ANNUAL LICENCE FEE FOR 2100 MHZ SPECTRUM

A report for Vodafone

September 2021

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EXECUTIVE SUMMARY

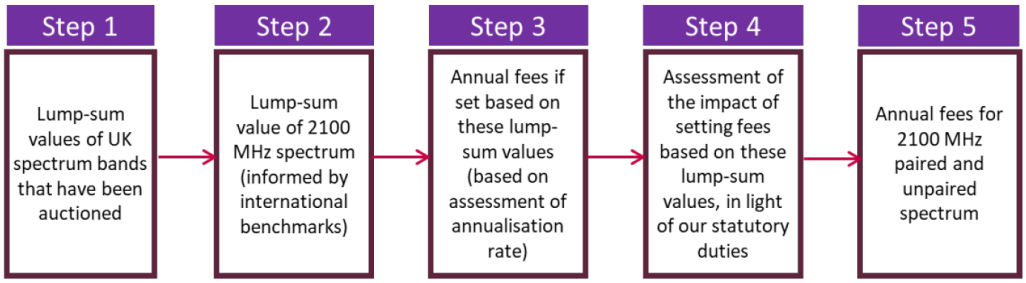
Ofcom has consulted on the appropriate Annual Licence Fee (ALF) to apply to 2100 MHz spectrum from 2021.

Given the lack of direct information on the market value of 2100 MHz spectrum in the UK, Ofcom has adapted the approach previously used to set the ALFs for 1800 MHz spectrum. More specifically, Ofcom uses:

- Estimated market values from UK auctions in other bands (700 MHz, 800 MHz, 2.3 GHz, 2.6 GHz, 3.4 GHz and 3.6 GHz);
- An interpolation (the 'distance method') to estimate the relationship between the prices for these bands and the 2100 MHz band, based on auction prices paid in other jurisdictions where a wider set of bands have been auctioned (including 2100 MHz), to estimate the UK lump sum market price for 2100 MHz;
- An annualisation approach to convert the lump sum value of the 2100 MHz spectrum into annual equivalents.

Ofcom also considers the likely impact of the proposed fees, in light of its statutory duties. Given the asymmetric risk in setting ALFs above or below the true market value, Ofcom aims to set a conservatively low value for the ALF in order to reduce the probability of over-estimation of the true market value of 2100 MHz spectrum.

Figure 1 Ofcom's overall framework for setting the 2100 MHz ALF



Source: Ofcom's 2100 MHz ALF consultation

The first step, to derive UK market values of spectrum auctions, introduces considerable uncertainty in the estimates:

- In the 8 years since the 2013 UK auction there have been significant developments in technology and the market, which mean Ofcom's approach of simply applying a price index to the estimated values at 2013 (which themselves were based on an unreliable de-composition of package bids in the auction) is unlikely to be a robust estimate of current market values;
- While the more recent 700 MHz and 3.4-3.8 GHz auctions are likely to better reflect current market values, the fact that the 3.4-3.8 GHz spectrum was auctioned in two separate auctions means the prices paid may have been affected by strategic bidding.

The 'distance method' used for the second step assumes that the relative valuations between spectrum bands are similar across European jurisdictions. Even when applied to setting the 1800 MHz spectrum the 'distance method'

showed a large degree of variation in relative valuations across the sample, calling into question the robustness of the method. As a result Ofcom set the valuation conservatively at the bottom of the range of values from the sample. The results of applying the distance method to estimate 2100 MHz lump sum valuations is even more uncertain. In particular:

- ***The approach is dependent on a very small sample*** of recent EU auctions of 2100 MHz spectrum which means that, at best, there is significant uncertainty on the correct level of the market value of 2100 MHz spectrum in the UK.
- ***In order to construct a larger data set, Ofcom has used data from auctions as far back as 2010.*** Using data spanning over a decade implicitly relies on the assumption that not only are relative valuations between bands similar across jurisdictions (which the data does not support), but also that relative valuations are stable over time. The approach does not take account of developments in the market which means that only the most recent auction data provides relevant information on the current relative valuations.
- ***Ofcom has given undue weight to the evidence from certain auctions***. We argue that benchmarks that rely on the 2015 and 2019 auctions in Germany and the 2021 auction in Slovenia are unlikely to be informative of the relative value of spectrum in the UK. In both cases auction-specific circumstances (discussed in the main body of the report) led to the auction prices of 2100 MHz spectrum exceeding the price of sub-1 GHz bands. This is counter-intuitive, as sub-1 GHz spectrum has better propagation characteristics, and is not consistent with the available evidence in the UK. Therefore, we recommend that these benchmarks should be classified as Tier 2.

For the remaining Tier 1 awards, the lower end for the range of lump sum value of 2100 MHz spectrum is **£7.4m per MHz**.

Ofcom's inputs to the annualisation of lump sum values for the third step relies on outdated information on the cost of debt and relies on a single data point for the asset beta, which is an outlier when compared to a broader range of evidence. We update the cost of debt using the latest available information (1.6% vs Ofcom's 1.94%) and use an asset beta based on a wider set of comparators reflective of the market as a whole (0.55 rather than 0.62). This leads to a reduction in the real post-tax discount rate from 0.2% to -0.1%, and corresponding reduction in the annualisation rate from 5.4% to c.**5.21%**.

Combining the updated lump-sum value of 2100 MHz paired spectrum and the updated annualisation rate produces an ALF of **£0.386m per MHz** at 2021 prices vs. Ofcom's estimated £0.567m (Figure 2). Given the reliance on a very small data set, there remains a significant risk that this value is above the true market value in the UK.

Figure 2 ALF per MHz, 2100 MHz paired spectrum

Scenario	Annualisation rate	Lump sum value, £ per MHz	ALF, £ per MHz
Ofcom's consultation	5.40%	10.5m	0.567m
Our recommendation	**5.21%**	**7.4m**	**0.386m**

Source: Frontier Economics

In relation to 2100 MHz unpaired spectrum, we note that Ofcom's approach is unlikely to be conservative. In the 2018 auction, Telefonica acquired 40 MHz of 2.3 GHz unpaired spectrum, and no bidder bid on less than 20 MHz. Generally, there is a consensus that larger blocks of TDD spectrum are more valuable than 5-10 MHz blocks (on per MHz basis). Ofcom should assess the contiguity premium associated with larger blocks and adjust Telefonica's bid accordingly.

The increased uncertainty in setting ALFs based solely on a benchmarking approach is likely to mean this approach becomes unsustainable in the future, for example when setting ALFs for other bands or when updating the ALFs for 900/1800 MHz:

- There may be no recent UK-specific benchmarks - Currently Ofcom uses a small number of recent UK-specific auctions as inputs. However, there may be few if any new auctions in the low/ mid bands in the UK in the next few years[1]. Ofcom accepts that older benchmarks are not relevant (for example completely discounting the UK 2100 MHz auction in 2000) due to market developments and as such the sample of relevant benchmarks will shrink over time.
- Similarly, the number of recent international benchmarks which pair the spectrum for which ALFs need to be set and a band for which there has been a recent UK auction is likely to decline over time. For example, in the 2100 MHz ALF consultation, Ofcom combines information from auctions in 2020 and 2021 with observations from 2010 in the same jurisdiction, which means some of the relativity is like to reflect changes in valuation over time.

Basing ALFs solely on the methodology used to set the 900/1800 ALF is likely to become unsustainable. In light of that, Ofcom may need to re-think its approach to setting ALFs in the future, for example, supplementing auction information with 'bottom up' modelling, taking into account recent technological and market developments. In particular, it is important to recognise that bands with similar propagation characteristics are becoming closer substitutes (as technology-specific premia get eroded), which in turn should translate into similar ALFs for bands with similar characteristics.

[1] Except potentially the 1492-1517MHz band, which Ofcom wants to make available for future wireless broadband services by December 2022

1 INTRODUCTION

The 2100 MHz spectrum band was initially auctioned in April 2000 for deployment of 3G mobile networks. This spectrum band included both paired and unpaired spectrum – 2x69.5 MHz and 1x20.5 MHz respectively. The licences were initially granted for a period of 20 years. In 2011, Ofcom varied these licences making them indefinite, but also requiring the payment of annual licence fees ("ALF") from 1 January 2022.

On 14 July 2021, Ofcom published a consultation setting out its proposed methodology and estimating the ALFs both for paired and unpaired 2100 MHz spectrum ("the Consultation").

Vodafone has commissioned Frontier Economics to review the consultation and to identify any potential issues with Ofcom's methodology and its application.

In the rest of this section, we set out in more detail Ofcom's rationale for setting ALFs, its approach to setting ALF for mobile spectrum and the application of the methodology to the 2100 MHz spectrum.

1.1 Ofcom's rationale for setting ALFs

Ofcom's spectrum pricing policy is set out in its Strategic Review of Spectrum Pricing ("SRSP"). Ofcom is obliged to ensure that spectrum is used efficiently, i.e. "*in a way that maximises the value that citizens and consumers derive from it, including broader social benefits*".[2]

More specifically, Ofcom considers that if there is excess demand for any particular spectrum band, spectrum fees for that band should reflect the market value of the spectrum (based on its opportunity cost). The opportunity cost is defined as the value of the spectrum to the next highest value use (or user) that is denied access to the spectrum.

Ofcom states:

"*benefits to society will be maximised over time if spectrum is priced to reflect opportunity cost. The opportunity cost is the price that would emerge in a well functioning market and reflects the value of spectrum to the best alternative use or user that is denied access to it*."

Ofcom wants to incentivise spectrum users who do not have the highest value to relinquish this spectrum/ to sell it to the higher-value users:

"*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 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*".

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

[2] SRSP: The revised Framework for Spectrum Pricing, Consultation 29 March 2010, paragraph 1.7

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 opportunity cost would provide a further incentive, i.e. that it would incentivise the existing users to relinquish their spectrum if there are other users who value that spectrum more highly.

1.2 Ofcom's approach to setting ALF

In order to set ALFs for any band for which there is likely to be excess demand but which is not auctioned, Ofcom needs to come to a view on the opportunity cost of that spectrum bands. Ofcom used different approaches for different spectrum bands over the years:

- **Technical Modelling**. Initially 900/1800 MHz spectrum fees were set by Oftel and later by Ofcom based on technical modelling. This was initially based on the Smith Nera STU (Spectrum Tariff Unit) which involved "*calculating reference rates based only on "own-use" opportunity cost*".[3] Subsequently this method was extended to include as well the opportunity cost of feasible alternative use.
- **Direct evidence of market values** where similar bands have been auctioned in the UK. For example, the ALF for the 3.4 GHz - 3.8 GHz spectrum was set based on the price paid for the 3.4 GHz spectrum in the UK in 2018.
- **A combination of UK auction results and international benchmarks**. In cases where the spectrum for which Ofcom wanted to set an ALF has not been recently auctioned in the UK, Ofcom used the UK-specific auction prices for other spectrum bands and adjusted those using international benchmarks to come to a view on the market value of the spectrum under consideration.

Ofcom previously used the latter approach to set ALFs for the 900 MHz and 1800 MHz spectrum bands. For the 900 MHz band, Ofcom used a combination of the auction price of the 800 MHz band in the UK and relative valuations of 800 MHz and 900 MHz from countries where both the 800 MHz and 900 MHz spectrum bands were auctioned.

A similar approach was used to set the ALF for the 1800 MHz band. However, for the 1800 MHz band, Ofcom used a weighted average of the UK auction prices of the 800 MHz and 2.6 GHz bands, with the weights being informed by international benchmarks. Ofcom referred to this approach as a 'distance method'.

1.3 2100 MHz consultation

The 2100 MHz spectrum was previously auctioned in the UK in 2000. Ofcom considers that it would not be appropriate to use the 2000 price to inform a forward-looking assessment of the market value of this spectrum given the significant market developments since 2000. Discounting the 2000 valuation appears

[3] Ofcom SRSP: The revised Framework for Spectrum Pricing, December 2010 at paragraph 5.93

reasonable given the overwhelming evidence that the prices paid in 2000 do not reflect the current market valuations of the spectrum.

Ofcom proposes to use the same approach for 2100 MHz as it used to set the ALFs for the 900 MHz and 1800 MHz bands, i.e. a combination of the UK evidence on market values and international benchmarks. However, Ofcom extends the number of bands used to calculate the 2100 MHz ALF. While for the 900 MHz/ 1800 MHz ALFs, Ofcom only used the prices of 800 MHz and 2.6 GHz bands, for the 2100 MHz ALF Ofcom also uses the UK-specific auction prices for the 700 MHz, 2300 MHz, 3.4 GHz and 3.6GHz spectrum bands. These spectrum bands were sold in the UK recently, between 2018 and 2021. As a result, Ofcom is able to apply the distance method to several combinations of spectrum bands as follows:

- 700 MHz and 2.3 GHz;
- 700 MHz and 2.6 GHz;
- 700 MHz and 3.4 GHz;
- 700 MHz and 3.6 GHz;
- 800 MHz and 2.6 GHz;
- 800 MHz and 3.4 GHz; and
- 800 MHz and 3.6 GHz.

Ofcom considers the relative benchmarks from each of these combinations "*on their merits*". Ofcom states:

"*We do not consider there are strong a priori reasons to believe that a particular distance method would be more informative of the forward-looking market value of UK paired 2100 MHz spectrum than another*."[4]

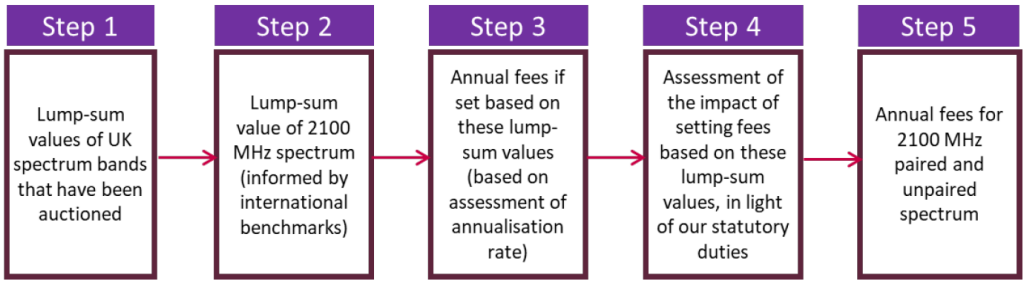
Ofcom's overall approach to setting ALF for 2100 MHz spectrum is set out in Figure 3 below:

- Using the UK-specific auction prices (Step 1) and relevant international benchmarks, Ofcom estimates the lump-sum value of the 2100 MHz spectrum (Step 2);
- Ofcom then converts the lump-sum values into equivalent annual rates by applying an annualisation rate (Step 3);
- Ofcom then considers the likely impact of the proposed fees, in light of its statutory duties (Step 4).

This assessment then leads to Ofcom's ALF proposals for the 2100 MHz spectrum.

[4] Ofcom 2100 MHz consultation, para 4.16

Figure 3 Ofcom's overall framework for setting the 2100 MHz ALF



Source: Ofcom's 2100 MHz ALF consultation

When assessing the evidence, Ofcom aims to "*take a conservative approach to interpreting the evidence to reflect the asymmetry of risk as between the effects on spectrum efficiency from inadvertently setting ALFs either above or below market value, given the uncertainty about the correct estimates for market value*".[5] Indeed, if the ALF is set too high, the spectrum will be left unutilised. On the other hand, if the ALF is set too low, it might impact efficiency in some scenarios, but the loss in efficiency is likely to be significantly smaller than in a scenario where the spectrum is not used at all. In light of that, it is important that the ALF is set conservatively.

Using the framework set out above and applying its regulatory judgement, Ofcom states that:

- The lump sum value of 2100 MHz spectrum is likely to be £10.5m per MHz of paired spectrum and £5.4m per MHz of unpaired spectrum; and
- The annualisation rate is estimated to be 5.4%.

As a result, Ofcom proposes to set the ALFs at **£0.567m** per MHz of 2100 MHz paired spectrum and at **£0.290m** per MHz of 2100 MHz unpaired spectrum.

For 2100 MHz unpaired spectrum, Ofcom proposes to use the auction price from the 2018 UK auction for 2.3 GHz unpaired spectrum.

The remainder of the report is structured as follows:

- Section 2 – We discuss the latest technological and market developments that are likely to impact the forward-looking value of spectrum and its relationship with historical information on market values
- Section 3 – We review and amend Ofcom's approach to calculating the lump-sum value of 2100 MHz spectrum
- Section 4 – We review and amend Ofcom's approach to annualisation
- Section 5 – We present the amended ALF for 2100 MHz
- Section 6 – We discuss issues that need to be considered when Ofcom updates the ALFs for 900/1800 MHz spectrum or sets ALFs for other spectrum bands.

[5] Ofcom 2100 MHz consultation, footnote 26

2 MARKET DEVELOPMENTS

In this section we provide a brief review of the latest technological developments that are expected to affect the forward-looking value of mobile spectrum bands, including the value of the 2100 MHz band and the relationship between this forward looking value and historical market valuations.

This understanding is critical when Ofcom is setting forward looking values based on historical empirical evidence. For example, as noted above, Ofcom has given no weight to the prices paid for the 2100 MHz spectrum in 2000, even though this is the only direct observation of UK market values for this band.[6]

This suggests that there must be a continuum between the most recent auction information having highest weight and a point in the past at which evidence from auction should be given no weight, with auction evidence between these points being given higher weight the more recent it is. The judgement on where the cut off applies needs to reflect the market and technology developments over time.

2.1 Technology is increasing band agnostic

Both 2G and 3G technologies were standardised on specific bands: 900 MHz/ 1800 MHz and 2100 MHz respectively in Europe. 4G was initially launched on a limited number of bands (800 MHz/ 1800 MHz/ 2600 MHz).

This meant that when spectrum was auctioned for a new generation of technology it attracted a premium related to the ability to launch services using this new technology, as existing spectrum could not be used, was required to deliver services for existing technology or was insufficient to support a full national roll out. This premium, however, gets eroded over time, as other bands get standardised for the latest technology and the specific technology is superseded by superior technology.[7] For example 800 MHz spectrum auctions in 2013 attracted a significant premium above the valuation of adjacent 900 MHz spectrum (as recognized in the ALF for 900 MHz spectrum) as operators, in particular Vodafone and O2, could not launch 4G services without acquiring additional spectrum. However, many other bands including 900 MHz are now also widely usable in the 4G device ecosystem and therefore the initial premium in the value of 800 MHz spectrum has largely disappeared.

Devices and base stations can now use a wide range of bands for 4G services allowing refarming of spectrum from previous generations. 5G follows the same pattern: while the roll out focussed on ‘pioneer bands’ not previously used for previous generations (700 MHz / 3.4-3.6 GHz), some operators have launched service in bands refarmed from other technologies, including 900 MHz, with 4G and 5G co-existing in a single band with dynamic spectrum sharing. Ofcom has also moved to allow legacy spectrum bands to be re-used for 4G/5G.

[6] Similarly in its recent Proposal to apply Administered Incentive Pricing for the 412–414 MHz, paired with 422–424 MHz, frequency bands, Ofcom completely discounted the price paid for the spectrum in 2006.

[7] For example the premium attached to 2100 MHz due to it being the spectrum licenced for 3G technology was largely eroded when 4G technology became commonplace.

Furthermore, there is an increasingly rapid decline in legacy technologies (2G/3G) which means that, except for the minimum required to support legacy uses which cannot be easily switched, most bands will be available for 4G and 5G usage in the near future.

This increased fungibility means, the value of the spectrum to operators will increasing be a function of the physical characteristics of the spectrum rather than the specific technologies:

- Propagation characteristics;
- Viability of higher order MIMO;
- TDD vs FDD.

Therefore, bands with similar frequencies and structure (e.g. TDD/FDD) will be expected to have increasingly similar market values.

Propagation characteristics

In the past spectrum bands with similar propagation characteristics often commanded different prices reflecting technology constraints. For example, in its 900/1800 MHz ALF statement, Ofcom established that, based on the evidence available at that time, the value of 900 MHz spectrum was on average 54% of the value of 800 MHz band, despite the fact that both bands had similar propagation characteristics. The premium paid for 800 MHz spectrum was largely driven by its being the only sub-1 GHz band that could be used to deploy 4G at the time.

However, the technology-specific premia, which were paid initially, are likely to disappear over time, as operators are now able to deploy 5G using all three sub-1 GHz bands (700 MHz, 800 MHz and 900 MHz) and also to share spectrum dynamically between 4G and 5G. This is expected to lead to a convergence in the values of sub-1 GHz bands, with the value being primarily driven by propagation characteristics.

Massive MIMO

Massive MIMO technology offers a significant increase in spectral efficiency compared to lower order MIMO technologies. However, mMIMO is only practical for higher frequency spectrum (>3 GHz). Beam forming will also provide increases in coverage for this higher frequency spectrum meaning that this higher frequency spectrum will be a better substitute for other spectrum bands, such as 1800 MHz, while also reducing the capacity constraints due to much higher spectral efficiency.

This will have increased the value of higher frequency spectrum while reducing the value of spectrum below 3 GHz.

FDD vs TDD

The potential for using unpaired TDD spectrum rather than paired FDD spectrum has been known for a considerable length of time with the 2000 ‘3G’ auction including a small element of TDD spectrum in addition to FDD spectrum. However, the utility of this spectrum was limited because of limited device/standards support with TDD spectrum remaining unused and attracting low valuations in auction.

3GPP release 12 supported carrier aggregation between TDD and FDD carriers which has increased the utility of TDD spectrum. TDD spectrum also allows greater flexibility in uplink/ downlink ratio allowing better matching with consumer data usage (which is predominantly downlink) than FDD spectrum, which implies a 50:50 split.

The ability to use TDD spectrum to effectively deliver incremental capacity could serve to reduce the value of FDD spectrum bands, including the value of 2100 MHz FDD spectrum.

Therefore, it is expected that going forward the propagation characteristics and spectrum structure (TDD/ FDD) will be the key drivers of spectrum value, rather than specific technologies, which could be deployed using these bands.

2.2 Relative values of low- and mid-band have changed

Low band spectrum was considered the most valuable spectrum because of its better propagation characteristics, allowing greater coverage from a given base station than equivalent mid-band spectrum. However, the advantages of low band spectrum have reduced over time:

- Traffic volumes have increased exponentially, requiring more capacity in populated areas than can be served by low frequency spectrum alone;
- Peak download speed has become a key differentiator for operators with the relatively limited bandwidth offered by low frequency spectrum offering uncompetitive speeds;
- Operators have increased the number of base stations in their network grid, meaning the proportion of geographic area/traffic served only by low frequency spectrum has declined;
- Wifi offload of both data and calls means that the importance of the benefits of low frequency spectrum for in-building coverage has declined; and
- Physical constraints on antenna size mean that low frequency spectrum cannot be used for massive MIMO and hence is less spectrally efficient than mid band spectrum.

This means that that the relative values of low and mid-band spectrum are likely to have changed over time, with the premium attached to the sub-1 GHz band diminishing.

In light of the above, it is important that historical observations of the relativities between different bands are used with caution.

2.3 Historical observations need to be used with caution

In Section 3, we discuss the evidence used by Ofcom in the 2100 MHz consultation. We observe that the number of observations (benchmarks) is small and moreover some of these observations go back to 2010. This is despite clear

evidence that the market value of spectrum can change significantly over time in response to new information and new technological developments set out above. This evidence includes:

- The much lower prices paid for low frequency spectrum in the 2021 UK Auction than in the 2013 Auction UK with Ofcom estimating the price per MHz at April 2021 being £14.1m and £37.0m respectively;[8]
- The relatively high prices paid for higher frequency TDD spectrum in recent auctions with prices per MHz at April 2021 between £4.2m and £7.9m[9] compared to a price for 2.6 MHz TDD spectrum in the 2013 Auction of £1.2m per MHz.[10]

These significant changes in value for similar spectrum over the last decade show that an assumption that relative values of spectrum bands are largely stable over time is not supported by the evidence.

It is critical that Ofcom recognise that the historical evidence might not provide a reliable measure of either the absolute or relative forward-looking value of spectrum and should attach a higher weight to more recent observations. Where this results in Ofcom relying on a limited sample of data, Ofcom should take account of the limited data in setting the resulting estimates conservatively.

8 Consultation Table 4.1

9 ibid

10 2015 Annual licence fees for 900 MHz and 1800 MHz spectrum Provisional decision and further consultation Table A6.25

3 REVIEW OF EVIDENCE USED BY OFCOM TO SET LUMP SUM VALUES

In this section, we review Ofcom's approach to calculating the lump sum value of the 2100 MHz spectrum. First, we comment on Ofcom's use of the UK specific auction prices. We then review the international benchmarks used by Ofcom and recommend modifications to its classification of the benchmarks into different tiers. In light of these changes, we estimate that the lump sum value of the 2100 MHz paired spectrum is c. £7.4m per MHz.

3.1 UK Auctions

As set out in Section 1.3 above, Ofcom derives the lump sum value of the 2100 MHz spectrum based on seven combinations of low and high frequency prices paid in the UK, using the distance method which is informed by the international benchmarks. Ofcom assesses these combinations "*based on their merits*", but without paying particular attention to the timing of the awards. For example, Ofcom attaches the same weight to the lump sum values, which were calculated based on the prices of 800 MHz and 2.6 GHz prices paid in 2013, as to the lump sum values calculated based on the prices of 700 MHz and 3.6 GHz spectrum paid in 2021.

As discussed in Section 2 above, it would be more appropriate to attach a greater weight to the more recent observations, i.e. to the estimates based on the 700 MHz and 3.6 GHz auction prices.

The 700 MHz prices are likely to be a reasonable estimate of the forward looking valuation of the spectrum with the relatively low valuation compared to the 800 MHz award reflecting the increased supply and fungibility of sub-1 GHz spectrum.

The prices for the two awards of 3.4 GHz to 3.8 GHz spectrum may have been influenced to an extent by strategic bidding given complexity on bidding on sequential auctions. However, it is unclear whether the resulting prices are likely to over- or under-estimate market values.

The prices paid for 800 MHz and 2.6 GHz spectrum in 2013 are unlikely to be informative of the current forward-looking value of these bands, given the trend for convergence in values of sub-1GHz spectrum. Furthermore, Frontier previously identified issues with Ofcom's approach to estimating the prices of 800 MHz and 2.6 GHz from the package bids.[11] This provides an additional rationale for disregarding/ attaching a lower weight to these prices.

However, we do recognise that in its analysis Ofcom is also limited by the availability of international benchmarks. Indeed, there is only a small number of countries where the 2100 MHz band was auctioned recently as well as the 700 MHz and the 3.4-3.8 GHz bands[12]. While Ofcom's inclusion of a wider set of benchmarks may give the illusion of a richer data set, the increased number of

[11] https://www.ofcom.org.uk/__data/assets/pdf_file/0023/62357/vodafone_annex_2.pdf

[12] Ofcom has identified 5 countries: Germany, Austria, Hungary, Slovenia and Greece. Out of these 5 countries, all, but Greece are treated as Tier 1 countries.

observations may not significantly increase the robustness of the results given the reliance on historical information which is unlikely to be reflective of current forward looking values. In particular in other jurisdictions the 800 MHz and 2.6 GHz spectrum was also auctioned in the early part of last decade and as a result is unlikely to be a robust estimate of current market values in those jurisdictions for the reasons set out in Chapter 2.

Ofcom's approach in the consultation to 'mixing and matching' spectrum prices from different time periods, with no consideration given to how recent each auction is, may actually decrease the accuracy of results because there have been movements in relative values over time.

3.2 International awards

3.2.1 Ofcom's approach to assessment of international awards

Ofcom considered a number of countries where 2100MHz spectrum was auctioned recently, as well as low frequency spectrum (700 MHz and 800 MHz) and mid-band spectrum (2.3 GHz, 2.6 GHz, 3.4 GHz and 3.6 GHz). These countries include Germany, Austria, Hungary, Slovenia, the Netherlands, Iceland, Croatia and Greece.

For the Netherlands and Croatia, there were 2100 MHz and sub-1 GHz benchmarks available, but no relevant high frequency benchmarks. In order to be able to use the available evidence from these countries, Ofcom has derived proxies for the value of high frequency bands using evidence about the relative prices from other countries. Again, this approach gives the appearance of a richer data set but does not increase the number of independent observations to use as inputs to the distance method.

Ofcom then reviews information on each auction and decides whether to classify these auctions as Tier 1, Tier 2 or Tier 3. Ofcom states:

"These categorisations reflect how informative of relative UK market values we consider the benchmarks to be, with Tier 1 most informative and Tier 3 least. Our criteria for placing a relative benchmark in Tier 1 are that:

a) *the auction prices appear likely to have been primarily determined by a market-driven process of bidding in the auctions (generally this means the prices were not set by reserve prices);*
b) *based on the evidence available to us, the relative prices in the auction are at least as likely to be based on bidders' intrinsic valuations of spectrum as on strategic bidding; and*
c) *the outcome appears likely to be informative of forward-looking relative spectrum values in the UK, having regard to country-specific circumstances and auction dates."*[13]

Ofcom classifies the awards in Germany, Austria, Hungary, Slovenia and Netherlands as Tier 1 countries, and Greece, Iceland and Croatia as Tier 3 countries.

[13] Ofcom Consultation, para 4.22-4.23

3.2.2 Our assessment of Ofcom's classification of auctions

We agree with Ofcom's classification of the awards in Greece, Iceland and Croatia as Tier 3.

However, on the Tier 1 awards, we disagree with Ofcom's assessment that distance method benchmarks using the German 700 MHz in 2015 and the multiband award in Slovenia in 2021 should be classified as Tier 1.

In these cases, the UK equivalent price per MHz for 2.1 GHz spectrum is greater than the UK equivalent price per MHz of 700 MHz spectrum. This is counter-intuitive, given relative propagation characteristics of the two bands, and indicative of issues in the underlying data. If these benchmarks are used in the distance method the result is that the method **extrapolates** the value of 2.1 GHz spectrum from the UK auction benchmarks for 700 MHz and 3.4-3.8 GHz spectrum rather than interpolating a value between these benchmarks as initially assumed when the distance method was proposed.[14]

For both of these cases, we have identified country-specific circumstances which suggest that the distance method benchmarks are unlikely to be informative of the relative spectrum values in the UK.

- **Germany.** The market structure and hence competition for spectrum in Germany has changed significantly in the period between the 2010 and 2019 auctions. In particular, in the 2015 auction there were three bidders, leading to an obvious focal point of symmetric holdings in the 700 MHz band. All other auctions took place with four bidders, and hence significantly more competition in the 2010 and 2019 auctions. As a result, distance method benchmarks that are calculated by comparing the relative value of 2.1 GHz spectrum auctioned in 2019 to the value of 700 MHz spectrum auctioned in 2015 are likely to be driven by changes in market structure in Germany that took place between 2015 and 2019 and are not informative of the relative value of spectrum in the UK.
- **Slovenia.** The coverage obligations, and eligibility and switching rules imposed by the Slovenian regulator means that there is significant uncertainty as to whether the outcome reflected market values. It is possible that the eligibility and switching rules led to the value of the 2.1 GHz band becoming over-inflated relative to the value of the 700 MHz band. The value of 700 MHz spectrum was also affected by strict coverage obligations imposed on this band which would reduce the value of the band to the smallest bidder. As a result, the 2.1 GHz and 700 MHz auction prices in Slovenia are unlikely to be informative of the relative spectrum values in the UK.

Given these issues, we consider that there is strong evidence for placing these benchmarks in Tier 2, as they do not meet the criteria that "*the outcome appears likely to be informative of forward-looking relative spectrum values in the UK"*.

We discuss both these auctions in more detail below.

[14] https://www.ofcom.org.uk/__data/assets/pdf_file/0024/80781/ee_annex_analysis_mason_aetha_report.pdf

Germany

Ofcom calculates six distance method benchmarks using the German 2010, 2015 and 2019 auctions.

Below we set out in more detail the (i) market context in Germany, (ii) the factors driving the outcomes in the three auctions (in 2010, 2015 and 2019) and (iii) the implications for German distance method benchmarks.

Market context

The market structure in the German mobile market has changed significantly between 2010 and 2020.

In 2010, there were four operators in the market: Deutsche Telecom, Vodafone, Telefonica and e-Plus. Deutsche Telecom and Vodafone were the two largest operators. However, spectrum was split relatively evenly with the fourth operator (E-Plus) having similar spectrum holdings to the other three operators ahead of the 2010 auction[15].

In 2014, Telefonica (the third largest operator in the market) acquired e-Plus creating a new market leader. As a condition for regulatory approval of the deal, the combined entity was required to enter into an MVNO agreement that allowed the remedy taker (Drillisch) to lease 20% of Telefonica's network capacity (with an option for a further 10%).

In January 2019, Drillisch applied to take part in the upcoming 5G spectrum auction. It acquired spectrum in the 2.1 GHz band (available from January 2026) and 3.4-3.8 GHz frequencies (available from January 2021). It stated that it had "laid the foundation for a successful and permanent positioning of the 1&1 Drillisch Group as Germany's fourth mobile network provider".[16] Later in the same year, it exercised one of two possible extensions of its agreement with Telefonica, allowing it to lease two frequency blocks of 10MHz each in the 2.6GHz band until December 2025.[17]

The 2010 800 MHz and 2.6 GHz auction

In the 2010 multi-band auction in Germany, 800 MHz and 2.6 GHz spectrum bands were allocated alongside other frequencies. As noted above, all four operators participated in the auction and entered the auction with relatively similar spectrum holdings.

In relation to the 2.6 GHz band, Ofcom has previously stated that "*we considered that the price of 2.6 GHz may understate market value in Germany*" due to the fact that "*[p]aired 2.6 GHz spectrum would normally be expected to sell for more than unpaired spectrum, whereas they sold at approximately the same average price in Germany*" due to "*'parking strategies', where bids are placed on relatively cheap*

[15] Ofcom, Annual Licence Fees for 900 MHz and 1800 MHz frequency bands, October 2013, https://www.ofcom.org.uk/__data/assets/pdf_file/0023/57326/900-1800-fees.pdf, Annex 7.

[16] https://www.united-internet.de/en/investor-relations/publications/announcements/announcements-detail/news/ad-hoc-disclosure-acc-to-art-17-mar-united-internet-group-subsidiary-11-drillisch-acquires-frequ.html

[17] Telegeography

lots so as to maintain eligibility and hence flexibility to bid on high-value lots later during the auction".[18]

In relation to the 800 MHz band, Ofcom previously considered that this may overstate the forward looking value of 800 MHz spectrum as it took place before WRC-12, i.e. operators were not yet aware that 700 MHz spectrum would be released in the medium term.[19]

The 2015 700 MHz auction

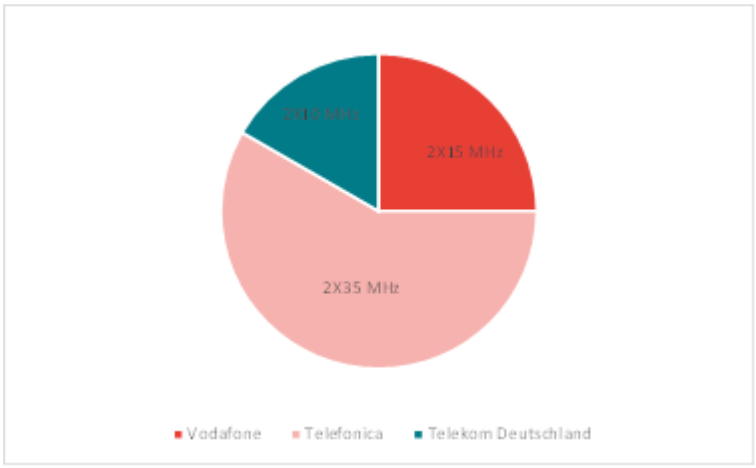
In 2015, 700 MHz spectrum was auctioned alongside other frequencies. Following the merger between E-plus and Telefonica, and with no entrant bidding, there were only 3 participants in the auction (Vodafone, DT and Telefonica). With 2x30 MHz of 700 MHz spectrum in total, each operator acquired 2x10 MHz - a natural focal point in a 3-player market – though there was competitive bidding for the band in the latter part of the auction.

The 2019 2.1 GHz and 3.4-3.8 GHz auction

The 2019 auction was characterised by aggressive bidding driven by the entry of Drillisch in addition to the 3 incumbents, as well as a limited supply of spectrum in the 3.4-3.8 GHz band[20]. The overall auction proceeds in the 2019 auction in Germany were c. €6.6 bn - significantly exceeding expert forecasts of €3 - 5 bn[21].

In the 2100 MHz band, prior to the 2019 award and Drillisch's entry to the market, the 2100 MHz spectrum band was split between the three incumbents – DT, Vodafone and Telefonica (Figure 4). Telefonica had more spectrum than the other two operators due to its merger with E-Plus in 2014.

Figure 4 2100 MHz spectrum holdings in Germany prior to the 2019 auction



Source: Telegeography

In order to roll out its own national network, Drillisch would have presumably preferred sub-1 GHz spectrum. However, by 2019, all sub-1 GHz spectrum had

[18] Ofcom, Annual Licence Fees for 900 MHz and 1800 MHz frequency bands, August 2015, https://www.ofcom.org.uk/__data/assets/pdf_file/0032/78629/annex_8.pdf, Annex 8, para A8.315-316

[19] Ibid. Annex 8, para A8.360

[20] The regulator reserved 100 MHz of 3.4-3.8 GHz spectrum for industrial users.

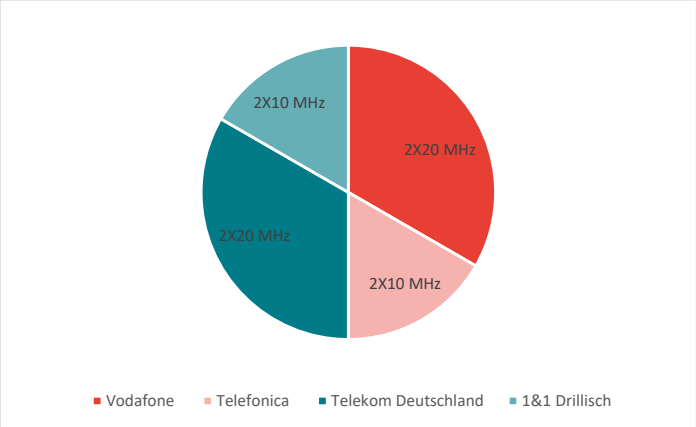
[21] FT: Germany raises €6.6bn in hard-fought 5G spectrum auction, https://www.ft.com/content/c6a6a47c-8d44-11e9-a1c1-51bf8f989972

already been allocated in Germany. [22] Therefore, Drillisch needed to acquire at least 2x10 MHz of 2100 MHz to have the ability to roll out its own network. Drillisch also needed 3.4 GHz spectrum in order to roll out 5G. As a result, Drillisch had a particularly high private valuation for both bands, which led to an intense competition in the auction.

The final allocation of 2.1 GHz spectrum is set out in Figure 5. The spectrum was split into eight 2x5 MHz blocks that were available from January 2021 and four 2x5 MHz blocks that were available from January 2026. Although initially Drillisch bid for 2100 MHz spectrum available from 2021 as well as 2026 (2x10 MHz in both periods), it eventually settled on 2x10 MHz available from 2026.[23]

DT and Vodafone also bid strongly for 2100 MHz spectrum and acquired incremental spectrum - over and above their previous allocation (Figure 5).

Figure 5 2100 MHz spectrum allocation in Germany post-2025



Source: Telegeography

There was also intense competition for the 3.4-3.8 GHz spectrum. This was caused by a combination of:

- Drillisch bidding aggressively to acquire spectrum; and
- a limited supply of spectrum due to BNetZa setting aside 100 MHz of 3.4-3.8 GHz spectrum for industrial users, which limited the amount of spectrum available to mobile operators to 300 MHz (compared to 390 MHz in the UK).

It is also noteworthy that competition for the limited supply of 3.4-3.8 GHz spectrum (failure to resolve the last 10-20 MHz of excess demand) caused significant inflation of **all** the spectrum prices, with Drillisch re-igniting the prices of the early 2100 spectrum before falling back again to 2x10 MHz from 2026. This odd behaviour of increased demand at an increased price was possible because of the German percentage activity rules, and would not have been possible under the stricter 100% activity rules used by Ofcom in UK auctions.

[22] Although current 800 MHz licences will expire in 2025, it is not clear whether this spectrum band will be re-auctioned immediately. BNetZa is currently consulting on 5 different options, including allocating all 800 MHz spectrum to a single network and renewing existing spectrum licences in hands of the incumbents. https://www.bundesnetzagentur.de/EN/Areas/Telecommunications/Companies/FrequencyManagement/ElectronicCommunicationsServices/ElectronicCommunicationServices_node.html

[23] Drillisch has also exercised a clause in its agreement with Telefonica which allowed it to lease two 2x10 MHz blocks of 2.6 GHz spectrum until 31 December 2025.

Implications for German distance method benchmarks

We consider that, based on the evidence presented above, the benchmarks calculated using the 700 MHz price from the 2015 auction and the 2019 price from the 2100 MHz auction are not informative of spectrum valuation in the UK as these benchmarks are driven by differences in competitive pressure across auctions due to changes in market structure. This is because:

- The 2015 700 MHz auction had three bidders with an obvious focal point - 2x10 MHz each; whereas
- In the 2019 2.1 GHz auction (as in the 2010 2.6 GHz auction), there were four bidders and consequently more competition.

This led to a Y/X ratio greater than 1, which is counterintuitive, given the propagation characteristics of the bands. It is also inconsistent with the bulk of the available empirical evidence. Indeed, in Hungary, Austria and in all Tier 3 countries, the Y/X ratio is around 0.3. Given this, we do not consider it to be appropriate to classify these three benchmarks as Tier 1, but instead to consider them as Tier 2.

Slovenia

Ofcom calculates three distance method benchmarks using the 2021 multi-band Slovenia auction where a range of frequencies, including 700 MHz, 2.1 GHz, 2.3 GHz, 2.6 GHz and 3.4-3.8 GHz, were auctioned simultaneously.

Below, we set out: (i) the relevant market context in Slovenia, (ii) the factors driving the outcomes of the 2021 multi-band auction, and (iii) the implications for Slovenian distance method benchmarks.

Market context

There are four mobile operators in Slovenia. The incumbent operator, Telekom Slovenije, remains the largest operator with a market share of 38% in March 2021. The second and third largest operators, A1 and Telemach, have market shares of 31% and 24%. The fourth smallest operator, T-2, has only 7% of the market. T-2 is also behind its competitors in terms of 4G coverage.[24]

2021 multi-band auction

All four operators participated in the 2021 auction, which was a variant of an SMRA auction with generic blocks. Alongside general coverage obligations that applied to FDD and TDD bands, the regulator imposed additional coverage obligations on the 700 MHz band. By 31 December 2025 (or 31 December 2028 for bidders with no existing sub 1 GHz spectrum), bidders who acquired 700 MHz had to cover:

- 99% of motorways, expressways and population (outdoor coverage);
- at least 60% of the main and regional roads; and
- at least 60% of active railways by passenger transport, with intra-train coverage being the responsibility of railway stakeholders.[25]

[24] Telegeography

[25] https://www.akos-rs.si/fileadmin/user_upload/dokumenti/Javna_posvetovanja_in_razpisi/2020/IM_multiband_10082020.pdf

It also imposed a spectrum cap which limited operators to 2x35 MHz sub-1 GHz spectrum.[26] The two largest operators entered the auction with 2x25 MHz of 800 and 900 MHz spectrum, meaning they were limited to 2x10 MHz of 700 MHz spectrum. The third largest operator entered the auction with 2x15 MHz of sub-1 GHz spectrum and the fourth operator entered without any sub-1 GHz spectrum.

The regulator also imposed rules on eligibility and switching

- Each "lot category" was associated with a "lot rating". The overall activity was measured in points, by multiplying the number of lots in each lot category by the lot rating, and summing across categories. A 2x5 MHz block of 700 MHz was assigned a lot rating of 6, while a 2x5 MHz block of 2100 MHz was assigned a lot rating of 4. This meant that bidders wishing to switch demand from 2100 MHz to 700 MHz needed to reduce demand for 2100 MHz by 2x10 MHz in order to be able to bid on 2x5 MHz of 700 MHz.
- In order to minimise the risk of spectrum being left unsold, the regulator constrained the bidders' ability to reduce demand. More specifically, whenever bidders wanted to reduce demand for a particular band or to switch demand from one band to another, the software checked whether the bid would lead to the aggregate demand in the band falling below supply. If that was the case, the bid was either rejected or partially accepted.

These two rules mean that it is possible that bidders could have become 'trapped' in bidding on 2100 MHz and were unable to switch to the 700 MHz band even though at some point the 700 MHz spectrum represented better value for money. For instance, this could have occurred if:

1. an operator initially bid on 700 MHz spectrum;
2. in response to price rises in the 700 MHz spectrum band, it then switched demand to an equivalent amount of 2.1 GHz spectrum;
3. the price of 2.1 GHz spectrum then rose.

In this scenario, the Bidder would be unable to switch its demand back to an equivalent amount of 700 MHz spectrum, even if it represented better value for money, due to the eligibility rules. It is also possible that bidders were unable to switch their demand from 2100 MHz to a smaller amount of 700 MHz spectrum due to rules on switching; or that they were blocked from drawing 2 points from another band to facilitate switching from 2100 MHz to 700 MHz.

Implications for the Slovenia distance method benchmarks

As noted by Ofcom, it is not possible for us to verify which bidders bid on each band, or the order of the bids.[27] However, there is reason to doubt whether distance method benchmarks calculated using the Slovenian auction are informative of the relative spectrum value in the UK. This is because:

- the stringent coverage obligation imposed on 700 MHz spectrum meant that the fourth operator would have needed to incur significant costs to achieve it. As a result, its valuation of 700 MHz spectrum was relatively low. Given this, and the fact that two other operators were constrained by the spectrum cap,

[26] Ibid.

[27] See footnote 73 of Annex 7 to the Consultation, which notes that Ofcom is unable to verify whether T-2 sought to acquire any spectrum in the 700 MHz band.

the 700 MHz auction had an obvious focal point of a symmetric 2x10 MHz split between the three largest operators.

- the auction rules that limited switching mean that there is a potential for operators to be 'trapped' into bidding on 2100 MHz, even if at some point they preferred switching demand to 700 MHz.

These two factors lead to an Y/X ratio greater than 1, a result which is at odds with the characteristics of the bands and the available empirical evidence.

It is highly unlikely that Ofcom would design an auction with similar rules as in the Slovenian auction. Therefore, it would be appropriate for Ofcom to consider these benchmarks as Tier 2, rather than Tier 1.

The implications for estimating the lump sum value of 2100 MHz spectrum in the UK

As discussed above, the 2100 MHz prices in Germany and Slovenia have exceeded the prices of 700 MHz spectrum in those countries, which is unlikely to be informative of forward-looking relative spectrum values in the UK.

Indeed, in the 2100 MHz ALF consultation Ofcom stated:

"*Notwithstanding significant price variation for mobile spectrum bands, the UK auction results indicate that sub-1 GHz spectrum is more highly valued than high frequency spectrum.*"[28]

This is also consistent with observations in Austria, Hungary, Greece, Iceland and Croatia.

Therefore, we consider that distance method benchmarks calculated using the 2015 700 MHz auction in Germany and the 2021 auction in Slovenia do not satisfy one of Ofcom's criteria for Tier 1, i.e. the prices being informative of forward-looking relative spectrum values in the UK. The other criteria in Ofcom's assessment appear to be satisfied, i.e.:

- the prices were not set based on the reserve prices; and
- the relative prices in the auction are at least as likely to be based on bidders' intrinsic valuations of spectrum as on strategic bidding.[29]

Based on our assessment, it appears that this evidence should be considered as Tier 2 rather than Tier 1.

There are currently no Tier 2 benchmarks in Ofcom's 2100 MHz ALF assessment. However, based on Ofcom's methodology set out in the 900 MHz and 1800 MHz ALF statement, we understand that Tier 2 benchmarks should be used to cross-check the results from Tier 1 benchmarks and to ensure that the proposed lump-sum is chosen conservatively.

Below we discuss the impact of the updated classification of the benchmarks on the estimated lump-sum value of 2100 MHz spectrum.

[28] The consultation, para 4.12

[29] In Slovenia, there is potentially a risk that bidders' intrinsic valuations were not fully revealed due to the specific auction rules, which limited switching.

3.2.3 Use of proxy data

In order to expand the data set, Ofcom resorts to creating 'proxy' valuations for the Netherland and Croatia where 700 MHz and 2100 MHz valuations are available but no higher frequency spectrum.[30]

As a 'work around' Ofcom proposes to:

- First estimate the values of higher band spectrum based on simple ratios between 700 MHz and 2100 MHz and the higher frequency bands drawn from the same sample of auction results used elsewhere in the consultation;
- Use the resulting values as inputs to the distance method for the high value spectrum.

There are two clear shortcomings with this approach.

First, Ofcom's use of the distance method to estimate spectrum valuations is an acknowledgement that simple ratios do not provide robust estimates of spectrum valuations. If they did than the simple ratio between 700 MHz and 2100 MHz in these two jurisdictions could be used to directly estimate the UK lump sum valuation of 2100 MHz from the value of 700 MHz in the UK auction. Using an approach which Ofcom clearly considers inappropriate as an input to the distance method is itself inappropriate. This is clearly shown by the very wide ranges of values generated by applying simple ratios.

Secondly, the resulting valuations are not truly independent of other estimates as the same set of auction data is used both to construct proxies and for applying the distance methodologies for other jurisdictions. This risks giving disproportionate weight to data from particular jurisdiction.

We consider that these shortcomings mean that the resulting estimates are less robust and should be demoted in importance in Ofcom's assessment. For example we consider that the Netherlands should be considered a Tier 2 country.

3.2.4 Auction date

As set out in Chapter 2, the absolute and relative values of spectrum vary significantly over time. Ofcom, appropriately, entirely discounts the prices in the 2000 auction when setting ALFs for 2100 MHz.

However, despite stating that it will "have regard to country-specific circumstances and auction dates"[31] Ofcom places equal weight on estimates based partially on auctions taking place in 2010-2015 as those based solely on auctions taking place most recently. However, on the assumption that ALFs will not be revised for at least five years, auctions in 2010 would still be being used to determine ALFs in 2027.

We consider that only those benchmarks based solely on the most recent auctions should be considered Tier 1, as the valuations in auctions prior to 2015 reflect

[30] Similarly in Croatia, evidence is available from 800 MHz and 2100 MHz auctions but not higher bands. This prevents the auction evidence being used directly in the distance method.

[31] Ofcom Consultation, para 4.22-4.23

market valuations based on 4G technology and services rather than forward looking valuations which reflect current technologies such as 5G and mMIMO.

3.3 Revised estimates of lump sum values for 2100 MHz paired spectrum

We consider that:

- the auctions in Germany and Slovenia should be re-classified as Tier 2 rather than Tier 1;
- the Netherlands auctions are re-classified as Tier 2 due to the use of a proxy value; and
- we exclude estimates which rely on data from actions before 2015.

This results in the following Tier 1 benchmarks

Figure 6 Revised Tier 1 benchmarks

Pair	Country	Y/X ratio	Implied 2100 MHz lump-sum value (£M/MHz)
700 MHz - 3.4 GHz	Austria	0.44	10.6
	Hungary	0.32	9.9
700 MHz - 3.6 GHz	Austria	0.44	8.6
	Hungary	0.32	7.4
Average			**9.1**

Source: Frontier Economics

This demonstrates that Ofcom's recommended value of £10.5m per MHz is not conservative being at the top end of the range of benchmarks. The reliance on a small number of Tier 1 benchmarks for 2100 MHz in itself means that there is a significant probability that the UK value lies outside the range provided by the benchmarks. For example, with only four independent Tier 1 benchmarks there would be a 20% chance that the true level of the UK market value lies outside the range given by the benchmarks.[32]

A conservative lump sum valuation would instead be at the bottom of this range, i.e. £7.4m per MHz. This is consistent with Ofcom's approach to setting the 1800 MHz ALF in 2018, where this was set towards the bottom of the range of Tier 1 values.[33]

Ofcom does not identify any Tier 2 benchmarks in the Consultation. However, we are suggesting that Ofcom demote some of the Tier 1 benchmarks to Tier 2. On its 2018 consultation on the setting of ALFs in the 900 MHz and 1800 MHz bands, it describes its approach as:

> *"We consider first the evidence from Tier 1 countries and then consider whether the evidence from the Tier 2 and 3 countries provide a sufficient*

[32] Assuming that the UK true market value and the estimates based on four benchmarks are randomly distributed, in a fifth of the cases the UK true market value will be the lowest value, i.e. will be below the range suggested by the benchmarks.

[33] 2018 Annual Licence Fees for 900 MHz and 1800 MHz frequency bands. Figure 4.2

basis for making an adjustment to the lump sum value we derive from the Tier 1 benchmarks."[34]

An inspection of the wider set of benchmarks presented by Ofcom, as in Figure 4.1 of the Consultation does not suggest that a value of £7.4m per MHz is out of line with a conservative estimate within this wider data set.

Overall, it appears that using a lump-sum value of £7.4m per MHz of 2100 MHz paired spectrum is more consistent with Ofcom's objective of setting the ALF conservatively and even this value risks setting the ALF above a true market value.

3.4 Our observations on Ofcom's approach to estimating the lump-sum value of 2100 MHz unpaired spectrum

To estimate the lump sum value of 2100 MHz unpaired spectrum, Ofcom proposes to use the price paid by Telefonica for 2.3 GHz unpaired spectrum in 2018. Ofcom considers this approach to be conservative as 2.1 GHz spectrum has slightly better propagation characteristics than 2.3 GHz spectrum.

We disagree that this approach is conservative for two reasons:

- The price paid by Telefonica is likely to reflect a contiguity premium; and
- Telefonica was able to deploy 2.3 GHz spectrum immediately, while 2.1 GHz unpaired spectrum has not been deployed yet.

We explain these two points in more detail below.

Contiguity premium

In the 2018 auction, Telefonica acquired 40 MHz of 2.3 GHz spectrum (i.e. the total amount of 2.3 GHz spectrum available in the auction). In the course of the auction, no bidder bid on less than 20 MHz.

It is widely recognised that for TDD spectrum there is likely be a minimum amount of spectrum needed to make its deployment worthwhile. In auctions, this requirement is reflected though spectrum floors. This implies that the value of small amounts of spectrum (below the threshold) is likely to be significantly lower than the value of spectrum above the threshold (on a per MHz basis).

In this case, Ofcom is setting ALF for 5-10 MHz of unpaired spectrum, while the minimum threshold is likely to be 20 MHz or more. This means that the 2.1 GHz spectrum is likely to be significantly less valuable (per MHz) than the spectrum acquired by Telefonica.

[34] Ofcom, Annual Licence Fees for 900 MHz and 1800 MHz frequency bands, December 2018, https://www.ofcom.org.uk/__data/assets/pdf_file/0020/130547/Statement-Annual-licence-fees-900-MHz-and-1800-MHz.pdf, para 450

Spectrum availability

We also understand that Telefonica was able to deploy its 2.3 GHz spectrum immediately after the auction[35], while, to our knowledge, the 2.1 GHz unpaired spectrum has never been deployed. Moreover, there is no clarity at this stage when it will be deployed.

Ofcom should take both these factors into account. It needs to assess the contiguity premium paid for larger amounts of spectrum and to adjust Telefonica's price accordingly. It should also adjust the lump-sum value to take account of the fact that it may be a number of years until the spectrum is deployed.

[35] https://news.o2.co.uk/press-release/o2s-customers-are-the-winners-as-telefonica-uk-makes-500m-airwaves-investment-to-further-strengthen-its-network/

4 ANNUALISATION FACTOR

In this section, we first set out in more detail Ofcom's approach to annualisation of the lump-sum value of the 2100 MHz spectrum, i.e. converting the lump-sum value into an equivalent annual charge.

While the overall approach is reasonable, we have identified two specific issues with Ofcom's application of its methodology in this case:

- The cost of debt estimate used by Ofcom is outdated. Ofcom uses data on 10-year BBB bond index yields over a 12-month period between November 2019 and October 2020. If the latest 12-month period is used (Sept 2020 – August 2021), the cost of debt is reduced from 1.9% to 1.64%;
- In the WACC calculation, Ofcom uses an asset beta based on analysis carried out to set the appropriate regulated return within the Wholesale Fixed Telecoms Market Review (WFTMR) Decision[36] and later used to set termination rates, including mobile termination rates.[37] Given the very different nature of these Decisions, simply re-using analysis conducted for a different purpose is not appropriate. In particular the asset beta is based on a single data point for BT. We recommend that the asset beta should be reduced from 0.62 to 0.55 to reflect the broader evidence on the asset betas for other comparators, including the owners of other mobile operators in the market.

When these two issues are addressed, the real post-tax discount rate is reduced from 0.2% to -0.10%, and the corresponding annualisation rate is reduced from 5.4% to 5.2%.

4.1 Ofcom's approach to annualisation

In order to convert the lump-sum spectrum values into their annual equivalents, Ofcom estimates a discount rate which seeks to leave MNOs indifferent between paying the lump-sum spectrum value and paying ALFs. In practice, estimating the correct discount rate is not straightforward due to the potential for fluctuations in the value of 2100 MHz spectrum over the licence period and the resulting possibility of re-evaluation of the ALF payments. Any future recalculation of ALFs during the licence period therefore exposes the government and MNOs to a degree of risk.

Ofcom considers that the discount rate which leaves operators indifferent between paying ALFs and paying the lump-sum falls between two 'polars':

- A 'lower polar', approximated by the post-tax real cost of debt, wherein MNOs bear the entire risk of fluctuations in spectrum value; and
- An 'upper polar', approximated by the post-tax real WACC, wherein the government bears the risk.

[36] https://www.ofcom.org.uk/consultations-and-statements/category-1/2021-26-wholesale-fixed-telecoms-market-review

[37] https://www.ofcom.org.uk/__data/assets/pdf_file/0029/216794/statement-2021-26-wholesale-voice-markets-review.pdf

To calculate the post-tax real cost of debt (the lower polar), Ofcom uses an average yield on a 10 year sterling-denominated bond index as the starting point (1.9%), and adjusts it for the inflation risk premium (10 bps) and liquidity risk premium (50 bps)[38]. The pre-tax nominal cost of debt is then converted into a post-tax real rate by adjusting for the average corporate tax rate (24.9%) and the CPI inflation forecast (2.0%). This results in a lower polar estimate of **-1.0%.**

To calculate the post-tax real WACC (the upper polar), Ofcom uses the Capital Asset Pricing Model (CAPM) with the following input parameters:

- a pre-tax nominal cost of debt is consistent with the lower polar case of 1.9%;
- a real expected market return (EMR) of 6.7%, which is combined with the CPI inflation forecast to produces a nominal EMR of 8.8%;
- a forward-looking gearing ratio of 45%,
- an asset beta of 0.62 and a debt beta of 0.10.

Ofcom uses these inputs to calculate a pre-tax nominal cost of equity of 12.3%. This results in a pre-tax nominal WACC of 7.6%, which is adjusted for the CPI forecast and the average tax rate to produce the upper polar estimate of **3.6%.**

To produce a final discount rate, Ofcom applies a risk sharing adjustment to reflect the balance of risk assumed by MNOs and by government, resulting in a weighted average of the upper and lower polar estimates. This risk sharing approach results in a real post-tax discount rate of **0.2%** and a corresponding annualisation rate of **5.4%[39].**

4.2 The cost of debt

Ofcom has set the nominal pre-tax cost of debt based on a 12-month average yield on 10 year BBB bond index for the period 31/10/2019 to 31/10/2020. Ofcom used this cost of debt estimate in the WFTMR 2021 Statement. This results in a cost of debt value of 1.9%. Figure 7 below plots the spot yield of the 10-year BBB bond index used by Ofcom, highlighting in grey the period used for calculating the cost of debt in the consultation. It is clear from the graph, that the yields were significantly affected by Covid-19 in April and May 2020.

Ofcom itself acknowledges that the final cost of debt figures should reflect the latest information available for the index. Frontier has considered the period 17/08/2020 to 17/08/2021, highlighted in blue in Figure 7 below. This results in a 12-month average spot yield of 1.64%, lower than Ofcom's figure primarily due to the exclusion of the peak in the spot yield in April-May 2020.

[38] The liquidity risk premium is calculated as the average debt premium multiplied by a debt premium reduction factor of 30%.

[39] The annualisaton rate reflects is calculating by applying a tax adjustment factor to a post-tax discount rate in order to reflect the more favourable tax treatment of annual fees compared to a lump-sum payment.

Figure 7 Spot yield on 10-year BBB bonds index

Source: Bloomberg BVCSGU10 Index

Keeping all other parameters constant, the reduction in the nominal pre-tax cost of debt results in a fall in the lower polar from -1.0% in Ofcom's consultation, to -1.12%. The change to the nominal pre-tax cost of debt also has the effect of reducing the upper polar from 3.6% in Ofcom's consultation to 3.55%.

Applying Ofcom's 25% risk-sharing adjustment to the revised values of the upper and lower polar stated above, produces a reduction in the discount rate from 0.2% to 0.05%, and a corresponding reduction in the annualisation rate from 5.4% to 5.3%.

4.3 Asset beta

Ofcom's calculation of the upper polar uses a forward-looking asset beta estimate of 0.62, consistent with the value calculated for BT Group in the WFTMR 2021 statement.

This asset beta is based on a single equity beta estimate for BT calculated by the Brattle Group.[40] Basing the asset beta on this estimate is not appropriate for three reasons:

- Estimates of equity betas by their nature have large confidence intervals, meaning that the accuracy of an estimate of the asset beta can be improved by looking at additional comparators;
- The BT Group equity beta may be affected by factors such as the substantial fixed business, with higher operational gearing than an equivalent mobile business, and a large pension deficit, which may increase the equity beta; and
- The estimate of the asset beta by the Brattle Group only took account of data up to October 2020.

The evidence on asset betas for other operators in Europe demonstrates that BT's asset beta is an outlier. BEREC's latest assessment[41] finds that the telecoms

[40] Brattle Group, "Cost of Capital: Beta and Gearing for WFTMR 2021", https://www.ofcom.org.uk/__data/assets/pdf_file/0011/216002/wftmr-statement-brattle-report.pdf

[41] BEREC Report on WACC parameter calculations according to the European Commission's WACC Notice of 6th November 2019. BEREC, 2021, Table 6.

operators' asset betas range between 0.33 and 0.57, with the average of 0.48 (Figure 8).

We also note that the EC recommends that for the purpose of WACC calculations the equity beta should be estimated based on the asset betas for all operators in the peer group.[42] While the peer group can be adjusted to reflect specificities of the national market (e.g. the size of the market, country-specific competition conditions, the share of regulated revenues, etc.), BEREC recommends that regulators should seek to maintain as wide a peer group as possible. While Ofcom does not have to follow the EC/ BEREC recommendations, it is clear that taking into account the evidence from a wider set of comparators is preferrable to Ofcom's current approach of relying on the evidence for one operator only.

Figure 8 provides BEREC's interpretation of the relevant peer group for 2021. Note that BT Group Plc has been excluded following the UK's exit from the EU. Vodafone Group plc and Telefónica S.A. were included in the peer group due to their extensive activities within the EU.

Figure 8 BEREC peer group 2021, Asset beta

Company	Asset beta
Vodafone Group plc	0.52
Deutsche Telekom AG	0.48
Elisa Oyj	0.41
Koninklijke KPN N.V.	0.49
NOS	0.57
Orange S.A.	0.44
Proximus S.A.	0.50
Tele2AB	0.52
Telecom Italia	0.42
Telefónica S.A.	0.56
Telecom Austria AG	0.47
Telenet Group Holding N.V.	0.41
Telenor	0.33
Telia Company AB	0.48
Average	**0.48**

Source: BEREC Report on WACC parameter calculations according to the European Commission's WACC Notice of 6th November 2019. BEREC, 2021, Table 6.

Figure 8 demonstrates that BT's asset beta of 0.62 is an outlier. It is higher than asset beta values for other operators present in the UK mobile market, Vodafone Group and Telefónica (0.52 and 0.56 respectively), and considerably higher than the asset beta for all other companies in BEREC's peer group.

There are other, more appropriate approaches available to Ofcom. These include:

[42] The peer group includes telecoms operators in the EU, which are listed on a stock exchange, have liquidly traded shares and credit rating BBB/Baa3 or above. See more details in the European Commission's Staff Working Document 2019, Section 5.3.

- Using the average of asset betas across the entire BEREC sample, which returns a value of 0.48. However, this sample includes a number of operators not active in the UK.
- Taking a simple average of the asset betas across BT Group, Vodafone Group plc and Telefónica S.A., which returns a value of 0.57. However, this does not take into account the asset beta of the fourth UK operator, Three.

On this basis, and in order to reflect the wider comparator group (as recommended by BEREC), we consider it to be more appropriate to use an asset beta of **0.55**. This would reflect the average asset beta across the three UK operators, while also accounting for the lower average across the wider set of benchmarks in the peer group.

Figure 9 shows the impact of our proposed asset beta on the post-tax real WACC, exclusive and inclusive of the cost of debt adjustment described in Section 4.2.

Figure 9 Post-tax real WACC with updated asset beta

Asset beta	WACC (without cost of debt adjustment)	WACC (with cost of debt adjustment)
Ofcom's proposed beta: 0.62	3.60%	3.55%
Average for BT, Vodafone and Telefonica: 0.57	3.23%	3.14%
Average for BEREC peer group: 0.48	2.48%	2.39%
Our recommendation: 0.55	**3.06%**	**2.97%**

Source: Frontier Economics

If both the cost of debt and the asset beta adjustments are implemented (i.e. WACC= 2.97%), the real post-tax discount rate falls from 0.2% to -0.10% and the associated annualisation rate is 5.21%.

In the following section, we combine the impact of the changes to the discount factor parameters and the reduced lump-sum estimate for 2100 MHz to assess the impact on ALF values.

5 IMPACT ON 2100 MHZ ALF

In this section, we combine the updated lump-sum value of the 2100 MHz band (£9.7m per MHz) and the update annualisation rate (5.21%) to estimate the ALF for 2100 MHz paired spectrum. The table below sets out:

- the impact of revising the annualisation rate;
- the impact of revising the lump sum value; and
- our recommended ALF, which combined both revisions.

The resulting ALF is £0.386m per MHz, which is significantly lower than the ALF estimated by Ofcom.

Figure 10 ALF per MHz, 2100 MHz paired spectrum

Scenario	Annualisation rate	Lump sum value, £ per MHz	ALF, £ per MHz
Ofcom's consultation	5.40%	10.5m	0.567m
Revised annualisation rate	5.21%	10.5m	0.547m
Revised lump sum value	5.40%	7.4m	0.400m
Our recommendation	**5.21%**	**7.4m**	**0.386m**

Source: Frontier Economics

When setting ALFs Ofcom emphasises the importance of taking a conservative approach *"to reflect the asymmetry of risk as between the effects on spectrum efficiency from inadvertently setting ALFs either above or below market value, given the uncertainty about the correct estimates for market value"*.[43]

We consider that basing the estimate of the lump sum value based on the bottom of the range of Tier 1 evidence and using a wider data set to estimate the appropriate asset beta takes into account this asymmetry.

[43] The consultation, footnote 26

6 ISSUES TO BE CONSIDERED IN SETTING ALF IN THE FUTURE

Ofcom's approach to setting the 2100 MHz ALF relies on mechanistically applying the approach used in setting ALF for 900 MHz and 1800 MHz. However, this may not be an optimal approach to setting ALFs in the future including additional bands as they become subject to ALFs and reviewing the ALFs applied to existing bands.

Robustly determining ALFs using the Ofcom's current methodology is dependent on recent UK auctions and benchmarks of relative values from recent auctions in other jurisdictions. If there are no recent UK auctions or there are few relevant benchmarks covering both the bands recently auctioned in the UK and the bands on which ALFs need to be set, then this approach cannot be adopted. While there was a co-ordinated approach to auctioning bands for 4G and 5G across Europe, which provided both UK reference values and benchmarks, there is unlikely to be similar exercises for the next decade.

There is strong empirical evidence, for example the UK prices for 800 MHz spectrum in 2013 and 700 MHz spectrum in 2021, that the value of spectrum is changing over time meaning that maintaining ALFs at a constant (real terms) value over time risks ALFs exceeding true market values.

There is also a risk of inconsistency between bands which are close substitutes, due to artefacts caused by different samples being used to set ALFs for different bands. For example the differences in value between 1800 MHz ALFs and those proposed for 2100 MHz may not reflect true difference in market value but simply the benchmarks available when the ALFs for each band were set. Such inconsistencies, rather than leading to more efficient spectrum allocations, could introduce friction in spectrum trading or lead to spectrum being inefficiently relinquished.

A sustainable approach may require combining any information from recent auctions both in the UK and Europe, with other sources of information on the absolute and relative values of different bands in order to ensure a consistent and conservative view of the market value of bands subject to ALF. Such information could include technical information on the fungibility of different bands and bottom up modelling of values.

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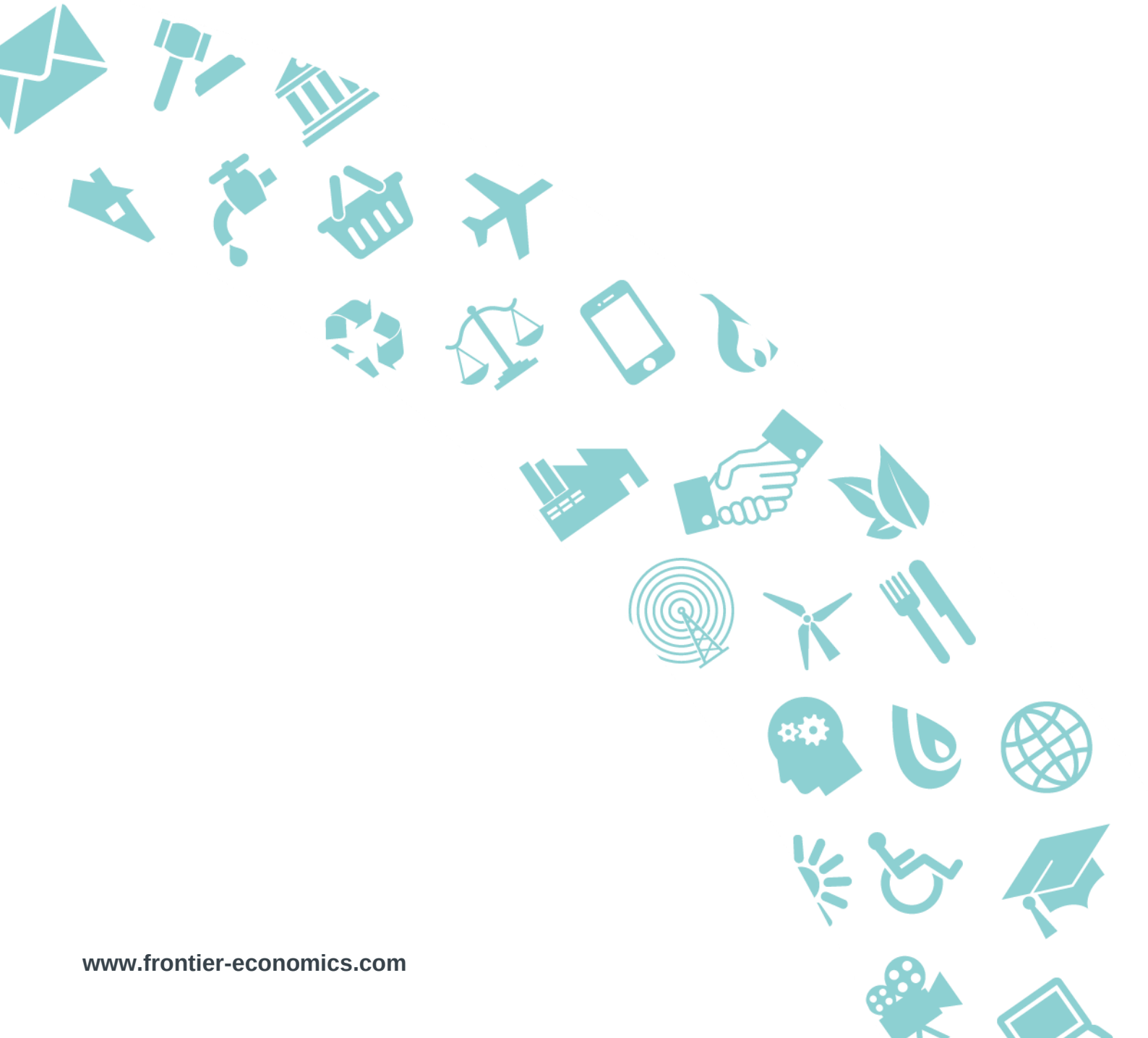

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