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OFCOM 2024 REVIEW OF ANNUAL LICENCE FEES

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Contents

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EXECUTIVE SUMMARY

Ofcom has announced a review of the annual licence fees (ALFs) for 900 MHz, 1800 MHz and 2100 MHz spectrum in response to a request from BT to review the fees for 1800 MHz spectrum.[1] Ofcom has decided to look at the fees for all three bands because of the commonalities in the approach to setting the fees. Vodafone has commissioned Frontier Economics to assess whether there is evidence for the current level of these ALFs to change.

ALFs are set based on a regulatory judgement about the market value of spectrum

ALFs are imposed for spectrum that has never been auctioned, or where spectrum has been auctioned but the initial term of the licence has expired.[2] The current level of ALFs is meant to reflect the true market value of the relevant spectrum to Mobile Network Operators (MNOs), in-line with a direction by the Secretary of State in 2010. This has been assumed to lead to an efficient allocation of spectrum, in line with Ofcom's statutory objectives. However, Ofcom has historically recognised that setting ALFs based on an overestimation of market value of spectrum could lead to inefficient spectrum use (more so than if the market value is underestimated). Therefore, Ofcom has taken a conservative approach to valuing spectrum when setting ALFs.

Given a lack of recent UK auction data in the relevant bands for Ofcom to draw on,[3] valuations are based on interpolation/extrapolation of UK auction prices using relationships between valuations of bands drawn from a limited set of overseas auction results.

This approach has required using a significant degree of regulatory judgement. International spectrum auction data, which is considered by Ofcom a robust estimate of valuations, is sparse (e.g. Ofcom has referred to overseas auctions dating back as far as 2010 when setting ALFs). Ofcom's approach also required the 2013 UK auction prices (which reflected MNOs' bids for combinations of spectrum bands) that fed into its benchmarking to be decomposed into prices associated with individual bands. The resulting estimates of 'lump-sum values' for ALF bands vary significantly, requiring judgement in choosing the appropriate point estimate.

To date, Ofcom has not updated the real market values of ALFs once set. Instead of reviewing the level of ALFs periodically, Ofcom has implicitly assumed that the market value of spectrum is stable in real terms (i.e. to date, ALFs have increased in-line with CPI inflation). If in fact the real market value of spectrum changes over time (in particular, if the value of spectrum decreases, or increases at a slower rate than overall inflation), then there is a risk that ALFs

1 https://www.ofcom.org.uk/spectrum/innovative-use-of-spectrum/ofcom-launches-review-of-spectrum-licence-fees/

2 Ofcom Statement: Annual licence fees for 900 MHz and 1800 MHz spectrum, 24 September 2015 (herein "the 2015 Statement"); Ofcom Statement: Annual licence fees for 900 MHz and 1800 MHz spectrum, 17 December 2018 (herein "the 2018 Statement"); and Ofcom Statement: Annual licence fees for 2100 MHz spectrum, 13 December 2021 (herein "the 2021 Statement").

3 This excludes C-band. The ALFs for UK Broadband's 3.4-3.6 GHz spectrum holdings were set based on auction prices for the 3.6-3.8 GHz bands in 2021.

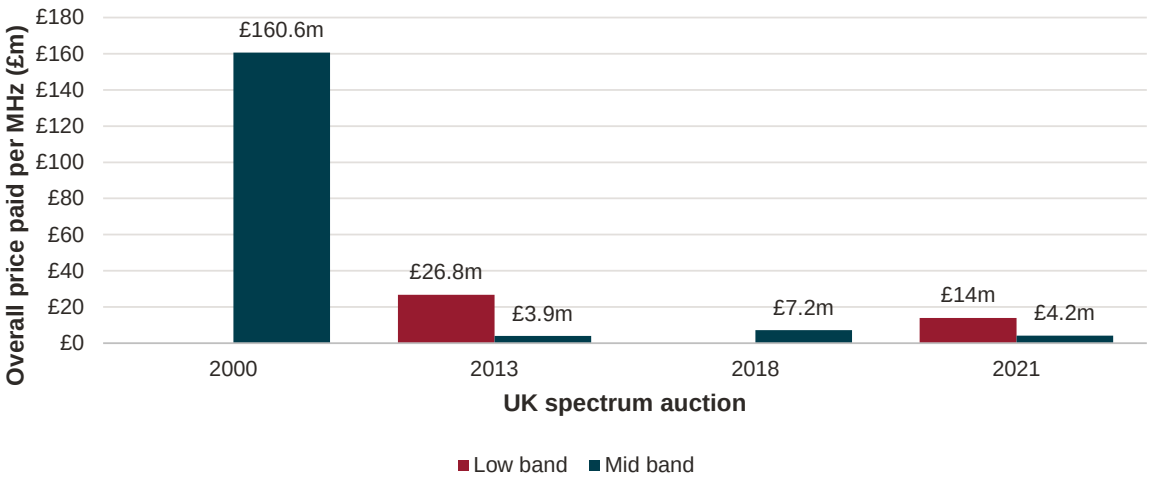
could rise above the market value of spectrum, causing inefficiencies. In addition there is a risk of inconsistency between valuations reflecting the different sets of data used to set ALFs, for example with the 2100 MHz ALF set more recently drawing on a wider range of auction data than the ALFs for 900 MHz and 1800 MHz.

Market developments suggest the real market value of spectrum has fallen over time and the relativities in values between bands have changed

There has been a number of market developments in recent years, which suggest the market value of spectrum has declined in general (in real terms) since Ofcom determined the ALFs for 900 MHz, 1800 MHz and 2100 MHz spectrum. These developments also suggest that the relative values between different spectrum bands have changed compared to when ALFs were set.

- **Technology changes** have reduced the scarcity of spectrum and altered the relative value of low-band compared to mid-band spectrum. As a result, the real market value of spectrum is likely to have fallen, and differences in the current level of ALFs between different bands are unlikely to reflect the relative value MNOs place on these bands. In particular, the accuracy of estimates of spectrum value using less recent data to populate the distance/ratio methods is likely to have decreased.
- **Commercial challenges** faced by MNOs in recent years, such as falling revenues and profitability, and the upcoming need to invest in 5G network roll-out, imply that MNOs/investors' willingness to pay for spectrum is likely to have fallen.
- **Evidence from auctions** is sparse, which has made it difficult for Ofcom to reliably set ALFs in the past, but implies a long-term downward trend in the prices paid at UK spectrum auctions over time.

Figure 1 There is a downward trend in UK spectrum auction prices

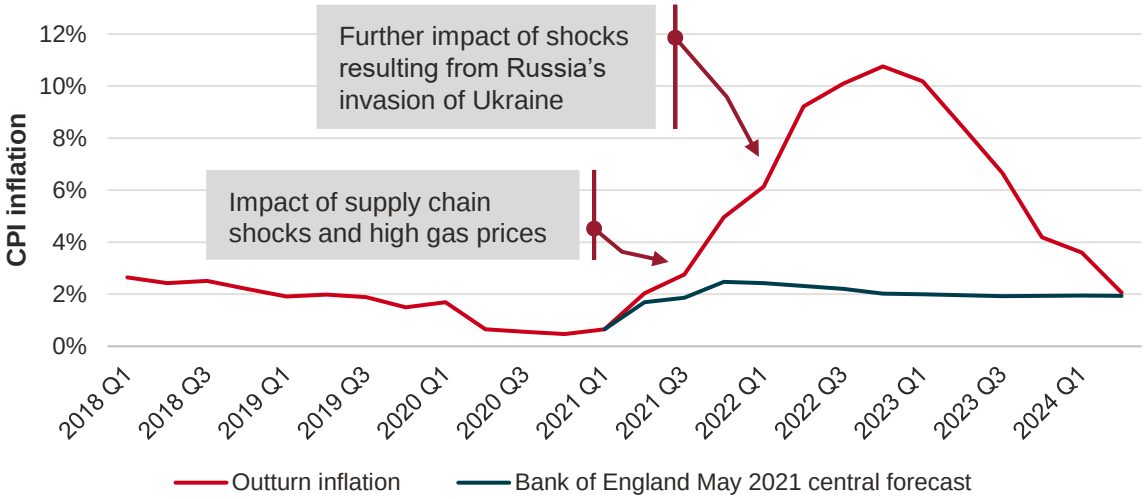


Source: *Frontier Economics analysis of Ofcom and Telegeography data*
Note: *See notes under Figure 12.*

Recent inflation is likely to have out-paced growth in the market value of spectrum

Ofcom's decision that ALFs should rise with CPI inflation was made at a time where the overall rate of inflation was subdued, with annual rates of inflation close to the Bank of England's target rate of 2%. As such, Ofcom considered this a reasonable expectation as to long-term CPI inflation. However, inflation has turned out much higher than Ofcom was expecting due to external shocks, such as the war in Ukraine.

Figure 2 External shocks drove inflation far above Ofcom and the Bank of England's expectations at the time when ALFs were being decided



Source: *Frontier Economics analysis of ONS and Bank of England data*

Note: *We note that the Bank of England's May 2021 Monetary Policy Report was the latest such report at the time that Ofcom first proposed the level of ALFs for paired 2100MHz spectrum in its July 2021 Consultation.*

The real value of spectrum licences is likely to have fallen as the economic shocks that have driven up inflation have not driven up the value of spectrum. In normal times, there is likely to be some correlation between changes in the purchasing power of money, as measured by general inflation, and the value of assets. However, the high rates of inflation that the UK (and global) economy is currently experiencing are not due to monetary policy but are mainly being driven by supply-side shocks, such as disrupted supply chains due to Covid-19, tight labour markets and the war in Ukraine. There are no obvious reasons why these external factors should be correlated with the value of spectrum. Therefore, it is likely that inflation has outpaced growth in the market value of spectrum (i.e. the real value of spectrum has fallen).

ALFs should be revised to reflect the current market value of the relevant spectrum

Given the above, we consider the level of ALFs should be revised to better reflect the market value of spectrum. Importantly, prices paid for 700 MHz spectrum at auction suggest the 900 MHz ALFs are too high, and changes in technology mean there is not a clear reason why 1800 MHz and 2100 MHz ALFs should differ significantly. We recommend that Ofcom considers:

- aligning the 900 MHz ALF with the lump-sum value of 700 MHz spectrum (updated based on a notional, long-run rate of inflation, e.g. 2%);
- aligning the level of 1800MHz and 2100 MHz ALFs, taking account of the latest auction data; and
- providing clarity on the periodic review of ALFs.

2 Introduction

Radio spectrum is a finite public resource used by MNOs to provide mobile services to consumers and businesses. Ofcom now generally issues perpetual licences (with a minimum 20-year term, and five-year notice of termination thereafter) for operators to use the spectrum via an auction process.[4] Prior to 2000, spectrum was issued directly to MNOs.

Ofcom has the power to impose fees for the use of radio spectrum, including the spectrum used by MNOs.[5] That includes the power to set fees above Ofcom's administrative costs incurred in executing its radio spectrum functions.[6] Ofcom does not impose ALFs during the initial term after an auction, but does impose ALFs for spectrum that has never been auctioned, or where spectrum has been auctioned but the initial term of the licence has expired. Ofcom currently charges ALFs for three mobile spectrum bands (900 MHz, 1800 MHz and 2100 MHz), with ALFs for 1400 MHz to be set once evidence of market value has been obtained from a forthcoming auction.[7]

2.1 Ofcom's objectives in setting ALFs

Ofcom has set out its general policy position for setting spectrum fees in its Strategic Review of Spectrum Pricing (SRSP),[8] which it uses as a guide when setting ALFs.[9] From 2010, a Government Direction ("the Direction") required Ofcom to set ALFs to reflect the full market value of the relevant spectrum frequencies.[10]

Ofcom has always asserted that ALFs increase spectrum efficiency, in line with its statutory objectives. Specifically, Ofcom set out in the SRSP that it considered ALFs reflecting opportunity cost (and therefore market value)[11] would promote efficient use of spectrum:

> *"If the value of spectrum to a particular user is less than* [the] *opportunity cost, then the spectrum is, by definition, valued more by someone else. If spectrum were reassigned to*

4 The upcoming mmWave award will be an exception.

5 Under section 12 of the Wireless Telegraphy Act 2006 (the "Wireless Telegraphy Act"), Ofcom has the power to require licensees to pay fees to Ofcom on the grant of a licence and subsequently.

6 Section 13 of the Wireless Telegraphy Act provides for Ofcom to set fees at an amount that is higher than the cost to Ofcom of carrying out our radio spectrum functions.

7 Ofcom also set ALFs for C-band spectrum used for fixed wireless access by UK Broadband, which was acquired by Hutchison 3G UK in 2017. We understand that Hutchison 3G subsequently paid a fee to align the ALF dates for this spectrum with that of spectrum acquired via auction,

8 SRSP: The revised Framework for Spectrum Pricing. Ofcom, 2010.

9 In the SRSP, spectrum fees set above administrative cost are referred to as Administered Incentive Pricing (AIP). In practice, Ofcom has used the terms ALF and AIP interchangeably – see paragraph 3.2 of the 2018 Statement.

10 https://www.legislation.gov.uk/uksi/2010/3024/article/6/made

11 Ofcom considers that setting ALFs based on opportunity cost results in fees reflecting market value of spectrum. See for example: Statement: Annual licence fees for 2100 MHz spectrum, Ofcom 2021, paragraph 2.6.

that alternative use or user then we would expect that user to generate greater benefits to consumers and therefore increase the efficiency of the spectrum use".[12]

In the UK, spectrum is generally tradeable which means that, in theory, if another user has a higher valuation of spectrum, then the existing holder would be willing to transfer the spectrum to the higher-value user at a price acceptable to both parties. As such, under spectrum trading, we would expect an efficient outcome in terms of spectrum use independently of ALFs being levied on the spectrum. However, Ofcom considers that setting ALFs to reflect market value provides a further incentive, i.e. that it incentivises the existing users to relinquish their spectrum if there are other users who value that spectrum more highly.[13],[14]

Given that MNOs already have an incentive to trade spectrum where it is not allocated efficiently (regardless of whether ALFs are imposed), the risk resulting from ALFs being set below market value is limited. On the other hand, Ofcom has recognised the potential for spectrum inefficiency from ALFs that are inadvertently set above market value and result in a fallow period.[15] As such, there is an asymmetry in the risk of spectrum inefficiency from inadvertently setting ALFs above or below market value. Ofcom has therefore taken a conservative approach to setting ALFs.[16]

2.2 Ofcom's current approach

Table 1 below summarises the ALFs currently paid by MNOs. In the rest of this sub-section, we set out how Ofcom has determined the level of ALFs that MNOs must pay.

Table 1 Current ALFs

Spectrum band	900 MHz	1800 MHz	2100 MHz
Date of first ALF payment	31st October 2019	31st October 2019	4th January 2022
Latest fee per MHz	£1.362m	£1.003m	£0.671m
Total cost to sector	£95m	£144m	£80m

Source: *Frontier Economics based on the 2018 Statement and 2021 Statement.*

Note: *Latest levels of 900MHz/1800MHz ALFs updated using the ratio between the August 2023 level of CPI to the April 2018 level of CPI. Latest levels of 2100MHz ALFs updated using the ratio between the November 2023 level of CPI to the April 2021 level of CPI. Total cost figure calculated based on MNOs' spectrum holdings in figure 2.2 of the 2018 Statement and table 2.3 of the 2021 Statement. Latest fee per MHz and total cost figures are rounded. Fee per MHz for 900/1800 ALFs is calculated by multiplying the latest ALF per 200kHz paired channel by 2.5.*

12 SRSP, paragraph 4.30

13 SRSP, paragraphs 4.189-4.191

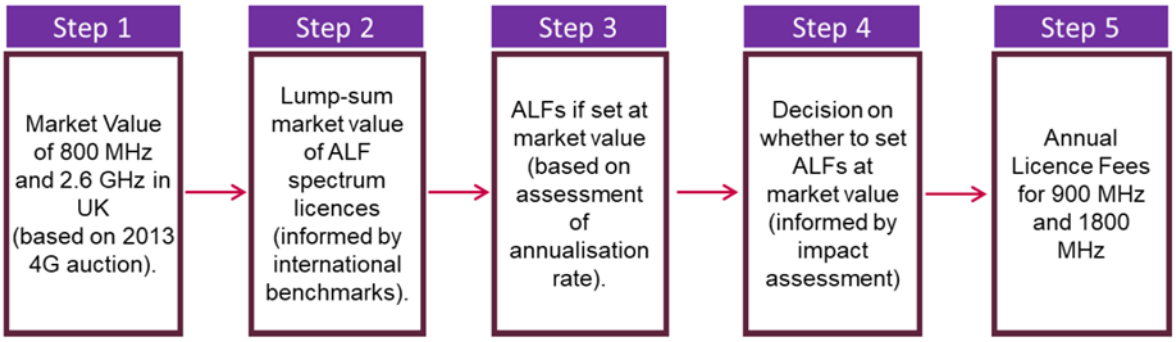
14 Ofcom has considered in particular that ALFs may improve spectrum efficiency where there are high transaction costs, lack of price information and co-ordination problems, and that MNOs may be more responsive to a direct cost via ALFs than to forgone revenue (i.e. an opportunity cost) that they might achieve through trading spectrum. See: SRSP, paragraphs 4.201-4.204

15 2015 Statement, paragraph 1.38(a)

16 See for example, 2018 Statement, paragraph 3.11

In determining the level of ALFs, Ofcom first assesses the market value of the spectrum concerned (taking into account evidence from previous UK spectrum auctions and international benchmarks), then converts the resulting lump-sum market value estimate into an equivalent annual payment over a 20-year period. To illustrate, Figure 3 below summarises Ofcom's approach to setting ALFs for the 900 MHz and 1800 MHz bands.

Figure 3 Ofcom's frameworks for setting the ALFs in the 2018 Statement



Source: Ofcom 2018 Statement

2.2.1 Lump sum valuation

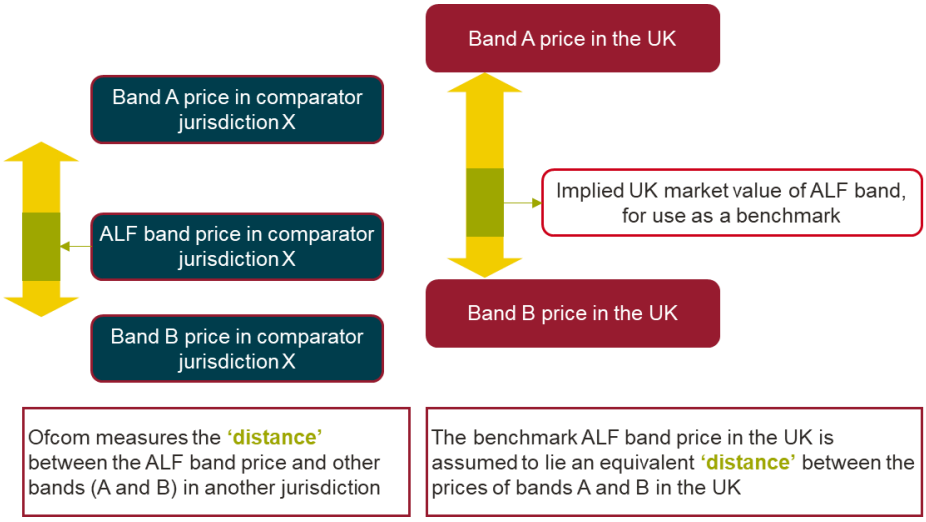
When a given spectrum band first becomes subject to ALFs, Ofcom uses the latest auction data to determine the unit lump-sum value of the spectrum.

Given the spectrum bands were not (with the exception of C-band) auctioned in the UK close to the time when ALFs were set, Ofcom has relied on interpolating/extrapolating from UK auctions for other bands to the ALF bands using data from overseas auctions (the 'ratio method' and 'distance method').

The ratio method involves assessing how the values of two spectrum bands with similar (but distinct) characteristics compare in jurisdictions where both bands were auctioned simultaneously. Specifically, to determine ALFs for 900 MHz spectrum, Ofcom considered the ratio of prices paid overseas for 800 MHz and 900 MHz spectrum, and inferred from these ratios the value UK MNOs would place on 900 MHz spectrum, given what they had paid at the 2013 auction for 800 MHz (as we set out below, this involved significant regulatory judgement).

The distance method involves first looking at where the value of the ALF band sits between the value of other bands in a limited set of benchmark countries. It then applies this 'distance' to the differential between the UK market value of these bands in recent auctions. The distance method is illustrated below. Both the distance and ratio methods assume relative values between bands are broadly stable over time and across jurisdictions, while absolute values vary between jurisdictions.

Figure 4 Illustration of Ofcom's 'distance method' for benchmarking



Source: Frontier Economics

Estimating lump-sum values of spectrum using the ratio and distance methods is uncertain and requires significant judgment. In setting out its view on the lump-sum value of 2100 MHz spectrum, Ofcom described how the process *"involved considerable exercise of* [regulatory] *judgement, reflecting the fact that trying to determine a forward-looking estimate of market value for a specific spectrum band is not a precise science"*.[17] In particular, regulatory judgement is required when:

- **Disaggregating prices paid for bands in combinatorial auctions**. Combinatorial auctions (such as the 2013 UK spectrum auction whose prices fed into Ofcom's ALFs) involve bidders submitting valuations for a package of lots rather than specific lots, and are used on the assumption that bidders value different lots differently depending on whether they are combined with other lots (i.e. bidders' valuations are non-additive). As such, there is no clear way for deriving the value of one lot in a specific spectrum band based on the price paid by a bidder for a package of lots across multiple spectrum bands.

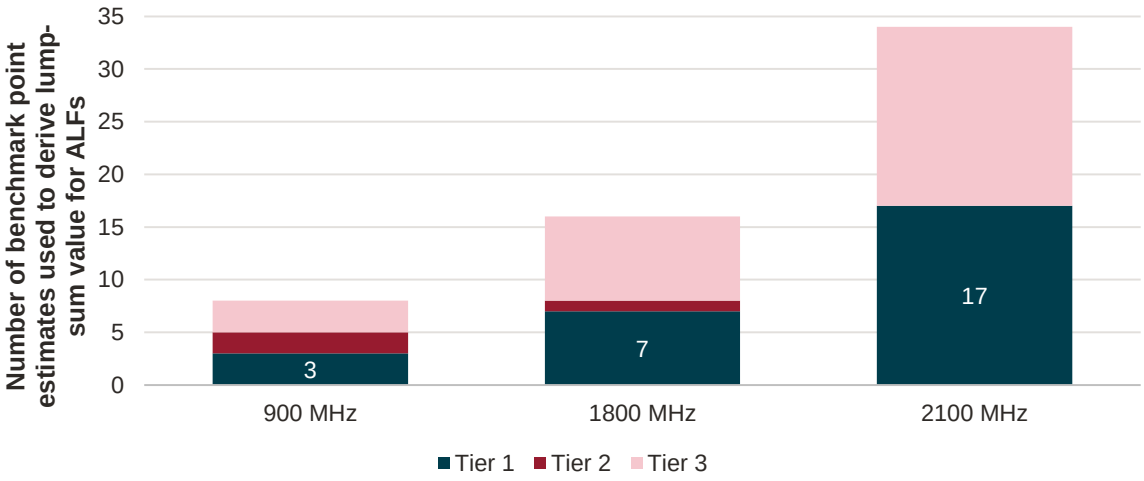
- **Determining whether auctions reflect true market value.** Ofcom's approach relies on the assumption that the auction prices it refers to reflect the true market value of the relevant spectrum bands. However, there are multiple reasons why auction prices may not reflect true market value. Flaws in auction design may lead MNOs to strategically bid above or below their intrinsic valuation of the relevant spectrum, which could distort the final auction price. Similarly, specific national circumstances at the time of an auction can distort its results – for example, if spectrum allocations prior to the auction are imbalanced, then certain MNOs may have an inflated valuation of certain spectrum bands. As such, it

[17] 2021 Statement, paragraph 4.68

may not be clear to what extent a given auction price actually reflects market value (rather than an under or overestimate).

- **Choosing point estimates when sample is small and variable.** Ofcom's judgement of the appropriate lump-sum value of spectrum for ALFs has been based on a small sample of benchmarks. In particular, as shown in Figure 5 below, only a portion of point estimates of spectrum value used in each ALFs decision were classed as "*most informative*" (i.e. those that related to 'Tier 1' benchmark jurisdictions).[18] To set ALFs for 2100 MHz, Ofcom derived multiple benchmark point estimates of the value of 2100 MHz spectrum from only four Tier 1 jurisdictions (by applying the distance method using different upper and lower reference bands). Even within these samples, the values implied by different benchmarks varied significantly (for example, the value at the top of Ofcom's benchmark range for 2100 MHz spectrum was more than double the value at the bottom of the range).[19] Ofcom has therefore exercised considerable regulatory judgement in interpreting its benchmark samples.

Figure 5 Number of benchmark point estimates used in calculating ALFs



Source: *Frontier Economics analysis of 2018 Statement paragraphs 4.42-4.23 and ALF 2100 MHz Consultation Benchmark Valuation Model*

Note: *Excludes benchmarks only used for cross-checks. Data labels refer to number of Tier 1 benchmark point estimates.*

18 Ofcom categorised benchmarks into three tiers. These categorisations reflect how informative of relative UK market values it considered the benchmarks to be, with Tier 1 the most informative and Tier 3 the least informative. See paragraph 4.29 and references therein for how Ofcom decides on how to tier its benchmarks.

19 Ofcom's highest and lowest tier 1 benchmark estimates of the lump-sum value per MHz of 2100 MHZ spectrum based on the distance method were £15.3m and £7.1m. See: 2021 Statement, Figure 4.1

2.2.2 Annualization factor

Once it has determined the appropriate lump-sum value of a spectrum band and adjusted for tax,[20] Ofcom annualises this over a 20-year period. ALFs are also indexed to inflation (CPI), on the implicit assumption the lump-sum values are stable in real terms.

Figure 6 Ofcom's formula for setting ALFs in a given year

$$ALF_t = LSV * TAF * \underbrace{\left[\frac{r}{1-(1+r)^{-t*}}\right] * \left[\frac{1}{(1+r)}\right]}_{\text{Annualisation rate}} * \left[\frac{CPI_t}{CPI_{t0}}\right]$$

Source: *Ofcom*

Note: *LSV = Lump-sum value; TAF = Tax adjustment factor; r = Discount rate; t* = time period; CPI = Consumer pricing index (CPI_t usually refers to the latest CPI index as of January each year, while CPI_{t0} refers to the index as of April 2018 in the case of the 2018 Statement, and April 2021 in the 2021 Statement).*

Ofcom uses a real discount rate to annualize the ALF over the 20-year period (represented as "r" in the formula above). The discount rate is set such that the present value of the payment stream of ALFs equals the lump-sum value if it had indeed been paid as a lump sum. The significance of the discount rate is that it reflects the uncertainty associated with the future level of ALFs – particularly changes in the market value of spectrum over time.[21] The real discount rate is based on an assumed cost of capital adjusted for the different treatment of corporation tax.[22]

20 Ofcom's tax adjustment factor (TAF) aimed to capture the tax benefits of ALFs as opposed to paying a lump sum for spectrum.

21 Specifically, paragraphs 4.77-4.78 of the 2018 Statement explain that: *"The discount rate depends on, among other things, the uncertainty associated with this future ALF payment stream. One significant uncertainty relates to changes in the market value of the spectrum over time. The discount rate which will leave licensees indifferent between paying ALFs and paying a lump-sum depends on the extent to which they (rather than the Government) are exposed to the effect of such changes in market value of spectrum over time and, therefore, it is an important consideration in determining the appropriate discount rate."*

22 Specifically, the real discount rate has been set between an adjusted post-tax real cost of debt (CoD) estimate, and a real post-tax weighted average cost of capital (WACC) estimate

3 Market developments

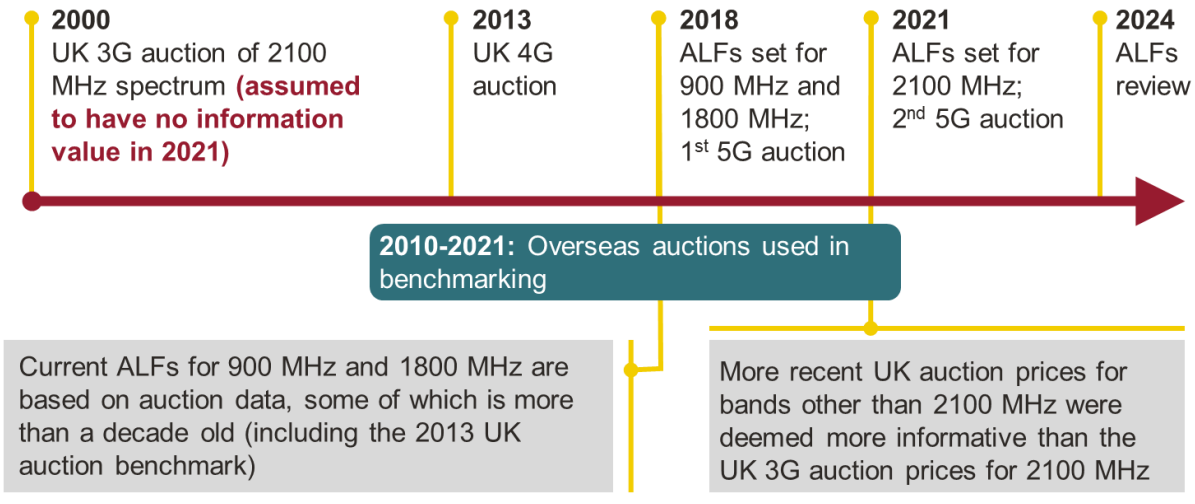
There has been a number of market developments since Ofcom developed its methodology for setting ALFs, and determined the current level of ALFs paid by MNOs. In light of these developments, the level of ALFs should be reconsidered. In particular, the rest of this Section sets out that technology changes, commercial challenges, and evidence from recent auctions suggest existing ALFs are likely to be set too high.

3.1 Technology changes

As set out in Section 2.2, a lack of directly-comparable UK auction data required Ofcom to set ALFs using the ratio and distance methods, and when using these methods (which rely on international benchmarking), Ofcom still only had a small and variable sample to work with.

We set out below that, while the ratio and distance methods offered a reasonable approach to determining the value of ALF-band spectrum in the past, technological changes suggest the accuracy of estimates based on older auction data is likely to have decreased. Specifically, changes in the supply of spectrum, and changes in how spectrum is used by MNOs, mean that the value MNOs place on spectrum bands subject to ALFs is likely to have changed since ALFs were set, including how different bands are valued relative to each other.

Figure 7 ALFs have been set based on (then) recent auction prices, recognising that spectrum values will change as technology develops over time



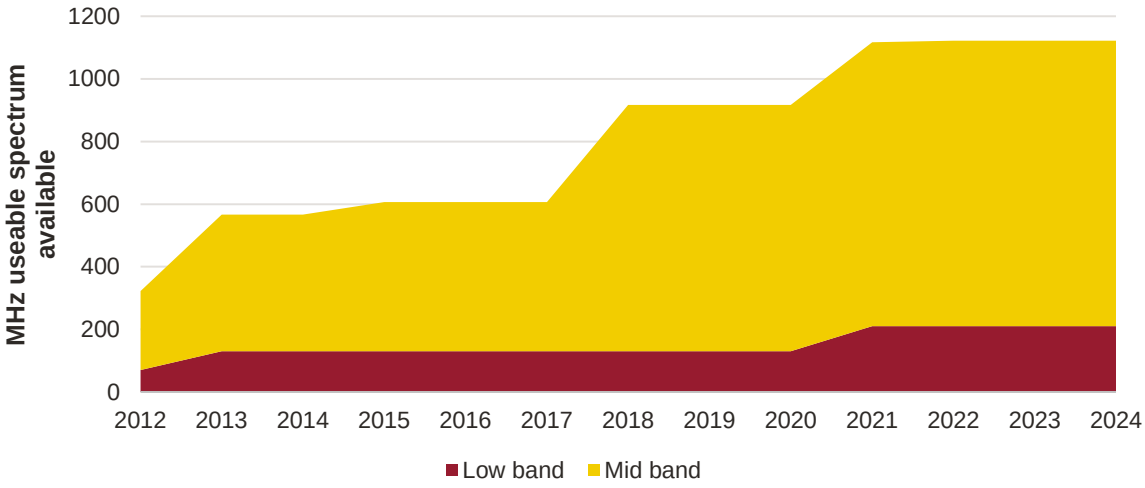
Source: Frontier Economics

3.1.1 Increased supply of spectrum over time

The supply of spectrum has increased in the UK over time. This will have put downward pressure on the value of spectrum to MNOs, absent a compensating increase in revenues. In

particular, each unit of spectrum is now a lower proportion of the total output of the sector. Figure 8 shows how the supply of both low and mid-band spectrum has increased significantly, relative to 10 years ago. There has been a particularly large absolute increase in useable mid-band spectrum holdings across MNOs.

Figure 8 Useable spectrum held across MNOs over time



Source: *Frontier Economics analysis of Vodafone and Telegeography data*

Note: *Low band defined as sub-1GHz spectrum holdings across MNOs. Mid band defined as 1-6GHz spectrum holdings across MNOs. Under this categorisation, 1.4GHz meets the definition of mid band, but it could equally be argued to have similar propagation characteristics to sub-1GHz spectrum.*

It has been three years since Ofcom set the level of ALFs for 2100 MHz spectrum, and six years since it set ALFs for 900 MHz and 1800 MHz spectrum. The benchmark UK auction prices that Ofcom used to set these ALFs have dated back even further, to March 2013, and some of the overseas auction data used dates back to 2010.[23] Therefore, increases in the supply of spectrum may have changed the value of spectrum relative to the inputs used by Ofcom at the time of setting ALFs. In Section 3.2 below, we set out evidence that this effect has not necessarily been offset by an increase in MNOs' demand for spectrum.

3.1.2 Increased fungibility of spectrum

MNOs now have more flexibility in how they use different spectrum bands to serve different mobile technologies on a forward looking basis (i.e. 5G, and legacy 4G technologies). This increased fungibility of spectrum is likely to have relaxed spectrum-related constraints for MNOs, as there will no longer be technology premia for certain bands.

When Ofcom developed its methodology for setting ALFs in 2014, MNOs used spectrum to deploy 2G, 3G and 4G technologies. Not all spectrum bands could be used for each type of

[23] Auction data from 2010 in Denmark and Germany were considered in setting ALFs for 900 MHz and 1800 MHz bands, albeit these were not Tier 1 benchmarks. The earliest Tier 1 benchmarks used date back to 2011 (Sweden and Italy).

technology, which constrained how MNOs could deploy spectrum. For example, when 4G (LTE) was launched, 900 MHz spectrum was largely still used for 2G (GSM), so only the 800 MHz band in low band was used for LTE. This meant that 900 MHz and 800 MHz spectrum were not good substitutes at this point. This constraint would have boosted the value MNOs held for certain spectrum bands, e.g. a premium for 800 MHz to allow MNOs to launch 4G.

Today, MNOs predominantly serve customers using LTE and 5G (NR) technologies. MNOs are switching off their 3G networks, with full switch-off expected in 2025, and are planning for 2G switch-off by 2033.[24] Unlike with legacy technologies, all the spectrum bands currently held by MNOs can be used for both 4G and 5G. Therefore, MNOs are now less constrained in how they deploy their spectrum (see Section 3.1.3).

Table 2 Shift in technologies served by spectrum bands

Spectrum band	Primary uses in 2014	Primary uses in 2024
700 MHz	Digital Terrestrial Television (DTT)	LTE and NR
800 MHz	LTE	LTE and NR
900 MHz	GSM	LTE and NR
1400 MHz	N/A	LTE and NR
1800 MHz	GSM and LTE	LTE and NR
2100 MHz	GSM and LTE	LTE and NR
2300 MHz	LTE	LTE and NR
2600 MHz	LTE	LTE and NR
3.4-3.8 GHz (C-Band)	N/A	NR

Source: https://pedroc.co.uk/content/uk-commercial-mobile-spectrum
https://www.ofcom.org.uk/spectrum/frequencies/700mhz-cfi/
Ofcom Consultation on assessment of future mobile competition and proposals for the award of 800 MHz and 2.6 GHz spectrum and related issues

While MNOs still use 2G, and 3G in some cases, they no longer need to reserve spectrum for these legacy technologies. In particular, Dynamic Spectrum Sharing (DSS) seeks to ensure the best balance of spectrum resource blocks available for each technology at a given moment in time, based on user needs.[25] This provides particular flexibility for deploying 4G and 5G spectrum.

[24] https://www.ofcom.org.uk/phones-and-broadband/coverage-and-speeds/3g-switch-off/

[25] https://www.ofcom.org.uk/siteassets/resources/documents/spectrum/spectrum-management/flexible-and-adaptive-spectrum-allocation/discussion-paper-flexible-adaptive-spectrum.pdf?v=329416

3.1.3 Relative value of low and mid-band spectrum has changed

The relative value of spectrum in a given band is a function of a number of variables:

- the availability of technologies that use the band;
- the effective spectral efficiency for the band;
- the propagation characteristics of the band;
- the availability of large spectrum holdings in the band; and
- the availability and substitutability of other similar spectrum.

Bands are technology neutral

The technological changes set out above mean that similar spectrum (in terms of other characteristics such as propagation) is largely fungible, for example with 700 MHz, 800 MHz and 900 MHz being close substitutes. This is demonstrated by the 700 MHz auction, where Vodafone, with good holdings of 900 MHz and 800 MHz, made relatively low bids for 700 MHz spectrum on the basis that it could re-farm existing spectrum holdings to deploy NR. Looking abroad, at the last European auction that saw 800 MHz and 900 MHz spectrum auctioned together (in Croatia in 2023),[26] the ratio of 900 MHz to 800 MHz prices was only 95-98% (i.e. price per MHz was almost equivalent across the two bands) – while international benchmarking comes with significant caveats, this is clearly consistent with a trend of different sub-1 GHz bands being increasingly substitutable.[27]

Similarly, 2100 MHz and 1800 MHz are close substitutes. In 2021 Ofcom stated an expectation for *"the value of the paired 2100 MHz spectrum to be relatively close to the value of the 1800 MHz spectrum given both bands are mainstream coverage bands with similar propagation characteristics and established equipment ecosystem"*.[28]

In light of the increasing substitutability of different sub-1 GHz bands, and 1800 MHz and 2100 MHz bands, MNOs' values of these bands are unlikely to differ materially. For example, MNOs are likely to value 900 MHz spectrum similarly to 700 MHz spectrum, given the similar functionality of these bands.

Where the capabilities offered by bands differ (e.g. between low and mid-band), there will remain differences in valuation. However, as set out in the following sections, relative valuations will vary over time as technology changes.

26 https://5gobservatory.eu/category/5g-auctions/

27 https://www.hakom.hr/UserDocsImages/2023/odluke_rjesenja_presude/Odluka_javna_dra%C5%BEba_nacionalno-20230308.pdf?vel=604872

28 2021 Statement, paragraph 4.22

Spectral efficiency

Spectral efficiency is a measure of the efficiency with which information (data) can be carried using a given amount of spectrum. Given spectrum is a scarce resource, increasing spectral efficiency allows for more data to be carried. Successive generations of technology from 1G to 4G achieved significant gains in spectral efficiency. However, there is a theoretical limit on the amount of information that can be carried over a single channel ('Shannon's law'). In order to materially increase spectral efficiency, 4G and 5G technologies can use multiple antennas to transmit and receive a number of signals (multi-path) with the same frequency – multiple input multiple output (MIMO) – to increase spectral efficiency in a cell.

With MIMO, spectral efficiency increases with the number of antennas (higher-order MIMO). But to be effective at lower frequencies (and hence longer wavelengths), more physical separation is needed between antenna to provide uncorrelated paths. This limits the number of antennas that can be physically installed in a terminal device and base station, with the number increasing as the frequency increases.

Massive MIMO (mMIMO) uses a large number of antennas at the base station to increase spectral efficiency, but is only available for higher frequency spectrum.

The availability of higher-order MIMO techniques as frequency increases has increased the relative value of high-frequency bands compared to lower-frequency bands in order to serve the exponential growth in traffic.

Propagation

Lower frequencies have better propagation characteristics meaning that they can provide a stronger signal-to-noise ratio at an equivalent distance between the terminal and the base station. This allows base station sites using lower-frequency spectrum to be spaced further apart, to provide seamless coverage in rural areas and provide coverage deeper indoors in urban areas. This means that higher-frequency spectrum is not a good substitute for low-band spectrum.

While higher-frequency spectrum has worse propagation characteristics, the availability of higher-order MIMO offsets this disadvantage to some degree – albeit at the cost of using more expensive mMIMO network equipment. For example, C-band (3.4-3.8 GHz) can provide coverage deployed on the same grid as 1800 MHz spectrum using mMIMO, providing additional capacity close to the base station. However, lower frequency bands are still required to provide coverage at the cell edge and deep indoors.

This means that low-band spectrum provides unique capabilities, such as the ability to provide coverage in rural areas, for which mid-band spectrum is a poor substitute. Similarly, while higher-order MIMO has increased MNOs' ability to deploy C-band as a complement for 1800-2100 MHz bands in more urban areas, C-band is not a close substitute for 1800-2100 MHz bands.

Availability of large spectrum holdings

1G, 2G and 3G technologies had fixed channel bandwidths. LTE introduced a range of channel bandwidths up to 2x20 MHz and allowed carrier aggregation to allow higher throughput. NR can use carriers of up to 100 MHz in sub-6 GHz spectrum. This means that bands which allow for large (contiguous) holdings can provide higher performance without the need for carrier aggregation. For example, C-band allows for 100 MHz spectrum holdings. This compares to much smaller contiguous holdings (e.g. 2x10 MHz) in low-band.

Availability of similar spectrum

Increasing amounts of spectrum have been allocated to mobile services over time (see Section 3.1.1). This has occurred through a large allocation of higher-frequency spectrum such as C-band, as well as a significant expansion in the amount of low-band spectrum relative to what has historically been available, as spectrum previously used for terrestrial television broadcast has been re-allocated to mobile. As supply of similar spectrum increases in relative terms, the value of spectrum would be expected to reduce.

Conclusion

A number of factors will have affected the relative valuation of different bands over the last decade, in addition to a general reduction in the level of spectrum values due to the increased supply of spectrum but no corresponding increase in revenues.

In general, ratios between different bands from less recent auctions are unlikely to provide robust information on the current relativity in current spectrum valuations.[29] Similarly, even if the distance and ratio methods (which assume that value of spectrum varies linearly with frequency) were valid in the past, they are unlikely to capture the differentials in value for future spectrum, especially when comparing bands that are not in close proximity with each other on the spectrum.

A number of the changes set out above will have likely reduced the value of 900 MHz spectrum relative to other bands:

- there has been increased supply of low-band spectrum in the form of 700 MHz and 800 MHz spectrum;
- all low-band spectrum is effectively fungible, being standardised for both 4G and 5G technologies and with DSS allowing for dynamic allocation between technologies; and
- relatively lower spectral efficiency and an increase in the available higher-frequency spectrum mean that the proportion of traffic carried in low-band has been decreasing over time.

[29] In any case the evidence from other jurisdictions was extremely variable, even within the small samples available

Notably, UK auction prices from 2021 imply MNOs have a significantly lower valuation of 700 MHz spectrum than the valuation of 900 MHz spectrum implicit in the current level of ALFs for this band, despite the two bands being close substitutes.

Also, the lump-sum values for the 1800 MHz and 2100 MHz bands based on the distance method applied using data from 2010 onwards may no longer be appropriate. Ofcom set ALFs for these bands based (in part) on the ratio in prices between these bands and sub-1 GHz bands in other countries.[30] Therefore, a change in that price ratio would imply a change in the level of ALFs (under the distance method). In light of the above, the ratio is likely to have changed, suggesting ALFs for these bands may be distorted.

3.2 Commercial challenges and impact on spectrum value

The market value for a block of spectrum is the private value of the marginal excluded user. And the private value of incremental spectrum to each operator reflects a combination of demand- and supply-side factors, specifically:

- revenue and hence profits foregone if the operator would have lower capacity, quality or coverage without the spectrum; and/or
- additional network costs required to achieve similar capacity, quality and coverage without the spectrum.

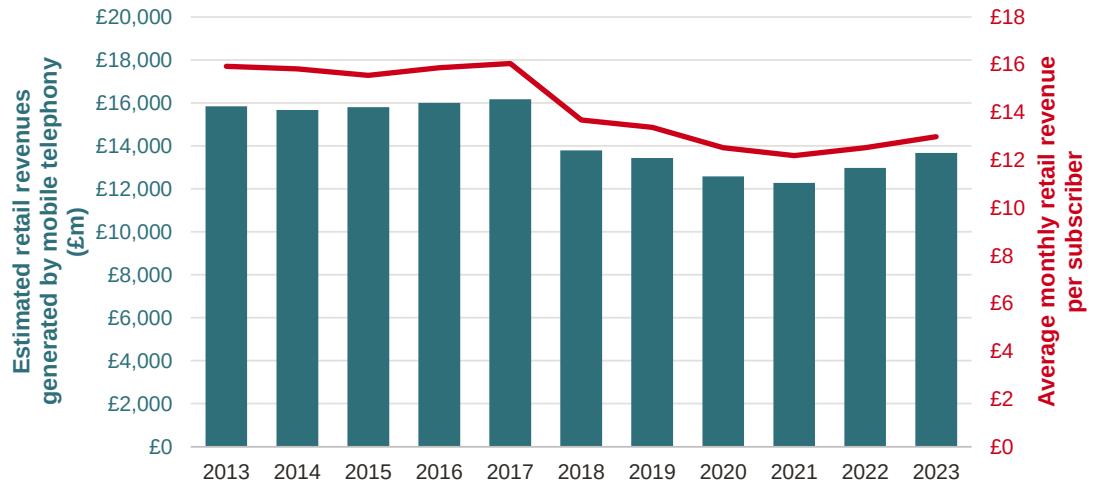
The mobile sector in the UK currently faces several challenges, which are likely to drive down MNOs' private value they would be willing to pay for spectrum at auction, and hence the market value of spectrum.

3.2.1 Static/falling revenues

Figure 9 below shows the evolution of retail revenues and average revenue per user (ARPU) for the UK mobile sector. Revenues have been broadly static in nominal terms, and are likely to have fallen in real terms in recent years. In particular, there has been a clear drop-off in revenues since 2018/2019. Slow growth in subscriber numbers means that ARPUs have also been sluggish and have fallen in recent years.

30 Specifically, ALFs for 1800 MHz spectrum drew on benchmarking that compared 800 MHz prices with 1800 MHz prices in other jurisdictions, and ALFs for the 2100 MHz spectrum drew on comparisons to 700 MHz and 800 MHz prices abroad.

Figure 9 Retail revenues and ARPUs over time (nominal)



Source: Frontier Economics analysis of Ofcom Telecommunications Market Data Update Q1 2024 data
Note: The sharp drop between 2017 and 2018 was caused at least partly by accounting changes. Values are nominal.

In the face of declining revenues, the market valuation of spectrum can be expected to fall, as lower revenues imply a weaker return on investment in spectrum (all else the same). Put another way, as MNOs would forego less revenues by not acquiring an additional unit of spectrum, their private valuation of spectrum is likely to have fallen.

While data volumes have increased significantly in recent years,[31] this would not necessarily increase MNOs' demand (and thus willingness to pay) for spectrum. Increasing data traffic has coincided with the significant increases in the supply and efficiency spectrum set out in Section 3.1, meaning the increase in data volumes (which itself is a function of deployable spectrum and spectral efficiency) is unlikely to have led to an additional constraint on MNOs' capacity.

3.2.2 Lower profitability

Declining revenues have not been accompanied/driven by significantly lower costs. Notably, the removal of Huawei equipment following a government direction,[32] the implementation of the provisions of the Telecoms Security Regulations,[33] and the development of a Shared Rural Network (SRN) are proving costly for MNOs. The Huawei equipment swap reportedly cost BT

31 Ofcom Telecommunications Market Data Update Q1 2024 data suggests sector data traffic increased from 2,451 PB in 2018 to 9,405PB in 2023.

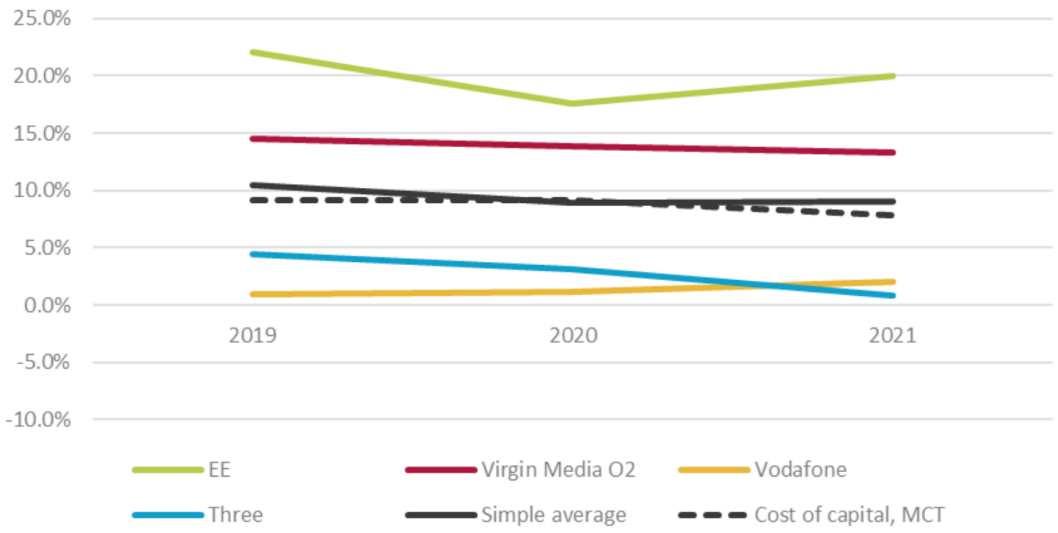
32 https://www.gov.uk/government/news/huawei-legal-notices-issued

33 https://www.legislation.gov.uk/uksi/2022/933/contents/made

alone £500m,[34] whereas MNOs committed to collectively invest over £530 million in the SRN.[35] In recent years in particular, MNOs have also faced similar cost pressures as other industries, driven by rising supply chain and energy costs – for example, energy costs have risen by about 75% and electrical equipment costs by 22% since April 2021.[36] As set out below, densifying networks to enable new 5G use-cases is also likely to increase MNOs' costs. Acquiring additional spectrum would not materially reduce such costs, meaning these increases in network costs would not imply a higher valuation of spectrum for MNOs.

As a result, profitability has also fallen, notably MNOs' return on capital employed has declined. Again, this suggests that the market value of spectrum is likely to be falling in real terms, since the value MNOs place on spectrum will stem from the returns that spectrum could generate for investors.

Figure 10 Economic return on capital employed (ROCE) by MNOs, pre-tax nominal including 5G spectrum



Source: *Ofcom's future approach to mobile markets Conclusions Paper, figure 4.2*

Note: *Ofcom calculations based on publicly available information from financial statements and Ofcom ALF decisions. The cost of capital (pre-tax nominal) comes from Ofcom's charge control decisions for mobile call termination (MCT) over the relevant period.*

The combination of decreasing ARPUs and profitability for MNOs is also consistent with monetizable end-user demand for spectrum growing more slowly than the supply of spectrum (see Section 3.1.1, above).

34 https://www.rcrwireless.com/20230925/5g/uk-telco-bt-says-huawei-ban-cost-firm-612-million-report

35 https://www.gov.uk/government/consultations/shared-rural-network-consultation/shared-rural-network-srn-consultation-document

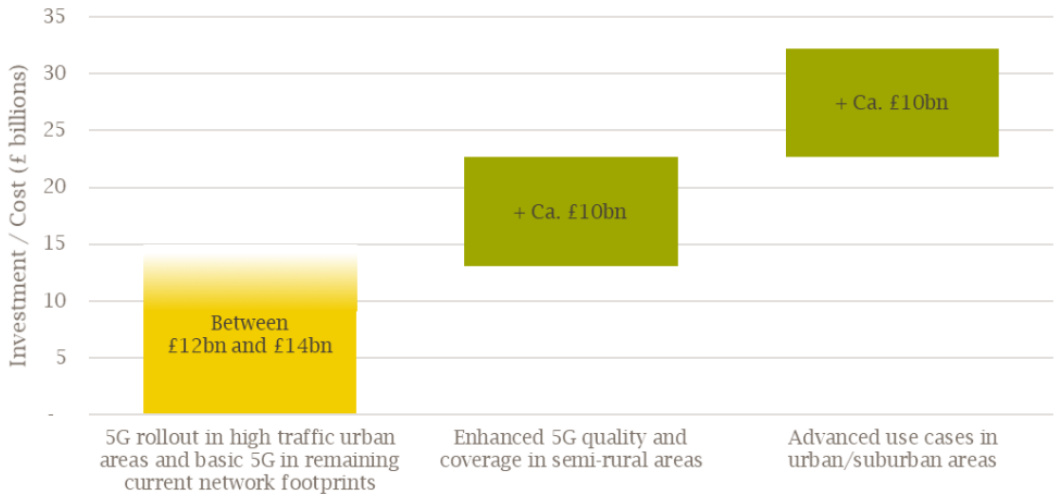
36 Increase in Producer Price Indices (output domestic) for Electricity, including Climate Change Levy, and Electrical equipment from April 2021 to July 2024.

3.2.3 5G investment challenge

Against the backdrop of falling revenues and profitability, MNOs face a significant additional forward-looking challenge in rolling out 5G. Compared to previous generations of mobile technologies, delivering the full capabilities of 5G requires a step-change in the amount of investment, partly because a much denser network of sites is required (and therefore more capex). For example, as of 2022, the investment required to roll out full 5G ranged from about £12bn to £34bn, depending on the scale of roll-out, whereas the investment likely to be committed by MNOs was about £9bn.[37]

With returns stagnating/declining, as suggested by the analysis above, there will be a limit on MNOs' costs that investors will be willing to support, especially if there is a risk that returns from 5G could be captured by firms outside the mobile sector. As such, the considerable scale of cost/investment required for rolling out 5G going forwards is likely to depress the value investors (and therefore MNOs) place on spectrum, all else the same. Importantly, the requirement to densify networks to deliver 5G capabilities means that the associated costs effectively cannot be avoided by acquiring more spectrum.

Figure 11 UK 5G investment required by 2030 depending on scale of roll-out



Source: *https://www.connectivityuk.org/wp-content/uploads/2022/09/The-Investment-Gap-to-Full-5G-Rollout.pdf*
Note: *Figures are presented in 2022 prices.*

3.3 Evidence from auctions

The quality of Ofcom's evidence for setting ALFs was limited. UK auctions are infrequent, meaning Ofcom has not been able to set ALFs based on high-quality price signals, however the 2021 5G auction prices paid for 700 MHz provides Ofcom with a strong, new indicator for

[37] https://www.connectivityuk.org/wp-content/uploads/2022/09/The-Investment-Gap-to-Full-5G-Rollout.pdf

the value of sub-1 GHz spectrum in the UK. More generally, the existing evidence from spectrum auctions in the UK is consistent with a decline in the market value of spectrum.

3.3.1 Auctions are infrequent

In the UK, Ofcom has held spectrum auctions (for mobile spectrum) four times in the last 24 years. Ofcom plans to auction mmWave spectrum (which has significantly different properties to existing spectrum holdings) and some 1400 MHz spectrum in 2025. This means that historically, and going forward, there is a relative paucity of UK data against which to assess the market value of spectrum. However, the 2021 auction provides highly-relevant data for assessing the level of the 900 MHz ALF.

Table 3 Timeline of UK (mobile) spectrum auctions

Auction date	Status	Bands
27th April 2000	Complete	2100 MHz
1st March 2013	Complete	800 MHz and 2.6 GHz
13th April 2018	Complete	2.3 GHz and 3.4-3.6 GHz
27th April 2021	Complete	700 MHz and 3.6-3.8 GHz
Early 2025	Planned	26 GHz
2025	Planned	1400 MHz

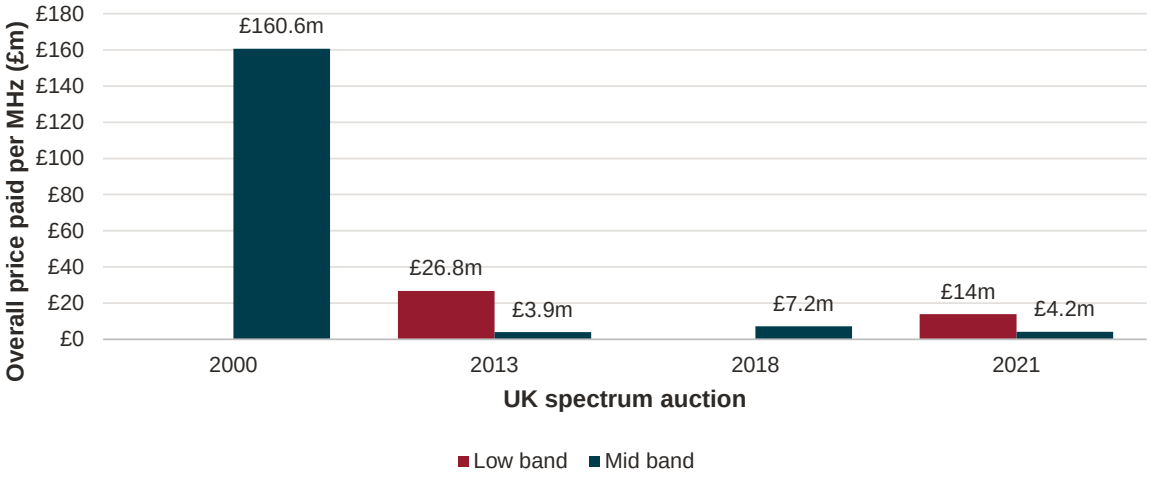
Source: Ofcom

3.3.2 Value of spectrum is decreasing over time

Where evidence is available on the value of spectrum, it tends to suggest that the market value of spectrum is decreasing over time. For example, Figure 12 below shows how the price paid per MHz of spectrum acquired at UK auctions has generally fallen over time. Specifically, the average price paid for mid-band spectrum has fallen very significantly compared to the 2000 auction, and also decreased in 2021 relative to 2018.[38] Meanwhile the average price paid at auction for low-band spectrum fell significantly in the 2021 auction, compared to 2013.

[38] While the value of mid-band spectrum rose between the 2013 auction of 2600 MHz spectrum and that of C-band spectrum, this may reflect the technological benefits of mMIMO in terms of spectral efficiency and propagation, which were not apparent in 2013.

Figure 12 Time series since 2000 of UK spectrum prices per MHz



Source: *Frontier Economics analysis of Ofcom and Telegeography data*

Note: *Nominal prices paid taken from Ofcom notices on auction results; conversion to £/MHz using data on purchased MHz from Telegeography. Low band means sub-1GHz and mid band means 1-6GHz. 2013 prices divided between low and mid band based on table 2.2 of the 2015 Statement. EE's payment of for low-band centre-gap frequencies and in-band position in 2021 is excluded. 2021 figures for mid-band are aligned with Ofcom's assessment of £/MHz paid for C-band in Table 4.1 of the 2021 Statement).*

This may also reflect a broader international trend. Analysys Mason estimated in 2022 that nominal MNO spending on 5G spectrum in Europe would be 10% less than that spent on 4G spectrum and 70% less than 3G spectrum.[39] The differential would likely be greater if spending was considered in real terms.

3.4 Conclusion

ALFs have been set on the implicit assumption that the real market value of spectrum, including the relative values of different spectrum bands, is stable over time. However, evidence suggests that this assumption may not hold in practice.

Changes in technology since ALFs (and the auction prices used to derive them) were determined suggest that both the overall value of spectrum and relativities between bands have changed. Commercial developments also point to the market value of spectrum having fallen since ALFs were set for the 900 MHz, 1800 MHz and 2100 MHz bands. As a result there is a risk that the current level of ALFs, which has risen significantly with inflation (see Section 4 below), exceeds or is close to exceeding the full market value of spectrum that ALFs were set to reflect.

[39] https://5gobservatory.eu/5g-spectrum-costs-in-europe-10-lower-than-4g/

Indeed, while data to estimate the actual market value of spectrum is scarce, the most relevant available data from recent UK auctions (700 MHz, 3400 MHz and 3600 MHz), demonstrates that the market value of spectrum is likely to have fallen.

4 Inflation

Under Ofcom's current approach, ALFs are increased by the rate of Consumer Price Index (CPI) inflation every year. Implicit in this indexation approach is an assumption that the market value of spectrum licences increases in line with inflation, i.e. is stable in real terms. In this Section we set out that:

- a series of external shocks have led to unexpected increases in inflation;
- ALFs have increased significantly in nominal terms as a result; and
- there is empirical and theoretical evidence that the current rate of inflation risks driving the level of ALFs above the true market value of spectrum.

4.1 Recent external shocks to inflation

Ofcom made its implicit assumption that the market value of spectrum is stable in real terms at a time where the overall rate of inflation was subdued, with annual rates of inflation close to the Bank of England's target rate of 2%. Ofcom's decision to index ALFs to CPI reflected that it did not foresee inflation greatly exceeding the Bank of England's 2% target.

> *"**We consider that 2% is a reasonable expectation as to long-term CPI inflation**. Figure A10.6 shows CPI inflation between June 1998 and June 2014. This shows that while CPI inflation more recently has been above 2%, it has not been consistently above this level over this period, having been below 2% prior to 2005. More recently, inflation has fallen to around 2% again, standing at 1.9% in the year to June 2014. The annual average CPI inflation between 1998 and 2013 was 2.2%. **While CPI inflation is unlikely to be constantly at 2%, we are not convinced that there is evidence that inflation will be consistently and significantly greater than 2% such that we should prefer a different inflation assumption**"*[40] *(emphasis added).*

However, inflation has turned out much higher than Ofcom was expecting due to external shocks, such as the war in Ukraine.[41] Since inflation has only fallen back to the 2% target, not to a very low or negative rate of inflation, recent increases in ALFs will not be offset in the future. Therefore, ALFs would likely end up being significantly higher, in nominal terms, than Ofcom had anticipated.[42]

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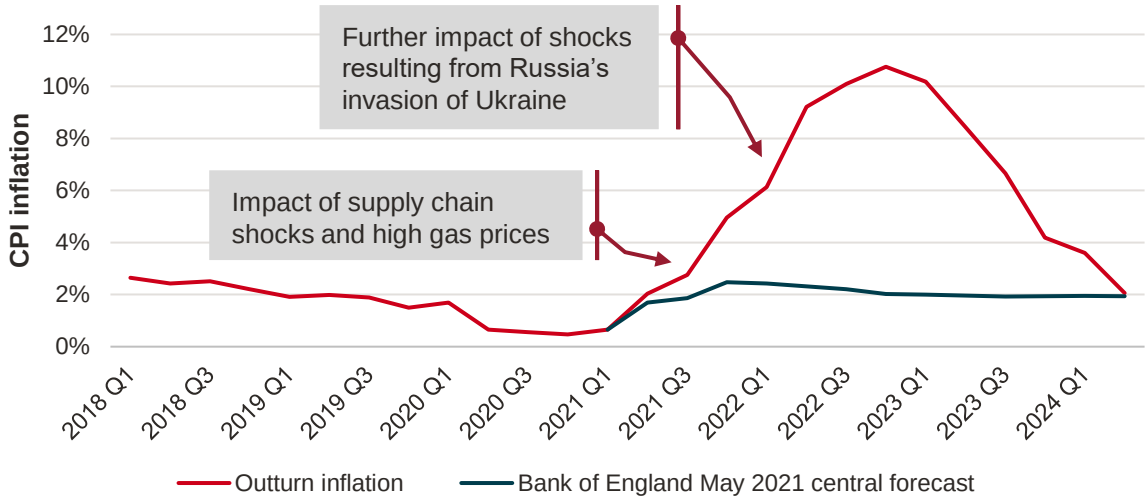
40 Ofcom Consultation: Annual licence fees for 900 MHz and 1800 MHz spectrum Further consultation, 1 August 2014, Annex 9, paragraph A10.53.

41 The Bank of England set out in 2022 that "[g]*lobal inflationary pressures have intensified sharply following Russia's invasion of Ukraine. This has led to a material deterioration in the outlook for world and UK growth. These developments have exacerbated greatly the combination of adverse supply shocks that the United Kingdom and other countries continue to face."* See: Monetary Policy Committee Monetary Policy Report May 2022. Bank of England, 2022, page 4.

42 All spectrum subject to ALFs is still in the early stages of 20-year licences, which are subject to extensions in any case.

Figure 13 Impact of external shocks on outturn inflation, relative to forecast



Source: *Frontier Economics analysis of ONS and Bank of England data*

Note: *Bank of England CPI inflation projections based on market interest rate expectations, other policy measures as announced. We note that the Bank of England's May 2021 Monetary Policy Report was the latest such report at the time that Ofcom first proposed the level of ALFs for paired 2100MHz spectrum in its July 2021 Consultation.*

4.2 Increases in the nominal level of ALFs

The recent high rates of CPI inflation mean that some ALFs have increased significantly (in nominal terms) compared to their baseline value determined by Ofcom, as shown in Table 4 below. If inflation had continued indefinitely at 2% per year as per Ofcom's broad expectation when setting ALFs, it would have taken until 2029-2030 for ALFs to reach their current levels.

Table 4 Evolution of total nominal cost of ALFs over time

Year	900 MHz	1800 MHz	2100 MHz
Baseline level	£76m (April 2018)	£115m (April 2018)	£67m (April 2021)
2019 cost	£78m	£119m	
2020 cost	£78m	£119m	
2021 cost	£81m	£123m	
2022 cost	£89m	£135m	£77m
2023 cost	£95m	£144m	£80m
Increase since first payment	**21%**	**21%**	**4%**
Increase from baseline level	**25%**	**25%**	**20%**

Source: *Frontier Economics analysis of 2018 Statement, 2021 Statement and ONS CPI data*

Note: Calculation of total cost (across MNOs) as per Table 1 above. Nominal level of ALFs is updated using CPI recorded in August each year for 900 MHz and 1800 MHz bands, and in November each year for the 2100 MHz band.

Under Ofcom's current approach to setting ALFs, operators bear all of the risk when inflation is different to forecast. In particular, if ALFs end up no longer reflecting the value of spectrum, this risk is borne by operators, unless ALFs are re-set by Ofcom. And while Ofcom has made a very small adjustment to ALFs to reflect this inflation risk,[43] its methodology is not robust to significant external shocks to inflation rather than more minor fluctuations due to monetary policy missing the targets.

There are two ways in which the current high rates of inflation create issues with Ofcom's approach towards setting ALFs.[44] First, and principally, recent economic shocks are likely to have reduced the real value of spectrum licences, meaning there is a risk that the value of future ALFs is driven above the market value of spectrum – in any case, the buffer created by any conservative decisions taken by Ofcom when determining the lump-sum value of spectrum for ALFs will have been eroded. Second, Ofcom's assumptions about long-term inflation and the extent to which MNOs should be compensated for inflation variability – important inputs for converting the lump-sum market value into ALFs – were too low. As a result, another interpretation is that MNOs were not appropriately compensated for inflation risk, again biassing ALFs upwards.

4.3 Evidence that inflation has outpaced growth in the value of spectrum

4.3.1 Economic theory suggests the value of operating assets is typically impaired by inflation driven by external shocks

There is economic literature showing that the real value of assets (or the real return on assets, which is what theory suggests economic agents use to form a view of real asset values)[45] is typically impaired by inflation driven by external shocks.

Our starting point for understanding the literature on the link between inflation and asset values is a paper by Danthine and Donaldson.[46] This paper sought to explain why real rates of return on assets tend to fall in light of rising inflation.[47] It provided the specific insight that, not only is the negative relationship between real asset returns (and hence the real asset value) and

43 A reduction in the discount rate by 10bps.

44 An alternative way of viewing the issue is that the real discount rate that Ofcom has used is now inappropriate, as Ofcom had assumed that CPI inflation would be 2% when setting the discount rate.

45 Inflation, Inflation Risks and Asset Returns. Corkish, J; and Miles, D. Bank of England Working Paper No. 27 (November, 1994).

46 Inflation and Asset Prices in an Exchange Economy. Danthine, JP; and Donaldson JB. Econometrica , May, 1986, Vol. 54, No. 3 (May, 1986), pp. 585-605.

47 See, for example: The Relation Between Stock Prices and Inflationary Expectations: The International Evidence. Solnik, B. Journal of Finance, 38 (1983), 35-65.

inflation negative, but this is particularly true in the case of non-monetary shocks – i.e. the types of shock that have led to recent levels of inflation in the UK.

> *"Thus it may be said that in this world stocks provide a perfect hedge against a purely monetary inflation.* ***They are no hedge at all, however, against temporary episodes of inflation of nonmonetary origin.***
>
> […] *Stocks, which represent ownership to real income streams generated by real assets, offer those who own them protection against purely nominal changes in the value of those underlying assets. They are, of course, no protection against changes in their real values"*[48] *(emphasis added).*

While this result was derived almost 30 years ago, it still applies today. More recently, a review of the theory of inflation, its sources and effects on asset prices in 2011 summarised that supply shocks reduce real rates of return on assets, and that this is reflected by the strong negative correlation between inflation and real and nominal stock prices.[49] It was also highlighted in this review that expected policy reactions to high rates of inflation can reduce economic activity, which would amplify the impairment of real asset values.

Similarly, a 2023 review of theoretical and empirical evidence of how inflation and investors' expectations of future inflation affect financial markets found that the body of evidence suggests that persistent, long-lived, shocks that increase inflation and stunt economic growth are costly.[50] Specifically, the authors pointed out that asset values fall when supply shocks drive up inflation.

Similarly, academic research from the Bank of England found the immediate impact of unexpected inflation on real returns of all assets is negative.[51] And even when high inflation has become sufficiently persistent to be considered 'anticipated', it continues to erode the real returns on the majority of assets.

4.3.2 The market value of operators' assets has fallen in real terms

Indeed, there is also current, real-world evidence that the real value of MNOs' assets – including their spectrum holdings – has fallen over recent years. Specifically, the share prices of MNOs that operate in the UK have clearly not kept up with recent inflation – see Figure 14, below. The evidence actually shows that operators' share prices have fallen in nominal terms, which means that they will have fallen even more in real terms.

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48 Inflation and Asset Prices in an Exchange Economy. Danthine, JP; and Donaldson JB. Econometrica , May, 1986, Vol. 54, No. 3 (May, 1986), pp. 585-605.

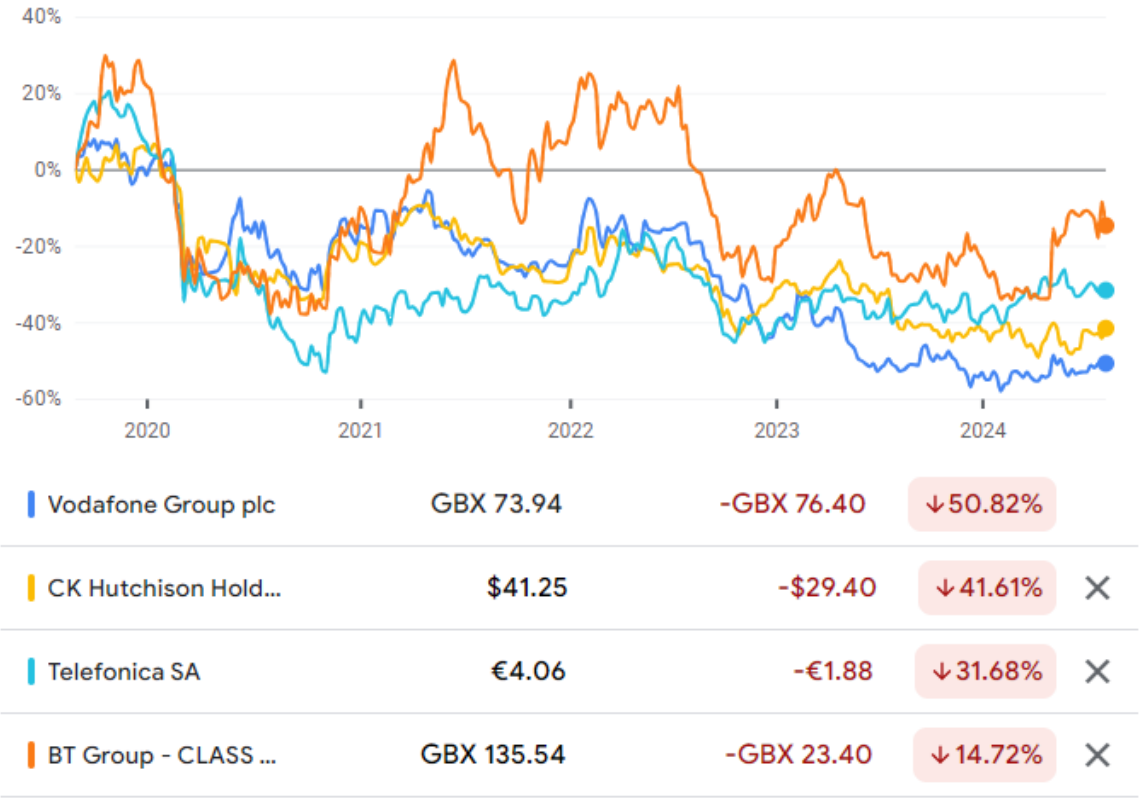
49 Inflation and asset prices. Tatum, J. Munich Personal RePEc Archive Paper No. 34606 (Nov, 2011).

50 Inflation And Asset Returns. Cieslak, A; and Pflueger, C. National Bureau of Economic Research Working Paper 30982 (March, 2023).

51 Inflation, Inflation Risks and Asset Returns. Corkish, J; and Miles, D. Bank of England Working Paper No. 27 (November, 1994).

This suggests that the value of MNOs' assets has not been stable in real terms. Share prices represent expectations of future cash flows to shareholders.[52] Therefore, the decline in share prices over recent years for all MNOs indicates a decrease in their expected profitability going forward. The decline in expected profitability of MNOs is inconsistent with the value of their assets remaining stable in real terms.

Figure 14 Evolution of MNOs' parent share prices in nominal terms over the last five years



Source: *Google Finance*

Note: *Share prices taken at the group level of MNOs meaning that they will also reflect investor confidence in the other relevant parts of MNOs' businesses, such as fixed broadband. Data accessed 20th August 2024.*

4.4 Conclusion

As a result of the exceptional recent levels of inflation caused by global supply-side shocks, nominal ALFs have increased significantly compared to their baseline levels determined by Ofcom. Evidence suggests that the market value of spectrum is unlikely to have grown at a similar rate to inflation (i.e. the value has fallen in real terms). Therefore ALFs may no longer reflect the true market value of spectrum.

[52] According to common theory, the price of a share equals the sum of all future cashflows discounted to its present value. See for example: Capital Equipment Analysis: The Required Rate of Profit. Management Science, 1956, vol.3, issue 1, 102-110. Myron J. Gordon and Eli Shapiro, 1956.

5 Recommendations

In light of the above, we consider the level of ALFs should be revised to better reflect the market value of spectrum, especially given the asymmetric risk that above-market-value ALFs may harm spectrum efficiency. Below, we set out three recommendations on how Ofcom could amend its ALF regime, to promote better outcomes in the mobile sector.

5.1 Align the 900 MHz ALF with the lump-sum value of 700 MHz spectrum

Ofcom auctioned spectrum in the 700 MHz band in 2021. Therefore, unlike when Ofcom set ALFs for 900 MHz in 2018, there is now relevant UK data on the market value of 900 MHz spectrum (as set out in Section 3.1, while then relatively recent 800 MHz auction prices were available in 2018, these would have included a technology premium over 900 MHz that no longer applies). MNOs paid on average about £14m/MHz for the 700 MHz spectrum,[53] which is considerably below the £19.8m/MHz lump-sum value for 900 MHz spectrum that Ofcom derived in its 2018 Statement (updating for inflation).[54]

The difference in apparent valuations of 700 MHz and 900 MHz spectrum is counterintuitive, given these bands are close substitutes in light of their similar propagation characteristics. If anything, 700 MHz spectrum should have a higher value for MNOs due to its further potential range of propagation.

Given this apparent divergence of the ALFs imposed on 900 MHz spectrum and the market value of this spectrum, we recommend that Ofcom adjust these ALFs to align with the market value of 700 MHz spectrum revealed at the 2021 auction. This would lower the level of ALFs and thus reduce the risk that ALFs lead to spectrum inefficiencies.

In keeping with Ofcom's approach of setting ALFs conservatively, when updating the prices paid for 700 MHz to account for inflation, Ofcom could use a notional estimate of long-run expected inflation of 2% per year, rather than actual CPI which has been distorted by external events uncorrelated with the market value of spectrum. Indexing the 700 MHz prices to outturn CPI may risk overstating the market value of this (and consequently 900 MHz) spectrum.

5.2 Align the level of 1800 MHz and 2100 MHz ALFs

There is also a difference in the current level of ALFs for 1800 MHz and 2100 MHz spectrum that is unlikely to reflect the actual relative market value of these bands. The latest ALF for the 1800 MHz band was almost 50% greater than the latest ALF for 2100 MHz spectrum (in terms

53 Frontier Economics analysis of Telegeography data

54 2018 Statement, paragraph 4.70 states that the lump-sum value of 700 MHz spectrum was £19m/MHz. Above, we have converted to April 2021 prices using CPI, given that ALFs currently assume the value of spectrum is constant in real terms.

of price per MHz).[55] Given these bands are close substitutes, there is no reason to have significantly different ALFs.

As set out in Sections 3 and 4, a number of market developments and recent inflationary shocks suggest that the current level of ALFs for these bands could exceed, or be close to exceeding, the market value of the relevant spectrum. Therefore, Ofcom should also consider whether reducing these ALFs would better achieve its objectives for setting ALFs, given the risk that above-market-value ALFs may result in inefficient use of spectrum. More generally, the basis of the lump-sum valuation of these bands underlying the ALFs may no longer be credible, as the relative values of low and mid-band spectrum have changed. In other words, ALFs based on the distance method (applied to auction data that is now more than a decade old) may no longer accurately reflect market value. A pragmatic and conservative solution, given the paucity of relevant UK and international auction data, may be to revise the current level of 1800 MHz ALFs down to the level of 2100 MHz ALFs.[56]

5.3 Provide clarity on the periodic review of ALFs

There is a perception that ALFs can systematically diverge from the market value of spectrum. Ofcom's current review of ALFs follows a broader review of the ALF regime in 2023 prompted by the government's Wireless Infrastructure Strategy (WIS). Given the cost of ALFs between 2022 and 2030 was projected to be around £3bn, the WIS called for Ofcom to assess how well ALFs had delivered their stated objectives to date and the extent to which they supported a strong investment environment.[57]

In Section 3 we set out how changes in technology and the commercial landscape can affect how MNOs use and value spectrum. Given recent market developments, there is indeed strong evidence that spectrum values are not likely to be stable over time, or to revert to some long-run average value to MNOs. And as set out in Section 4, high levels of recent inflation caused by external supply-side shocks to the economy are likely to have led nominal ALFs to grow faster than the underlying market value of spectrum.

In light of the above, Ofcom should consider setting out a more transparent and periodic process (either at fixed intervals, or based on clear 'trigger' events) for reviewing the level of ALFs. This would reduce the risk that ALFs drift above the market value of spectrum going forwards, and provide stakeholders with greater clarity and certainty over how the ALF regime may evolve over time. It may also reduce the administrative burden on Ofcom in the long run, compared to a more reactive regime.

55 See Table 1 above.

56 We note that the current level of 2100 MHz ALFs was set with reference to more recent auction data (via the distance method) than the 1800 MHz ALFs, and may therefore be consistent with a more up-to-date the value estimate for both bands.

57 https://www.gov.uk/government/publications/uk-wireless-infrastructure-strategy/uk-wireless-infrastructure-strategy