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13th Meeting of the Advisory Expert Group on National Accounts,
1-3 October 2019, Washington D.C., USA

Agenda item: 2.3.6

Price and Volume Measurement of Goods and Services Affected by Digitalization

<u>Introduction</u>

This paper presents a draft guidance note on price and volume measurement of goods and services affected by digitalization. Chapter 1 introduces the challenges for the national accountants, based on concrete examples; chapter 2 reviews the relevant research so far; chapter 3 describes possible options for price deflation of existing assets and products and for the measurement of digital intermediaries (platforms); chapter 4 proposes preliminary recommendations on conceptual aspects regarding the treatment of digital platforms.

A paper on: price and volume measurements of goods and services affected by digitalization

<u>Main issues to be discussed</u>

The AEG is invited:

- To comment on the draft guidance note
- To discuss the options in chapter 3, suggesting which one may be developed into recommended approach
- In general, indicate directions for future work

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Documentation

Please refer to the bibliography at the end of the paper.

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Price and volume measurement of goods and services affected by digitalization - draft guidance note

1. Introduction to the issue

Digitalisation, the process of goods and services being delivered in new and innovative ways utilising digital technology is having a wide-reaching and deep impact on many parts of the productive economy and how we measure it.

Digital technology is the representation of information in bits. This technology has reduced the cost of storage, cost of storage, computation and transmission of data.1 Schreyer (2019)2 states that the provider of the digital service such as Facebook or Google or the consumer herself combines capital services or intermediate services from digital providers with household time to produce own-account entertainment or communication services.

Thus, digital goods and services are intellectual property products. They are assets and are non-rival. They provide capital services used in the production of other goods and services. And, in order to enforce excludability, different business models are used (Goldfarb and Tucker, 2017). These models range from advertising (e.g. Facebook, Google etc), subscription (e.g. Amazon music, Netflix, Spotify etc), digital product embedded in hardware (computer hardware, mobile phones etc), etc.

We have reached a juncture where the impacts of digital can be seen in a number of discreet areas which this paper considers in turn:

- Measuring the impact of digitalisation on price deflation of existing assets and products, including but not exclusive to:
    - Telecommunications
    - ICT hardware
    - ICT software
    - Intangible Assets
    - Are digitally-enabled services the same product as their traditional competitors, or a different product

[1] Goldfarb, Avi and Catherine Tucker. (2017). Digital Economics, NBER Working Paper no. 23684
[2]

        - (e.g. is an Uber a taxi service, or should we view it as a different product – potentially with different price dynamics, similarly Airbnb and hotels).
- The measurement of digital intermediaries (platforms), including:
    - dynamic pricing (e.g. Uber surge pricing)
    - price discrimination (e.g. Airbnb, Amazon).
    - Asset-sharing (Uber, Airbnb)
- The measurement of digital 'cloud computing' services
- Valuing digital assets - mobile spectrums and communication technologies (e.g. 5G+) internationally comparably
- Price deflation of new digital products[3]
    - Airbnb for example
- Sourcing current price output data on new digital products
- The conflation of the value of data and the value of data content.

This paper excludes from its scope the following:

- New digital products with a zero cash price at the point of delivery are excluded as a parallel team is tackling these.
- The finance sector. Whilst this is a sector which is heavily digitalised and has a multitude of issues relating to measuring prices and volume (FISIM etc), there is a parallel team looking at crypto-currencies / fintech and other financial matters who are better placed to consider these issues.
- The resolution of the international flow of cloud computing services is considered out of scope as the 'Globalisation' team are better placed to consider this.

The quantitative size of some issues is known, although many depend on the treatment to be applied.

1.1. Measuring the impact of digitalisation on price deflation of existing assets and products

National accountants rely – to a large extent – for price and volume measurement on price statisticians to compile detailed and high quality Consumer Price Indices (CPIs), Producer Price Indices (PPIs) and others.

CPIs are generally constructed by following – each month – the prices of a representative basket of goods and services. The prices are observed, for the most part, by visiting outlets that sell those products. Great care is taken that the collected prices are for the same products as in the previous month, in order to compute pure price changes, i.e. not affected by any changes in the quality of the products followed. The indices are computed with a formula that

[3] Where these have a non-zero and positive price

also takes into account the importance of each product as indicated by its share in total consumption. These shares are updated each year.

When a product in the sample disappears from the market, it will be replaced in the basket with an equivalent product, if that can be found. Fully new products are introduced in the sample once a year. Generally, the introduction of new products is carried out so that it has no impact on the price index. Changes in the characteristics of products that occur during the year are taken care of by means of quality adjustment techniques, which make explicit or implicit valuations of the changes.

As a consequence of digitalisation price statisticians struggle to capture the large and fast changes in the quality of the products produced and consumed, and with the fact that many products are becoming more and more customised.

Within the existing classification of products almost anything could be affected in some way by digitalisation through classic outlet substitution effects; on-line consumer prices may differ from 'bricks and mortar' prices as the logistics, warehousing and commercial property costs of these two business models can differ significantly. However, this is an old problem which we do not propose to discuss.

Digitalisation is important because it has the potential to impact on some specific products in three ways where general principles may be beneficially articulated / re-articulated:

- **Quality change of existing products:** the utility delivered by various products could change as they become increasingly affected by digital: for example, a fridge which is now part of the 'internet of things' can now communicate with your smartphone to tell you that you are short on milk and need to buy some. These quality changes raise the following specific questions:
    - **Classification of products:** Is an 'internet-connected fridge' the same product as a traditional fridge or should it be treated as a different product? This depends not just on the physical attributes of the product but also the price behaviour observed? One of the interesting aspects of the digital agenda is not where one product is replaced by a different product, but where two products are becoming the same product – cameras and mobile telephones both becoming components of mobile telephones. As such, the treatment of these and how they interact together in terms of deflators is a key question. This creates a challenge to updating international classifications while preserving continuity for statistics.
    - **The applicability of traditional price measurement approaches:** Rapid change in technology goods means it is vital we identify strong methods to control for quality change, recognising that even well-established methods may have limitations. Can hedonic models be produced efficiently as part of routine production, as the identity as well as the value of the quality variables to be included in the model might change dramatically over time? Does quality change apply equally across all products in the class – looking to

mobile telephone contracts where quality change is more commonly observed in more expensive contracts, rather than 'entry-level' contracts, where countries use a 'basket of consumers' approach, where the cheapest contract which meets the requirements of a set of consumers is tracked for price data, this is likely to be biased towards entry-level contracts, which would miss quality change and under-estimate the impact of these on deflators. Should therefore this approach be discouraged and might other methods of adjusting for quality be considered both more effective and more pragmatic in terms of delivery?

- **The price deflation of 'data':** We need clarity on the product, particularly where data and content (information) can have very different characteristics. One of the most significant issues in relation to new digital services is that there is a product (data) which is ubiquitous across the digital space which, at first glance can be valued significantly differently dependent on the purpose it is put to. One form of content might have a very different value to consumers in the market-place compared to another. Similar to the discussion above around the value of digital technology products, does the value of data change as the content, or information, the data carries changes, or should these be seen as different products, as they currently are, where data transmission by telecommunications companies in industry 61 is distinct from the production of software and content which occurs in the software and entertainment industries? In either case, how should data transmission services be deflated?

- **When old products become substitutes for one another / become the same product:** One of the key challenges of the digital revolution is that any of the data-driven services (video, music, telephony, text messaging, email, electronic money transfer etc) which we currently record as separate products has the potential to find a new competitor emerge which can be a virtual identical substitute from a different product. For example, Skype, which is considered 'software' is a perfect substitute for normal telephony, either using fixed line or satellite technologies. Whatsapp is a perfect substitute for 'text' or SMS messaging, a telecommunications service, but Whatsapp again is considered an 'app' or software product. Both new products are free, therefore bringing them into the same product would produce clear deflation issues, but this problem extends to services like Uber and Airbnb. These intermediaries, charging a different price for a slightly different service which acts as a close substitute for traditional taxis and hotels, are addressed below.
- **Does the value of a digital device (item of ICT hardware) change with the quality of the apps which can be downloaded onto it?** The digital revolution means that many of the devices which we purchase today (Phone, computer, tablet, television, sat-nav, smart-watches, 'Alexa' style virtual assistants etc) have only a fraction of their functionality inherent in their make-up[4]. The rest of the 'functionality' is purchased/sourced as services which can be accessed via the data which are received

[4] And even this is potentially more limited than one may immediately imagine – phones without sims beings used as mini-tablets without phone capability (i.e. without a SIM).

by the device. Should the value placed on the device vary by the quality of the apps which can be downloaded or should the value of the apps be attributed to the industry which has created the app?[5] Is value created in these products in a multiplicative rather than additive model?[6] This issue interacts heavily with the debate on free digital services, as many of these services are downloadable and usable (at least in a basic form) without charge.

- **Price differences between different types of outlets.** As Dollt & Konijn (2018) explain, for lack of better information, statisticians traditionally assume most substitution between outlets is regarded as volume change. This methodology has often been criticised as new outlets are often cheaper than the old ones, which is automatically interpreted as meaning that they provide a lower quality service, rather than a cheaper one. The decline in expenditure caused by shifting to cheaper outlets is entirely and arguably erroneously treated as a decline in the quality of the services and thus leads to a reduction of the volume of GDP.

The example of Travel Agents

One example which is frequently discussed (see Bean 2016) relates to travel agencies, which historically sold travel agency service via commercial properties (shops) where this has moved increasingly into being an on-line activity. There is a question which arises about whether this reduces the volume of GDP because the household are now undertaking their own travel agency services through digital devices.

Considering the cost of providing travel agency services as being built up from staff, IT and property costs. The transition from traditional to digital means has shifted these costs as follows:

Input	Traditional	Digital
Labour	High	Low
IT Capital	Low	High
Property Capital	High	Low

Imagine a scenario where the travel agency moves from traditional to digital delivery: it is still providing the service and the same volume of holidays can be purchased, but the production cost of the agency / intermediation services are now significantly lower. The impact of digitalisation in this case is exposed through the price deflator (exposing the improved efficiency), rather than volume. As such the key implication is that in such instances the need is to capture and appropriately weight the volume of services delivered requires the price deflator to reflect the new outlet / production technology, noting the key

[5] See Annex C for further detail
[6] Explain digital as integrator theory

question raised in Eurostat (2018), which is whether the quality of the two travel agency services are equivalent, or whether consumers receive additional benefits from interacting with a human? Given the shift observed in the market, answer appears to be that if there is a benefit it is less than the value of the cost saving in the eyes of the consumer.

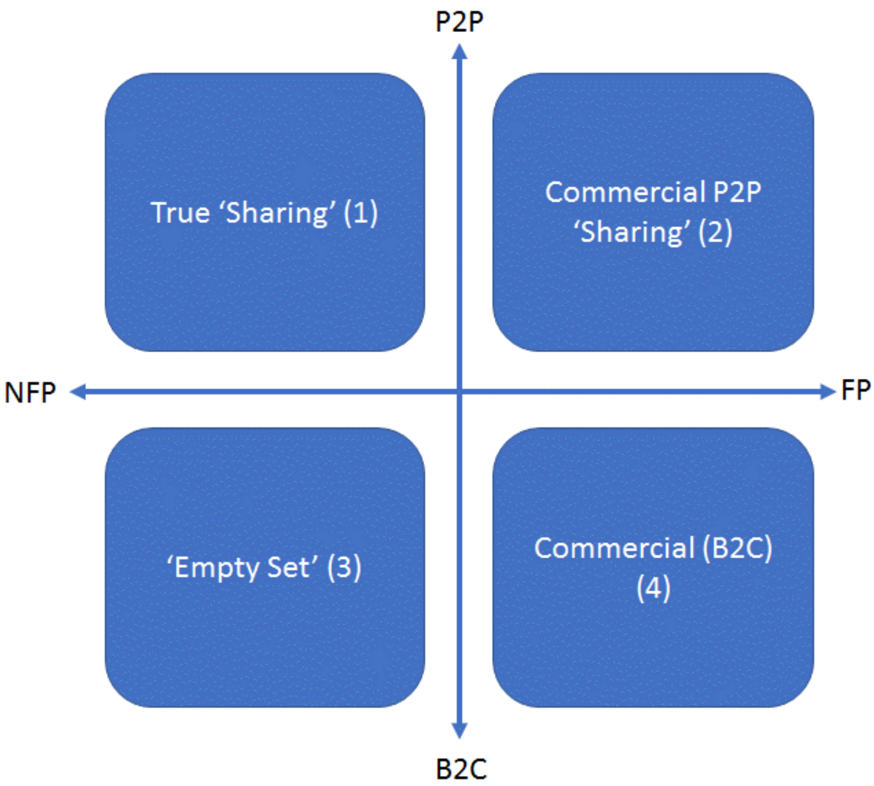
As noted by Dollt and Konijn (2018):

'There is one consistent issue in the above examples: through the internet and other technological advances, new or alternative goods and services can be produced in a more efficient way than their traditional counterparts, i.e. at lower prices. These new products are often seen by consumers as improvements to the existing products on offer, at least in some of their characteristics. However, national accounts and price statistics generally assume that price differences can be taken to equal quality differences, i.e. a higher price must imply a higher quality. This fundamental assumption seems less and less appropriate in the modern digital economy.'

1.2. The measurement of digital intermediaries (platforms)

One of the areas where the impact of digitalisation is most visible to final consumers is services of digital intermediaries or digital platforms. In fact, a number of different terms are around with sometimes very similar meaning (sharing platforms, collaborative platforms, just to mention a few). A good overview can be found in Eurostat (2019 - forthcoming). A mapping of the different digital platform types can be found in Codagnone and Martens (2016):

Conceptual Mapping of Sharing Platforms



Source: Codagnone & Martens (2016)
Notes: FP – 'for profit', NFP – 'not for profit'(which is a proxy for 'real sharing'. B2C – business to consumer sales, P2P – 'peer to peer',
Quadrant 1 equates to platforms with true sharing motives.
Quadrant 2 equates to collaborative economy platforms, such as Uber or Airbnb.
Quadrant 3 is an empty set by definition
Quadrant 4 connects the collaborative economy with normal B2C transactions.

This analysis is restricted to the second quadrant, i.e. peer-to-peer transactions with a for-profit intention. The classical examples, which will also be followed below, are Airbnb and Uber (or Lyft). This is justified with the economic importance these two companies have gained in many countries, while numerous other of such platforms exist and are growing in importance.
The setting of the scope already makes clear that these economic activities are within the existing SNA production boundary and therefore already now covered in the national accounts.

Therefore, the analysis will follow three steps: 1) identifying digital intermediaries in current statistics, 2) the measurement of prices and 3) discussion of volume measures.

The example of Airbnb

Airbnb is a good example where a new type of digital enabled service competes with an existing service. Airbnb provides consumers with the possibility to rent out spare rooms or other living space to other consumers. Airbnb competes directly with traditional hotels, although they provide quite a different service. It is clear that an Airbnb service cannot be directly compared to a service provided by a hotel. In price statistics, the two will be seen as different products. The market share of Airbnb, at the moment, is still limited, reducing the need to introduce it into the CPI samples. So far, the ascent of Airbnb has an impact on the CPI only through the presumably downward effect its very existence has on hotel prices. The inclusion of Airbnb in the CPI would have no direct price impact, i.e. the presumably lower prices of Airbnb would be seen as a lower quality services than the traditional hotels, which is a contentious assumption.

The example of Uber

Uber provides individuals the possibility to use their private cars to provide taxi services. The rides are arranged through a smartphone app. Uber has become, where available, a significant competitor to traditional taxis. The question for statisticians is how to reflect the rise of Uber in GDP and price statistics? Apart from the practical question of getting complete data on Uber transactions, there is the conceptual question of what additional, if any, quality Uber brings to consumers. To determine this, one would theoretically:

- find out what are the characteristics of a taxi ride that people (on average) value most. Options are price, speed, comfort, safety, ease of use, payment options, etc...,
- find a way to measure or evaluate these characteristics, and
- assign a value to them in order to be able to quality-adjust the prices.

It is obvious that this would not be an easy task. Statisticians will have to find more approximate ways to make the comparison.

1.3. The measurement of digital 'cloud computing' services

Available estimates indicate a dramatic rise in cloud computing, which is forecast to continue; see Figure 1. While there are differences in the extent to which adoption is taking place across countries, the percentage of businesses that purchase any cloud services can be above 40% for some countries, and is above 20% for the EU-28 countries; see Figure 2.

As much of cloud computing is an intermediate input to production, it is hard to track in the statistical system. Specifically, the data do not typically distinguish between cloud services and traditional services and whether services are produced internally or purchased, or generated at the "edge" (Byrne, Corrado and Sichel 2018).

The advent of cloud computing poses several challenges for national accounting, including the following:

1. The measurement of volumes: It is unclear how to create volume measures of cloud computing services, and proxies are either unsatisfactory or hard to collect.
2. The measurement of prices: Quality change is rapid, necessitating the collection and use of product characteristics in quality adjusting price indexes to appropriately capture price declines.
3. Mismeasurement of investment due to own-account investment in equipment by cloud service providers. Purchases or electrical equipment may be treated as intermediate inputs for the cloud provider, while they are actually used for own-account investment.
4. New and disappearing goods: Within cloud computing services, there appears to be rapid product churn, with a huge variety of services available. Ensuring that the entry of new products is captured in a timely fashion is important for price indexes and the corresponding volumes. Similarly for disappearing goods.
5. Trade implications: The location of data and computing may be in a different country from the owner/user/creator. There are potential implications for e.g. the balance of payments if computing processes and transactions cross national borders.

The fifth point above is not dealt with here, as it is perhaps something that the Globalisation group is better placed to consider.

It is clear rapid product turnover and increasing product varieties are a feature of cloud computing services. These features cause measurement problems for even for regular products, but here there is also an increase in the use of such services, highlighting the need to focus attention on improving measurement.

1.4. Valuing digital assets - mobile spectrums and communication technologies (e.g. 5G+) internationally comparably

One area where digitalisation has impacted is in the creation of new public assets through the creation of intense demand for radio spectrum bandwidth across the frequency range of 3 kHz to 300 GHz as used for wireless communication. Telecommunications and broadcasting services, amongst other things, rely to a large extent on the use of the naturally occurring electromagnetic radio spectra to transmit information. In some countries at least parts of the radio spectrum are sold or licensed to users, either administratively or via auctions. To ensure consistency across countries methods need to be developed to impute prices for spectrum in countries where there is not a market price.

1.5. Price deflation of new digital products[7]

[7] Where these have a non-zero and positive price

The speed at which products are brought into the basket is a vital aspect as many technology products display rapidly falling prices in their early years in the market. However, they may also exhibit very low sales levels, leading to them receiving extremely low weights in the basket. This is not a simple decision as many products can fail to gain market traction, irrespective of the quality of the product (e.g. the sound quality of the Sony solid-state 'Walkman' MP3 player was discernibly superior than the Apple iPod, but it was the iPod which dominated this market with the Sony Walkman being ultimately withdrawn[8]).

Whilst statisticians cannot be expected to second-guess the market, it may be generally helpful to, where possible capture new technology products, even where these are awarded extremely low weights to enable the price change to be tracked and contribute to price indices as they become more impactful.

Moves by countries to harvest web-scraped data on the characteristics of a variety of products should be encouraged to provide the datasets to support quality adjustment methods.

1.6. Sourcing current price output data on new digital products

The ability of digital services to 'go viral' raises significant questions about how statisticians track current price output data, particularly when sales may be through discreet websites / on-line stores and the provider may not be domestic. A classic example is the Pokemon Go phenomenon where sales of a particular computer game devised in one country exploded in a short time period around the world, going from being irrelevant in terms of price collection terms to becoming of noticeably more significant weight. Sold via 'appstores', which themselves might not necessarily be domestic in nature, sourcing data on these rapidly changing sales numbers is a challenge which requires statistical agencies to actively interact with these alternative 'market-makers'. This issue is likely to be discussed by the Globalisation team in greater depth.

2. Existing material

The existing SNA approach, and a brief summary of the extensive research into these issues undertaken in recent years, both within the economic measurement and academic communities is provided, by topic below:

2.1. Measuring the impact of digitalisation on price deflation of existing assets and products

There is a substantial literature, which is captured in the bibliography below, but key papers include:

- Abdirahman, Coyle, Heys, and Stewart (2017) & Abdirahman, Coyle, Heys, and Stewart (forthcoming).
- Byrne & Corrado (2019)
- Dollt, A, & Konijn P. (2018)

[8] An interesting example of the impact on tangible goods of intangible services. The iPod was supported by superior software and online shop facilities, which dominated the sound quality of the player for consumers.

- Papa, A., Murray L., Murphy B, Holocsy, I.H., Blang, D., Puchter, C, Kalko, J. (2018)
- Application of Hedonics on broadband by the US Bureau of Labor Statistics[9]

Abdirahman, Coyle, Heys, and Stewart (2017) & Abdirahman, Coyle, Heys, and Stewart (forthcoming).

This pair of papers focusses on the methodological challenges presented in measuring the price of data (bits transmission via telecommunications, as opposed to the value of the information carried by the bits of data.

'Between 2010 and 2015 data usage in the UK expanded by 900%, yet real Gross Value Added for the industry fell by 4%, while the sector experienced one of the slowest rates of recorded productivity growth. The apparent disconnect between rapid technological improvements and the measured economic performance of the industry is largely due to the deflators applied to nominal output…. Intuitively, this huge gain in achieved data transmission performance at constant or declining cost should represent a significant gain in real output, irrespective of the content transmitted by the data, or the price charged for this content.'

The paper compares a traditional approach to derive a services producer prices index and a data usage based unit value index. A unit value is calculated using total revenue and total volume for a particular service. Unit value indices are both dependent on the choice of units deployed, and need the goods to be broadly homogenous as otherwise the price series might be biased. This is because the unit price captures both price and quantity changes. Only if the products are completely homogeneous, and a shift in consumption therefore occurs for some reason other than substitution for product characteristics, is there no bias.[10] Statistical offices sometimes use unit value indices for pragmatic reasons but economic theory favours price indices.

The papers argue that traditional Laspeyres index answers the question: How much would a given consumer with given preferences need today to make her as well off as she was yesterday *still consuming yesterday's basket of goods*? It therefore forms an upper bound because it rules out consumer substitution when the relative prices of goods change.[11] However, from the perspective of economic theory, the price index should answer a subtly different question: How would a hypothetical consumer evaluate the two different sets of prices and goods? What is the compensating variation that keeps the consumer on the same indifference curve, given price changes and substitutions? For instance, suppose a laptop cost £1,000 in both 2012 and 2017 but the 2017 laptop has much better performance characteristics such as speed and memory. It is possible that a given consumer would be equally satisfied in 2012 and 2017, given what is available on the market and her (socially-influenced) expectations (and hence the intuitive

[9] https://www.bls.gov/ppi/broadbandhedonicmodel.htm
[10] Equally, there is not really an index number problem in that case.
[11] Conversely, the Paasche will form a lower bound, looking back from today's basket of goods.

appeal of unit value comparisons). However, to reflect the real growth through innovation, the price ought to record a decline; there has been an increase in consumer surplus.

Hence economists prefer a superlative index such as the Fisher Index, which approximates the theoretical cost of living index that keeps consumers' utility constant. However, superlative indices such as the Fisher require expenditure data for the current period that is usually unavailable when price indices are being calculated. The Laspeyres (or Lowe[12]) index is therefore typically used in practice (either with fixed weights or annually updated weights).

Given standard practice, there are several ways of reducing the potential bias, employed to differing degrees by statistical offices, particularly after the Boskin Commission Report (1996). One is to update the index weights frequently. Another is to introduce new goods into price indices more swiftly than had previously been the practice, to capture better the rapid price declines that often occur in the early years of the product lifecycle.

A third, often seen as the gold-standard solution to the problem of adjusting for rapid quality change, is hedonic adjustment based on regressions on definable characteristics, in order to link prices per unit "to a yardstick more nearly relevant to its intrinsic utility".[13] For instance, hedonic regressions for computer prices might include processor speed, RAM, hard drive capacity, screen resolution, built-in camera and so on. In effect, products are seen as bundles of more fundamental characteristics. Hedonic adjustment is typically applied to a few goods experiencing rapid change in their quality or characteristics, accounting for a small proportion of the consumption basket (0.39 % in the UK[14]), in part because of the significant data requirements. To be a solution to the bias, hedonic adjustment also requires the assumption that the price contribution of different components equals their marginal contribution to consumers' valuation of the product.

There is an extensive literature on both the new goods problem and the hedonic approach. On the topic of new goods, the introduction of broadband as a product has attracted noticeable interest. The common approach in these studies is to evaluate quality-adjusted prices using hedonic regressions (Griliches, 1961). Williams (2008) considers internet access prices in the US for the period December 2004 to January 2007. The study uses 135 price quotes from the BLS' CPI database and constructs hedonic functions where the main quality characteristic is bandwidth. Williams finds that quality adjusting the internet access price index makes little difference. Greenstein and McDevitt (2010) use a sample of over 1,500 price quotes for the period 2004 to 2009 obtained from a private consultancy. They use this to construct a hedonic model where the main quality characteristic is the download and upload speed. They find that quality adjusted prices fell by around 3%-10% in the period. This was a steeper decline than the official measure but still much smaller than the quality-adjusted price changes for other products such as computers.

[12] The Lowe will exceed the Laspeyres in a period when there are long term trends in relative prices and consumers are substituting to lower priced items.

[13] Adelman & Griliches (1961)

[14] This figure relates to the Consumer Price Index

However, hedonic studies have limitations. There is a question about the completeness of product characteristics used in the hedonic regression. Bandwidth and upload/download speeds, while important, are not individually sufficient to explain price and quality changes of broadband. Other factors such as data caps, speed limitations (‘throttling’) at peak times, latency (round-trip delay) and geographical coverage are important quality considerations of the broadband service itself. There is also interaction with the services available via digital data transmission, and the degree to which access to this data may become more valuable as more products become available to consumers, and more services only accessible online. In addition, even the bandwidth needs to be treated carefully as there is a difference between advertised and actual bandwidth. Advertised speeds can remain static whilst actual download and upload speeds improve, and vice versa. Furthermore, actual bandwidth cannot be captured in hedonic functions, as the actual speeds cannot be observed on an individual service contract level.

It is also difficult to construct representative baskets of broadband service contracts, given the complexity of pricing in the industry and the wide range of available tariffs and options available and their dynamic nature. The use of a basket of goods approach in constructing a price index is therefore questionable in this case.

The paper goes on to argue that one of the results of the rapid technological change in the telecoms services industry is that the volume weights for the different services differ significantly from their respective revenue weights. For example, while data services are weighted very highly in volume (as measured by bits for all services), the weight of data services in revenue is much lower. A similar problem is observable in the price of drugs. When generic versions of a drug enter the market, the price index is hardly affected, even though the price of generic drugs is much lower (Griliches 1994). This is because the price index usually uses revenue weights. The incumbents often maintain a large share in the revenue while generics account for the bulk of volume.

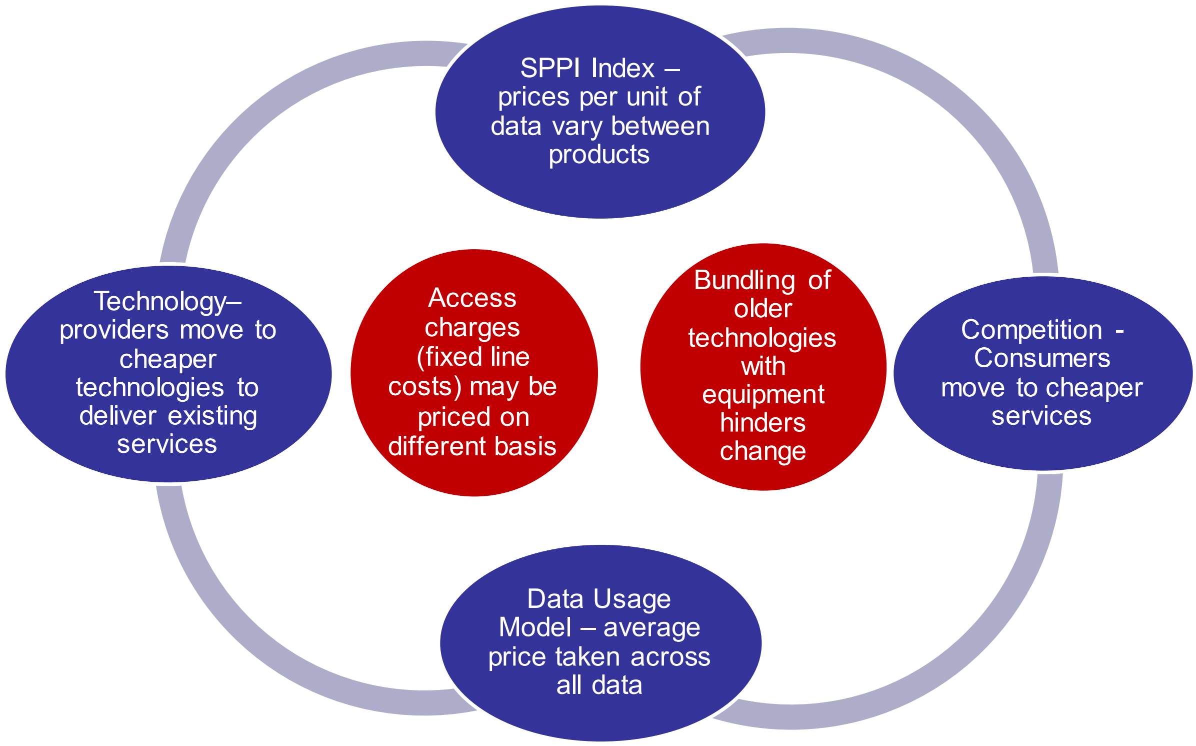
To control for this in a data usage based unit value index, the paper adjusts all telecommunications services (telephony and SMS) into their inherent data to deliver a total volume of data, which is used to divide through revenue to derive a simple unit cost index. The logic behind this treatment is that data is a homogenous good, characterised by the transmission of a series of binary (0/1) signals which in combination can be used to transfer data of almost any sort (a summary of these is at Annex C). As such a unit cost index is unbiased. The alternative argument is that where consumers are willing to pay different prices for different data driven services (in terms of variable costs per unit of data) this reflects a different valuation placed on these different purposes which should be reflected in different weights in a traditional SPPI.

The challenge to this traditional approach is two-fold:

- Does variable pricing reflect different valuations on the data or the informational content? If one uses the parallel of water or electricity transmission, the analogy can be drawn that national accounts does not care if consumers drink the water, use it to wash the car, or pour it straight down the drain, it is a single homogenous good.

Where there are different charges, such as for hospitals, these relate not the water but to guarantees of provision.

- Will a traditional SPPI, using weights to bring together the different prices for the different products, keep pace with the changes in the market. As shown in the figure below there are two mechanisms which suggest that the consumer experience is going to naturally move towards a homogenisation of prices: firstly there is the process by which hardware providers increasingly select cheaper technologies to drive certain functionalities – e.g. using skype to replace traditional telephony inherent within mobile phones, and secondly the process by which consumers substitute cheaper substitutes for more expensive equivalents (using Whatsapp as a substitute for SMS Texting).



A data usage unit cost index would 'future-proof' against these changes and allow more consistent price deflation through a period of technology transition.

A simple example illustrates the importance of considering these two approaches. A simple example illustrates the potential scale of the bias in the data usage approach if consumers value services differently. Consider the price of traditional voice telephone calls and VOIP calls such as Skype. The following table is an illustrative example[15] where the price of each service does not change between time periods, but the volume of calls via each method changes, and so total revenues change. We can contrast a Laspeyres/Paasche/Fisher type approach with one that views both traditional telephony and Skype (or any other data driven application) as substitutes,

[15] These are not actual prices and volumes and are only used for illustrative purposes. It is worth pointing out that the above illustration uses a price relative of 10 but initial analysis suggests that the price relative between traditional voice and Skype/WhatsApp calls could be much higher, so the bias could be more pronounced.

calculating aggregate unit values based on total revenue and total volume.

	Voice telephony			Skype			Total		
	Quantity	Price	Revenue	Quantity	Price	Revenue	Quantity	Revenue	Average price
Year 1	100	10	1000	10	1	10	110	1010	9.1818
Year 2	10	10	100	100	1	100	110	200	1.8181

Under this example we can produce the following results, where both the Year 1 price and volume indices are set to equal 100.

	Year 2 price index	Year 2 volume index
Laspeyres/Paasche/Fisher	100	19.8
Aggregate Unit value index (Data usage approach)	19.8	100

A Laspeyres (or Fisher) index by construction in this example shows no price change and a decline of around 80% in volume. It implies that consumers in the second year are buying more Skype and fewer telephone calls, which *by assumption are not substitutable*, for non-price and non-preference-change reasons.

By contrast, a simple (aggregate) unit value calculation shows a decline of 80% in the price index between years 1 and 2, and no change in the volume of calls. When products are heterogeneous so that consumers may be substituting to higher quality ones, the data usage approach will be biased (upward if the consumption mix is shifting toward more expensive alternatives, and conversely). In this example, in using aggregate unit values as a proxy to measure price change there is an implicit assumption that *the two products are perfect substitutes*, and consumers are switching from voice calls to Skype entirely for price reasons – and so would within a short time have completely switched so voice calls would drop out of the market. It is not surprising that contrasting assumptions lead to contrasting results.

There are two complexities inherent in the data usage model which the papers consider:

- Why data usage rather than data purchased? Unlike a tangible product where if one buys a bag of six apples but only eat five, the market volume of apples sold and 'consumed' is still six, taking into account that the sixth, disposed of apple is still consumed, for an intangible like data, if the product is not used, it is not created. Telecoms companies do not produce and transmit data if it is not 'called', therefore data usage is a more accurate measure of volume than data purchased.

- How to treat fixed cost items such as line rental charges? Where these are artefacts of regulatory data collection methods or likely to be rapidly phased out, these revenues could justifiably be included within the core data usage approach.

Byrne & Corrado (2019)

This paper posits the following question:

'Capturing the impact of innovations in consumer content delivery in conventional well-being measures, e.g., GDP, presents significant challenges. It also seemingly requires a new approach because the manifestation of these innovations in consumer welfare (e.g., time spent consuming high quality content via networked IT devices) does not involve a market transaction at the time of consumption, which is where price collectors/estimators look to pick up new goods as they appear… innovations in consumer content delivery have been very rapid since the turn of this century, suggesting their impacts may be missed in existing GDP; indeed, they are clustered in the mid-2000's when the slow down in the trend GDP growth emerged. Is it possible that the substitution of uncounted, so-called free goods for purchased counterparts is a culprit in this much-discussed slowdown? …To understand why a use-adjusted version of an "old" approach is both (a) needed and (b) up to the task of capturing 21st century innovations, consider first that it is consumer-owned devices with advanced processing technology /computers, powerful smartphones, smart TVs, and video game consoles that enable the consumption of high quality content in many homes (and elsewhere), and these services currently are uncounted in national accounts (though their paid-for predecessors often were).'

In short, if free goods and services substitute for goods and services with a non-zero cost, how should we take account of this? Byrne and Corrado argue that *'consumers' IT capital use is inextricably tied to household's utilisation of public broadband, wireless and cable networks)*'. They '*review the relationship between device use rates and the volume of services*[16] *that deliver content over networks*' to derive '*the quality-adjusted price index for network access services.*' They estimate this method would boost consumer surplus by nearly $1,700 (2017 dollars) per connected user per year between 1987-2017, contributing more than half a percentage point to US real GDP growth in the same period.

"It is tempting to associate the capture of "free goods" as solved by the imputation for home services that we propose in this paper, but the derived demand dynamic underscores it is equally important to use quality-adjusted price statistics for the purchased parts of content delivery systems, as improvements in quality are also seemingly "free."

[16] *Paid-for and home services generated via household's use of IT goods purposed for accessing digital networks*

This method does not differ from the framework proposed in Heys, Martin & Mkandwire (forthcoming), which argues that whilst the impact of free goods should be captured in the household account, there is obviously a need to quality adjust the price of the IT capital to reflect the quality of the telecommunications service it provides. Byrne and Corrado provide a framework to consider quality across three dimensions:

a) The quality of the equipment used to access content via networks (e.g., the storage capacity of smartphones, etc.),
b) The quality of network services (e.g., download and upload speeds of broadband service, channel variety in video service, etc.), and
c) The use intensity of the combined content delivery system (i.e., the equipment plus the access service).

Byrne and Corrado argue that '*after controlling for the quality of systems (equipment cum access services) at the time of their purchase, the change in system use intensity reflects changes in the system's performance, i.e., change in the marginal product of its combined net capital stocks (just as ex post private capital income reflects changes in the return to capital). Not much of (b) and none of (c) is in existing GDP, and while (a) is included to a significant degree…*[it can be improved].*'* They go on to propose methods for doing this.

It appears logical that the close inter-relationship between digital services and IT capital mean that when considering the quality adjustment of these capital products (smartphones, tablets, laptops etc) the inclusion of such factors would appear to complement the approach in Abdirahman, Coyle, Heys and Stewart (2017 and forthcoming) – how could we argue that greater data usage has led to an increase in volume of data[17] if we simultaneously do not reflect the increasing capability of the IT capital to handle and manipulate these data into a form consumers can use? This complementarity is visible in equation 10 in their paper which proposes a feasible and timely measure of access services (telecommunications) prices as producer revenue divided by a volume metric such as the megabytes of data traffic per year, although importantly they widen their scope:

'For video services, quality is not so simple; cross-country studies have found that the quality dimension for video services is captured by a range of controls, including the number of channels (HD and standard), and availability of premium channels and 4K display resolution (Corrado and Ukhaneva, 2016, 2019; Diaz-Pines and Fanfalone, 2015).'

In terms of IT capital, Byrne and Corrado argue a use rate needs to be calculated, specific to each device type, which is simply time (hours) in use over the potential number of hours per day any device could be used, and a weighted aggregate of these factors is then used as the adjustment factor for the price of relevant stock of IT capital to derive capital services volumes and thus a price of the capital services offered.

[17] Byrne and Corrado use a factor which broadly means they look at data used, not data purchased, as per Abdirahman et al.

Dollt, A, & Konijn P. (2018)

This paper is based on the results of a Eurostat Task Force on price and volume measures for service activities. (Eurostat 2018).

In particular this paper addresses the way the internet is shifting an increasingly large share of transactions from traditional to on-line stores.

The fundamental question is how to treat the price differences between different types of outlets. For lack of better information, statisticians traditionally assume that price differences between outlets, for the same product, are fully attributable to differences in quality of the services delivered by these outlets (i.e. that the market is perfectly competitive and outlets would charge the same price for the same bundle of product and associated services). Thus, the difference in price between a screwdriver bought in a DIY store and exactly the same screwdriver bought in a specialised shop is equal to the value of the difference in service quality between the DIY store and the specialised shop. In this classic example, most consumers would agree that the specialised shop provides the better service, as its staff is often more knowledgeable and can provide better advice on which screwdriver to buy, justifying the higher price. However, the DIY store can benefit from advantages of scale to be able to sell the screwdriver at a lesser price, which raises doubts about the assumption that the price difference is fully due to quality.
Thus, currently, most substitution between outlets is regarded as volume change. Also, the introduction of new outlets does not lead to a change in price. This methodology, which is rather standard, has often been criticised (see e.g. National Research Council (2002)). One reason for criticism is that new outlets are often cheaper than the old ones, which is automatically interpreted as meaning that they provide a lower quality service. The decline in expenditure caused by shifting to cheaper outlets is entirely treated as a decline in the quality of the services and thus leads to a reduction of the volume of GDP. Dollt and Kinijn question this approach.
This paper discusses this in greater depth through worked examples, but concludes:

- *"It is important to be aware of the risk of substitution bias related to the emergence of new products, the "digitalisation" of existing products or the increase in on-line shopping. In principle, in each case, an evaluation should be made whether new products or outlets constitute quality changes or not. One should be careful with the default assumption that a higher price implies a higher quality.*
- *Streaming services are becoming more important and will thus need to be reflected in price indices. Normal updates of the offered content are not to be seen as quality changes as they are deemed to be part of the service. On the other hand a significant shift in the offer, for example the number of films or songs available is significantly increased or the speed or quality of streaming is significantly improved, should be considered a quality change.*

- *Cloud computing services should, if possible, be separated in the three types described in section 4; the recording and deflation depends on the type of service.*
- *E-platforms like Uber and Airbnb, should be considered as providing intermediation services between households as producers and households as consumers. These intermediation services should be deflated with price indices combining changes in the fee percentages charged and changes in the prices of the underlying services. The services produced by the households should be deflated with dedicated price indices for these services (mostly still to be developed), or alternatively, with price indices for taxi and accommodations services, resp., as proxy. Compilers should be aware of the risk of substitution bias."*

Papa, A., Murray L., Murphy B, Holocsy, I.H., Blang, D., Puchter, C, Kalko, J. (2018)

The UN's Voorburg City Group on the Prices and Volumes of Services has in recent years undertaken a significant workstream on telecommunications measurement, drawing on the latest work in multiple countries.

In particular the following aspects were noted:

Industry Classification: As a result of a lengthy harmonisation process spanning several years, there is a great degree of consistency across the four main international industrial classifications ISIC (Rev.4), NACE (Rev. 2), NAICS (v. 2017) and ANZSIC (v.2006, Rev.1). However, ANZSIC does not separate out satellite telecommunication activities from other telecommunication activities. Greater uniformity of classification may present benefits for international comparisons.

This table below provides a synopsis of the four main industrial classifications for Telecommunication services.

Table 1: Main industrial classifications for Telecommunication services

<table>
<tr><th>ISIC
(Rev. 4)</th><th>NACE
(Rev. 2)</th><th>NAICS
(v. 2017)</th><th>ANZSIC
(v. 2006/Rev. 1)</th><th>Class (Group)</th></tr>
<tr><td>6110</td><td>6110</td><td>5173</td><td>5801</td><td>Wired telecommunication activities</td></tr>
<tr><td>6120</td><td>6120</td><td>5173</td><td>5802</td><td>Wireless telecommunication activities</td></tr>
<tr><td>6130</td><td>6130</td><td>5174</td><td rowspan="2">5809</td><td>Satellite telecommunication activities</td></tr>
<tr><td>6190</td><td>6190</td><td>5179</td><td>Other telecommunication activities</td></tr>
</table>

Classification issues: Unlike the industry classification comparison, product classifications are not harmonised to the same degree. The Central Product Classification (CPC Rev. 2) is the main product classification system applicable for this industry and the relevant categories are namely:

- 841 “Telephony and other telecommunications services”
- 842 “Internet communication services”
- 8463 “Broadcasting, programming and programme distribution services”

Other groups in this division include on-line content, news agency services and library and archive services but they fall out of scope for the purpose of this paper. There are also 15 different subclasses for the telecommunications services with a breakdown according to technical criteria.

Another classification commonly used is the European Statistical Classification of Products by Activity (CPA 2008). There is a direct link between this classification of products and the NACE industry classification (the coding rules for the first four digits are the same as those for the NACE Rev. 2); and there are 24 CPA 2008 items for telecommunication services. The CPC Rev. 2 and the CPA 2008 are comparable, but CPA is more detailed. The 2007 North American Product Classification System (NAPCS) is complimentary to NAICS including more than 50 sub-items; however some of the items, such as installation of services for telecommunication networks and maintenance and repair services for telecommunication equipments, fall out of scope. Again, greater uniformity may aid international comparability.

In relation to the measurement of turnover data, Papa et al (2018) note that:

‘*As with other industries there are challenges in the definition of turnover. In principle, the value of invoiced sales of goods and services supplied to third parties during the reference period should be collected. Therefore, particular care needs to be taken when using administrative data to ensure conformity with the required concept. For example, when using tax declaration for tax purposes, any revenues generated from non-turnover producing activities, such as sales of fixed assets should be excluded. In addition, when selecting a sample for a turnover survey it is important to ensure that turnover is broken down by primary and other activities as there could be substantial over/under coverage in the frame and estimates…*

‘*Care should be taken to differentiate provision of access to resellers from provision of services directly to consumers although both are measured in gross terms.’*

This paper collects infomation on the frequency of collections and publications by countries, noting that monthly publications of SPPIs is delivered by several countries.

Application of Hedonics on broadband by the US Bureau of Labor Statistics

The Bureau of Labor Statistics began using hedonic quality adjustment for broadband items within Producer Price Index (PPI) data from December 2016, applied to the following divisions:

- Wired telecommunications carriers: Internet access services[18]
- Telecommunication, cable, and internet user services: Internet access services[19]

The BLS has announced it plans to re-estimate the hedonic broadband Internet access model annually.

To generate the hedonic adjustment, the following method is applied:

$Log\ P_{it} = \alpha_0 + \beta_2\ (Log\ X_{2i}) + \beta_3\ (Log\ X_{3i})\ \ldots\ (\beta_k\ Log\ X_{ki}) + \upsilon_i$

Where:

$Log\ P_{it}$ is the Log price of the *i* th model in period *t*

α_0 is the intercept

$Log\ X_i$ are the logged variables representing observed product characteristics

$\beta_2 \ldots \beta_k$ are the regression/slope coefficients

υ_i is the residual or error term

Applying this method, the BLS generated the following results for 2016.

Table 1. PPI Hedonic Model Regression results for broadband internet access for 2016 [a,b,c]

	Coefficient	Standard Error	t-statistic	P-value	Variance Inflation Factor
(Intercept)	2.8844	0.3072	9.390	0.000	-
Log Download Mbps	0.3075	0.0977	3.147	0.005	23.6840
Residential	0.0320	0.3352	0.095	0.925	86.0865
Company A	0.5906	0.1025	5.762	0.000	4.9199
Company B	0.7529	0.1539	4.892	0.000	18.3561
Company C	0.7068	0.1551	4.557	0.000	5.1195
Log Download: Residential	0.1411	0.1096	1.287	0.213	50.5616
Log Download: Company B	-0.8863	0.1684	-5.263	0.000	16.9078

(a) Adjusted R-Squared = 0.9400; F = 59.17; Root Mean Squared Error = 0.0933
(b) Base Configuration: Business; Several Companies
(c) Dependent variable: Log Price

Source BLS website

As the BLS explains:

[18] PCU5173115173116
[19] WPU3741

'The main variables of interest in this model are Log Download Mbps *and* Log Download: Residential*. These two variables permit changes in download speed to be valued for both residential and business broadband. In this case,* Log Download: Residential *is not significant, which implies that there is no difference in the pricing behavior between residential and business broadband Internet access services.'*

2.1.1. The measurement of digital intermediaries (platforms)

2.1.1.1. Digital intermediaries in current statistics

As explained above, digital intermediaries should already now be included in national account. One of the main difficulties lies in identifying them separately. In the existing ISIC classification, digital intermediaries are not identified separately. The next revision of the ISIC is expected to bring some progress in this respect. However, this process might take several years.

At the moment digital intermediaries might be classified in different areas. We explain the issue with the example of Uber.

2.1.1.2. The classification issue

Uber is a technology platform market place matching the needs of consumers on the one hand and independent third party service providers on the other. These services are provided by fixed assets. In the case of Uber, it is the car providing a taxi ride. The role of the digital product in this case is to facilitate search information, payment arrangements etc. The price paid to Uber or Airbnb is a composite price: part for the payment for the service provided by the physical asset and the other by the digital product. Since we have two activities undertaken by one enterprise partitioning is currently necessary to reflect the business model (See SNA2008[20], Chapter 5 section C).

However, in the perception of users, Uber is mainly seen as a transportation service provider. Also, Uber competes with traditional taxis. Uber drivers, even if formally independent, may consider Uber to be their employer (as their source of income is generated by Uber). It is these different perceptions of the different actors involved in Uber transactions that complicate the classification of these transactions.

On 20 December 2017, the European Court of Justice settled the classification of Uber from a legal point of view. It ruled that Uber provides more than an intermediation service as the use of the app is indispensable for the service to take place and Uber exercises decisive influence over the conditions under which the drivers provide their services. It therefore finds that the "intermediation service must be regarded as forming an integral part of an overall service whose main component is a transport service and, accordingly, must be classified not as 'an information society service' but as 'a service in the field of transport'"21.

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[20] UN et al (2009). *System of National Accounts*, New York

[21] https://curia.europa.eu/jcms/jcms/p1_653286/en/

It is this combination of providing an intermediation service and involvement in the provision of the transport service that stands Uber apart from e.g. travel agencies. In terms of CPA version 2.1, the service is a combination of 49.32.1 (Taxi operation services) and 79.11.1 (Travel agency services for transport reservations) or 79.90.3 (Other reservation services n.e.c.). The current CPA does not provide for precisely such a combination.

Hence, it needs to be decided in which of the current CPA classes Uber's services should be classified (and as a consequence in which NACE category Uber belongs). In this respect, it should be noted that in Europe, all Uber transactions appear to be invoiced by Uber BV, Netherlands, the European head office of the company. Uber has offices in other European countries but they appear to provide advertising services or programming services. Their classification should be in line with their main activity. So the main classification question only concerns the Dutch head office.

A second problem is to receive data from digital intermediaries. As the intermediation service is provided over the internet, it can be provided from any place. For example Airbnb has its main seat in Europe in Ireland, and Uber in the Netherlands. This means that NSIs might have difficulties to identify an adequate reporting unit within their country. Secondly, exports and imports of services will have to be recorded for a proper recording in national accounts.

In Europe, an initiative has been set up to receive the relevant data centrally for all of Europe (the European Statistical System) in collaboration with the main digital intermediary platforms. However, it is premature at this stage to say if this initiative will be successful.

2.1.1.3. Price measurement for digital intermediaries

As business statistics on digital intermediaries are still under development, separate SPPIs cannot be expected to be available at this stage.

Consumer prices are observable. The consumer price will consist of the underlying service and the transaction fee for the intermediary. The intermediation fee can be a fixed value, a certain percentage or any other function. It can be shown separately or included in the purchaser's price. With the example of Uber and Airbnb it was explained earlier, that for price statistics these transportation or accommodation services would be considered as different products, because they constitute a different quality of the product. They should enter the index calculation as soon as their economic weight justifies.

Digital intermediaries typically follow a dynamic price setting for the underlying services. This means that prices can change frequently, even within one day or hours. This poses some difficulties to measuring a representative price, and in turn volumes. A discussion on how to deal with dynamic pricing can be found in Blaudow and Burg (2018)[22]. In principle price statistics should react to a higher volatility with observing prices in a frequency

[22] Further references from the USA and Japan, which use hedonics for oil and accommodation prices, have been identified and will be added later.

corresponding to the price changes. This is of course a challenge when confronted with dynamic pricing techniques.

2.1.1.4. Volume measures for digital intermediaries

Once the transactions of digital intermediaries have properly identified in current prices – at basic prices for the supply and at purchasers' price for the use side – and representative price indices are available (SPPIs or CPIs), the volume calculation will follow as a technical exercise, although this will made more complex by the fact the price observed is a composite of the service price itself and the intermediation fee. Appropriate steps need to be taken, in line with existing guidance to ensure the correct treatment. One approach would be to treat the 'market creation' function of the digital intermediaries to justify treating their service as intermediate consumption for the service provider, in that they are delivering a service integral to the creation of the core service

2.2. The measurement of digital 'cloud computing' services

Cloud computing services can be thought of as a substitute for investment in computer and communications hardware by firms, as well as the development of own-account software. Essentially, fixed capital investment is replaced by the purchase of an intermediate input, cloud computing services.

There are a diverse range of services provided, which can be categorized into the following product classes (Byrne, Corrado and Sichel 2018; p. 6):

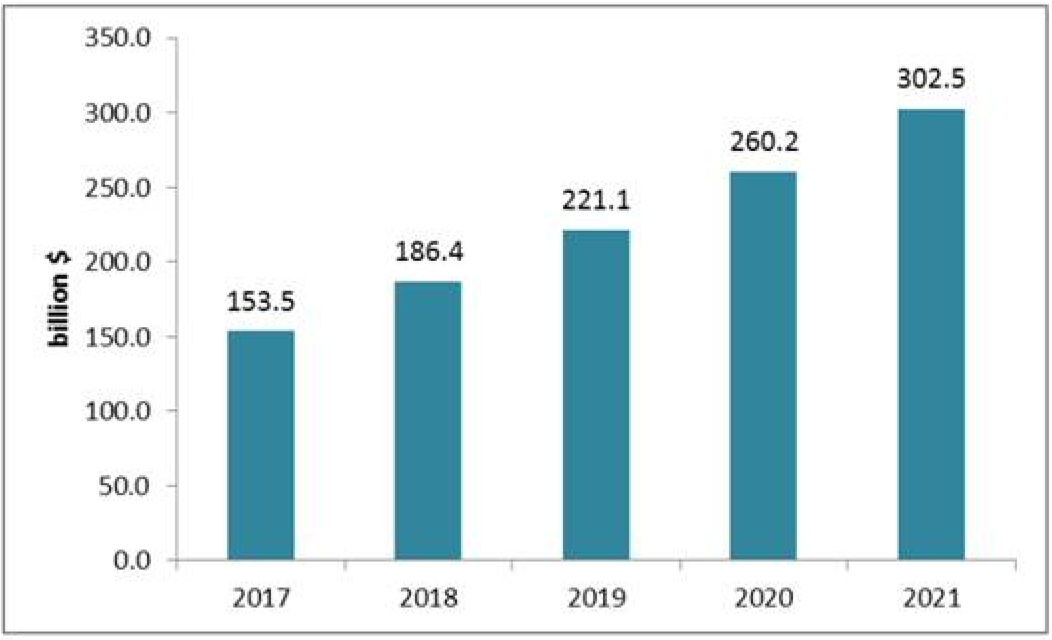
- Infrastructure as a Service (IaaS) – provides processing, storage, networksm and other fundamental computing services, where the consumer can deploy and run arbitrary software, including operating systems as well as applications. *The consumer neither manages nor controls the underlying cloud infrastructure but has control over operating systems, storage and deployed applications, and possibly some control of select networking components.*
- Platform as a Service (PaaS) – provides ability to deploy consumer-created applications created using programming languages, libraries, services, and tools. *The consumer neither manages nor controls the underlying cloud infrastructure including network, servers, operating systems, or storage but has control over the deployed applications*
- Software as a Service (SaaS) – provides the capability of running providers' application on a cloud infrastructure. The applications are accessible from various client devices through either a thin-client interface (e.g. web browser) or a programme interface. *The consumer neither manages nor controls the underlying cloud infrastructure including network, servers, operating system, storage, or even*

individual application capabilities, apart from limited user-specific application configuration settings.

- Function as a Service (FaaS) – Provides the capability of deploying functions (code) on a cloud infrastructure where an Application Programme Interface (API) gateway controls all aspect of execution. *The consumer (who would be a software developer) no longer manages nor controls the underlying cloud infrastructure including networks, servers, operating systems, storage or the computing programme.*

Cloud computing is a rapidly expanding market, as shown in Figure One.

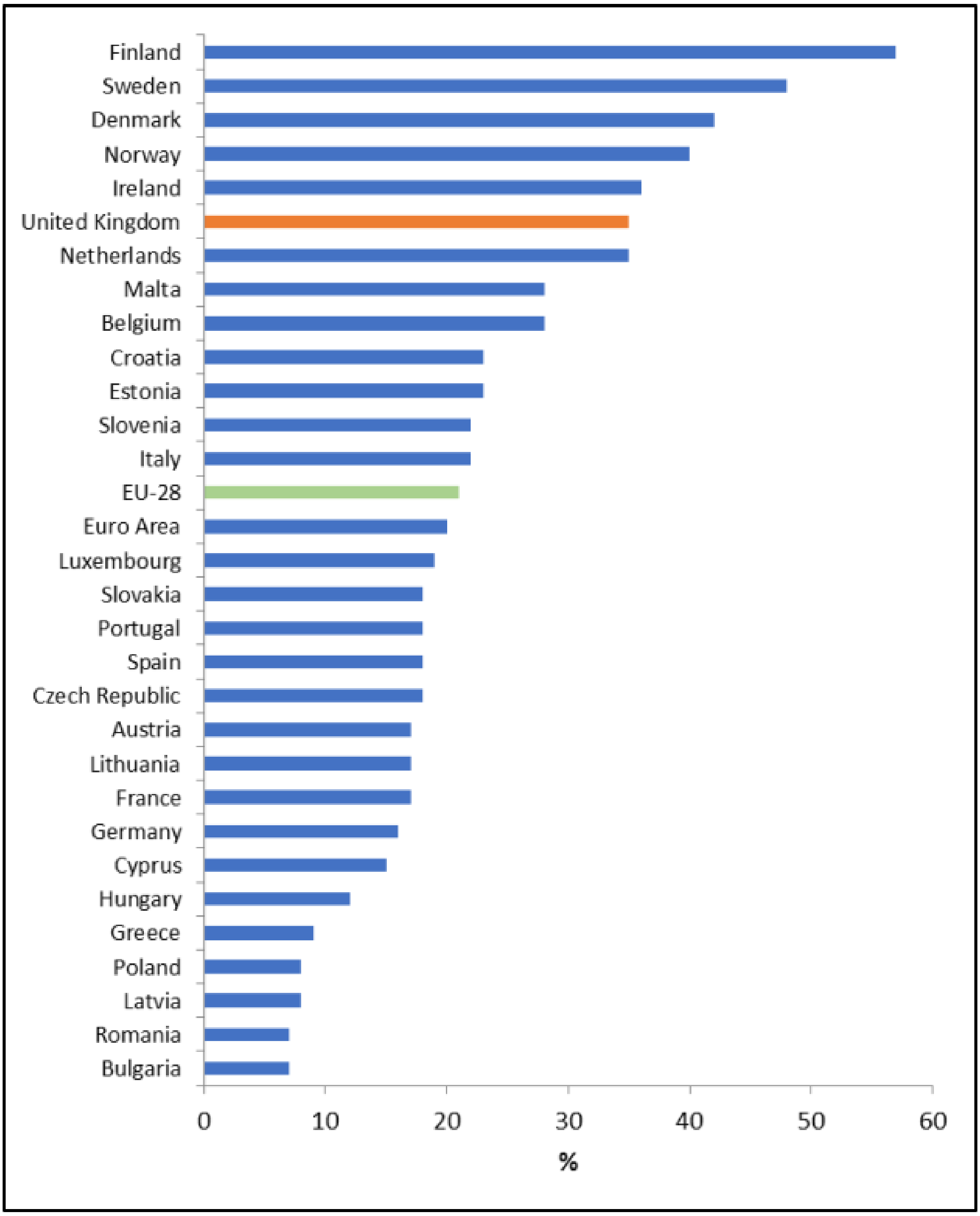
Figure 1: Global cloud market revenue forecast, 2017-2021.



Source: Gartner (2018). Reproduced from Coyle and Nguyen (2018, p. 3)

Market penetration varies across countries, but is already reaching the majority of firms in some countries, as shown in Figure Two.

Figure 2: Percentage of enterprises that buy any cloud service, comparison by EU countries, 2015.



Source: Eurostat. Reproduced from Coyle and Nguyen (2018; p. 10).

There are a huge range of options available to consumers for each of the categories. For example, Amazon Web Services (AWS) provides a range of services across four regions in the U.S., with different prices by region. Their services include EC2 – Elastic Compute Cloud (renting a virtual machine from AWS), RDS – Relational Database Service (renting database software with a virtual machine) and S3 – Simple Storage Solution (renting hard disk space). Various services and pricing options are available within each. As an example, Coyle and Nguyen (2018, p. 24) provide the information for EC2 compute products from AWS in Table 1, where compute products are called "instances":

Table 1: Overview of AWS EC2 General Purpose Instance Types

Instance type	Introduced	ECU	vCPUs	Memory (GiB)
M1 General Purpose small	Aug'06	1	1	1.7
M1 General Purpose medium	Mar'12	2	1	3.75
M1 General Purpose large	Oct'07	4	2	7.5
M1 General Purpose xlarge	Oct'07	8	4	15
M3 General Purpose medium	Jan'14	3	1	3.75
M3 General Purpose large	Jan'14	6.5	2	7.5
M3 General Purpose xlarge	Oct'12	13	4	15
M3 General Purpose 2xlarge	Oct'12	26	8	30
M4 General Purpose large	Jun'15	6.5	2	8
M4 General Purpose xlarge	Jun'15	13	4	16
M4 General Purpose 2xlarge	Jun'15	26	8	32
M4 General Purpose 4xlarge	Jun'15	53.5	16	64
M4 General Purpose 12xlarge	Jun'15	124.5	40	160
M4 General Purpose 16xlarge	Sep'16	188	64	256
M5 General Purpose large	Nov'17	10	2	8
M5 General Purpose xlarge	Nov'17	15	4	16
M5 General Purpose 2xlarge	Nov'17	31	8	32
M5 General Purpose 4xlarge	Nov'17	61	16	64
M5 General Purpose 12xlarge	Nov'17	173	48	192
M5 General Purpose 24xlarge	Nov'17	345	96	384

Source: AWS press releases.

2.3. Valuing digital assets - mobile spectrums and communication technologies

Various countries have implemented auctions for sections of spectrum. Whilst these vary in design, which can affect the prices attained, it is clear there is significant value in these assets. A selection of examples is given below:

- Canada 2008 Wireless Spectrum Auction (105MHz band) - $4.25bn
- Canada 2014 (700MHz & 2500 MHz bands) - $5.3bn
- Germany 2000 (12 blocks) – DEM 98.8bn
- Germany 2015 (5G) – E5bn
- India 2015 - $13bn
- Ireland 2012 – (4G)
- Slovakia 2013 (800 MHz, 1800MHz & 2600 MHz / 4G) – E163.9m
- Sweden 2008 (190 MHz band in the 2.6 GHz band) – SEK 2.1bn
- UK 2000 (3G) - £22.5bn
- UK 2013 (4G) - £2.3bn
- UK 2018 (further 4G and 5G) - £1.4bn
- USA multiple repeated auctions since 1994 raising over $60bn

Under the current SNA, radio spectra are treated as 'non-produced assets'. Non-produced assets consist of assets that have not been produced within the production boundary, and that may be used in the production of goods and services. 'Natural resources' are one type of non-produced asset, alongside 'contracts, leases and licenses', and 'goodwill and marketing assets'. National resources comprises land, mineral and energy reserves, non-cultivated biological resources, water resources, radio spectra, and other natural resources.

Payments for temporary use of natural resources are treated as rent, but payments for the license to use natural resources over a multi-year period fulfil that the criteria of another type of non-produced asset in their own right – 'contracts, leases and licenses'. As such, the issuance of a license to use radio spectra by government is an example of a license (non-produced asset) being issued on a natural resource (non-produced asset). Both should be captured in the national accounts.

3. Options considered

A list of options, with advantages and disadvantages considered. The options should clearly distinguish between those which would require a change in the central system from those which would be developed out of the central system.

Options are presented against each of the headline areas proposed above:

3.1. Measuring the impact of digitalisation on price deflation of existing assets and products

In relation to the price deflation of **digitally streamed products** (books, movies, music, etc), as per Eurostat (2018), whilst few countries produce Services Producer Prices Indices for divisions 58 Publishing activities, 59 Motion picture, video and television programme production, sound recording and music publishing activities and 60 Programming and broadcasting activities, the preferable approach, consistent with other services, would be to deflate the current price output data at CPA class 4-digit level with suitable SPPIs, produced with appropriate methods applied to control for changes in quality.

Where this is not feasible a pragmatic alternative would be to use suitable quality adjusted CPIs, adjusted to basic prices. This is a second-best option because the CPI currently available, for the ECOICOP "09.4.2.3 Television and radio licence fees, subscriptions", is an aggregate of numerous activities. Online streaming is only one of these, and the aggregates do not exactly match the CPA/NACE classes 58 to 60.

HFCE data should be deflated with suitably quality adjusted CPIs or business-to-all SPPIs, whichever is the highest quality. As described above the CPIs available are composed of different products, and it is generally not clear if and how online streaming activities are included in the index. This will depend on each individual country's construction of the price index.

Quality changes in principle constitute a volume effect and should accordingly be taken into account in the price indices used for deflation. However, this does not mean adjusting for different qualities of the content itself; similarly as cinema tickets would not be adjusted for the quality of the film. In this context it should be taken into account that online content is in most cases dynamic and not static.

This could take two dimensions:

- The number of films or songs available within each contract period (month or year), while others disappear. This would not constitute a change in quality. Within any defined time period there is a fixed quantity of films or music which can be consumed. In one hour, irrespective of the number of songs available, I can only download and listen to one hour of music. No matter how many songs are added to the ‘store’, the quality of the service does not change.
- The second dimension is changes in the characteristics of the films or songs available to download: for example the number of films or songs the contractee is permitted to download within any fixed period, or the speed or quality of streaming is significantly improved, should be considered a quality change. Up to now such CPIs or SPPIs have not been developed.

In relation to **information and communication services**[23], as recommended by Eurostat (2018), it is important to differentiate between standalone contracts and bundles which combine different combinations of fixed line telephony, mobile telephony, SMS text messaging, fixed line internet access, mobile internet access, and hardware (routers, mobiles, TV-sets). Using existing principles, bundles should be classified according to the main component. If the bundle is itemized and expenditure can easily be split then the components can be allocated to the relevant ECOICOP or CPA class. The following is therefore proposed:

[23] Detailed in Annex D

- **Pure bundles**[24], that is bundles of services that are only available as a bundle and not sold separately should be allocated to the COICOP subclass according to the purpose of the main component, with two exceptions:
  - Mobile call plans often include mobile internet and these bundles are to be included in wireless telephone services, regardless of the importance or weight of the two components.
  - In the case of call plans that include the cost of a mobile telephone; these are also to be included in wireless telephone services.
- **Mixed bundles**[25] **are** products which are sold both in bundles and, separately, as stand-alone products. The expenditure on stand-alone products belongs in their respective COICOP subclasses. The expenditure of mixed bundles should be dealt with according to principles previously laid down where unless the constituent components can be weighed and itemised easily, the bundle should be allocated to the COICOP subclass according to the purpose of the main component. Mixed bundles that include combinations of telephony, internet and television are allocated to COICOP 08.3.0.4 'Bundled telecommunication services'.

In relation to the deflation of telecommunications services, there are two main approaches which can be considered:

- A traditional SPPI, including suitable quality adjustment, such as hedonic adjustments according to the key factors of quality, as per the US approach, or
- A SPPI derived from a data usage unit cost index, as derived by Abdirahman, Coyle, Heys and Stewart (2017), where all data services are converted into data and a unit cost index is derived for this homogenous product based on quantities of data usage. In this case countries need to consider the appropriateness of including revenues relating to fixed line rentals and other fixed charges into the unit cost index, as described in Abdirahman, Coyle, Heys and Stewart (forthcoming).

3.2. The measurement of digital intermediaries (platforms)

Below, we'll analyse the possible recording of Uber in supply and use tables following different classifications.

Recording of Uber in supply and use tables

Below some options for the recording of Uber payment flows in the supply and use tables are set out. It is assumed, for simplicity, that Uber is based in the same country as the consumer

[24] Eurostat (2018) provides this example: '*An example of a pure bundle is a mobile call plan where calls and SMS are not available separately. An example of a mixed bundle is the purchase of a tablet (personal computers, ECOICOP 09.1.3.1) and internet data plan (telecommunication services) as a package for a single monthly fee, because both tablets and internet data plans can be bought separately.*'

[25] Eurostat (2018) provides two examples: '*Two other commonly available mixed bundles are the purchases of mobile phones with a mobile call plan and the triple play package consisting of fixed phone, internet and TV.*'

and the taxi driver. In reality, the service provided by Uber should in most cases be seen as an import.

A household buys a Uber ride for 50 euro. From this, Uber pays the taxi driver 30 euro, keeping 20 euro as the intermediation fee.

a1) Treat Uber as a taxi company with self-employed drivers

	Supply				Use		
	NACE 49				NACE 49		
	Driver	Uber			Driver	Uber	HFCE
CPA 49	30	50		CPA 49		30	50
				value added	30	20	

It is assumed that the taxi drivers are self-employed, providing a service to Uber. A small disadvantage of this treatment is that the total gross output of taxi services includes a double counting of the amount produced by the taxi driver (because taxi services are used as intermediate consumption to produce taxi services).

a2) Treat Uber as a taxi company with employees

If the taxi drivers are to be seen as employees of Uber, the recording would be:

	Supply				Use		
	NACE 49				NACE 49		
	Driver	Uber			Driver	Uber	HFCE
CPA 49		50		CPA 49			50
				value added		50	

b) Treat Uber as providing intermediation services to the taxi driver

	Supply			Use		
	NACE 49	NACE 79		NACE 49	NACE 79	
	Driver	Uber		Driver	Uber	HFCE
CPA 49	50		CPA 49			50
CPA 79		20	CPA 79	20		
			value added	30	20	

In this recording, the taxi driver is seen to purchase services from Uber. This does not correspond to the actual payment flows.

c) Treat Uber as providing intermediation services to households

	Supply			Use		
	NACE 49	NACE 79		NACE 49	NACE 79	
	Driver	Uber		Driver	Uber	HFCE
CPA 49	30		CPA 49		30	
CPA 79		50	CPA 79			50
			value added	30	20	

Here, the household pays Uber for intermediation services provided, who in turn purchases taxi services as intermediate consumption. The household expenses have to be reclassified from taxi services to intermediation services.

d) Split the transaction in two parts

	Supply			Use		
	NACE 49	NACE 79		NACE 49	NACE 79	
	Driver	Uber		Driver	Uber	HFCE
CPA 49	30		CPA 49			30
CPA 79		20	CPA 79			20
			value added	30	20	

Now, the household is seen to have two transactions: one directly with the taxi driver and one with Uber. It may be difficult in practice to re-allocate household expenditures in this way.

Note that in these options we adhere to the NACE rule that the classification of a unit follows its dominant output. More options would be available if we allowed, for example, Uber to be classified as an intermediation company while still producing mainly taxi services:

e) Treat Uber as an intermediation company that produces taxi services

	Supply			Use		
	NACE 49	NACE 79		NACE 49	NACE 79	
	Driver	Uber		Driver	Uber	HFCE
CPA 49	30	50	CPA 49		30	50
CPA 79			CPA 79			
			value added	30	20	

A final option is to see Uber as a trader of taxi services, producing a margin:

f) Treat Uber as merchanter of services

	Supply				Use		
	NACE 47	NACE 49	trade margin		NACE 47	NACE 49	
	Uber	Driver			Uber	Driver	HFCE
CPA 47	20		-20	CPA 47			
CPA 49		30	20	CPA 49			50
				value added	20	30	

However, opinions are divided on whether SNA 2008 would allow this option.

Price and volume measures

The choice between the options also impact on the choice of deflators. It should be noted first of all that Uber will likely be included in consumer price indices for taxi services. The HICP, for example, uses COICOP as classification and thus classifies transactions by purpose. COICOP does not have categories for reservation services. So for deflation of consumption using CPIs, it would be best to follow either options a) or b) above. (However, this does not answer the question how to deal with the substitution of traditional taxis by Uber – see the discussion in section 4.2.)

Producer price indices are based on NACE; it is likely that no countries have yet included Uber. However, if the Uber fee is a percentage of the trip fare, compiling a price index for this fee is conceptually not complicated (the difficulty is of course getting information on the actual percentage).

2.4. The treatment of digital ‘cloud computing’ services

Volumes

There seems to be no consensus on how to think about the volume of cloud computing services. Direct measures could be as follows:

1. Terabytes per second;
2. Megaflops per processor per unit time;
3. Gigabytes of bandwidth.

Coyle and Nguyen (2018, p. 29) note that while such measures cover the core services in cloud provision (data storage, computer processing and communication), in practice it appears complicated to separate storage from computation inside a data centre.

They note the following alternative proxies for the volume of cloud services:

- Number of fibre links into data centres, and their maximum capacity
- Data flow volumes
- Mflops of installed capacity
- Internal bandwidth
- Physical footprint of data centres (requiring assumptions about capacity and also geographical location of data centres)

None of these is easy to collect. Neither are they clearly optimal. Hence Coyle and Nguyen conclude that they "do not consider a unit value index approach to be feasible" (p. 29).

Prices

Their preferred solution is to use quality adjusted price indexes to deflate values. This corresponds with the work of Byrne, Corrado and Sichel (2018), who estimate hedonic price indexes for cloud computing services. Prices and characteristics can be taken from online price schedules, or for older data, scraped from an archive. Problems with this approach include the lack of corresponding qualities for use as weights in the regression.

Coyle and Nguyen (2018) similarly attempt to quality adjust price indexes, but in a simpler fashion, taking one product characteristic as the key determinant of quality. (In their specific case, they take this to be the AWS measure of processing performance of instances, EC2 Computing Units, or "ECU".)

Both Byrne, Corrado and Sichel (2018) and Coyle and Nguyen (2018) find large declines in price indexes. To the extent that such price declines are not reflected in official data collections, both prices and volumes will be mismeasured.

Own-account investment

Byrne, Corrado and Sichel (2018), highlight the possible mismeasurement of investment by cloud service providers undertaking large amounts of own-account investment in equipment; their electronics purchases may be counted as intermediate inputs rather than capital formation. Adding their estimates for this investment, for the U.S. nominal IT equipment and software investment would be $58 billion higher in 2015 than in the official estimates, or 0.32 percent of GDP. For 2007-2015, this would boost annual nominal GDP growth by around three basis points per year.

Product entry and exit

In such a dynamic new industry, the issue of product churn (i.e. new and disappearing goods) also becomes an issue, with potential biases in prices and corresponding volumes in standard statistical agency practice arising through not appropriate dealing with product entries and exists in price indexes. Diewert, Fox and Schreyer (2018) provide exact expressions for these potential biases. They also examine potential biases that arise from product substitutions for disappearing items. Given the dynamism of the cloud computing industry, some attention to ameliorating these potential biases seems appropriate.

Capital Services
Cloud computing delivers capital services from outsourced capital providers. As such efforts should be taken through the sequence of accounts to ensure that a realistic capital services picture is produced for productivity analysis.

2.5. Valuing digital assets - mobile spectrums and communication technologies (e.g. 5G+) internationally comparably

The payments for these licenses are a financial transaction, and so do not have an impact on GDP. Specifically, they represent a reduction in deposits for the bidding unit, and an increase in deposits of the government. This follows since neither the radio spectra, nor the licenses, are produced. Even if the payment is by a non-resident unit, it will only affect the financial account with the rest of the world, but not the trade balance or GDP of either country.

However, it is possible for 'costs of ownership transfer' (a produced asset) to be recorded on the transaction in the non-produced assets. These transfer costs could include administrative or legal fees associated with administering or participating in the auction. These costs should be treated as gross fixed capital formation in the produced asset 'costs of ownership transfer on non-produced assets', and thus constitute production and will have a GDP impact. This reflects the production done in the course of the auction. This is likely to be small in comparison to the value of the radio spectra and licenses themselves. The licenses, and the radio spectra if not previously identified, should be added to the balance sheet as non-produced assets through the 'other changes in volume account' as 'economic appearance'.

Non-produced assets also deliver capital services, and these should be estimates in multi-factor productivity estimates. These capital services will be used by the broadcasting and telecommunications industries (and possibly others to a much smaller degree). They would be a contributor to gross operating surplus (GOS), and thus expanding the asset base from produced assets to include also these non-produced assets without increasing GOS would reduce the rate of return on capital.

Perhaps the most challenging aspect is correctly valuing the non-produced assets. To achieve international consistency, countries should impute values for mobile spectrum using market prices available from comparator countries to estimate a value of the asset, implemented as a re-valuation of assets. The most obvious approach is using the net present value of future income, which could be modelled using data on payments by users for services that depend on the radio spectra. These values should be confronted against market prices from auctions when these are realised.

2.6. Price deflation of new digital products[26]

Countries should look to target a small part of their price collection activity towards capturing the prices of emergent technology products, even if these have not yet gained sufficient weight to normally merit inclusion in samples, to provide a first approximation of reservation prices to enable the calculation of price change in these products.

2.7. Sourcing current price output data on new digital products

Countries should look to ensure their price collection methods are up to date and fully capture 'appstores' and other online market-maker activity which traditional price collection models may fail to capture.

4. Recommended approach – conceptual aspects

Summary of the recommended conceptual approach. Detailed impacts across the accounts to be described in the Annex (including potential impacts on key indicators like GDP, GNI…).

Digital intermediation

A Eurostat task force preferred option b) from a statistical perspective, which considers that Uber provides an intermediation service to the taxi driver, while consumers purchase taxi services. This would provide a coherent deflation method for consumption, as well as for the output of taxi drivers. The intermediation service of Uber itself will need to be included in the service producer price indices.

Option d) was considered a good alternative, provided data can be obtained to distribute household expenses over the taxi service and the intermediation service.

If, at some point, it is decided that Uber drivers are legally to be seen as employees of Uber, and thereby have all the rights and responsibilities of employees (e.g. for social contributions) then for consistency reasons option a2) seems to be only solution.

5. Recommended approach – practical aspects

Focus on practical feasibility of the approach – availability of data sources, their quality and timeliness, need for modelling/assumptions.

Identification of further work needed to develop/test the approach.

6. Changes required to the 2008 SNA and other statistical domains

If relevant, identification of all paragraphs in the 2008 SNA which would need to be updated (with suggested text) and guidance of other statistical domains which would need to be updated to introduce/retain consistency.

[26] Where these have a non-zero and positive price

Annex – elaboration of the impacts of the recommended recording on the full sequence of accounts

Annex C: The classification of digital content

Sourced from Eurostat (2018)

While the current ECOICOP is somewhat outdated, a revised version agreed at UN Statistical Commission in March 2018 will bring considerable improvements as concerns digitalisation issues.[27] The relevant categories, which are still subject to future implementation in ECOICOP, are:

08.3.9.2 Subscription to audio-visual content, streaming services and rentals of audio-visual content
Includes
- streaming services (film and music);
- rental, download or subscription of CDs, video tapes, DVDs, Blurays, software (excluding game software);
- subscription to cable TV, satellite TV, IPTV, and Pay-TV;
- VOD services;
- subscription to TV via decoder and rental of decoders;

09.4.3.1 Rental of game software and subscription to on-line games
Includes:
- rental of game software (games on CDs, DVDs, Blue-rays etc);
- Subscription to play online games (or streaming);

09.5.2.0 Audio-visual media
Includes inter alia:
- downloads of music and films;

09.7.1 Books
Includes inter alia:
- all electronic forms of books (e-books and audio-books);
- all electronic forms of educational books (e-books and audio-books);

[27] For further details please refer to the documents presented at the 49th Session of the UN Statistical Commission, available at https://unstats.un.org/unsd/class/revisions/coicop_revision.asp

Annex D: The Classification of telecommunication services

The provision of telecommunication services is classified in division 61 of CPA Ver. 2.1, with a breakdown into classes:

- 61.10 Wired telecommunications services (including provision of internet access),
- 61.20 Wireless telecommunications services (including provision of internet access),
- 61.30 Satellite telecommunication services (including provision of internet access) and
- 61.90 Other telecommunication services (including voice over internet protocol provision).

When bundles of telecommunication services are offered, for example wired and wireless telecommunication services in one package, the product should be classified in CPA 61.90.

On the consumer side the following ECOICOP classes are the relevant ones for telecommunication services:

- 08.3.0.1 Wired telephone services
- 08.3.0.2 Wireless telephone services
- 08.3.0.3 Internet access provision services
- 08.3.0.4 Bundled telecommunication services

In the revised COICOP classification agreed at UN level in March 2018 is very close to the existing one. These categories are foreseen:

- 08.3.1 Fixed communication services
- 08.3.2 Mobile communication services
- 08.3.3 Internet access provision services and net storage services
- 08.3.4 Bundled telecommunication services

The new COICOP also brings together telecommunication and information services into the same division 8.

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