. When the MNO "exercises" the put option, the MNO receives the present value of the remaining payments under the original ALF; the option payoff and the payments under the original ALF net to zero. MNO is therefore fully ensured against downside risk.

Below we set out how the "insurance" fee to be charged to the MNOs can be calculated using real options. A binomial tree can be used to value real option in such settings:[18]

1. Selection of the input parameters describing the key elements of the contract (set out in section A.2);
2. Construction of a "binomial tree" to model the possible outcomes of the "underlying", i.e. the value of spectrum over time (set out in section A.3);
3. Valuation of the put option using "backward induction" for each individual state of the world (set out in section A.4); and
4. Conversion of the option value into a discount rate premium (set out together with a stylised example in section A.5).

Real option valuation is generally undertaken in a framework which is referred to risk neutrality. It allows to price options correctly in the real world where investors are risk averse. John Hull writes in his seminal book:

"[We] can make the assumption that investors are risk-neutral. … The world we live in is, of course, not a risk-neutral world. The higher the risks investors take, the higher the expected

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16 NERA, September 2014, "Deriving ALFs from Lump-Sum Valuations – A Response to Ofcom's Second Consultation".

17 Strictly speaking the government does not only extend a single put option to the MNOs but rather a series of options as (subject to meeting a materiality threshold) the MNOs may renegotiate more than once during the period in question.

18 Our model is a discrete time version of the Black and Scholes model (1973). See e.g. Cox et al (1979). A discrete time model is better suited to the situation at hand as the ALF is paid annually and not time continuously.

returns they require. However, it turns out that assuming a risk-neutral world gives us the right option price for the world we live in, as well as for a risk-neutral world. Almost miraculously, it finesses the problem that we know hardly anything about the risk aversion of the buyers and sellers of options."[19]

We apply the concept of risk neutrality to value the real option associated with renegotiating the license.

A.2. Inputs into deriving the Option Value

The value of the option in the ALF setting is driven by a number of parameters that require calibration:

- the relevant "underlying" and the number of periods;
- the volatility of the "underlying";
- the risk-free rate (for discounting in a real option setting); and
- the strike price; the price or present value for which the MNO can sell the remaining ALFs.

Ofcom's proposed risk-sharing formula fails to incorporate the specific payoff and valuation features associated with real options. Instead it relies on what it acknowledges itself is a highly stylised approach.[20]

A.2.1. The relevant "Underlying" and the Number of Periods

In the ALF setting, the "underlying" is the value of spectrum. The put option formalises the idea that the licensee can hand back the spectrum during the 20-year period.[21] This is equivalent to the licensee having the right to "sell" the spectrum to the government at a price equal to the present value of the originally agreed stream of future ALF payments, independent of the spectrum's actual market value.

In the binomial option pricing model, the value of the underlying follows a binomial stochastic process. This process is discrete in time, with the number of periods corresponding to the length of the license period (i.e. 20 years). The model assumes that in each period, the value of spectrum can go either up or down. The probability for either the up or down movements to occur relies essentially on the volatility of the underlying (see section A.2.2). The "branches" of the binomial tree over the 20-year license period span all possible developments from 20 consecutive "up" movements to 20 consecutive "down" movements and all combinations in between (see Figure A.1 for a simplified illustration).

[19] Hull, John, "Options, Futures and Other Derivatives", 8th Edition, p. 257.

[20] Annual licence fees for 900 MHz and 1800 MHz spectrum: Aug. 2014 further consultation, paragraph 4.59

[21] Re-negotiation can be thought of as a two-stage process where the licensee first returns the license and then "buys" it back at the new current market value thus making it similar in "optionality" terms to the outright return of the license and use of the funds for some other market rate opportunity.

A.2.2. The Volatility of the "Underlying"

The volatility of the underlying is a key value driver in the option pricing model. The simple intuition is that the value of the "insurance" provided by the option of renegotiating the ALF payment is higher the more volatile the value of the spectrum and thus the more likely a material misalignment.

In the case of a traded security historical volatility can provide guidance on the underlying's volatility. A common method used to remedy the lack of volatility data on an untraded underlying is the use of traded comparators. Brealey and Myers (2000) state:

> *"When we value a real option by the risk-neutral method, we are calculating the option's value if it could be traded. This exactly parallels standard capital budgeting."*[22]

Telefonica's share price could be used as a proxy to calculate the volatility of the underlying. This approach is in line with Ofcom's assumption that the risk of the license is comparable to the risk of the MNO parent companies.[23] In a second step we would need to adjust the volatility of Telefonica's share price to calculate its *asset* volatilities by correcting for the impact of leverage. A straightforward and most widely used approach is as follows:

Equation 1
$$\boldsymbol{\sigma_A = \sigma_E \frac{E}{A}},$$

where σ_A is the asset volatility, σ_E the equity volatility, E the firm's equity (which we empirically measure as the firm's market capitalisation) and A the firms total assets (which we empirically measure as the sum of market capitalisation and the book value of debt). While more complex approaches such as Merton's boundary condition[24] exist and potentially provide more precise estimates under certain criteria regarding the firm's debt, they tend to produce results of a roughly similar order of magnitude.[25]

Over the past twelve months we estimate a volatility of 19.02% (as of 30 March 2015). Based on an equity share of 49% we estimate an asset volatility of 9.29%, which we use as proxy for the asset volatility of spectrum value in our option model. Table A.1 shows volatility and equity share estimates for Telefonica for different averaging periods. We retain the 12-month

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22 See also Trigeorgis (1998): "*The 'correctness' of using NPV (value maximization) rests, of course, on the assumption of market completeness*".

23 Annual licence fees for 900 MHz and 1800 MHz spectrum: Feb. 2015 further consultation, paragraph 4.28.

24 More complex approaches exist, notably Merton's boundary condition (Merton 1974), of which Equation **1** is a simplified version. Merton follows an option pricing approach to relate equity and debt volatility, showing that:

(2)
$$\sigma_A = \sigma_E \frac{E}{A\,N(d1)}$$

Where N(d1) derives from the option-theoretic approach as in the classic Black-Scholes-formula.

25 See Nikolova (2003), who provides empirical asset volatility estimates under different approaches including Equation **1** as well as Merton's boundary condition (Merton 1974) and shows that these methods lead to similar asset volatility estimates.

asset volatility for our analysis considering that it most accurately reflects current market conditions.[26]

Table A.1
Volatility Estimates Based on Telefonica Share Price

Time Horizon	Equity Volatility	E/(D+E)	Asset Volatility
1 Year	19.02%	0.49	9.29%
2 Years	19.37%	0.47	9.06%
5 Years	24.75%	0.48	11.92%

Source: NERA analysis

A.2.3. The Discount Rate

Another parameter influencing the option price is the discount rate, which is equal to the risk free rate in a risk neutral setting of real option pricing. For the purpose of modelling the option to return the spectrum during the ALF period, a real risk-free rate of 0% would be broadly consistent with longer-term maturity ILG bonds.

A.2.4. The Strike Price

The strike price is the price the holder of a put option receives when the option is exercised. In the case at hand, the strike price corresponds to the present value of the remaining stream of ALF payments at the original ALF level before negotiation. With every annual payment the value of the future stream of ALF payments falls (as the period covered by the contract becomes shorter) thus implicitly re-setting the strike price after each payment. In technical terms we value the put option "at the money."

Setting the strike price at the money is a very conservative assumption as the payoff of the option is positive if the value of spectrum falls below the original assumed spectrum value. This is because:

- There are financial and reputational costs to renegotiating the license;
- Ofcom has already indicated that it will apply a significant materiality threshold before allowing any adjustment;[27] and
- Ofcom has already indicated that it will not undertake any adjustment in the first five years unless there are exceptional circumstances.[28]

The above means that the "exercise" of the option (revocation or renegotiation) will occur less likely than under the approach where we value the option "at the money". Our approach

[26] We have cross-checked our equity volatility estimates for Telefonica with share price volatilities of other MNO parent companies, which are also used as comparators in the cost of debt analysis: Deutsche Telekom, Vodafone and Orange.

[27] Annual licence fees for 900 MHz and 1800 MHz spectrum: Feb. 2015 further consultation, 4.61.

[28] Annual licence fees for 900 MHz and 1800 MHz spectrum: Feb. 2015 further consultation, 7.40.

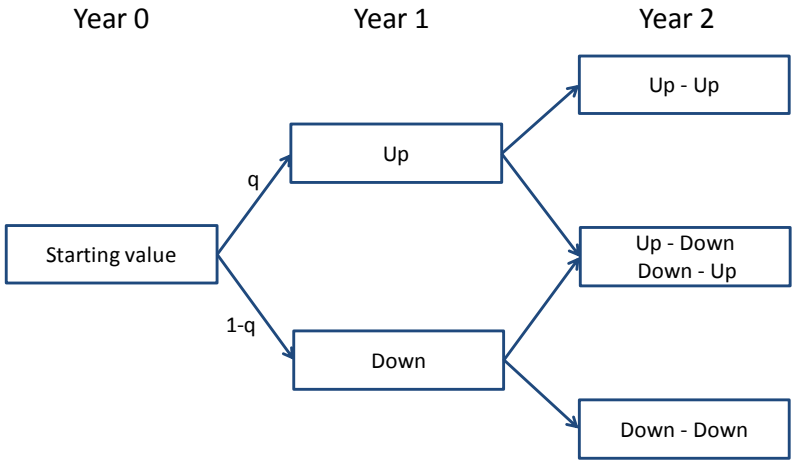
will therefore overestimate the value of the option and thus the risk sharing borne by the government.

A more realistic but more complex approach would be to value the risk sharing using "barrier options". For example a "down-and-in option" gives the holder the right but not the obligation to sell (in the case of a put) shares of an underlying asset at a pre-determined strike price if the price of that asset falls below a pre-determined barrier during the option lifetime. That is, once the price of the underlying asset falls below the barrier, the option is "knocked-in".

A.3. Constructing a Binomial Tree

According to the Black and Scholes' formula, the option value depends by far and foremost on the expected volatility of the underlying. As set out above we use a discrete time model for valuing the real option. In discrete time, the volatility determines the size of the up- and down-movement of the binomial tree (or "lattice") which models the evolution of the underlying.

Figure A.1
Stylised Visualisation of the Evolution of Value along the Binomial Tree



Source: NERA illustration.

Cox et al (1979) show that the following relationship between the volatility and the size of the up- and down-movement holds:[29]

Equation 2 $$\text{up} = e^{\sigma\sqrt{t/n}} \text{ and } \text{down} = 1/\text{up},$$

where σ is the volatility of the security return and *e* is the base of the natural logarithm (2.71828…), *t* is the time period and *n* is the number of price changes within one period.[30] The risk neutral probabilities are given as:

[29] See Cox, J.C., S.A. Ross and M. Rubinstein (1979). Options Pricing: A Simplified Approach," Journal of Financial Economics, No. 7, No. 3, pp. 229- 264.

Equation 3 $$q = \frac{\text{Risk free rate - Down}}{\text{Up - Down}},$$

where q is the risk neutral probability of the up-state and (1-q) is the probability of the down-state. Based on Equation 2 and Equation 3 , the volatility of the underlying security (together with the risk free rate) defines the size of the up- and down-movements and the risk neutral probabilities – the key inputs to any option analysis.

A.4. Valuation of the Put Option – Backward Induction

MNO will consider the expected value of the option in future years before considering to exercise the option "today" since, once exercised (i.e. renegotiated), it will be difficult for the MNO to renegotiate the licence terms a second (or third) time during the 20 year contract lifetime. We assume that the MNO considers that a potential renegotiation is only possible once during the license lifetime.

Based on the stochastic process of the underlying, we determine in each node of the lattice the payoff of the put option. The payoff of a put option is given by:

Eq. 4: Payoff Put = Max [Payoff today; expected probability weighted payoff in the future]

The payoff today is given by K-P; the difference between the strike price and the market price of the underlying. The expected future payoff depends on the future development of the strike price and one's expectation of the market price.

To determine these we use a process referred to as "backward induction" – that is, a process of reasoning backwards in time to determine a sequence of optimal actions at each point in time. The value of the real option is equal to the value following the sequence of optimal decisions.

In the last period, the value of the put option is equal to the payoff of the put as it no longer holds any optionality value. I.e. Eq. 4 simplifies to:

Equation 4: Payoff Put = Max [K-P ; 0] in the last period where

- K is the strike price, i.e. the exercise price of the put option; and
- P is the price of the underlying.

Eq. 4 can be interpreted as the option holder having the following choices:

- Exercise the option and sell the spectrum (with market value P) at the strike price K thus realising K-P as a benefit; or

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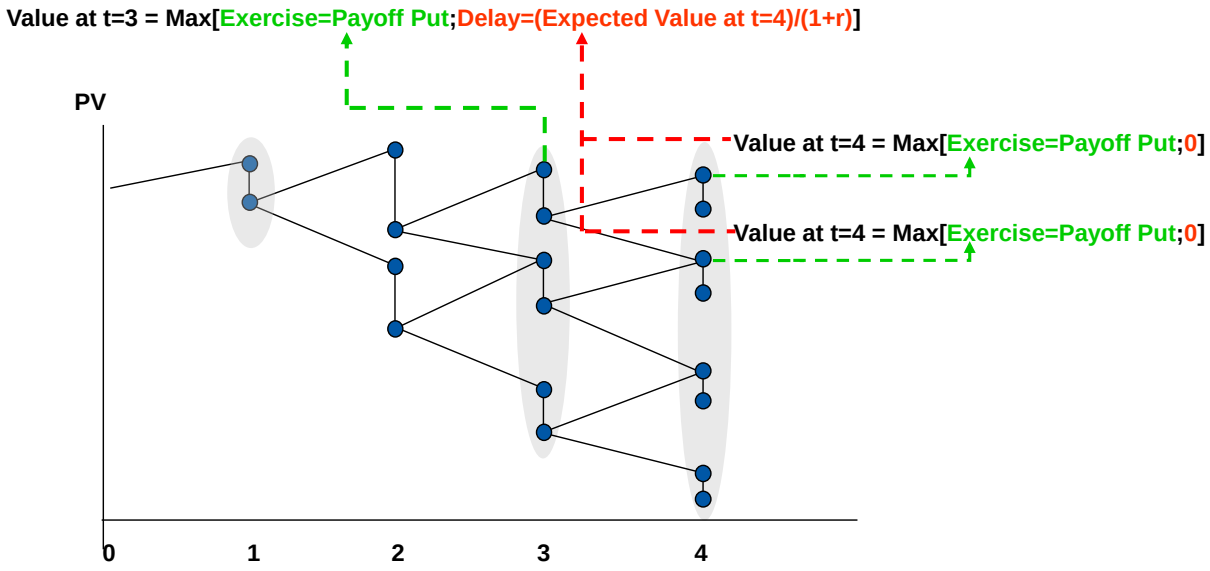
[30] When *t* and *n* are equal to 1 the formula simplifies to $Up = e^{\sigma}$.

- Not exercising the option since the market value is worth more than the strike price. The holder of a put option will only exercise the option if the price of the underlying (P) is below the strike price (K).

A rational investor will factor these impending outcomes into the decision-making process at the penultimate stage when deciding whether to exercise the option or to keep hold of it. This process can be repeated at each earlier stage in order to value the option at these stages, as illustrated in the figure below.

Figure A.2
Valuing a Put Option – The Concept of Backward Induction



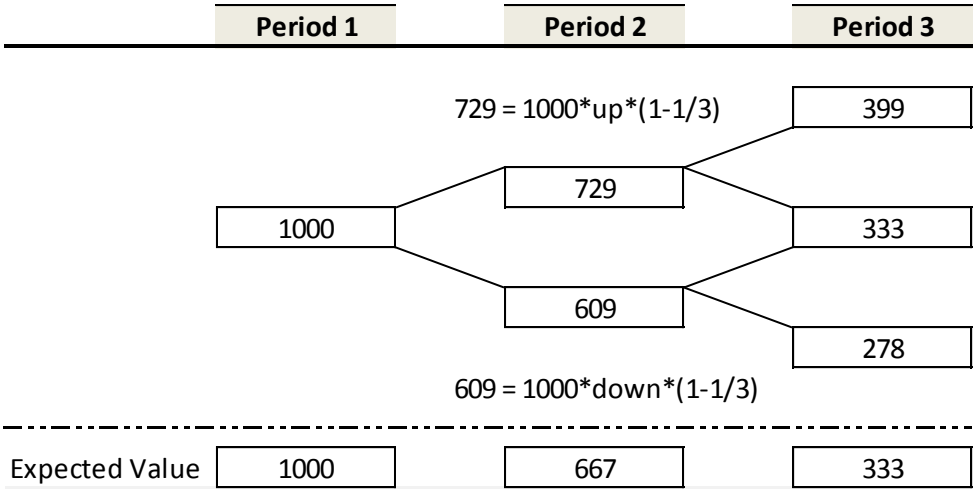
A.5. Example of Option Valuation

Putting these elements together, one can derive the option value associated with the licensee's right to renegotiate the ALF or revoke the license during the 20-year period. The option valuation proceeds in several steps illustrated in more detail below.

We illustrate the construction of a binomial lattice used for the valuation of a real option. For the sake of tractability we limit our example to three periods. The expected volatility of the underlying determines the up- and down movements of the lump sum value. We use an estimate for the volatility of 9% to illustrate the construction of the binomial lattice used for the quantification of the real options in the following chapters.

Using Equation 2 shown above, the size of the up movement consistent with 9% volatility is 1.09 and 0.91 for the down movement. In each period the value of spectrum can go up by a multiple of 1.09 or down by a multiple of 0.91 (see Figure A.3). Since the project has a lifetime of three periods, we assume that in Period 2 the value of the underlying declines by one third (as one instalment of the ALF has already been paid in the previous period). Figure A.3 shows the evolution of the underlying with an initial notional price of 1000 over the three year period.

Figure A.3
Binomial Lattice – Evolution of the Lump Sum Value of Spectrum (€m)

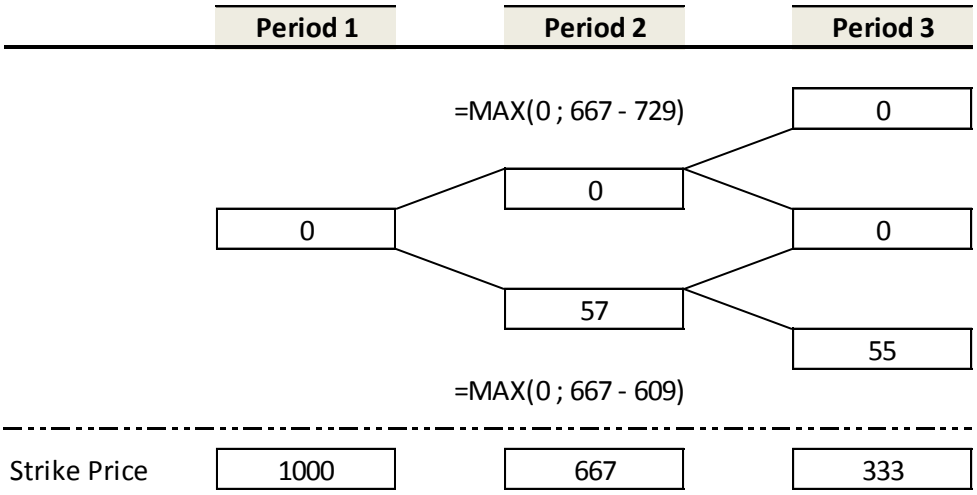


Source: NERA illustration

Using Equation 3 shown above and a current real risk free rate of 0% produces probabilities for the up and down states of 0.48 and 0.52 respectively. Discounting the expected value in Period 2 by the real risk free rate and using the probabilities yields the present value (PV) of future payments of 667 in period 2 (equal to the value in Period 1 minus the depreciation of value due to the shortening of the licence lifetime by one year.)

Figure A.4 estimates the payoff of the put option at every node.

Figure A.4
Binomial Lattice – Payoff Put Option (€m)



Source: NERA illustration

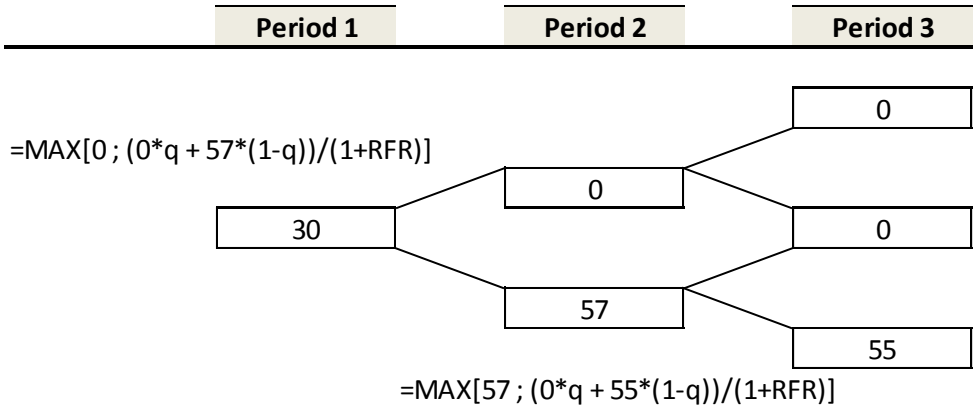
Figure A.5 illustrates the valuation of the option by backward induction based on the optimal actions at each of the payoff nodes.

We illustrate the process using the bottom state in Period 2: Valuation through backward induction follows the same maximisation process as Figure A.4, namely we calculate the maximum of:

- The value of exercising the option today (57 in the bottom Period 2 state);
- The probability weighted average of the expected value of the option in future states:
  - "Up": Option valued at zero (as no insurance is required) [with probability q]; and
  - "Down": Option valued at 55 discounted by 1+RFR [with probability 1-q]

On this basis the value for the put option is €30m (for this stylised example).

Figure A.5
Binomial Lattice – Valuing the Put Option (€m)



Source: NERA illustration

In this context it is worth noting that although the *payoff* of the put is zero in Period 1 (cf. Figure A.4), the *value* of the put is positive at €30m as there is a reasonable expectation that the option will have a positive payoff in the future.

As a final step the option value needs to be converted into a discount rate premium. To do so Ofcom needs to solve for the increase in discount rate such that an average efficient MNO would be indifferent between paying the lump sum license value (which includes no option) and the ALF (including the option). This approach would follow the objective originally set out by Ofcom in its first consultation and restated in the latest consultation document:

> *In principle, an average efficient MNO (on which our estimation of the discount rate is based) and the Government should be indifferent between payment for the spectrum in the form of a lump-sum payment or ALF. (4.31)*

A.6. Further Considerations

We have made a number of limiting assumptions in the stylised example above. Following such an approach is likely to overestimate the value of risk sharing:

- The approach set out above assumes that the put option is valued "at the money". As Ofcom has stated that it will apply a substantial materiality threshold, i.e. only a material

change in spectrum value would trigger a tariff review.[31] This would reduce the value of any real put option valued "at the money".

- The approach set out above assumes that the put option can be exercised from year 1 onwards. However it is highly unlikely that the MNO would start renegotiations in the first few years. This reduces further the option value.
- Finally, our approach does not value the existence of the option for Ofcom to increase ALFs in case spectrum increases in value in favourable market conditions. The right of Ofcom to renegotiate the ALF payments is a "call option" and its value would need to be subtracted from any option value associated with the right of the MNO to renegotiate or revoke the license in unfavourable market conditions ("put option"). Therefore, given the symmetry of potential renegotiations, the net value of the two options is likely to be close to zero and cannot justify a risk sharing premium as high as 1.1% as proposed by Ofcom.

[31] Annual licence fees for 900 MHz and 1800 MHz spectrum - Provisional decision and further consultation, February 2015, para 4.61.

Report qualifications/assumptions and limiting conditions

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