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Abstract

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This paper builds on previous work by the authors to provide improved alternatives for telecoms services deflators, calculated for the UK, focussing on whether using revenue-weights or whether using volume weights for fixed components of contract bundles delivers more reasonable results. Our new options deliver declines in the deflator series of between 58% and 84% between 2010 and 2017. These are far faster declines than the deflator calculated by the existing method but considerably reduce the range calculated in earlier work.

Keywords: technological progress, telecommunications, deflators

JEL classification: E01, L16, L96

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Mo Abdirahman, Diane Coyle, Richard Heys, and Will Stewart[1]

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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 whether using revenue-weights or whether using volume weights for fixed components of contract bundles delivers more reasonable results. Our new options deliver declines in the deflator series of between 58% and 84% between 2010 and 2017. These are far faster declines than the deflator calculated by the existing method but considerably reduce the range calculated in earlier work.

[1] Mo Abdirahman: Intellectual Property Office (UK). Diane Coyle: University of Cambridge and ESCoE. Richard Heys: Office for National Statistics (UK). Will Stewart: The Institution of Engineering and Technology.

Introduction

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. 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. 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. This is an enhanced version of the current method. The second option was to depart from the index theory-based 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 37% and 96% 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.

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

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.[3]

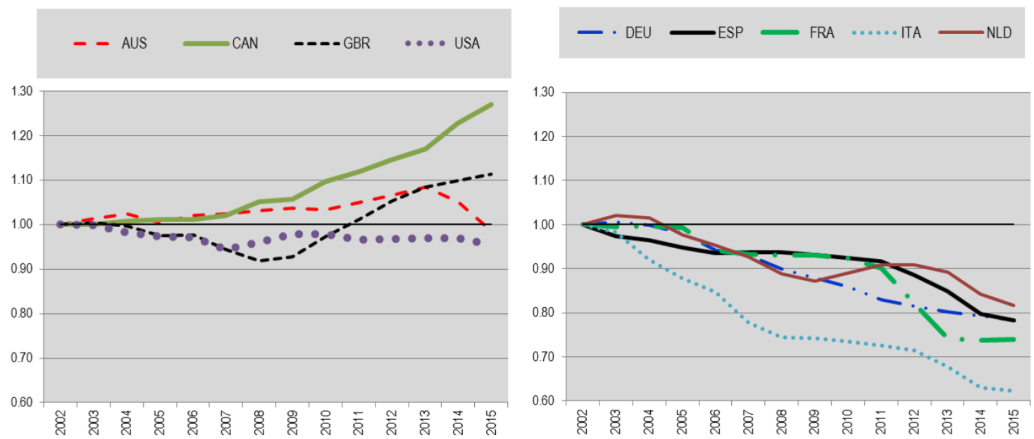
Consumers also pay an access charge for fixed line services. The access charge is treated in the current index as a separate service in its own right, and our first step is to allocate it to the component communication services. This is appropriate because consumers do not appear to select their telecoms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

[3] 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]

Figure 1: Price Indices for Telecommunications Services for selected OECD countries, 2002 = 1.00



Source: OECD Prices and Purchasing Power Parities database, Australian Bureau of Statistics (ABS), US Bureau of Economic Analyses (BEA) and Statistics Canada, February 2017.

Source: Ahmad, Ribarsky and Reinsdorf (2017)

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.

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)[4], 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

[4] ONS article: "Shrinkflation: How many of our products are getting smaller?": [https://www.ons.gov.uk/economy/inflationandpriceindices/articles/theimpactofshrinkflationoncpihuk/howmanyofourproductsaregettingsmaller]

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) a constant utility index, an essentially abstract concept, using observed expenditure data. 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:

$$u = v\ (z_1q_1,\ z_2q_2\ ....\ z_nq_n)$$

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 'effective' (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:

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

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:

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

The constant utility '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'*." (p40) 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 physical quality characteristics assumed to contribute to consumer utility. This depends on the availability of measurements for various characteristics. Crawford and 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, Byrne and Sichel (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[5]. 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 tariff, rather than individual contract level data. This means that hedonics 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. As a result, statistical guidelines 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 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 volume of usage therefore seem appropriate metrics for taking quality change into account and

[5] Bureau of Labor Statistics – Producer Price Indexes: [https://www.bls.gov/ppi/broadbandhedonicmodel.htm]

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.

Methodology

The Improved SPPI method, outlined in detail in Abdirahman et al (2020) and summarised in Annex A , involved updating the SPPI while retaining the current methodology. This paper introduces further improvements to the Improved SPPI model. These refinements 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 operators increasingly bundle more and more mobile 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 observe easily the access charge, as it is included in the total bundle price without separate identification. 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 of the basis of the information available to them, the primary considerations for consumers appear to be their call, text and data allowances[6], 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.

Our improved method therefore proposes ceasing pricing the fixed line access charge as a separate service, and instead apportioning the relevant revenues to the services of interest to consumers: 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 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, Eppen, Hansen et al 1991, Bakor & Brynjolfsson 1997). 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, de Meza, and Seidmann 1990), and particularly so when the marginal cost of some of the goods is zero (Carlton, Gans, and Waldman 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 Improved SPPI method used out-of-bundle revenue weights (see Annex A).[7] 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 in addition proposes three refinements to the Improved SPPI option described there:

- Option A.1: This presents a new version of the Improved SPPI where Access Charges are broken down using revenue weights.

[6] On access charges, the authors have identified some operators have already stopped listing these as a separate charge. In addition, its value is fixed by the regulator, so it plays no role in influencing consumers on which provider/tariff to go for.
[7] ‘Out-of-bundle’ refer to the pattern of purchases for those telecommunication services purchased outside of a bundled contract.

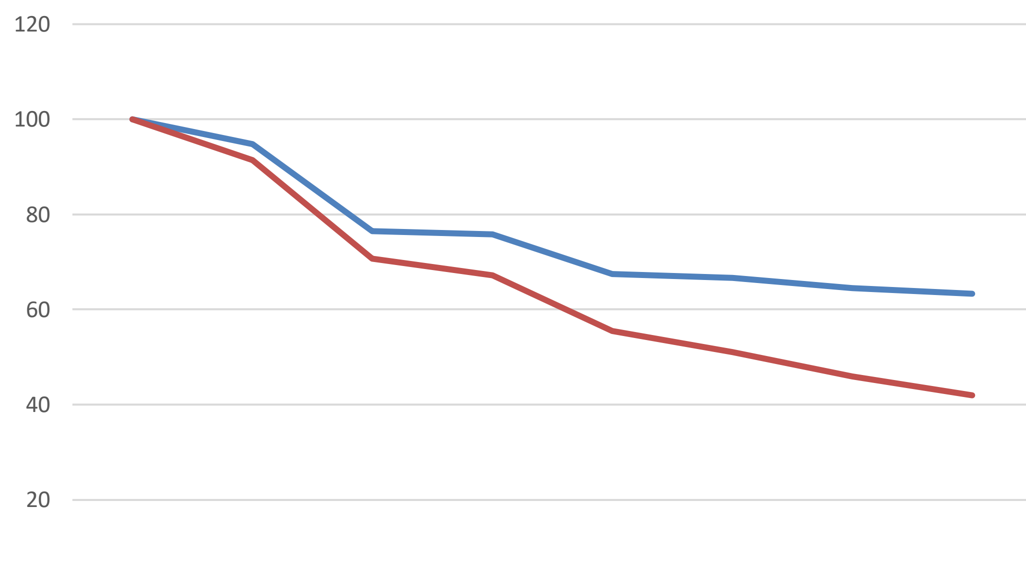
- Option A.2: This presents a second alternative Improved SPPI where Access Charges are broken down using volume weights.
- Option A.3: This builds on option A.2, where Bundled Mobile Charges are also broken down using volume weights.

Results

<u>Option A.1: Breaking down Fixed Line Access Charges using Revenue Weights</u>

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.

Figure 2: Option A1 vs earlier Improved SPPI



	2010	2011	2012	2013	2014	2015	2016	2017
Improved SPPI	100	95	77	76	68	67	65	63
Option A.1	100	91	71	67	55	51	46	42

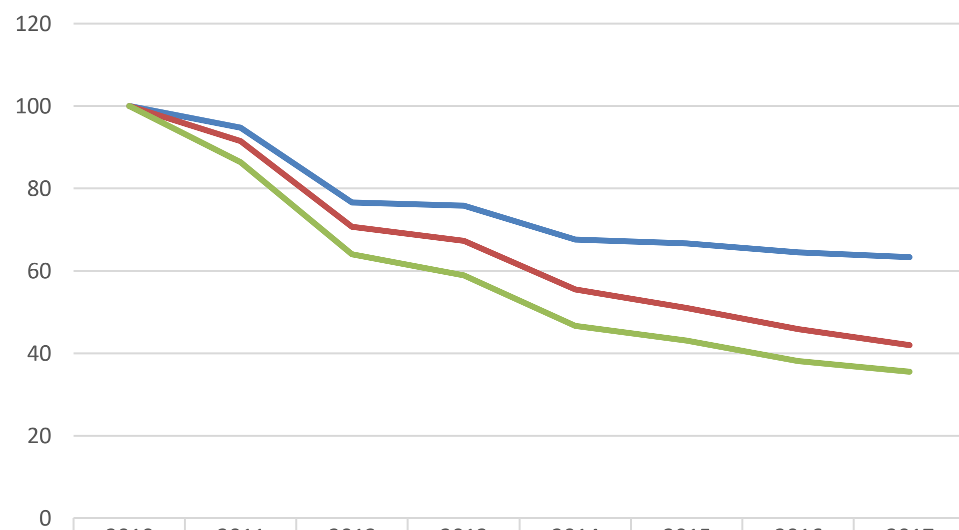
Figure 2 shows the resulting Option A1 SPPI index for telecoms services, alongside the earlier Improved SPPI method. The Option A.1 deflator shows a more significant decline than the Improved SPPI, of around 58% between 2010 and 2017, compared to 37% for the Improved SPPI. This is due to the fact that in the Improved SPPI 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.

<u>Option A2: Breaking down Fixed Line Access Charges using Volume Weights</u>

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 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 apportioned to the broadband revenue as this dominates the usage of telecommunication services. In 2010, data services already accounted for around 97% of usage, and by 2017 it was almost 100%.

Figure 3: Option A2 vs Option A1 and earlier Improved SPPI



	2010	2011	2012	2013	2014	2015	2016	2017
Improved SPPI	100	95	77	76	68	67	65	63
Option A.1	100	91	71	67	55	51	46	42
Option A.2	100	86	64	59	47	43	38	36

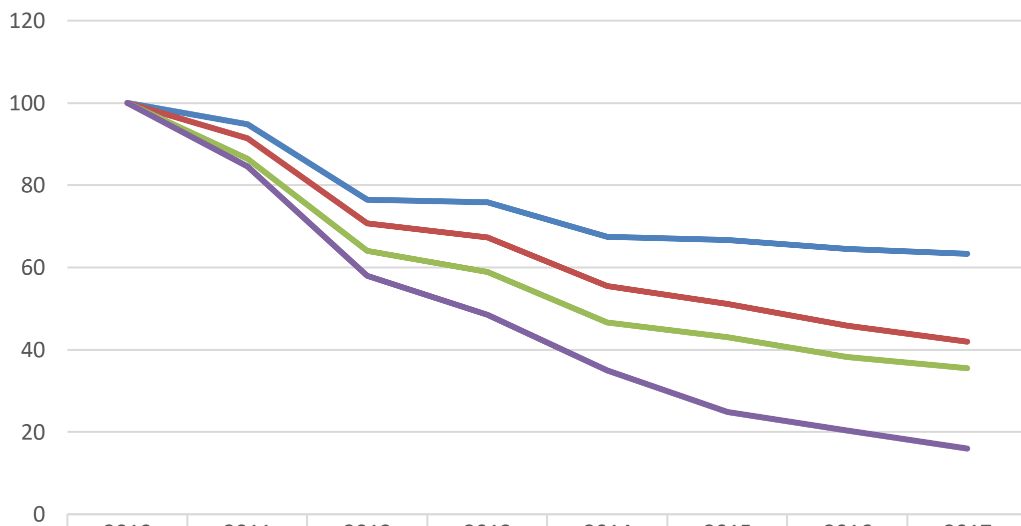
Figure 3 shows the resulting SPPI index from this option, alongside the earlier Improved SPPI and the Option A.1 deflator. The Option A.2 index declines by 64% between 2010 and 2017. This is not substantially different from Option A.1 as fixed line access charges are only one component of the overall 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.

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.

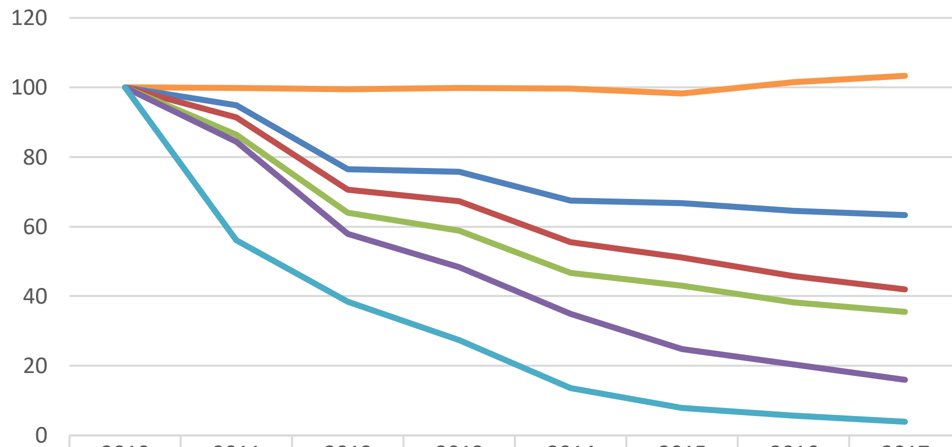
Figure 4: Option A3 vs Options A2, A1 and earlier Improved SPPI



	2010	2011	2012	2013	2014	2015	2016	2017
Improved SPPI	100	95	77	76	68	67	65	63
Option A.1	100	91	71	67	55	51	46	42
Option A.2	100	86	64	59	47	43	38	36
Option A.3	100	84	58	48	35	25	20	16

Figure 4 shows the resulting Option 3 SPPI index, alongside the Improved SPPI index and the options A.1 and A.2 deflators. As can be seen, the option A.3 index declines by 84% between 2010 and 2017, showing that the A.3 treatment of mobile phone charges also decrease faster than that applied in the improved SPPI (and closer to the naïve data usage approach described in Abdirahman et al 2020). The reason for this is 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.

Figure 5: Range of potential Telecoms Deflators



	2010	2011	2012	2013	2014	2015	2016	2017
Current Deflator	100	100	100	100	100	98	102	103
Improved SPPI	100	95	77	76	68	67	65	63
Option A.1	100	91	71	67	55	51	46	42
Option A.2	100	86	64	59	47	43	38	36
Option A.3	100	84	58	48	35	25	20	16
Data Usage Approach	100	56	38	27	14	8	6	4

The original deflator options proposed in Abdirahman et al (2020), along with the refinements proposed in this paper are all presented together in Figure 5. The price changes from 2010 to 2017 range from plus 3% for the current deflator to minus 96% under the alternative options.

Discussion

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 Improved SPPI and the naïve data usage 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 Improved SPPI, which uses exclusively revenue weights, toward the data usage approach, 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 A2 deflator.

A similar argument can be made for bundled mobile charges as well as fixed access charges. The original Improved SPPI 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.

Table 1: Out of Bundle Mobile Revenues and Weights by Service Type

Out of Bundle	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%

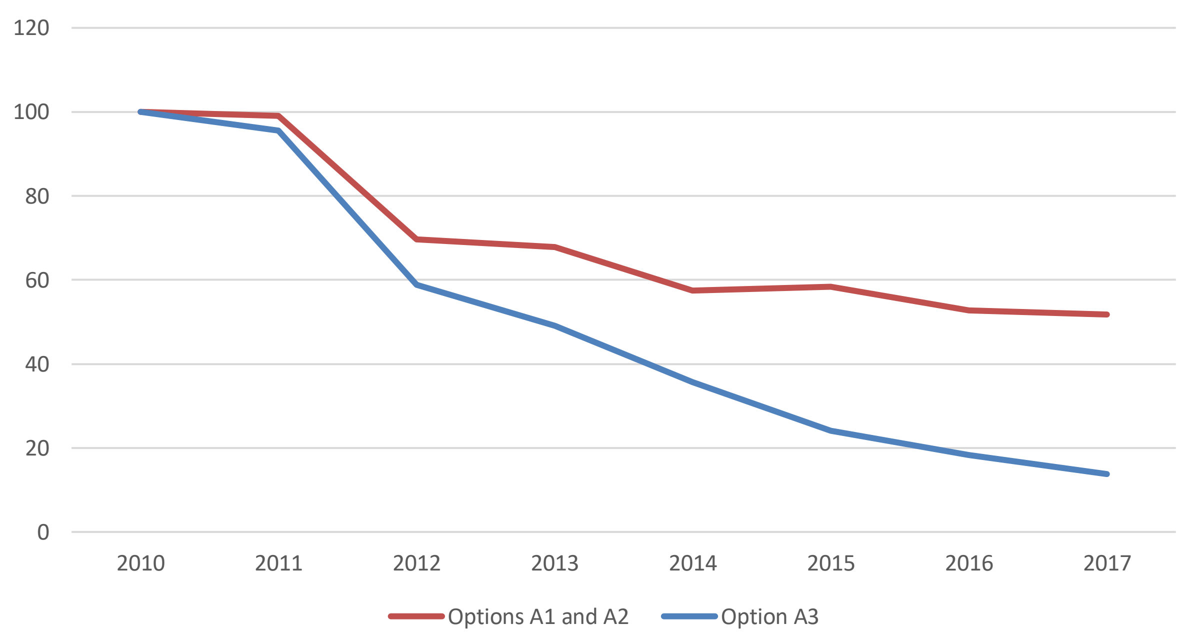
Source: Ofcom, Author's calculations

Table 2: Imputed Bundled Mobile Revenues and Weights by Service Type for Option A.3

Imputed Bundle	**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%

Source: Authors' calculations

Figure 6: Mobile Services Component Comparison



However, Option A.3 has some limitations. Table 1 shows the out-of-bundle mobile revenues and corresponding weights used for Options A.1 and A.2. Although the data share of revenues is gradually increasing, voice calls and texts still accounted for 57% in 2017. This still-substantial share is reflected in the option A.1 and A.2 deflators, where the component index for mobile services declines much more slowly than the corresponding mobile services component index for option A3 (see figure 6).

But when it comes to the option A.3 deflator, table 2 shows the imputed revenues and revenue shares for bundled mobile revenue calculated using volume weights to break down the total. This reduces the revenue shares of voice and text services significantly as the usage of data services has been increasing exponentially. 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 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, Griliches 1998, Hausman 2003, Diewert, Fox & Schreyer 2018). Laspeyres indices are biased upward while Paasche indices are biased downward. The challenge in trying to calculate a ‘true’ cost of living 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 Improved SPPI 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 64% from 2010-2017, rather than remaining broadly flat as suggested by the current deflator.

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Annex A: A summary of the Improved SPPI methodology

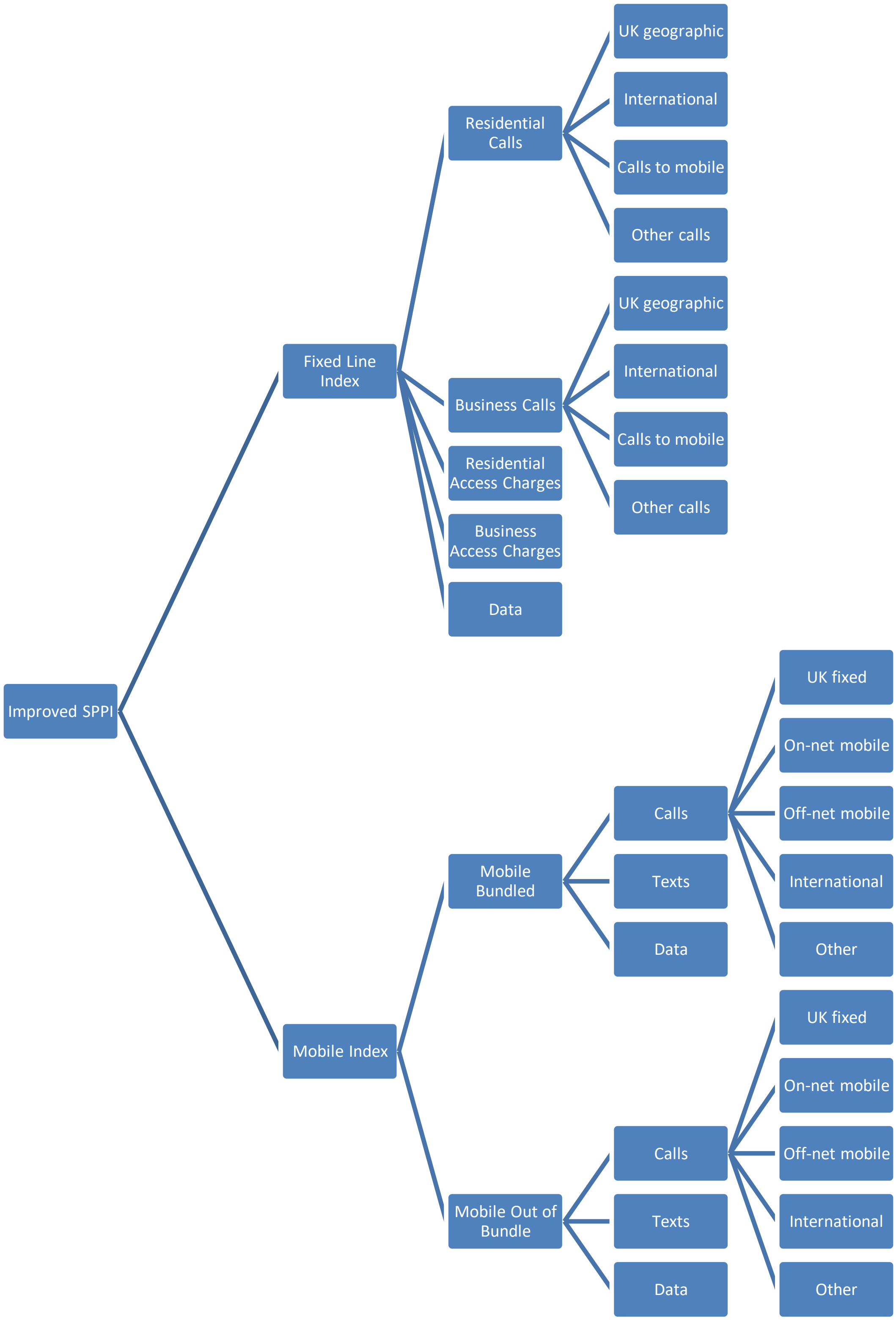
The methodology of the improved SPPI closely follows that of the existing SPPI for Telecommunications Services, but extends it in several important ways:

1. Introduces fixed line and mobile internet services in the index
2. Updates revenue weights for the different service components annually
3. Expands the scope of the index from Business-to-Business to Business-to-All, i.e. including consumers and businesses[8]

The improved SPPI, along with the current SPPI for Telecommunications Services use a Unit Value methodology. Unit values are obtained by dividing revenue of a particular service with the corresponding volume. To ensure that the resulting unit values are not biased, the relevant revenues and volumes must be from a broadly homogenous set of services. We therefore construct granular set of unit values for broadly homogenous services and aggregate up into our top level indices using revenue weights (Figure A1).

[8] The move from a Business-to-Business to Business-to-All index has recently been implemented for the SPPI at the UK Office for National Statistics

Figure A1: Aggregation Structure for Improved SPPI



All the revenue and volume data to construct the unit values is obtained from Ofcom. Finding a corresponding volume for fixed line access charges is difficult. The Improved SPPI therefore continues to use the number of subscribers as the relevant volume metric. In addition, the bundled mobile services revenues are not broken down in sufficient detail. We therefore use the out-of-bundle revenue weights to breakdown bundled mobile services revenue into its different components.