Telecoms Deflators: A Story of Volume and Revenue Weights

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Abstract – Fast-changing technology products present inherent measurement challenges in relation to ensuring that deflators adequately adjust for quality change to allow a like-for-like comparison of volumes of output. Telecommunications services present significant challenges in this area not just because of rapid changes in prices and volumes, but also because the different services provided (text, voice, data) are displaying increasing substitutability. This paper builds on previous work by the authors to provide improved alternatives for telecoms services deflators, calculated for the UK, focussing on treatment of access charges and also whether using revenue weights or volume weights for fixed components of contract bundles delivers more reasonable results. Our new options deliver declines in the deflator series of between 64% and 85% between 2010 and 2017. These are far faster declines than the deflator calculated by the existing method but considerably reduce the range of price declines calculated in earlier work. Overall, we recommend using our volume-weighted deflator options, as these seem to better reflect how consumers evaluate the utility of different telecoms services components.

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The measurement of telecommunications (often shortened to telecoms) services prices for the purpose of deflating output in the sector is a matter of considerable debate among economists and national statistics experts. This discussion has focused on how to quality-adjust the price of the service in view of the incredible growth in data usage and transport. For example, the 2001 Ottawa Group meeting of prices experts considered telecoms services prices, and highlighted quality change and changing patterns of usage as key challenges (summarised in Diewert, 2001). This issue of quality-adjusting a rapidly-innovating product is of wider application to a number of digital services whose usage has increased dramatically in recent years.

While data services now represent the primary output of the telecommunications services sector, the existing output deflator used in the UK and elsewhere gives higher weight to traditional voice and text (SMS) services. Because the price of these traditional services has demonstrated less change, using a deflator weighted towards these items implies slow growth in the real-terms output and productivity of the sector, which seems at odds with the considerable usage growth and experience of service improvements, and motivated the consideration of alternatives.

Abdirahman *et al.* (2020), therefore, developed two alternatives to the current deflator for telecommunications services, used in the output measure of GDP within the UK's National Accounts (see Box for an overview of the 2020 article). The first option was an improved Services Producer Price Index (SPPI) for telecommunications services, adding broadband and mobile data, annually updating weights, and capturing both producer and consumer prices within the index.[1] This is an enhanced version of the current method. The second option was to depart from the standard approach and instead adopt a data usage approach through utilising a unit value index that considered all the component services as being essentially equivalent to bit transport services. Voice and text services were converted into bytes, like data services, and this data usage deflator was defined simply as the average price per byte.

These alternatives both attempted to adjust for quality change due to rapid technological advances. However, although using the same data sources,[2] they deliver radically different pictures of a quality-adjusted deflator, showing respectively a 51% and 96%[3] decline over the years 2010 to 2017, compared to a broadly flat index on the current definition. In this paper we analyse why the two options differ so much and propose three new alternatives.

Telecommunications services include a mix of traditional services such as voice calls and newer data-based services, which often substitute directly for traditional services; sometimes the services are also bundled with handsets although our focus is on the service, not the hardware. Almost all services, traditional (like voice or fax) or more modern, use the same physical networks and provide transport and routing to the desired destination in much the same way; the content is digitised and sent as data 'packets' with an address 'header' attached in front. The header data content is typically much less than 1% of the data in a packet; the cost of routing may be greater than this but is similar for all the types of service.

However, for historic or market reasons traditional services are often charged at a much higher rate per unit of data. For example, the price per byte for a traditional voice call is significantly higher than the price of transporting a similar quantity of 'data' (and this gap is much greater if the call is international). As newer technologies for voice calls, such as Skype or WhatsApp, count as data services they are thus significantly cheaper, especially for longer distance calls. Naturally, users are migrating away from more expensive traditional services to relatively cheaper newer ones. These may also offer new service 'bundles', for example by integrating 'text and voice' or 'voice and video' in a single 'call'. This is in line with consumers' shift toward purchasing bundles of different services with different caps and usage limits. For example, Ofcom estimates that 79% of all fixed line telecommunications services contracts were bundles of multiple services, up from 39% in 2009.[4]

Consumers also pay an access charge for fixed line services. The access charge is treated in the current index as a separate service in its own right, and our first step is to allocate it to the component communication services. This is appropriate because consumers do not appear

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[1] Background to the change of the SPPI from a Business to Business to a Business to All index can be found here: https://www.ons.gov.uk/economy/inflationandpriceindices/articles/improvementstotheimportandexportpriceindicesipiandepiandservicesproducerpriceindicessppi/november2016#regulatory-change (Retrieved: 5th November 2021)

[2] Acquired from Ofcom, the UK's telecommunications regulator.

[3] This range differs from the original range in Abdirahman et al. *(2020). This is due to the fact the the Improved SPPI index was changed to a chained Laspeyres type index. Methodological details for the Improved SPPI (called Option A in this paper) can be found in Appendix 2.*

[4] Ofcom Review of the market for stand-alone landline telephone services, Figure 1: https://www.ofcom.org.uk/__data/assets/pdf_file/0014/107321/standalone-landline-evidence.pdf (Retrieved: 5th November 2021)

Box – **Synthesis of the 2020 article (Abdirahman *et al.*, 2020)**

In the article, we considered the role that deflators could play in explaining why real Gross Value Added (GVA) for the telecoms services industry in the UK declined even as data traffic had grown exponentially. Between 2010 and 2017, data usage in the UK increased by 2,300%, whilst the measured real GVA for the industry declined by 8%. We found that the construction of the telecoms services deflators played a significant role in understating telecoms services GVA.

At the time, the telecoms services output deflator was constructed from a combination of the Consumer Price Index (CPI) for Telecommunication Services and Equipment (with a weight of around two thirds) and the Services Producer Price Index (SPPI) for Telecommunications Services (with a weight of around one third). The paper discussed various problems with this approach, including that the CPI captured many unrelated items, such as telecoms equipment, and did not adequately take into account quality changes in the telecoms services products. The SPPI, on the other hand, was only capturing business prices and, more importantly, did not include any fixed or mobile data services in the index. As a result of these, and other problems with the methods, the measured telecoms services deflator suggested that prices increased by 3% between 2010 and 2017, even though there were substantial technological advances during that time, such as the move from 3G to 4G on the mobile side and considerable improvement in fixed broadband speeds.

We found that even modest improvements to the method had a large impact on the telecoms services deflator. So we proposed a modest change to the deflator which we called Improved SPPI (Option A). The main changes were thereby:

- Removing the CPI from the deflator
- Including business-to-consumer transactions in the scope of the SPPI to ensure continued coverage of both business-to-business and business-to-consumer sales
- Introducing fixed and mobile data service items into the SPPI
- Annually updating weights

As a consequence of these relatively modest changes, the Option A deflator suggested that telecoms services prices might have fallen by around 37% between 2010 and 2017, instead of the 3% increase suggested by the official deflator at the time.

Despite this substantial decline in the Option A deflator, we argued that this could still be upwardly biased. This was due to traditional telecoms services such as voice calls and text messages being heavily weighted in the Option A deflator, despite their diminished importance to consumers and operators. In addition, there was a particular issue with the treatment of fixed access charges which were included as a separate, highly weighted service, despite it bearing little relevance to consumers when choosing telecoms contracts in the UK.

We therefore also considered a more radical method change to the deflator which was more reflective of the quality and technological improvement to the service. From an engineering and production perspective, telecoms services are primarily a bit-transport service, and data the output. Consumers, we argued, would notice little difference between using traditional services (e.g. sending a text message) or sending a message through a service like WhatsApp. Traditional services such as calls and text messages could equally be represented in data bits and the output of the telecoms services industry measured as bits of data transported.

Based on the above, we proposed an alternative, data usage-based deflator (Option B). This was an aggregate unit value index (UVI) for the price per unit of data transmitted across all telecoms services. The Option B UVI deflator suggested that telecoms services prices declined by 96% between 2010 and 2017, considerably faster than the decline that was suggested by the Option A deflator.

The paper acknowledged the wide range of estimates between the two deflator improvement options for the UK and the need for further research to better explain and narrow the range. This is the starting point of the present article.

to select their telecoms service on the basis of the access charges or ever purchase the access charge as a standalone product. We then consider the treatment of the prices of each component service in mobile bundles. The current practice in the UK is to use out-of-bundle revenue weights to apply to the bundled price. We consider total usage volume weights instead.

Our results show that the key explanation for different paces of decline in the range of deflator options is the extent to which the index uses volume rather than revenue shares to weight the component services. The alternative deflators we construct progressively trend towards the data usage unit value index, the greater the use of volume weights.

The telecommunications services sector is thus a stark illustration of an old conceptual problem in the construction of deflators: how to adequately control for quality change when there is a new or higher quality product, with rapid volume growth and declining price, which substitutes for an existing good or service. The challenge arises across the spectrum of digital services and has implications for the interpretation of the calculated deflators and thus real growth rates for such sectors. This issue may be important in the case of a number of digital goods, where bundling is becoming increasingly common. In the case of telecommunications services, the price trends differ greatly between OECD countries, although the technological advances are similar everywhere, suggesting statistical offices may be implementing a variety of approaches to the challenges we discuss. For instance, price indices increased from 100 in 2002 to almost 130 in 2015 in Canada, while they decreased in various European countries during the same period (see Ahmad *et al.*, 2017, p. 11).

Our practical recommendation is that statistical offices should for now allocate fixed line access charges using volume weights, as revenue weights reflect accounting allocations rather than consumer choices, but should not apply volume weights to bundled charges for mobile services. However, the key point is to be aware of the sensitivity of the price index to the assumptions made about weights.

The rest of this paper has the following structure. The next section provides the context to the paper and the challenges of constructing deflators for telecommunication services. Section 2 discusses the methodology and Section 3 presents the impacts of the method changes to the telecoms services deflator. Finally, Section 4 provides a discussion of the results and highlights its limitation.

1. Context

Deflators are used in National Accounts to convert nominal measures of output into consistent volume measures. This conceptually involves splitting price change into two elements: a consistent measure of changes in prices of the same 'like-for-like' products over time, and an adjustment to control for quality change. In short, price changes can either reflect a true change in the price of a unit of product, or reflect that purchasers are receiving more (or less) volume of the product through the quality of any individual unit. This may be a change in the size of the product at a certain price (for example there have been recent complaints about 'shrinkflation' whereby the price of chocolate bars remain constant whilst their size in grams falls),[5] or a change in the character of the product.

When it comes to technology goods and digital services the latter is a key factor. For these products the rate of technological change can be rapid, and in some instances the sample product in the basket of goods in the deflator can be withdrawn before statisticians construct the new basket, making it difficult to find consistent prices for some goods. Controlling for quality change is therefore considered essential to estimating accurately a 'like-for-like' price change.

The challenge stems from the construction of deflators as being (as close as possible to) the target measure of a constant utility index, an essentially abstract concept, using observed expenditure data. In addition, statistical offices need to consider the practicalities of data collection and timely statistical production. Their actual practices will reflect these practicalities as well as standard international definitions. In the case of the UK's existing deflator for telecoms services, this has previously been a chain-linked fixed basket index weighting together producer and consumer price indices. In line with best practice recommendations, it will in future need to be constructed as a single business-to-all price index which will be delivered through an improved SPPI index. In this paper, we consider how best to align the actual telecoms services price index with a constant utility index.

The utility delivered by an improved or new good will depend on the characteristics of consumer demand, as well as on observable expenditure, and in particular on how close a substitute the new good is for the old one (or the price elasticity of demand). One way to conceptualize this is to think of a quality improvement as a scalar change in quantity, for example, one byte of data providing as much communication as two bytes previously thanks to better compression. Then, if q_i and z_i are respectively the quantity and quality of good i, we can write consumer utility over n goods as:

$$u = v(z_1 q_1, z_2 q_2, \dots , z_n q_n)$$

The z_i can be thought of as hedonic functions of characteristics of each good. This formulation makes it apparent that a quality improvement has two effects: directly reducing demand because less of the good is needed to deliver the same utility; but also acting as a price reduction for the same (constant utility) quantity, and hence tending to increase demand indirectly. For if prices are p_i and the consumer has total expenditure of x then the demand functions g_i are:

$$q_i = (1/z_i)\, g_i(x, p_1/z_1, p_2/z_2, \dots, p_n/z_n)$$

A constant utility price index requires the use of 'effective' prices, which in this set up are the prices divided by their associated quality scalar. If one byte now does what two used to, the price per byte should be halved. Then the minimum cost of obtaining utility u is given by:

$$c(u, p_1/z_1, p_2/z_2, \dots, p_n/z_n)$$

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[5] *ONS, 'Shrinkflation: How many of our products are getting smaller?': https://www.ons.gov.uk/economy/inflationandpriceindices/articles/theimpactofshrinkflationoncpihuk/howmanyofourproductsaregettingsmaller (Retrieved: 5th November 2021)*

The constant utility (or 'cost of living') change would be given by the cost of attaining a fixed utility level in each of two periods. We would like to construct a price index using the p_i/z_i. Deaton (1998) suggests the thought experiment of homothetic preferences (so an increase in income does not change the relative demand for different goods) and an identical increase in the quality of all goods: "The quality change is precisely equivalent to consumers becoming more efficient as 'utility machines'" (p. 40). They have higher utility but there is nothing in the empirical evidence to reveal the fact. In general, it will be impossible to recover some welfare consequences of quality changes from the data. Quality-adjustment of a price index is in effect partly adjustment for preferences unless we believe it is possible to identify separately changes in quality and changes in preferences.

Either conventional hedonic regressions, or Nordhaus's (1994; 2007) direct approach of calculating the cost of technologies such as lighting and computing power, do provide information about quality change. Hedonic adjustment estimates the value of specific characteristics of a product whose quality is improving and uses this to estimate a price closer to the level delivering unchanged consumer utility. For example, some information technology goods prices in the consumer price index (CPI) basket in the UK and other countries are hedonically adjusted and so in theory capture the rapid change in the price of a consistent unit of utility provided by the goods. However, national statistical offices only apply hedonic adjustment to a small number of goods, and these vary considerably between countries. The method requires the selection of measurable quality characteristics assumed to contribute to consumer utility. This depends on the availability of measurements for various characteristics. Crawford & Neary (2019) also note that hedonic methods only incorporate intensive quality change – that is, improvements in existing characteristics; they omit extensive changes such as the introduction of new characteristics (or loss of old ones) and therefore feature what is in effect an omitted variables bias, unless the equations are regularly updated. Hedonic methods have been applied to mobile phone handsets in the United States, while Aizcorbe *et al.* (2019) also propose a method for adjusting the prices of handsets bundled with telecommunications services. The US Bureau of Labor Statistics has improved on some hedonic adjustment of wireless communications services by considering features such as the size of data bundles consumers purchase.[6] However, hedonic adjustment of telecommunication services to reflect significant technological improvements in compression, data speeds, reduced latency, and call reliability appears not to be generally applied. What's more, it does not contain all the necessary information about the utility consumers derive from the quality change.

Hedonic methods also have significant practical limitations that make them less suited for application in telecommunications services. Many hedonic regressions for broadband often use download and upload speeds as the main quality characteristics. However, these regressions rely on high level tariffs, rather than individual contract level data. This means that hedonic regressions tend to use advertised, rather than actual, speeds since actual speeds can only be observed at the individual contract level. Advertised speeds can oftentimes remain unchanged whilst consumers experience improvements to their actual speeds and so hedonic regressions can mis-estimate quality change from improvements. Further, whilst speeds are one of the main quality characteristics in telecommunications services, other factors are also important such as coverage and latency. These factors are also not observable at the tariff level and vary for individual consumers. More broadly, hedonic regressions rely on the use of traditional price indices and accompanying basket of goods. However, it is difficult to construct a representative basket of tariffs, especially mobile tariffs. This is due to the large range of available and constantly changing tariffs which consumers subscribe to. While one could consider treating parts of telecommunications services, such as bundle options, as a separate good for hedonic adjustment, these same practical challenges would arise. As a result, statistical guidelines[7] often recommend the use of a 'basket of consumers' approach, where a set of consumer profiles are identified (e.g. high, medium, low usage) and their profiles are then matched to the cheapest available tariff for a given usage profile.

We therefore do not propose hedonic adjustment. This paper instead focuses on alternative ways of improving deflators in an area where there is general scepticism whether quality adjustment has been or can be adequately applied. As we are looking at telecommunications services, rather than purchased durable goods, we in effect make

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[6] *Bureau of Labor Statistics – Producer Price Indexes: https://www.bls.gov/ppi/broadbandhedonicmodel.htm (Retrieved: 5th November 2021)*

[7] *See for example: https://ec.europa.eu/eurostat/documents/272892/7048317/HICP+recommendation+on+telecoms+-+June+2015 (Retrieved: 5th November 2021)*

the simplifying assumption that consumers will gain utility from quality improvements in aspects such as speed and latency as they actually use the services. The value and/or actual volume of usage therefore seem appropriate metrics for taking quality change into account and calculating an actual transaction price as consumers do not always use all the data in their monthly bundle or all the apps provided.

As described in Abdirahman *et al.* (2020), the existing UK price indices for telecommunications services have failed to keep pace with the rapid rate of change in this part of the economy. Following Bean (2016), improved deflators for improving the UK's National Accounts have been a focus of research, although the issue arises in other countries also. The two alternative methods in the earlier paper resulted in strikingly different profiles for telecoms services prices. In this paper we propose refinements of our earlier methodology, taking thorough account of the way the services are priced, with access charges for some services and bundling, and using value or volume of data usage as alternative weights. These alternatives can be viewed as reducing the bounds derived from the two countervailing effects of quality change, one reducing demand due to the greater utility per unit of data used, the other increasing demand and usage due to the decline in the price.

2. Methodology

The Data Usage Approach (called Option B in this paper) and Improved SPPI (called Option A in this paper) methods are outlined in Abdirahman *et al.* (2020). A summary of the Option B methodology can be found in Appendix 1 and a summary of the Option A method can be found in Appendix 2.

The Option A method involved updating the SPPI while broadly retaining the current methodology. This paper introduces further improvements to the Option A model. These refinements primarily focus on the treatment of fixed line access charges and bundled mobile charges.

Telecoms service providers typically set a separate access charge, and offer either a usage fee (price per call or SMS or per GB of data) or – more often – a bundled fee with a mixture of services. In the UK, many consumers now purchase a bundle of text messages, voice calls and a data allowance, with the following characteristic components:

- Access Charges: These are currently treated as a separate service in the SPPI. In the below refinement options, we re-assign this revenue to the Voice and Data service components using either revenue or volume weights.

- Bundled Mobile Revenues: As mobile operators increasingly bundle more and more services into a single monthly payment, the current approach of using out-of-bundle revenue weights for each mobile service to proxy the weights within the bundle seems inappropriate. This paper investigates using total volume weights, instead of out-of-bundle revenue weights, to apply to the bundled revenue.

Fixed line access charges have to date been treated as a distinct telecoms service in the SPPI. This treatment is debatable. In the UK market, the regulator Ofcom sets the level of access charges and requires providers to report data against this concept. However, consumers are increasingly unable to easily observe the access charge, as it is included in the total bundle price without separate identification. The authors' investigation of prices presented on-line, for example, has found that many operators no longer present information in this form. It appears prudent to assume, therefore, that users do not base their purchasing decision on the cost of these access charges. If one imagines they are making their decision on the basis of the information available to them, the primary considerations for consumers appear to be their call, text and data allowances,[8] alongside the speed of the service. On this basis, the access charge revenue should be apportioned to the services that consumers are using, just as, if one goes to a restaurant, one does not pay one charge for the food and a separate charge to contribute to the capital costs of the building and kitchen equipment. A further rationale for this approach is the 'matching principle' in accounting for allocation of fixed costs, whereby these are matched to the profile of future revenue streams they enable (Diewert, 2005; Bierman, 2009).

Our improved method therefore proposes ceasing to price the fixed line access charge as a separate service, and instead apportioning the relevant revenues to the services whose prices are likely to influence consumer choice: voice calls and broadband internet. This can be done using either revenue or volume weights, and we consider both. The access charge share of total fixed line revenues in the UK has increased from around 40% to 44% between 2010 and 2017, likely

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[8] *On access charges, the authors have additionally identified that some operators have already stopped listing these as a separate charge. In addition, their value is fixed by the regulator.*

reflecting competitive pressure on pricing in terms of the services which are salient to consumers.

Bundled mobile tariffs are the second area we have identified for further investigation. This pricing strategy is frequently found in markets where incumbents have market power. The literature on bundling by multi-product producers concludes that when consumer valuations of bundle components are high relative to marginal costs (as in telecoms and digital markets), bundling will tend to be more profitable than pricing and selling the goods separately (Stigler, 1963; Adams & Yellen, 1976; Lewbel, 1985; Eppen *et al.*, 1991). The bundled pricing strategy enables the firm to introduce a version of price discrimination that would otherwise be impractical in the face of multiple products and heterogeneous demand, as there is less variation in demand for bundles than in demand for the individual components. There are also strategic reasons to bundle to reduce competition (Carbajo *et al.*, 1990), and particularly so when the marginal cost of some of the goods is zero (Carlton *et al.*, 2010; Choi, 2012).

In calculating a deflator, bundled mobile revenues need to be split into calls, texts and data and appropriate weights derived for each element in the absence of separate prices for each component. Our earlier Option A method used out-of-bundle revenue weights (see Appendix 2).[9] However, this implied that the usage patterns within the bundle were similar to those outside the bundle. This is a strong assumption as it implies consumers would not have a strong reason for selecting bundled service packages, and yet it appears this is what a majority do. We, therefore, consider as an alternative using total volume weights to split the bundle.

This paper therefore updates the estimates introduced in Abdirahman *et al.* (2020) with the latest available data and uses a chained Laspeyres type method to calculate the indices. In addition, it proposes three refinements to the Improved SPPI/Option A option described there:

- Option A.1: This presents a new version of the Improved SPPI where Access Charges are broken down using revenue weights.
- Option A.2: This presents a second alternative to the Improved SPPI where Access Charges are broken down using volume weights.
- Option A.3: This builds on option A.2, where Bundled Mobile Charges are also broken down using volume weights.

3. Results

3.1. Option A.1: Breaking Down Fixed Line Access Charges Using Revenue Weights

Under this option we break down the fixed line access charges using revenue weights. We first subtract the access charge revenues from total revenue. From the remaining revenue we then calculate weights for voice and broadband. Using these revenue weights, we break down the access charge revenue into voice and broadband revenue, and add these to the revenue of the respective service.

The Option A.1 deflator shows a more significant decline than the Option A, of around 64% between 2010 and 2017, compared to 51% for the Improved SPPI (Figure I). This is due to the fact that in the Option A deflator the increasing and highly weighted access charges have a significant effect in counteracting the decline in data costs. Option A.1 instead assigns a higher weight to the broadband data component, whose price is declining at a rapid pace.

3.2. Option A.2: Breaking Down Fixed Line Access Charges Using Volume Weights

The revenue weights for Option A.1 are derived from the relative revenue share of voice and data services. However, due to differential pricing of these services, it is unlikely that the revenue weights would represent consumer usage; the price per byte differs considerably between the component services, being lowest for data (and data services), higher for voice and highest for SMS.

A volume-weighted approach to breaking down the access charges might therefore be preferable. Option A.2 is similar to A.1 but uses volume weights so the breakdown of fixed line access charges reflects the services consumers are using. First, we convert voice usage into bytes of data, using our standard conversion rate of 480 kBytes per minute. We then calculate volume weights (based on actual usage) for voice and broadband. We use these weights to break down the fixed line access charge revenues and apportion them to voice and broadband respectively. This results in nearly all of the access charge revenues being allocated to the broadband revenue as this dominates the usage

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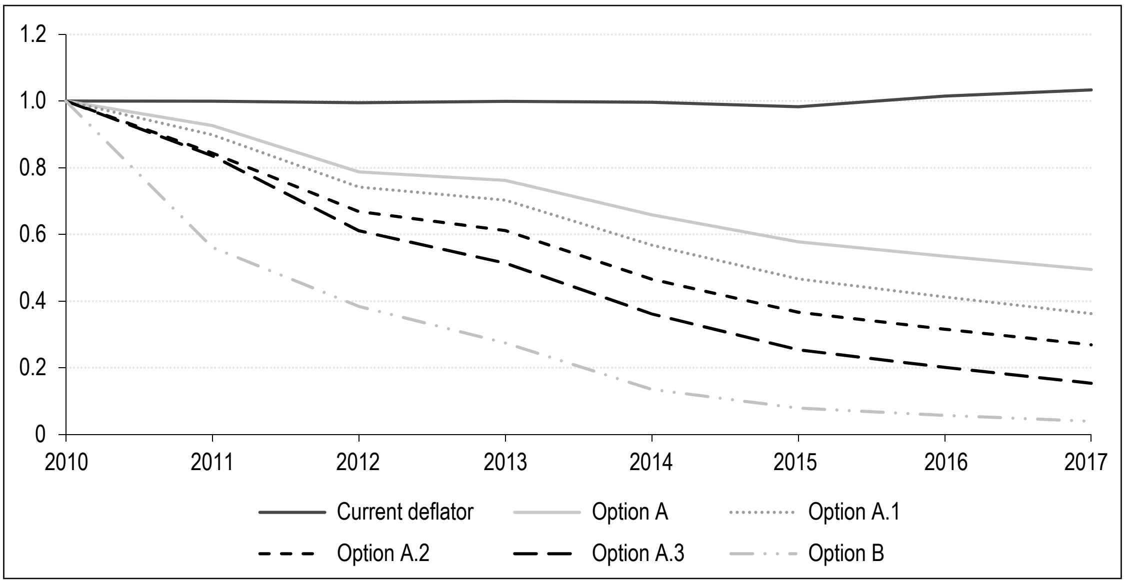
[9] 'Out-of-bundle' refer to the pattern of purchases for those telecommunication services purchased outside of a bundled contract.

Figure I – **Range of potential telecoms deflators**



Sources: Authors' calculations – see Appendices 1&2.

of telecommunication services. In 2010, data services already accounted for around 97% of usage, and by 2017 it was almost 100%.

The Option A.2 index declines by 73% between 2010 and 2017 (Figure I). This is not substantially different from Option A.1 as fixed line access charges are only one component of the overall SPPI index. In addition, even in Option A.1 the (revenue) weight of the data services was around 77% by 2017 so the Option A.2 changes therefore only have a limited additional impact.

3.3. Option A.3: Breaking Down Both Fixed Line Access Charges and Bundled Mobile Tariffs Using Volume Weights

This option builds on Option A.2 by retaining the breakdown of fixed line access charges using volume weights. Option A.3 also breaks down the bundled mobile tariffs using volume, rather than (out-of-bundle) revenue, weights. This again enables the bundle breakdown to reflect consumers' actual usage of the services.

We start by converting all telecoms services into a common quantity measure: bytes of data. As with Option A.2, we convert voice services using our conversion rate of 480 kBytes per minute. For text messages we use a conversion rate of 140 bytes per text. We then calculate volume weights for the different services and use these to allocate the bundled mobile revenue to the different services.

As can be seen (Figure I), the Option A.3 index declines by 85% between 2010 and 2017, showing that it also decreases faster than the original Option A deflator (and closer to the naïve unit value, Option B deflator). The reason for this is that the largest share of the bundled revenue gets allocated to mobile data services, whose price has been declining at a rapid pace. While data services accounted for 56% of mobile volume in 2010, this increased to 96% in 2017.

The original deflator options proposed in Abdirahman *et al.* (2020), along with the refinements proposed in this paper are all presented together (Figure I). The price changes from 2010 to 2017 range from plus 3% for the current deflator (top line) to minus 96% (bottom line, the Data Usage Approach/Option B unit value index from Abdirahman *et al.* (2020)).

As can be seen, all the proposed options are significantly lower than the deflator currently used in the UK National Accounts, but the differences between them are large. The three options A.1-A.3 segment the gap between our original Option A and Option B deflators. This is because, as the different options allocate the access charge and gradually extend the role of volume weights in constructing the deflator, they progress from the Option A, which uses exclusively revenue weights, toward the Option B, which uses exclusively volume weights. The variation between the deflator options is therefore a story of revenue and volume weights. Data services are showing significant decreases in prices but tend to have relatively low weight in terms of revenue. As we extend the use of volume weighting, the resulting deflators decline much faster. The choice of the 'correct' deflator for telecommunication services therefore depends on whether revenue or volume weights are more appropriate.

While revenue-weighted indices are always argued to represent consumer value considerations appropriately, it is not clear how much force these arguments have in this context. For one thing, the apportionment of revenue (particularly bundled revenue) is often simply an accounting exercise, potentially to meet regulatory requirements, rather than reflecting economic transactions. Where bundling is not a big issue – for example in fixed line telephone contracts where voice service allowances are not usually (in the UK) included in the bundled price – data services account for a much greater revenue share. An index which makes greater use of volume weights thereby avoids potential distortions resulting from conflating accounting assignments with true price signals.

Option A.2 thus uses volume weights to break down access charges. Although this approach is preferable for the reason just given, it does require obtaining a like-for-like volume measure for both data and voice services. We rely on a fixed conversion rate of voice into kBytes/min of data, a rate which represents the average data usage for a voice message. This has been fairly constant over many years. Although complex processors can compress voice signals into lower data rates this takes processor time and invariably involves some loss of quality. Thus, given the fairly low rates required for voice, and the tight latency (processing delay) specifications compared to video for example, extra compression is not seen as being worth the saving. But this assumption has little effect on the deflator calculated, because the volume-weighted approach assigns nearly all access revenue to data services. Even if we assumed a substantially higher data consumption for voice calls, it would still have little effect on the Option A.2 deflator.

A similar argument can be made for bundled mobile charges as well as fixed access charges. The original Option A deflator, and the new Options A.1 and A.2, break down bundled mobile charges using out-of-bundle revenue weights. However, if usage patterns between bundled and out-of-bundle services differ – as one might expect – then this would appear an erroneous assumption to apply. In A.3, therefore we consider an alternative of the same model as applied to fixed line charges in A.2, where we look to break down bundled revenue using total volume weights to represent usage, rather than revenue weights. This is the Option A.3 deflator.

However, Option A.3 has some limitations. Although the data share of revenues is gradually increasing, voice calls and texts still accounted for 57% in 2017 (Table 1). This still-substantial share is reflected in the Option A.1 and A.2 deflators, where the component index for the services in mobile bundles declines much more slowly than the corresponding index for Option A.3 (Figure II).

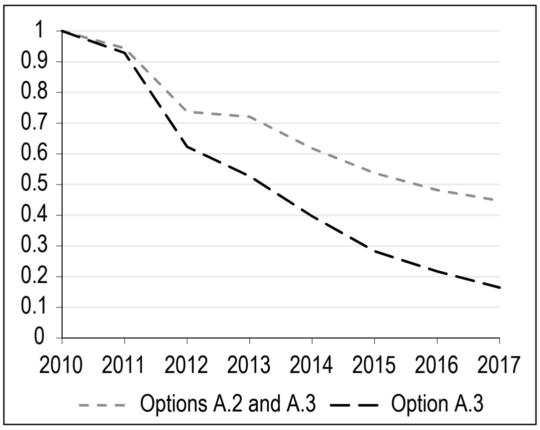
But when it comes to the Option A.3 deflator, the revenue shares of voice and text services reduces significantly as the usage of data services has been increasing exponentially (Table 2). Thus, using this volume approach to break down the bundle into component elements would suggest that in-bundle revenues for text services in the UK in 2017 were only around £60,000 for the entire industry. This looks highly implausible given the fact that out-of-bundle revenues for text services in 2017 were around £642m. A similar pattern, though less extreme, is observed for voice services where the estimated in-bundle revenue for 2017 is £423m but the out-of-bundle revenue is significantly higher at £1.6bn. These imputed figures reflect the fact

Table 1 – **Out-of-bundle mobile revenues and weights by service type**

	Revenues (£millions)			Weights (%)		
	Calls	Texts	Data	Calls	Texts	Data
2010	4,181	2,578	1,731	49	30	20
2011	4,863	2,573	2,247	50	27	23
2012	3,670	2,420	2,506	43	28	29
2013	3,213	1,807	2,651	42	24	35
2014	2,878	1,298	2,734	42	19	40
2015	2,352	773	1,758	48	16	36
2016	1,996	713	1,772	45	16	40
2017	1,644	642	1,731	41	16	43

Sources: Ofcom, Author's calculations.

Figure II – **Services in mobile bundle, component comparison**



Sources: Authors' calculations.

Table 2 – **Imputed bundled mobile revenues and weights by service type for Option A.3**

	Revenues (£millions)			Weights (%)		
	Calls	Texts	Data	Calls	Texts	Data
2010	2,768	0.83	3,646	43	0.01	57
2011	2,289	0.78	3,637	39	0.01	61
2012	1,533	0.58	5,778	21	0.01	79
2013	1,221	0.34	6,605	16	0.00	84
2014	904	0.21	7,428	11	0.00	89
2015	748	0.15	9,589	7	0.00	93
2016	588	0.10	10,295	5	0.00	95
2017	423	0.06	11,127	4	0.00	96

Sources: Ofcom, Author's calculations.

that the estimated in-bundle volume weight for data services under Option A.3 increases from 57% in 2010 to 96% in 2017. While the data component is probably the biggest consideration for consumers in selecting their bundle, it is not clear that its deflator weight should be so high. On the other hand, using out-of-bundle revenue weights would significantly underestimate the share of data services in the bundled tariff. For example, the figures in Table 1 suggest that the data share in the bundle on the basis of revenue weights should be around 43%. Yet this also seems improbable, in light of the fact that we observe falling calls and text volumes and an exponential increase in data usage.

* *
*

The above considerations are familiar in the extensive literature on bias in price indices (for example Reinsdorf, 1993; Diewert, 1998; Hausman, 2003; Diewert *et al.*, 2018). In general, Laspeyres indices using base period weights are biased upward relative to an ideal constant utility index while Paasche indices using current period weights are biased downward (Diewert, 1998). The challenge in trying to calculate a 'true' constant utility price index is the inability to observe 'missing' reservation prices, or constant utility prices, which consumers would have paid for the new (or higher quality) product had it been available previously. Estimating these prices is an econometric and data challenge. As discussed earlier, the results of using revenue and volume weights can be considered as bounds on the 'true' constant utility index.

As statisticians have to produce deflators meanwhile, we have argued there is strong reason to move on from the current UK deflator for telecommunications services, and from the Option A index we calculated previously, to allocate access charges using volume weights (in our A.2 deflator), as revenue weights for bundled access charges reflect accounting convenience rather than exchange values. At present we would caution against using our Option A.3, at least without further exploration of the large difference between actual (revenue-weighted, albeit out-of-bundle revenue) and imputed (volume-weighted) revenues for the different components, as the revenues we use are out of bundle and may not be a good proxy for bundles. Using our preferred option, which may still be characterised by some upward bias, the price of telecommunication services in the UK declined by 73% from 2010-2017, rather than remaining broadly flat as suggested by the current deflator. ☐

BIBLIOGRAPHY

Abdirahman, M., Coyle, D., Heys, R. & Stewart, W. (2020). A Comparison of Deflators for Telecommunications Services Output. *Economie et Statistique / Economics and Statistics*, 517-518-519, 103–122. https://doi.org/10.24187/ecostat.2020.517t.2017

Adams, W. & Yellen, J. (1976). Commodity Bundling and the Burden of Monopoly. *Quarterly Journal of Economics,* 90, 475–498. https://doi.org/10.2307/1886045

Ahmad, N., Ribarsky, J. & Reinsdorf, M. (2017). Can potential mismeasurement of the digital economy explain the post-crisis slowdown in GDP and productivity growth? OECD*, Working Paper* N° 2017/09. https://doi.org/10.1787/a8e751b7-en

Aizcorbe, A., Byrne, D. & Sichel, D. (2019). Getting Smart About Phones: New Price Indexes and the Allocation of Spending Between Devices and Services Plans in Personal Consumption Expenditures. NBER, *Working Paper* N° 25645. https://www.nber.org/papers/w25645

Bean, C. (2016). Independent Review of Economic Statistics. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/507081/2904936_Bean_Review_Web_Accessible.pdf

Bierman, H. (2009). The Missing Concept: What Happened to the Importance of Matching? *The Certified Public Accountant Journal,* 79(4), 22–27.
https://www.nysscpa.org/news/publications/the-cpa-journal/article-preview?ArticleID=10308#sthash.yjGNYUAf.dpbs

Carbajo, J., De Meza, D. & Seidmann, D. (1990). A Strategic Motivation for Commodity Bundling. *The Journal of Industrial Economics,* 38(3), 283–298. https://doi.org/10.2307/2098499

Carlton, D., Gans, J. & Waldman, M. (2010). Why Tie a Product Consumers Do Not Use? *American Economic Journal: Microeconomics*, 2(3), 85–105. https://doi.org/10.1257/mic.2.3.85

Choi, J. (2012). Bundling Information Goods. In: M Peltz, M. &Waldfogel, J. (Eds), *The Oxford Handbook of the Digital Economy*, Ch. 11. Oxford University Press.

Crawford, I. & Neary, P. (2019). New Characteristics and Hedonic Price index Numbers. CESifo *Working Paper Series* N° 7529. https://www.cesifo.org/DocDL/cesifo1_wp7529.pdf

Deaton, A. (1998). Getting Prices Right: What Should Be Done? *Journal of Economic Perspectives,* 12(1), 37–46. https://doi.org/10.1257/jep.12.1.37

Diewert, E. (1998). Index Number Issues in the Consumer Price Index. *Journal of Economic Perspectives*, 12(1), 47–58. https://doi.org/10.1257/jep.12.1.47

Diewert, E. (2001). Telecommunications Services, *Ottawa Group Session Summary*.
https://www.ottawagroup.org/Ottawa/ottawagroup.nsf/home/Meeting+6/$file/2001%206th%20Meeting%20-%20Diewert%20Erwin%20-%20Session%20Summary%20-%20Telecommunications.pdf

Diewert, E. (2005). Constructing a Capital Stock for R&D Investments. *The Measurement of Business Capital, Income and Performance*, Ch. 4. https://econ.sites.olt.ubc.ca/files/2013/06/pdf_paper_erwin-diewert-barc4.pdf

Diewert, E., Fox, K. & Schreyer, P. (2018). The Digital Economy, New Products and Consumer Welfare. *ESCoE Discussion Paper* N° 2018-16.
https://www.escoe.ac.uk/publications/the-digital-economy-new-products-and-consumer-welfare/

Eppen, G., Hanson, W. & Martin, R. (1991). Bundling – new products, new markets, low risk. *Sloan Management Review,* 32(Summer), 7–14. https://sloanreview.mit.edu/article/bundling-new-products-new-markets-low-risk/

Hausman, J. (2003). Sources of Bias and Solutions to Bias in the Consumer Price Index. *Journal of Economic Perspectives*, 17(1), 23–44. https://doi.org/10.1257/089533003321164930

Lewbel, A. (1985). Bundling of Substitutes or Complements. *International Journal of Industrial Organization,* 3, 101–107. https://doi.org/10.1016/0167-7187(85)90016-5

Nordhaus, W. (1994). Do Real Output and Real Wage Measures Capture Reality? The History of Lighting Suggests Not. *Cowles Foundation Discussion Papers* N° 1078.
https://cowles.yale.edu/sites/default/files/files/pub/d10/d1078.pdf

Nordhaus, W. (2007). Two Centuries of Productivity Growth in Computing. *The Journal of Economic History,* 67(1), 128–159. https://doi.org/10.1017/S0022050707000058. Updated 2010 appendix available at www.econ.yale.edu/~nordhaus/homepage/

Reinsdorf, M. (1993). The Effect of Outlet Price Differentials on the U.S. Consumer Price Index. In: Foss, M., Manser, M. & Young, A. (Eds), *Price Measurements and Their Use*, pp. 227–258. National Bureau of Economic Research, Inc.

Stigler, G. (1963). United States v. Loew's Inc.: A Note on Block-Booking. *U.S. Supreme Court Review*, 152–157. https://doi.org/10.1086/scr.1963.3108731

METHODOLOGY GUIDE TO THE DATA USAGE APPROACH (OPTION B)

Data Sources

The data used in this paper comes from Ofcom's Communication Market Reports. We thereby use the reports for the years 2016, 2017 and 2018 for this paper. Whilst the data in the reports is available for all of 2010-2017, some years are missing for fixed line and mobile broadband. We extrapolate the missing values by fitting exponential growth functions. Table A1-1 below shows the data used in constructing the Option B deflator.

Table A1-1 – **Data used in constructing Option B deflator**

	Total operator reported revenues (£bn)	Fixed calls (bn mins)	Mobile calls (bn mins)	SMS & MMS (bn texts)	Fixed data usage (PB)	Mobile data usage (PB)
2010	40.5	123.0	131.1	129	2,352.0	79.0
2011	39.5	111.1	131.3	150	4,222.8	98.9
2012	38.8	103.1	132.1	151	6,016.8	239.3
2013	37.7	93.2	133.7	129	8,208.0	347.3
2014	36.7	82.2	137.3	110	16,495.2	541.7
2015	37.1	73.9	143.0	101	28,750.8	880.3
2016	37.6	64.8	151.2	91	40,233.6	1,270.1
2017	38.1	53.6	148.6	77	59,280.0	1,877.1

Sources: Ofcom, Author's calculations.

Constructing the Deflator

The construction of the Option B deflator starts by converting all calls and text messages into data bytes. We thereby use conversion rates of 480 kb/min for a voice call and 140 byte/text message. We then aggregate all the volumes into one measure for the total amount of data usage across all telecommunication products. We divide the total revenue for telecommunications services by the total volume to get a unit value and index these unit values to get a deflator, such that:

$$I_t = \frac{R_t / Q_t}{R_0 / Q_0}$$

where I_t is the deflator index in time period t, R is the total revenue for telecommunications services and Q is the total volume of data used across all telecommunications services types (expressed in bytes of data).

APPENDIX 2

METHODOLOGY GUIDE TO THE IMPROVED SPPIS (OPTION A)

Data Sources

The data used of the Option A deflators come from Ofcom's Telecommunications Market Data Tables and the Communications Market Reports for the years 2016, 2017 and 2018. This data is complete for the years 2010-2017, with the exceptions of the fixed line and broadband data which is only available until 2011. We estimate the 2010 figures by fitting exponential growth function. Table A2-1 below shows the data used in constructing the Option A deflators.

Table A2-1 – **Data used in constructing Option deflators A.1 to A.3**

Fixed line retail data

	Revenues					Volumes				
	UK geographic calls	International calls	Calls to mobiles	Other calls	Access charges	UK geographic calls	International calls	Calls to mobiles	Other calls	Number of lines
2010	935	293	849	824	3,259	65,134	4,850	5,642	14,736	23,752
2011	787	237	675	742	3,375	56,083	4,570	4,471	13,066	23,872
2012	723	198	566	659	3,706	51,985	4,111	3,902	11,506	24,462
2013	673	155	488	620	3,964	46,191	3,455	3,351	10,681	24,970
2014	577	132	430	620	4,148	40,766	3,015	2,940	9,028	25,549
2015	498	123	369	604	4,462	35,586	2,749	2,735	8,855	26,075
2016	428	111	270	596	4,776	30,471	2,169	2,811	7,826	26,482
2017	362	89	228	543	4,969	24,705	1,550	2,587	6,126	26,661

Fixed line business data

	Revenues					Volumes				
	UK geographic calls	International calls	Calls to mobiles	Other calls	Access charges	UK geographic calls	International calls	Calls to mobiles	Other calls	Number of lines
2010	393	181	628	252	1,743	23,229	2,346	6,205	7,948	9,658
2011	302	143	554	195	1,768	18,483	1,899	5,875	7,449	9,381
2012	265	132	466	193	1,640	17,045	1,756	5,490	7,280	8,754
2013	233	116	408	173	1,778	14,666	1,470	5,023	7,130	8,377
2014	208	103	333	208	1,654	14,394	1,401	4,720	5,915	7,988
2015	188	91	293	185	1,556	12,818	1,294	4,356	5,453	7,647
2016	198	77	259	211	1,580	11,456	1,131	4,069	4,888	7,083
2017	189	68	213	212	1,496	9,988	964	3,665	3,997	6,437

Mobile Data

	Revenues							
	Calls					Texts	Data	Bundled
	UK fixed calls	On-net mobile calls	Off-net mobile calls	International calls	Other calls			
2010	638	607	1,228	353	1,355	2,578	1,731	6,415
2011	650	542	1,093	486	2,092	2,573	2,247	5,926
2012	639	420	924	594	1,093	2,420	2,506	7,311
2013	574	316	694	637	992	1,807	2,651	7,826
2014	486	375	518	598	901	1,298	2,734	8,332
2015	395	315	434	523	685	773	1,758	10,337
2016	313	280	364	453	586	713	1,772	10,883
2017	253	243	296	415	437	642	1,731	11,550

	Volumes						
	Calls					Texts	Data
	UK fixed calls	On-net mobile calls	Off-net mobile calls	International calls	Other calls		
2010	31.999	44.528	38.074	2.051	8.296	129.012	79
2011	31.71	43.45	41.57	5.5	7.41	151	98.88
2012	31.47	41.62	43.6	7.86	7.74	171.88	239.328
2013	32.36	40.57	47.04	7.92	5.84	129.44	347.34
2014	32.07	39.29	51.59	6.98	7.43	109.61	541.728
2015	33.22	39.59	56.18	6.49	7.51	101.01	880.296
2016	33.78	42.98	60.65	5.94	7.82	90.95	1270.08
2017	32.59	43.85	59.53	4.72	7.95	77.23	1877.112

Notes: The following units are used for the above data: Revenues (in £m), Calls (bn of minutes), Texts (bn of texts), Data (Petabytes), Number of lines (in thousands). The Mobile Revenue data for calls, texts and data is the out-of-bundle revenue.
Sources: Ofcom, Authors' calculations.

Construction of Deflators

As with the Option B deflator, the Option A methods use unit values. However, these will be based on low level aggregates which are aggregated up using either revenue or volume weights. The general formula for constructing all indices is given below:

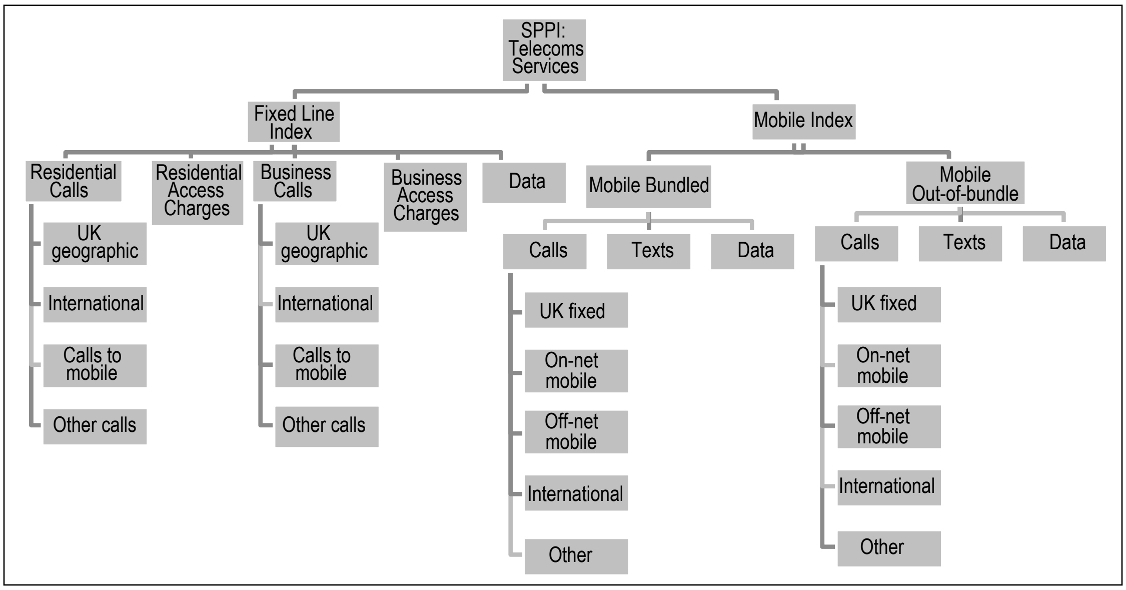
$$I_t = \sum_i \frac{W_{i,t-1}\left(\frac{R_t^i}{Q_t^i}\right)}{\left(\frac{R_{t-1}^i}{Q_{t-1}^i}\right)} / \sum_i W_{i,t-1}$$

where I_t is the final deflator index in time period, R and Q are the total revenue and volumes respectively for items i and W_i is the weight of the item in the final index. The index is then annually chain linked, such that:

$$I_{CL,t} = \left(\sum_i \frac{W_{i,t-1}\left(\frac{R_t^i}{Q_t^i}\right)}{\left(\frac{R_{t-1}^i}{Q_{t-1}^i}\right)} / \sum_i W_{i,t-1} \right) \times I_{CL,t-1}$$

The aggregation structure for the Option A deflator is presented in Figure A2-I below.

Figure A2-I – **Aggregation structure for improved SPPI**



This aggregation structure is similar to the one currently used in the UK's SPPI Telecommunications Services, with the main addition of fixed line and mobile broadband items.

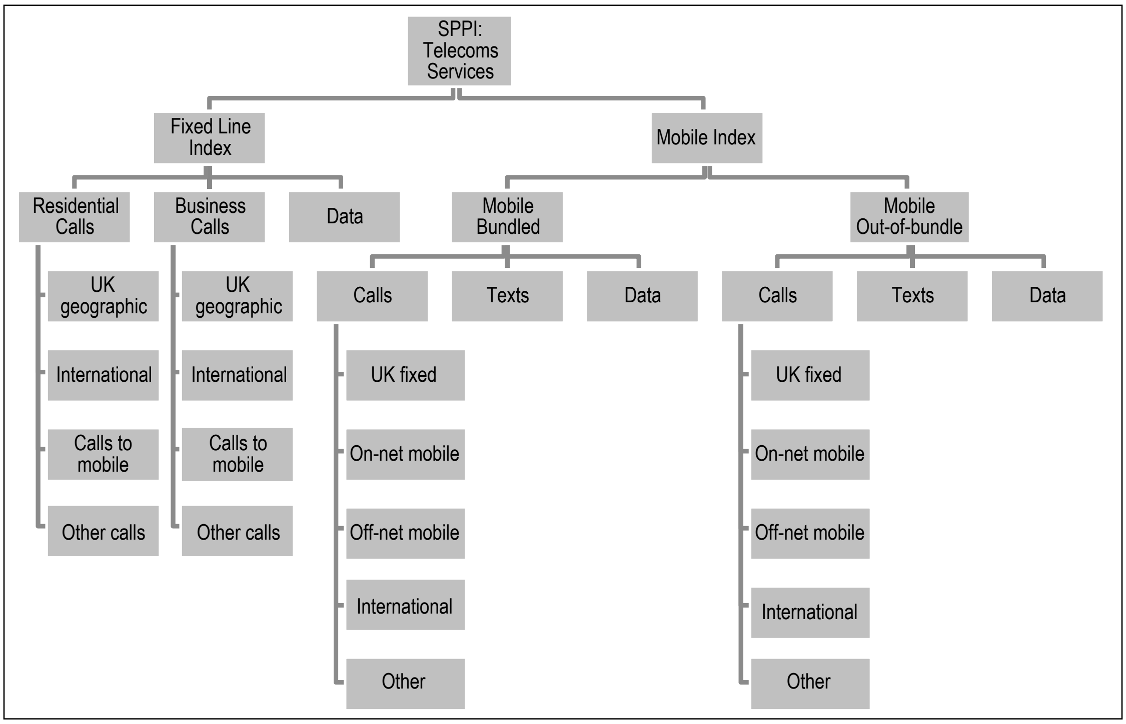
Unit values are calculated for each item and then aggregated up using revenue weights. This is straightforward for most items but some challenges present themselves for a few items. On the fixed line side, it is difficult to determine an appropriate volume by which to construct unit values for access charges. Under Option A, we use the number of subscribers as the corresponding volume. On the mobile side, we have to deal with a mismatch between revenues and corresponding volumes. Whilst the volume data contains total usage, the corresponding revenue data is not available at such a granularity as bundled revenues are not broken down by service type. To overcome this problem, we impute a breakdown for mobile revenues and volumes assuming that the bundled revenue breakdown by service type (shares of calls, texts and data) is the same as in the out of bundle revenue.

We also have to breakdown the total volume figures into bundled and out-of-bundle volumes. To do this, we assume again that bundled/out-of-bundle split in the volume (shares of calls, texts and data) is the same as the split in the revenue.

Option A.1

The aggregation structure for the Option A.1 deflator is shown in Figure A2-II below.

Figure A2-II – **Aggregation structure for Option A.1 deflator**



The aggregation structure is similar to the Option A with the main exception that it excludes fixed line access charges. These are redistributed towards the individual fixed line services using revenue weights. Table A2-2 below presents the revenue weights used to breakdown the access charges in any given year. As can be seen, the weight of the data item increases rapidly from around 43% in 2010 to around 77% in 2017.

Table A2-2 – **Revenue weights for breakdown of access charges**

	Residential				Business				Data
	UK geographic calls	International calls	Calls to mobiles	Other calls	UK geographic calls	International calls	Calls to mobiles	Other calls	
2010	0.123059	0.038563	0.11174	0.10845	0.051724	0.023822	0.082653	0.033167	0.426823
2011	0.108021	0.03253	0.092649	0.101845	0.041452	0.019628	0.07604	0.026765	0.501071
2012	0.101859	0.027895	0.07974	0.092843	0.037334	0.018597	0.065652	0.027191	0.54889
2013	0.097849	0.022536	0.070952	0.090143	0.033876	0.016866	0.05932	0.025153	0.583305
2014	0.080303	0.018371	0.059844	0.086287	0.028948	0.014335	0.046345	0.028948	0.63662
2015	0.066358	0.01639	0.049169	0.080482	0.025051	0.012126	0.039042	0.024651	0.686732
2016	0.053821	0.013958	0.033952	0.074947	0.024898	0.009683	0.032569	0.026533	0.729638
2017	0.043891	0.010791	0.027644	0.065837	0.022916	0.008245	0.025826	0.025704	0.769147

Option A.2

The aggregation structure for the Option A.2 deflator is the same as for Option A.1. The only difference between the Option A.1 and A.2 deflators is the choice of weights. Whilst the Option A.1 deflator uses revenue weights, the Option A.2 deflator uses volume weights. Table A2-3 below shows the volume weights used in breaking down the access charges for Option A.2. Using volume weights assigns almost all access charge revenues to the data service. Data services accounted for around 97% of the volume weights in 2010 but by 2017 it accounted nearly 100% of the volume weights.

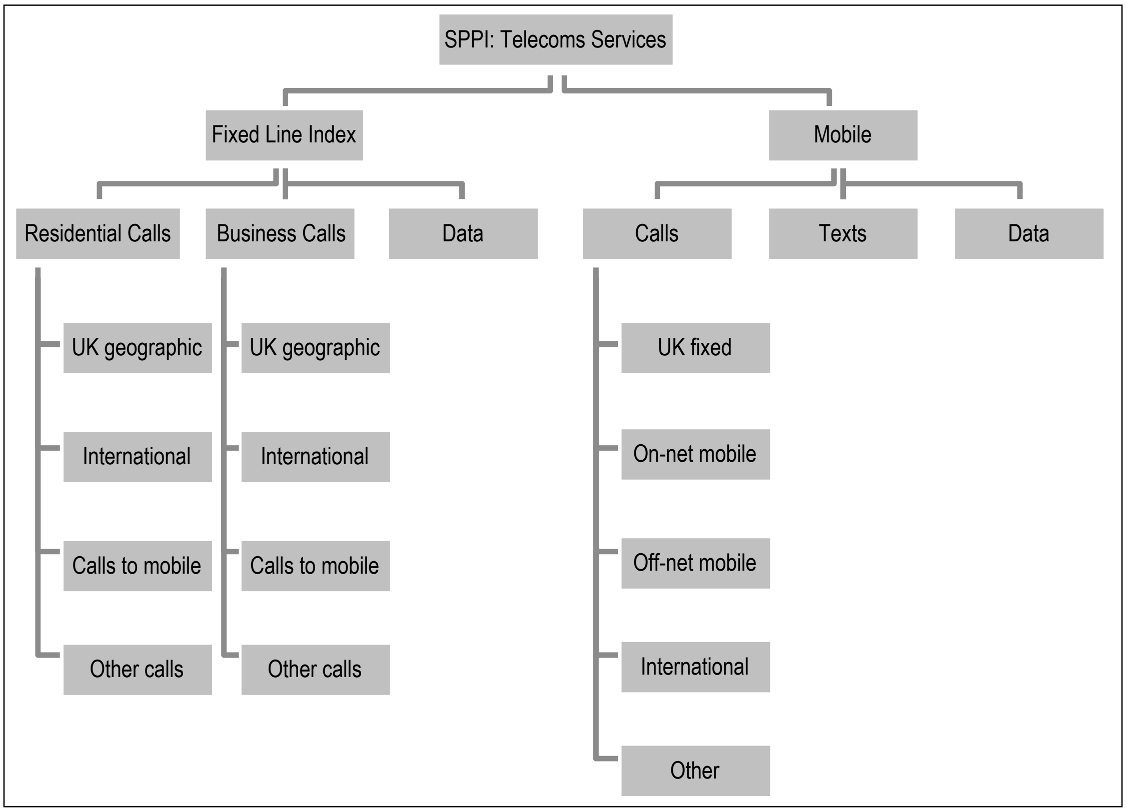
Table A2-3 – **Volume weights to break down access charges**

	Residential				Business				Data
	UK geographic calls	International calls	Calls to mobiles	Other calls	UK geographic calls	International calls	Calls to mobiles	Other calls	
2010	0.012949	0.000964	0.001122	0.00293	0.004618	0.000466	0.001234	0.00158	0.974138
2011	0.006295	0.000513	0.000502	0.001467	0.002075	0.000213	0.000659	0.000836	0.987441
2012	0.004113	0.000325	0.000309	0.00091	0.001349	0.000139	0.000434	0.000576	0.991844
2013	0.002687	0.000201	0.000195	0.000621	0.000853	8.55E-05	0.000292	0.000415	0.994651
2014	0.001183	8.75E-05	8.53E-05	0.000262	0.000418	4.07E-05	0.000137	0.000172	0.997614
2015	0.000593	4.58E-05	4.56E-05	0.000148	0.000214	2.16E-05	7.26E-05	9.09E-05	0.998769
2016	0.000363	2.59E-05	3.35E-05	9.33E-05	0.000137	1.35E-05	4.85E-05	5.83E-05	0.999227
2017	0.0002	1.25E-05	2.09E-05	4.96E-05	8.08E-05	7.8E-06	2.97E-05	3.24E-05	0.999566

Option A.3

The aggregation structure for the Option A.3 deflator is shown in Figure A2-III:

Figure A2-III – **Aggregation structure for Option A.3 deflator**



Similar to the Option A.2 deflator, the Option A.3 deflator uses volume weights to break down fixed line access charges. However, unlike the other deflators, the Option A.3 deflator also breaks down the bundled mobile revenues down using volume weights. Table A2-4 below shows the volume weights used to break down the bundled mobile revenues. As can be seen, the weight of the data item increases rapidly from around 57% in 2010 to over 96% in 2017. Traditional text messages on the other hand have only negligible weights throughout our assessment period.

Table A2-4 – **Volume weights to break down bundled mobile revenues**

	Calls					Texts	Data
	UK fixed calls	On-net mobile calls	Off-net mobile calls	International calls	Other calls		
2010	0.110506	0.153773	0.131485	0.007083	0.028649	0.00013	0.568374
2011	0.094464	0.129437	0.123837	0.016384	0.022074	0.000131	0.613672
2012	0.049878	0.065965	0.069103	0.012458	0.012267	7.95E-05	0.790249
2013	0.037742	0.047318	0.054864	0.009237	0.006811	4.4E-05	0.843983
2014	0.025332	0.031035	0.040751	0.005513	0.005869	2.53E-05	0.891475
2015	0.016803	0.020026	0.028417	0.003283	0.003799	1.49E-05	0.927657
2016	0.012076	0.015365	0.021682	0.002124	0.002796	9.48E-06	0.945947
2017	0.008028	0.010802	0.014665	0.001163	0.001958	5.55E-06	0.963377