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PRICE AND VOLUME MEASUREMENT OF GOODS AND SERVICES AFFECTED BY DIGITALISATION

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Introduction

This paper presents a draft guidance note on price and volume measurement of goods and services affected by digitalisation. Chapter 1 introduces the challenges for the national accountants, based on concrete examples; chapter 2 describes how to source current price output data; 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, and chapter 5 reviews methods to address fast-paced price change for e-commerce products.

Contents

Questions for Review

The following document presents a draft guidance note on the measurement of prices and volumes which have been affected by digitalisation. In preparing this report the authors have worked to consolidate the existing research and capture existing and developing consensus. There remains a number of areas where the authors would be keen to collect additional information or viewpoints to inform a final draft. These are:

1. Can any country provide further insights on how they assemble current price data on nominal output of digital products which overcomes the challenges of rapid product development, and potentially rapid shifts in price and weight in the basket, to feed into Chapter 2?
2. In Section 2.2 we identify three approaches to measure current price data for digital products given many platforms and providers of new digital products such as digital intermediaries tend to be located in specific territories:
    a. an international organisation or national statistical agency in the territory collect the relevant data from them and disseminate via data sharing arrangements to other international/supranational organisations or national statistical agencies.
    b. collaborating with specialized third-party market research firms to collect the input data and then make the necessary adjustments before using these data for compiling national accounts.
    c. Countries could look to domestic estimates with substitute mirror trade data for particular categories produced by the host NSO in that territory

    Can anyone provide evidence of the successful application of any of these approaches?
3. Chapter 3 reviews existing best practice guidance on how to deflate existing well-defined goods and services in the national accounts. Any additional sources which could augment this chapter would be appreciated.
4. Section 3.2.7. considers the deflation of databases dependent on the treatment of data. Opinions relating to this question, or examples from NSO would be appreciated to provide alternatives for the guidance to consider.
5. Section 3.3.4 provides options and analysis of options for telecommunications services, which propose bringing the treatment of this service in line with electricity. Opinions on this treatment are requested.
6. Section 3.5.1 is dependent on decisions reached elsewhere in the digitalisation task-team on the treatment of data in the national accounts. Views on this issue should be directed accordingly.
7. In section 4.1.2, we discuss how to treat the instance where one room in a home is rented out through Airbnb. Should this room be excluded in the calculation of the imputed rental price, or should an adjustment be applied, and does this affect the weight of owner-occupied housing in the CPI?
8. In section 4.1.3, we discuss cloud computing and recommend using quality adjusted price indexes to deflate values developed using hedonic models which capture the variety of attributes. We would appreciate any information from NSOs which have attempted such an approach, or any alternatives.

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

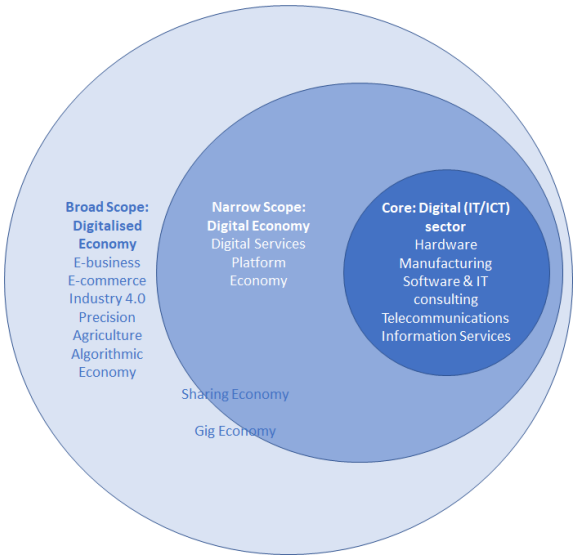
1. Introduction to the issue

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.

Digitalisation is the representation of information in bits. This technology has reduced the cost of storage, computation and transmission of data.[1] However, this is not the end of digital's impact. As Schreyer (2019) states, the provider of a digital service such as Facebook or Google or the consumer herself combines capital or intermediate services from digital services with household time to produce own-account entertainment or communication services. This similarly applies to businesses.

Thus, digital goods and services are key to our understanding of how modern economies work, and therefore we need to consider how best to capture their effect in national accounts. Whilst the other guidance notes in this series address particular instances of the impact of the digital economy, and how we measure activity in current price terms, this paper casts a wider net over how we derive prices, deflators and ultimately volume measures both for these products in the core and narrow scope, as illustrated below, but also in the broad scope those who are affected by digitalisation.

Figure One: The 'digital' economy using a tiered approach



Source: The Digital Economy Report, 2019, UNCTAD – adapted from Bukht and Heeks, 2017

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

It should be noted that the SNA does not have a supporting manual which specifically addresses how best to tackle issues of prices and volumes across the broad sweep of 'traditional' goods and services. This guidance note however, does not inhabit a guidance vacuum: the most noticeable contribution is Eurostat's '*Handbook on prices and volumes measures in national accounts*'[2], although this rests on four other manuals:

- the '*Manual on Producer Price Indices*' prepared by the IMF[3],
- the Eurostat-OECD '*Methodological Guide for Developing Producer Price Indices for Services*'[4], and
- the '*Manual on Consumer Price Indices*' prepared by the ILO[5]
- the '*Export and Import Price Index Manual*' prepared by the IMF[6]

This guidance note takes these manuals as given, but looks to answer three particular questions in relation to the specific instance where digitalisation is having a material impact on measurement of deflators and volumes, and where additional guidance may be beneficial:

- What does 'best practice' look like in the context of products which have seen a strong digital influence?
- For countries which cannot either afford the 'best practice', or do not have access to the necessary data what does 'acceptable practice' look like, and
- Given the particular nature of these products, are there current, well-recognised, practices which are not valid/optimal in this context and which should be avoided, even if they are entirely suitable in relation to other products?

To navigate this paper, we address the following areas where the impacts of digital in turn:

- Sourcing current price output data on new digital products
- Price deflation and volume estimation of existing assets and products, including whether the digitally enabled services are the same or different products compared to their traditional competitors, particularly:
    - Telecommunications
    - ICT hardware
    - ICT software
    - Intangible Assets
    - Other goods and services of a non-digital nature (e.g. taxi or accommodation services)
- Price deflation and volume estimation of new digital goods, services, and assets[7], including:
    - Digital intermediaries

[2] See https://ec.europa.eu/eurostat/web/products-manuals-and-guidelines/-/KS-GQ-14-005
[3] See http://www.imf.org/external/pubs/ft/ppi/2010/manual/ppi.pdf
[4] See http://www.oecd.org/publications/eurostat-oecd-methodological-guide-for-developing-producer-priceindices-for-services-9789264220676-en.htm
[5] See https://unstats.un.org/unsd/statcom/51st-session/documents/BG-Item3f-IWG-price-statistics-E.pdf for 2020 draft update by ILO, IMF, UNECE, Eurostat, OECD, and World Bank
[6] See https://www.imf.org/external/np/sta/xipim/pdf/xipim.pdf
[7] Where these have a non-zero and positive price

    - Cloud computing services
- The challenges presented in rapidly changing price data particularly in non-survey data

This paper excludes from its scope the following:

- New digital products with a zero cash price at the point of delivery, as a parallel paper 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 paper looking at crypto-assets / fintech and other financial matters which is 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, but the deflation of cloud computing is addressed below.

2. Sourcing current price output data on digital products

2.1. Existing Material

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 which may be too small, until the product gains rapid market-share to be captured in a survey, or where 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 in 2016, Whilst this individual product would obviously be grouped within software, this example signposts the key challenges which statisticians currently face:

- By going from being irrelevant in price collection terms to becoming of noticeably more significant weight, if only for a short period, there is an obvious question of how to capture this firm in surveys and how to update weights for aggregation to the whole-economy level.
- By being sold via '*appstores*', which themselves might not necessarily be domestic in nature, it is obvious that the sourcing of data on these rapidly changing sales numbers is a challenge which requires statistical agencies to actively interact with these alternative 'market-makers'.[8]

In line with other products, given the preferred method to obtain volume measures of digital products is by deflating their current-price output by appropriate price indices, it is essential to discuss how to obtain the current-price output of these products.

2.1.1. Cloud computing – an example

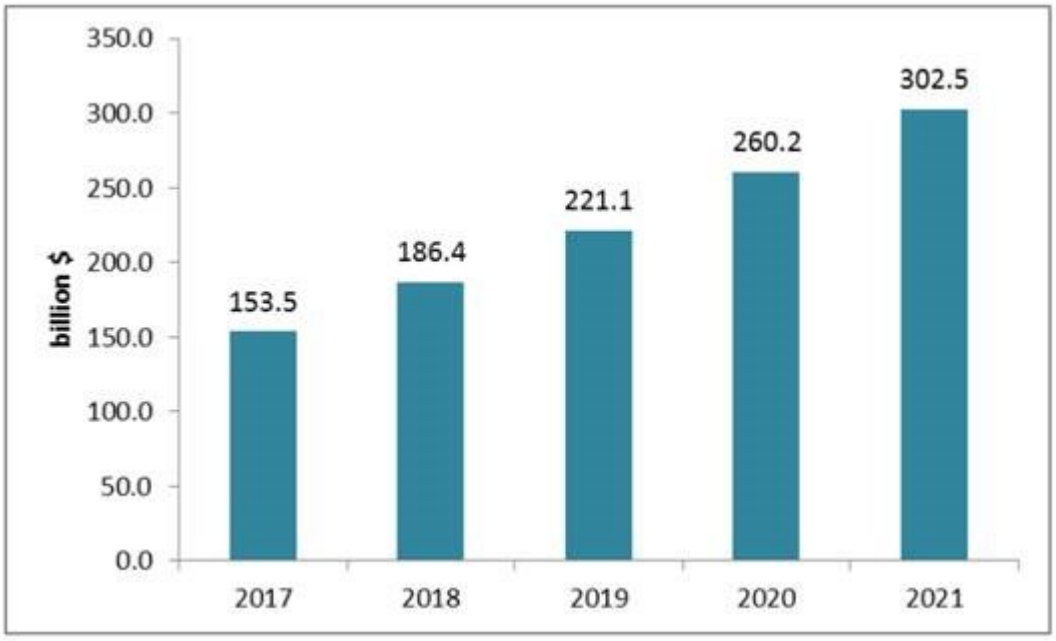
A core example here is cloud computing, where available estimates indicate a dramatic rise in nominal output, which is forecast to continue; see Figure Two. While there are differences in the extent to which adoption is taking place across countries, the percentage of businesses that purchase any cloud services can be above 40% for some countries and is above 20% for the EU-28 countries, as shown in Figure Three.

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).[9]

[8] See also the parallel papers from the Globalisation task team.

[9] A large increase in the volume of data means that it is not feasible to transmit all of it to the cloud for processing in real time. Hence, businesses and governments locate the processing and storage data collections close to internet providers networks, giving rise to the terminology "edge computing", reflecting this proximity. This data streamlining solution allows the transmission of only higher-value data to a cloud centre for further use.

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



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

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.

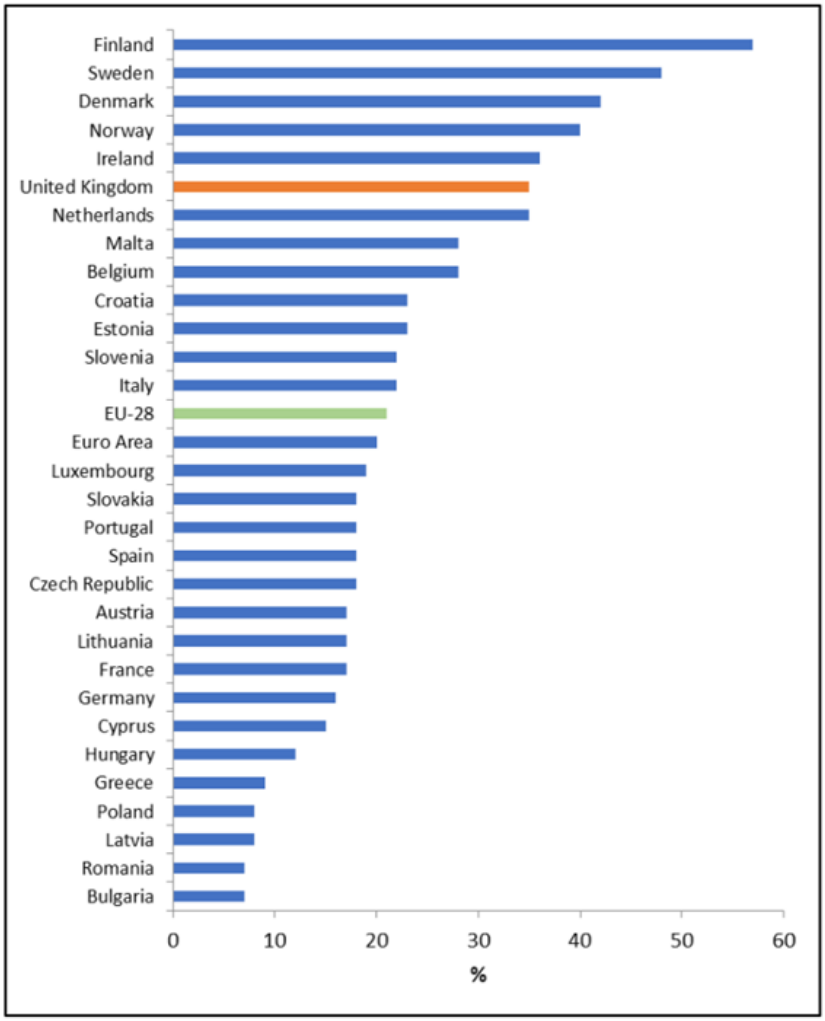
Cloud computing services can be thought of as a substitute for investment in computer and communications hardware by firms, as well as the development of own-account software. Essentially, fixed capital investment is replaced by the purchase of an intermediate input, cloud computing services.

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, networks, 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.*

Figure Three: 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.

AS such it is clear that before we can consider how to effectively tackle prices and volumes, it is key for statisticians to take care to address how they assemble high quality nominal output data, or in the absence of this, how they extract sufficient insights from their existing data to be able to tackle measurement of the digital sector. Examples of country practices are presented below, together with a discussion of the conceptual and empirical issues which need to be addressed. Some of the country examples also discuss the methods used to obtain the current-

price output of new digital products, such as those provided by digital intermediaries. A proposed strategy to address these issues is also outlined.

2.1.2. United States of America

The US Bureau of Economic Analysis (BEA)[10] has constructed estimates of the US digital economy within a supply-use framework following a three step process. First, BEA developed a conceptual definition of the digital economy. Second, BEA identified specific goods and services categories within BEA's supply-use framework relevant to measuring the digital economy. Third, BEA used the supply-use framework to identify the industries responsible for producing these goods and services, and estimated output, value added, employment and compensation for these industries. The BEA included in its definition of the digital economy (1) the digital-enabling infrastructure needed for a computer network to exist and operate, (2) the digital transactions that take place using that system ("e-commerce"), and (3) the content that digital economy users create and access ("digital media").

The data sources for the current-price output depend on whether the year in question in a benchmark year for the input-output tables. In benchmark years, the key data source is the U.S. Census Bureau's Economic Census, which is conducted once every five years. In non-benchmark years, the key data source is the annual surveys that cover selected industries, such as manufacturing and services.

2.1.3. *Australia*

The Australian Bureau of Statistics (ABS) has developed preliminary experimental estimates of digital activity in the Australian economy using the US Bureau of Economic Analysis approach. Under this approach, digital products were selected from ABS supply-use tables for three broad digital activities (digital enabling infrastructure, digital media and E-commerce), after which the industry sources were identified for these digital products.

The current price estimation of the digital activities involved modelling the relevant digital products; compiling the gross output, intermediate consumption and value added of the digital activities within the source supply-use industry classifications (SUICs); and aggregating the estimated inputs and outputs across the industries.

Within some of the selected supply-use product classifications (SUPCs), only certain components were relevant to the conceptual measurement of digital activities. To ensure consistency within the established scope, the supply-use gross output of such components were modelled using other data sources such as ABS input-output table, NAB online retail sales index (NORSI), retail turnover by industry group and ABS Business Characteristics Survey (BCS).

Next, the digital activities were estimated in each of the identified primary and secondary industries. In a particular SUIC, digital gross output was estimated as the sum of the selected and modelled products. Due to the lack of information on the production processes, the industry production function for the digital products was assumed to be identical to the "non-digital"

[10] See Barefoot et al (2018)

counterpart. Hence, the associated digital value added was estimated as the total value added weighted by the share of the estimated digital output in total output. Total intermediate consumption for the production of the digital products was calculated as the difference between the digital gross output and digital value added, which was then proportionately split amongst SUPCs.

Gross output, intermediate consumption and value added by digital activity were estimated as the sum of the relevant products across the source SUICs.[11]

2.1.4. Canada

In 2019, Statistics Canada released the results of a study on the provisional estimates of private short-term accommodation in Canada. Private short-term accommodation is defined as the listing and rental of privately-owned dwellings on a short-term basis via an intermediary digital platform. The input data for the study were acquired from a third-party market research firm that specializes in providing data analytics for private short-term accommodation rental platforms. The acquired data included public information, such as the listing type and rental price, that the firm collects, via web scraping, from various short-term rental platforms. The third-party firm also provided additional market information, such as estimated occupancy rates and earned revenue, that they derived using their own proprietary methods.[12] The experience of Statistics Canada suggests that, besides using traditional surveys, national statistical offices should explore alternative data sources such as third-party firms to collect input data to estimate the current-price output of digital products.

2.1.5. Japan

Japan has conducted a study to construct a digital supply and use table (SUT) for 2015 using the framework for the digital SUT which was developed by the OECD. From the national benchmark SUTs and input-output tables, the current-price output of industries operating in the digital economy were identified and estimated.

A number of approaches were used to measure the current-price output of the industries and products in the digital economy, with each approach dependent on the industry or product concerned. For digitally enabling industries, the standard SUT (which was constructed using economic censuses as one of the data sources) was used to identify these industries and the corresponding current-price output. In the case of e-tailers (i.e., retail establishment with online sales ratio of 50% or more) and firms dependent on intermediary platforms, economic census data were used to identify these units using indicators such as the share of Internet transactions of retailers and share of e-commerce before their current-price output was calculated. The current-price output of e-tailers was obtained by multiplying their margin rate by their sales revenue at the most detailed level possible. The current-price output of firms dependent on intermediary platforms was obtained by summing up the current-price output of the individual firms. In the case of digital platforms and digital only firms providing finance/insurance services, additional survey results were used to identify these firms and obtain their

[11] More information on the methods used is available from "Measuring digital activity".
[12] More information on the detailed methodology and limitations encountered is available on https://www150.statcan.gc.ca/n1/pub/13-605-x/2019001/article/00001-eng.pdf.

corresponding current-price output. In addition, ICT services were split into (1) cloud computing service (paid), (2) digital intermediary service (paid), and (3) internet-ad space provision service by dividing and re-organizing Internet-related services. For these services, the sub-divided Benchmark Make and Use tables were used as the basis for estimation. For the third service, the ratio of ad revenues estimated from the "basic survey of telecommunication industry" was used as the basis for estimation. With regard to digital intermediary service (paid), the amount was based on the report on sharing economy services by the Cabinet Office.

The Japanese experience shows how to some extent the current-price output of the digital economy can be obtained using existing data sources.

2.2. Options Considered

There are at least three key challenges in tracking and measuring the current-price output of digital products:

- Most of the businesses which produce digital products have complex and non-traditional legal structures and business models. This makes classifying the economic activity and agents very challenging. For example, digital intermediaries perform an important facilitation process which must be appropriately accounted for within the SNA. The facilitation activity is distinct from the actual goods or services exchanged between producers and consumers. As a result, even where the national accounts may capture the economic activity, care must be taken to ensure it is classified appropriately.
- There are important questions about where some of the economic agents providing the final services which may be 'digitally-enabled'[13] are located vis-à-vis the production boundary. Household production of such services would not be identified in traditional business surveys, but it is an open matter of debate whether such activity should be captured in the household sector within the national accounts and how best to do this. Nevertheless, since most of this production is delivered by households engaging in non-traditional production activities, traditional data sources are likely not picking up this activity.
- Large proportions of the economic activity are with economic agents in different countries. For example, most sharing businesses are not incorporated or registered in the territories where they conduct their business; thus they are classified as non-residents in the national accounts. As a result, their economic activity is out of scope of business surveys of the territories in which they operate.

To address the above-mentioned issues, the following strategies can be considered. One, a typology of digital intermediary platforms may need to be developed to facilitate their classification and the subsequent development of recommendations on how to classify and

[13] That is, have only come into being because the digital market-place has enabled their emergence – this may cover Airbnb and other 'room-rental' models or Uber where households use their domestic car to deliver taxi-style services

record their transactions in the national accounts. This is under consideration in the ISIC review and this guidance will need to be updated to reflect the outcome of this.

Secondly, given the proliferation of household participation in digitally-enabled production activities (such as Uber or Airbnb), household surveys may need to be expanded to include questions on household production. Alternatively, if resources permit, special digital economy surveys such as those conducted by Statistics Canada can be considered[14].

Thirdly, given that many platforms and providers of new digital products such as digital intermediaries tend to be located in specific territories, it may be most efficient and effective for the international organisation or national statistical agency in the territory in which the platform or provider is located to collect the relevant data from them. After that, the international/supranational organisation or national statistical agency concerned should, if necessary, adjust the data collected so that they can be used for compiling national accounts and share these data with other national statistical agencies of countries that consume/import the digital services. This would require data sharing arrangements between international/supranational organisation or national statistical agencies to be strengthened and enhanced. Similar data exchange arrangements are already in place, for example, in Europe for the EuroGroups Register.

Under this arrangement, Eurostat collects input information on enterprise group members and on their relationships from the national statistical business registers of EU countries and participating EFTA countries, and from commercial sources. After consolidation and validation, the register contains the global structure of the multinational enterprise groups. National register staff and statistics compilers are given access to all units of the multinational enterprise groups, if at least one of the group's units is within their national territory. These populations can be used for national survey frames.

A practical example to be mentioned is that Eurostat has reached an agreement with Airbnb, Booking, Expedia Group and Tripadvisor on data sharing.[15] This allows Eurostat to publish data on short-stay accommodations offered via these platforms across the EU, although it is as yet uncertain whether this can be extended to current-price output. The intention is to share with the national statistical institutes the sum of the four platforms, but not confidential individual data. Agreements on this exchange are currently under preparation. The variables transmitted will be on occupancy data only, but not prices or values. Nonetheless, such data sources can be a very useful and consistent basis for further estimates for national accounts purposes.

As an alternative, national statistical agencies can consider collaborating with specialized third-party market research firms to collect the input data for digital intermediary platforms and providers of new digital products and then make the necessary adjustments before using these data for compiling national accounts. Also, countries could look to substitute mirror trade data for particular categories with that from other countries (so for example, the UK could use the

[14] see https://www150.statcan.gc.ca/n1/daily-quotidien/180829/dq180829b-eng.pdf
[15] See press release: https://ec.europa.eu/commission/presscorner/detail/en/ip_20_194

American estimate of computer game exports to the UK as their measure of imports of this category of products.) This approach would require countries to be in agreement in the version of the BPM manual they comply with and detailed agreement around definitions and time periods which would likely require detailed negotiations but may side-step data-sharing concerns.

2.3. Recommended approach – conceptual aspects

In principle, a variety of traditional and emerging data sources are available to derive the current-price output of digital products. These include economic censuses, enterprise surveys, household surveys, special surveys targeted at specific digital products and web-scrapped data from relevant third-party data providers. To the extent that these data sources capture information on locally-produced digital products which were previously not accounted for in the national accounts, the incorporation of their results in the national accounts will likely result in an increase in nominal GDP and GNI, or a movement of GVA between industries, or their trade data.

Databases

In relation to databases there remains as StatCan (2019) explains an outstanding conceptual question:

'The 2008 SNA specified that databases should be valued on a sum of costs basis and only reflect the cost of preparing data in the appropriate format but not the cost of acquiring or producing the underlying data. In line with business accounting rules, data are considered non-produced assets and appear residually under goodwill only when a market purchase of a firm occurs. However, recent growth in the digital economy and in the monetisation of data holdings by firms has raised concerns regarding the lack of visibility of data in the national accounts.'

Whilst this means that the cost of labour and capital inputs to create databases, this model fails to reflect the value of data being incorporated into the database. Data is not currently one of the traditional categories of intangible assets outside the National Accounts, so can be considered in isolation from these. This leads to two clear options:

- Revising the method for calculating the value of databases to include the value of the data incorporated into these databases, or:
- Leaving the method for creating databases as it currently stands, but creating a new intangible asset, data, which will reflect the value of the data, noting that this data could be included in multiple databases, sold to third parties or used for product development.

The parallel group on data and free digital services is developing a solution which may affect the nominal measurement of databases, so this section is pending completion once this decision is reached.

2.4. Recommended approach – practical aspects

The choice of which data source to use would largely depend on the amount of resources available to national statistical agencies and whether the units providing the digital products are within the scope of surveys. Special regular surveys would most likely require more resources. On the other hand, existing surveys may not be disaggregated enough to directly capture estimates of digital products and activities. As a result, estimates of digital products and activities are obtained indirectly using various assumptions. One solution is to consider expanding the level of detail in existing surveys to get direct estimates of digital products and activities.

Also, many economic agents providing the digital products are not incorporated or registered in the territories where they conduct their business. As a result, they may be out of the scope of the business surveys of the territories in which they operate. One solution is for the international organisation or national statistical agency in the territory in which the economic agent is located to collect the relevant data from them for sharing with other data compilers. In this respect, data sharing arrangements may need to be developed or existing ones enhanced and strengthened.

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

The recommendations in the section are unlikely to require changes to the SNA itself, but can be viewed as additional supplementary guidance which provides further detail to support the successful implementation of the SNA, except in one area.

The 2008 SNA explicitly references the recording of data in the context of the discussion on databases in paragraphs 10.113 (author's underlining):

10.113 The creation of a database will generally have to be estimated by a sum-of-costs approach. The cost of the database management system (DBMS) used should not be included in the costs but be treated as a computer software asset unless it is used under an operating lease. The cost of preparing data in the appropriate format is included in the cost of the database <u>but not the cost of acquiring or producing the data</u>. Other costs will include staff time estimated on the basis of the amount of time spent in developing the database, an estimate of the capital services of the assets used in developing the database and costs of items used as intermediate consumption.

However, in the following paragraph where the value of the data acquired is included within the market value, it is then in scope:

10.114 Databases for sale should be valued at their market price, which includes the value of the information content. If the value of a software component is available separately, it should be recorded as the sale of software."

Dependent on the treatment of databases and data proposed in other papers, this inconsistency may be addressed.

3. Price deflation and volume estimation of existing assets and products

3.1. Existing Material

The digital economy and digital goods, services and assets are not new phenomena. Large parts of the productive economy have been employed in and around these activities for a long time and the SNA and supporting manuals recognise that. 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:

This section addresses two parallel challenges:

- Even within existing digital products, such as ICT hardware, software and telecommunications, properly accounting for rapid product innovation is difficult, particularly if the pace of change has become more rapid. As such, we need to assure our existing methods are fit for purpose.
- Digital goods, services and assets play an increasingly important part in the production, retailing, and intermediation of other more traditional goods. It is important to ensure estimates of prices and volumes of these products reflect this appropriately.

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

- **Quality change** - The large and fast changes in the quality of the products produced and consumed may be hard to identify and capture[16].
- **Outlet substitution bias** - 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.
- **Customisation** – Digitalisation allows products to become more and more customised, reflecting the preferences of the consumers, but potentially affecting the homogenous nature of the product, and
- **Bundling** - The bundling / coming together of products in new combinations (for example, mobile phones, torches, bankcards, maps, and pedometers into smart phones).

Taking each of these in turn:

3.1.1. Quality change of existing products

When any product changes price this can be for one of two reasons: either this reflects an upwards movement in the price-level of the same product between two time periods, or because

[16] *"The quality of a product is defined by its (physical and non-physical) characteristics. In principle, whenever a characteristic of a product changes, it is to be considered a different quality of the product. These changes in characteristics are to be recorded as changes in volume and not as changes in price*" ESA 2010, par. 10.18.

something in the nature, or quality, of the product has changed which causes consumers to place a different value on the good, reflecting their valuation of the utility they gain from the product. As such, to construct a price index which measures price change through time, price statisticians use various methods to strip out quality change to be able to compare prices on a 'like-for-like' basis.

Digitalisation has made this more complex because rapid quality change and product innovation are key characteristics of the digital revolutions. This process has also become more ubiquitous: no longer do we only see this in laptops, PCs, smartphones and digital camera, this process increasingly affects all sorts of other goods and services: for example, a fridge which is now part of the 'internet of things' and can 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? Does this depend 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: the variables included in the model, as well as their value might change dramatically over time?[17]
    - 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, rather than 'entry-level' contracts, this suggests that countries using a 'basket of consumers' approach for this product may potentially deliver biased results. This approach, using price data for the cheapest contract which meets the requirements of a set of consumers is likely to be biased towards entry-level contracts, and therefore under-estimate quality change and hence over-estimate price change and deflators.
      Should such approaches be discouraged for some digital products, and what alternative methods of adjusting for quality might be considered both more effective and more pragmatic in terms of delivery?

[17] The OECD published a Handbook on Hedonic Indices and Quality Adjustment in Price Indices (http://www.oecd-ilibrary.org/science-and-technology/handbook-on-hedonic-indexes-and-qualityadjustments-in-price-indexes_643587187107), in which the technical aspects of hedonics are elaborated as well as a comparison is made with other quality adjustment methods.

- **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 the national accounts 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[18]. The rest of the 'functionality' is purchased/sourced as services which can be accessed via the data which are received 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? Is value created in these products in a multiplicative rather than additive model? 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.

3.1.2. Outlet substitution bias[19]

There is no consensus on how to deal with the outlet substitution bias problem. For example, in the case of retail outlets, where the problem was first discussed, the intra-agency CPI manual[20] states:

'Reinsdorf (1993) estimated the degree of new outlet bias by comparing average prices at outlets entering and disappearing from US CPI samples. There has been little or no empirical work, however, on the measurement or consumer valuation of outlet quality such as product variety, location, car parking, and customer services. As a consequence, there is little evidence on how to evaluate the accuracy of new outlet bias estimates.'

While statistical agencies incorrectly assign all of the price difference to quality differences, conceptual exercises that try to assess the magnitude of the bias (like Nakamura et al) assume

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

[19] See Nakamura, Diewert, Greenlees, Nakamura, and Reinsdorf. (2015). for a recent review of this problem and the potential biases in indexes obtained from traditional approaches.

[20] **Para 11.63, Consumer Price Index Manual: Theory and Practice (2004)**
By International Labour Office, OECD, International Monetary Fund, The World Bank, The United Nations Economic Commission for Europe, Statistical Office of the European Communities, Luxembourg

the polar opposite: they assume that the goods are perfect substitutes (i.e., no quality difference).

As Dollt & Konijn (2018) explain, for lack of better information, statisticians traditionally assume most substitution between outlets is regarded as volume change driven by quality differences. This methodology has often been criticised[21] 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 physical 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 to capture and appropriately weight the volume of services delivered requires the price deflator to reflect the new outlet / production technology, noting the key 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):

[21] See Nakamura et al (2015), which assumes the goods are perfect substitutes, that is there is no quality change resulting in changes in volume

'...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.[22] *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.'*

This guidance note therefore identifies that in such circumstances, national accountants and price statisticians need to work in close tandem to ensure price deflators compares like-for-like transactions so that current price data is appropriately deflated to give the correct volume of activity. At the heart of this is the requirement to discretely collect data on digital and physical transactions to capture the different price change and price levels of a common transaction in both its physical and digital manifestation.

3.1.3. Customisation

All products can be customised in some way (for example, I could put a towbar on my car), but with digital products the capacity to be customised is often one of the selling points. In this instance, the product which is purchased has customisable qualities, but these are the same for all consumers at the point of purchase. How the product is subsequently altered is akin to how I might treat an apple. I might eat it raw, I might chop it up and put it in a pie, I might use it to make apple sauce. National Accounts does not have an interest in the customisation of the apple, and this principle should be extended to digital goods and services.

The key issue in this context, however, is where customisation occurs at the point of purchase, most obviously seen in customised software. As stated in Bean (2016)[23]:

'....measuring the output and prices of services is inherently more difficult than for goods as, in contrast to goods, the basic unit of production for services is often hard to define. Services are frequently tailored to a particular consumer's requirement and such customisation makes it hard to compare like with like and thus to construct an appropriate price index.'

3.1.4. Bundling

Bundling, or the selling of multiple products under a single price is a standard problem for price statisticians. In the case of digital, problems can emerge in the different classifications of products for consumer and producer price series, particularly where bundles may include both goods and services.[24]

An example is telecommunications: in the UK, for example, both CPI and SPPI measures are created. However, the CPI product level index captures both goods and services (phones and phone contracts, despite the product group to be deflated only including services. The CPI and

[22] The same item may cost less on, say, Ebay, than in a brick-and-mortar store, but Ebay may provide a better buyer protection service if there are disputes between the buyer and seller after the sale.
[23] Para 2.41
[24] For example, a paid subscription to Amazon Prime includes benefits such as free two-day delivery, streaming music and video, and other benefits. If the price of Amazon Prime were to change, there will be a need to determine the source(s) of this price change.

the product group that is deflated are also classified using different systems that do not easily map[25]. The CPI is based on the Classification of Individual Consumption According to Purpose (COICOP) while the National Accounts product classification is based on the Classification of Products by Activity (CPA). The SPPI classification is based on CPA. Obviously in such circumstances it is important for countries to make the best, pragmatic decisions they can to correctly marry price deflators with the product group to be deflated using standard approaches, such as identifying standalone smartphone costs to strip these out from the bundle to observe the value of the contract.

Annex A elaborates on these issues in the context of four key studies on price indexes for digital goods and services that were recently conducted.

3.2. Options Considered

This section looks to existing goods and services which have been affected by digitalisation. The following table outlines the headline CPC codes which we will consider

Two digit CPC group	Two digit title	Detailed CPC class / subclass	Digital good / service or Traditional service affected by digitalisation
45	Office, accounting and computing machinery		
		45.2 Computing machinery and parts and accessories thereof, particularly 45.22 (laptops) and 45.23 (PCs)	Digital good / service
47	Radio, television and communication equipment and apparatus		
		47.215 Digital Cameras	Digital good / service
		47.222 Telephones for cellular networks or for other wireless networks	Digital good / service
		47.8 Packaged software	Digital good / service
61	Wholesale Trade		Traditional service affected by digitalisation
62	Retail Trade		Traditional service affected by digitalisation

[25] Telecommunications presents particular challenges around bundling of goods and services. Various accounting bodies have reviewed their accounting rules in recent years with some jurisdictions requiring firms to separate revenue earned from phones from revenues earned for contract services. See https://assets.kpmg/content/dam/kpmg/xx/pdf/2016/09/revenue-for-telecoms-issues-in-depth-2016.pdf as an example. Some regulators also require data to be presented in particular ways.

63	Accommodation, food and beverage services		
		63.1 Accommodation services for visitors, particularly 63.11 Room or unit accommodation for visitors with daily housekeeping services and 63.12 Room or unit accommodation for visitors without daily housekeeping services	Traditional service affected by digitalisation
64	Passenger transport services		
		64.115 Taxi services and 64.116 Rental services of passenger cars with operators	Traditional service affected by digitalisation
68	Postal and courier services		
		68.011 Postal services relating to letters	Traditional service affected by digitalisation
83	Professional, technical and business services		
		83.13 IT consulting and support services	Digital good / service
		83.14 IT design and development services, especially 83.141 Software produced under contract for others and 83.143 Software originals	Digital good / service
		83.15 Hosting and IT infrastructure[26]	Digital good / service
		83.99 Other professional, technical and business services n.e.c. (*including databases*)	Digital good / service
84	Telecommunications, broadcasting and information supply services		
		84.1 Telecommunications, specifically 84.12 fixed telephony and 84.13 mobile telecommunications services	Digital good / service
		84.2 Internet telecommunications services	Digital good / service
		84.3 Online content, including 83.49 Online games and online software	Digital good / service

In the following sections this guidance will tackle digital goods and services in turn before providing general guidance for traditional services affected by digitalisation.

[26] This product will be mostly considered in the next section covering new products, specifically cloud computing.

Looking across the relevant research and manuals, this guidance particularly refers to the strongest materials, such as Eurostat's Prices and Volume Handbook (2016) as there is limited international best practice guidance beyond this. This lays out a tiered hierarchy of methods. This paper does not use the same hierarchy, but tries to indicate the preferred and acceptable alternatives in a similar fashion.

3.2.1. CPC 45.2 Computing machinery and parts and accessories thereof, particularly 45.22 (laptops) and 45.23 (PCs)

In relation to ICT hardware, the key options are well summarised in Eurostat (2016)[27]:

"An A method is deflation with a PPI that uses an appropriate quality adjustment procedure, which can be… the hedonic approach, option prices, or resampling. For household consumption of PCs, list prices will provide an acceptable alternative for actual prices, but only for that case. List prices can for example be obtained from computer magazines or from the internet.

B methods are less appropriate PPIs, e.g. with a less appropriate quality adjustment procedure, such as the judgmental approach or production costs. Another possible B method is the use of information from the US price index for computers, provided it can be shown that it is sufficiently representative for the domestic prices. The most appropriate option in this case is to use the US prices of computer characteristics, and to use these to make explicit quality adjustments to price data collected domestically. An appropriate mechanism for taking into account different general price changes or exchange rate changes should be applied….

Proxy methods, such as using price indexes from other electronic products should be classified as C methods. Also, methods based upon unit values are C methods. The use of a price index that does not take account of quality changes is also a C method. The unadjusted price comparison method and automatic linking are always C methods for computers."

In combination, therefore this suggests an optimal strategy of regularly updating and hedonically adjusting domestically produced ICT hardware and using PPI series with exchange rate adjustment for foreign produced goods as a first best approach. However, clearly this is labour intensive and so consideration should be given to second-best alternatives.

3.2.2. CPC 47.215 Digital Cameras

Digital cameras are a product which highlight some of the key challenges caused by digitalisation, which is the simple pace of change imposed by new technology. Digital cameras are a technology which rapidly overtook film cameras but which have been rapidly overtaken by equivalent technology built into smartphones and other mobile devices making this category almost superfluous. One area in which this section can be useful is to identify at the transition point when smartphones began to offer camera technologies is to use digital camera prices to quantify the quality change component in the price index for smartphones. However, this may still under-estimate the value of in-built technology, given the inherent benefits of bundling transmission technology with the camera technology.

[27] Section 4.3.3. (page 77).

As per other goods, development and maintenance of producer prices indices and consumer prices indices using frequently updated product lists and hedonic adjustment for quality change would be the optimal strategy, although given the decline in use of this product, the value of significant investment should be strongly questioned before being undertaken. As such this guidance does not consider this product in further detail.

3.2.3. CPC 47.222 Telephones for cellular networks or for other wireless networks

There has been significant work in multiple countries on how to address quality change in smartphone and similar mobile phones. In the UK[28], for example, hedonic regressions incorporating characteristics such as the screen size and resolution or the number of camera megapixels in its consumer prices index.

Clearly this type of approach has strengths, but may not be as easily deployed for producer prices indices where many countries collect far less data. One approach which can be considered is the application of hedonic adjustments from consumer price series to purchaser price series, although care should be taken to ensure the products and the markets they are sold into are comparable and this is a valid adjustment. For example, if a hedonic adjustment was made to a smartphone for consumers relating to an in-built facility which could only be used by consumers and could not be used on a commercial basis, then this adjustment could be assumed to have no impact on price behaviour in the business-to-business sector.

Because of the rapid pace of change in this market, other quality adjustment methods can be considered but are likely to be inferior. PPIs and CPIs without quality adjustment, or for other alternative products should be considered as even more inferior alternatives which countries should look to replace as these shouldn't be considered long-term acceptable options.

3.2.4. CPC 47.8 Packaged software, 83.141 Software produced under contract for others, 83.143 Software originals, and 83.49 Online games and online software

ICT software is found in various parts of the current CPC. Future revisions may amend this, but this document looks to offer guidance across these. Similarly to ICT hardware, the main options for ICT software are:

- Relevant domestic PPI and CPIs for output and consumer prices respectively, including appropriate quality adjustment (e.g. hedonics). Due to the differences between domestic production and domestic consumption in most cases it is unlikely a CPI will give an unbiased output price and hence should be avoided.
- Foreign PPIs with appropriate exchange rate adjustment, assuming this has an appropriate quality adjustment (e.g. hedonics).
- Other PPIs may be 'second-best' alternatives, such as where these cover bundled software and hardware, but these are clearly inferior to the alternatives described above.

[28] See https://www.ons.gov.uk/economy/inflationandpriceindices/methodologies/consumerpricesindicestechnicalmanual2019" \l "special-issues-principles-and-procedures

However, as Eurostat (2016) notes: *"In view of the differences in the speed of quality changes, the use of an index for hardware to deflate software should be called a 'C' method."*[29]

The approaches suggested for ICT hardware are again of relevance:

- If domestic prices are unavailable, using prices from producing countries is permissible if combined with an appropriate exchange rate adjustment for producer price series. Consumer prices should be unaffected by this challenge.
- To ensure quality change is adequately addressed, price statisticians need to deploy methods, such as hedonics, to adequately adjust for the change in capability / quality inherent in rapidly changing technology products.
- Both consumer and producer price baskets of goods need to be more regularly reviewed and updated for ICT software products than for traditional products.
- Own-account software should be calculated using a cost of production approach unless a discounted flow of revenues can be calculated.

3.2.5. CPC 83.13 IT consulting and support services, CPC 83.14 IT design and development services, and CPC 84.2 Internet telecommunications services

This grouping faces the same challenges as many personal services. These are not distinctly caused by the digital nature of the product but rather how to measure a series of discreet services each of which is distinct from other examples of this activity.

Since every project is different from the others means that matched-model and other traditional methods cannot be applied, hedonics may appear a solution to this there are two key challenges statisticians must consider: firstly the time and effort required to collect and analyse the necessary data and secondly the challenges which the fast pace of change in technology and digital products provides. It is easy to find examples where not only the value of the variable (e.g. megapixels in a smartphone camera), but also the type of variable (number of cameras in a phone) rapidly change.

However, this area is not considered in greater depth here because this problem of tracking quality change across a heterogenous set of service provisions is a wider and older issue which has been tackled in other guidance.

3.2.6. CPC 83.15 Hosting and IT infrastructure

This grouping and the challenges it presents are considered in the following section in respect to the new product of cloud computing. As such it is not considered in further depth in this section.

3.2.7. CPC 83.99 Other Professional, technical and business services (including databases)

[29] Page 100

Intangible assets fall into two groups which face different challenges:

- Those intangible assets already recognised in the National Accounts[30] can be heavily affected by digitalisation.
- Those intangible assets not already recognised in the National Accounts[31] are obviously currently out of scope but to move forward countries should still be looking to identify how to measure them consistently.[32]

Focussing on software and databases, where these are currently considered together, the deflation of databases can be assumed to mirror that of software which has been tackled above. However, if the treatment of data is changed, dependent on whether this is included as a component of databases or separately, consideration would need to be given to whether the deflation of databases needs to be adjusted to come into line with this.

Other non-capitalised intangible assets are treated as outside the scope of this guidance note.

3.2.8. CPC 84.1 Telecommunications, specifically 84.12 fixed telephony and 84.13 mobile telecommunications 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[33] 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).

Details of these two approaches are covered in Annex A.

3.2.9. CPC 84.3 Online content

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 CPA 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.

[30] These are software and databases, entertainment, literary and artistic originals, mineral exploration and evaluation, and research and development

[31] Design, financial product innovation, branding, organisational capital and firm-specific training.

[32] Martin, O'Brien and Procter (2018) provides methods to quantify these in the UK.

[33] As explained in Eurostat (2016): *'A 'unit value' is calculated by dividing the total value with the total quantity. Comparing this unit value in two different periods gives a unit value index, which can be used as a measure for the price trend.'*

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), taking account of those being added or subtracted from the menu. 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.

These products should be minimally affected so we do not present options for these.

3.2.10. Other goods and services of a non-digital nature (e.g. taxi or accommodation services)

Whilst in the table above we have presented a number of divisions which are currently affected by digitalisation, the all-pervasive nature of new technology means that this list should not be read as excluding other sectors of the economy. The impact of digitalisation is likely to be increasingly felt in a wider and wider set of the divisions as new methods of applying these technologies are identified. As such, the list provided is merely those we can identify obvious impacts, but many others, such as finance and architecture services could make as strong a case for inclusion.

Digitalisation affects goods and service beyond the digital and ICT sectors. This primarily happens through two means:

- The use of a digital intermediate changes the production model for the final product, without the final product itself changing.
- Digital inputs into the production method change the nature of the final product.

In relation to the first of these, standard methods of collecting price and output data and deriving volume estimates should be sufficient, as long as these are reviewed and updated on a routine basis. This should reflect a change in intermediate consumption patterns and final goods prices adequately to track the change in volume GVA.

In relation to the second, we must consider how far we should consider products with a significant digital component to be the same product. Classically we have looked at the core nature of the product: a fridge is a fridge whether it is green, blue, silver or includes an ice-maker, because the principal element of the product is its capability to refrigerate food products.

The challenge with digital is whether this core nature of the product has changed. A second key aspect to consider here is the impact of digital intermediation. Excluding the type of peer-to-peer arrangements described in section 3 below, how firms change their behaviour when selling via a digital intermediary is key topic here. A classic example here is taxi services. Is a taxi service 'hailed' using an app the same product as a taxi 'hailed' on the street or via telephone? One needs to also consider any regulatory distinctions which may divide the market and impose the need to treat products as different goods.

One may consider that they are, although new research[34] into ride-sharing and taxi services in New York City to construct price deflators for taxi services[35] has identified that price indices constructed under different assumptions can show very different patterns. In particular, excluding ridesharing from the sample shows appreciably faster growth than an index that includes it. Moreover, there is a potential substitution bias problem: indices that treat ridesharing and taxi services as the same service show slower price increases than those that treat them as different services. In the circumstance where different versions of the same product have markedly different price growth, these should be appropriately captured in the product classification breakdown, at lower levels of disaggregation to allow aggregation to the top-level product to appropriately weight the high-level index.

To achieve this, we need to carefully consider how existing and new firms may be affected by this principle. Continuing with the taxi industry we need to therefore consider where to place the following instances:

- An existing taxi/minicab firm moves to using their own web-app for customers to 'hail' a taxi either alongside or instead of a phone-based approach.
- An existing taxi/minicab firm who moves to use a third-party ride-hailing app as an alternative marketing strategy[36]

[34] "Taxi and ridesharing services in New York City" Ana Aizcorbe, US Bureau of Economic Analysis (BEA)
[35] NAICS 485310
[36] This is a common case in some areas affected by digital. For example, in the UK many hotels use AirBnB type webpages as an alternative marketing strategy alongside their other channels, alongside hotel bookings websites such as hotels.com, even though we 'traditionally' view AirBnB as a non-hotel portal.

- A sole-trader who moves from sub-contracting to a minicab firm moves to using a ride-hailing app.

All three are examples of traditional taxi providers interacting with the new digital element to enhance their core function. However, has there been enough change to merit either seeing these firms as providing a 'digitally enabled' taxi-service, as the new Digital Supply-Use Table may require? Clearly a new business joining the taxi industry *only* because the new digital enabling technology is now available is clearly 'digitally enabled', but for the rest there are clearly boundary issues which need to be adequately addressed in explanatory notes.

In general, there appears minimal value in moving an existing taxi firm between different parts of the taxi industry, particularly if the majority of their peers are implementing the same type of change. When taxis moved from using horse-drawn carriages to motor vehicles, would we have re-classified the new car users as a different type of taxi service, particularly if the majority of taxis were making the same transition at the same time? At the present this, this guidance proposes that a firm's classification should not be changed just because it adopts an app-based reservation system. This might mean that two otherwise identical firms may be placed into different lower-level classifications, but at higher levels of aggregation a consistent view can be acquired.

3.3. Recommended Approach – Conceptual Aspects

The following sections run through the recommendations under each heading and the main conceptual aspects of these. This table summarises each of these, but alongside these specific recommendations this guidance also captures some generic guidance which can be applied by countries even if they are unable to address the specific recommendations.

Across all the areas outlined where fast-moving quality change is a result of the process of digitalisation countries are advised to review both:

- The frequency with which they update their survey collections, specifically in relation to prices to ensure they continue to capture the rapidly changing nature of these product classes and
- The level at which data is collected and deflation takes place to create volume estimates should be kept under review. In a number of products being able to deflate at more granular levels within the product classification and weighting these at more aggregated levels will be an important component of delivering more robust estimates.

Division	Recommendation
CPC 45.2 Computing machinery and parts and accessories thereof, particularly 45.22 (laptops) and 45.23 (PCs)	If domestic prices are unavailable, using prices from producing countries is permissible if combined with an appropriate exchange rate adjustment for producer price series. Consumer prices used in relation to consumption should be unaffected by this challenge.

	To ensure quality change is adequately addressed, price statisticians need to deploy methods, such as hedonics, to adequately adjust for the change in power inherent in rapidly changing technology products. Both consumer and producer price baskets of goods need to be more regularly reviewed and updated for ICT hardware products than for traditional products.
CPC 47.222 Telephones for cellular networks or for other wireless networks	As per CPC 45.2.
CPC 47.8 Packaged software, 83.141 Software produced under contract for others, 83.143 Software originals, and 83.49 Online games and online software	Hedonic adjustment is considered the gold standard, recognising need to account for foreign prices.
CPC 84.1 Telecommunications, specifically 84.12 fixed telephony and 84.13 mobile telecommunications services	A data usage unit value index is recommended as first best. A standard SPPI is viewed as acceptable, but countries will need to frequently review the weights and products included in the basket. CPI-based deflators are acceptable, unless they use a 'basket of consumers' approach.
2.1.5. Other goods and services of a non-digital nature (e.g. taxi or accommodation services)	Goods and services which have undergone significant differentiation because of the introduction of a new digital component should be disaggregated at a lower level in the classification structure so top-level product measures can be correctly weighted. Products with significant digital components should be subject to frequent quality reviews to ensure price statistics achieve a like-for-like comparison. Hedonic methods should be considered in such cases if possible.

3.3.1. CPC 45.2 Computing machinery and parts and accessories thereof, particularly 45.22 (laptops) and 45.23 (PCs)

ICT hardware presents challenges in terms of measuring prices and volumes for five reasons[37]:

[37] For reference, Eurostat's Prices and Volume Handbook (2016) gives generic guidance (Page 76) across CPA C (Manufactured Goods) of:

- ICT hardware is increasingly made in specific countries and imported by others. Many countries therefore do not have domestic prices available to derive appropriate deflators.
- Rapid technology change means that achieving a like-for-like comparison as required can be difficult.
- Products don't just change in terms of quality, they can also change in terms of the nature of the product itself (laptops replacing desktops, tablets replacing laptops etc) within product classifications.
- Due to specialisation in the manufacture of ICT hardware many countries, even relatively large ones will find their domestic production basket may be very different from that consumed.
- ICT hardware is often bundled with software products.

Whilst some of these challenges can be addressed through regular reviews of samples and weights, the issue of quality change is more difficult to address. As Eurostat (2016) notes, various methods have been considered in the past:

"The problem is one of quality change... The various methods of handling quality changes were introduced there. The following methods can be appropriate to use for computers:

- *the hedonic approach, since it is possible to determine and quantify the characteristics that influence the price;*
- *option prices, since in many cases separately priced options can be distinguished (such as additional memory or a DVD drive[38]);*
- *the resampling method, as long as the sample is representative and large enough.*

"In view of the discounting practices for computers, in particular for PCs, the overlap method is less appropriate for these products. The hedonic approach seems to be the best… [as] …it is very well possible to define and measure the characteristics that determine computer prices. The hedonic approach has proven itself in the USA as a useful and feasible tool for handling the problems of fast technological change. The hedonic approach is most appropriate if it is used for the estimation of prices of characteristics (and thus for quality adjustments only), and not for a direct price index. It is also possible to combine it with other methods such as option prices."[39]

'The A method for manufactured goods is to use suitable PPIs to deflate the value of output, in particular PPIs that are representative of the product group, are valued at basic prices, and take proper account of quality. Clearly the PPIs should be sufficiently disaggregated to undertake deflation at the lowest possible product level… For certain manufactured products, where there are precise quality standards set for a homogenous product, an A method could also be to use data on the quantities of product at the necessary level of disaggregation, as long as these quantity data are fully representative. Examples of products that could be suitable for this treatment include bulk chemicals, wood pulp and petroleum. One B method is to use detailed CPI data adjusted to basic prices for deflating the value of output. Use of less appropriate PPIs, for example where there is incomplete product coverage, would also be a B method. Any methods based on input costs (except for unique products like large equipment goods), or which use an unrepresentative price index, are considered C methods.'

[38] This is a powerful example of the pace of quality change in these products. In 2016, the characteristic of having a DVD player was seen as a premium characteristics. By 2019-20, when this guidance was drafted, many laptops no longer come with a DVD drive.

[39] S4.3.3. p77

In addition, when attempting to bridge the gap between home production and consumption, Eurostat (2016) flags that in combination with hedonics:

"These costs can be reduced however by international co-operation. It can be expected that the hedonic function is not very different across countries due to the openness and competitiveness of the computer market worldwide."

Broadly across these three challenges price statisticians need to consider the following:

- Direct volume measures are also likely to be problematic due to the challenge of rapid quality change.
- The use of CPIs to proxy for producer prices can only be recommended if the types of hardware product produced domestically is similar in composition to the consumption basket. If domestic prices are unavailable, using prices from producing countries is permissible if combined with an appropriate exchange rate adjustment for producer price series. Consumer prices used in relation to consumption should be unaffected by this challenge.
- To ensure quality change is adequately addressed, price statisticians need to deploy methods, such as hedonics, to adequately adjust for the change in power inherent in rapidly changing technology products.
- Both consumer and producer price baskets of goods need to be more regularly reviewed and updated for ICT hardware products than for traditional products.

3.3.2. CPC 47.222 Telephones for cellular networks or for other wireless networks

Telephone technology faces the same conceptual challenges as ICT hardware described above. The same guidance should be applied in this instance.

3.3.3. CPC 47.8 Packaged software, 83.141 Software produced under contract for others, 83.143 Software originals, and 83.49 Online games and online software

In considering the conceptual challenges of ICT software, it is impossible to set aside the influence and role of free software, or free services derived from own-account software. This guidance does not address this, which is covered in parallel guidance.

However, the conceptual issues relating to software are not limited to this issue. ICT software suffers many of the same challenges as ICT hardware:

- Very few countries produce software
- Specialisation of software production
- Rapid quality change

But also suffers from more:

- As an intangible asset it is hard to observe

- Software produced for own use is generally hard to price, with many countries reverting to cost of production methods.

As with IT hardware and smartphones, the gold standard would be hedonics conceptually, although there are practical issues related to software which are addressed below. Particularly for CPC 47.8 (packaged software), there may be a need to use an appropriately exchange rate adjusted foreign producer prices series from a country who is the major manufacturer of these products, although conceptually a market lacking in competition is not likely to reveal quality change through price changes cleanly. As Eurostat (2016) outlines, this affected "*the market for operating systems and general office applications*" at that time, but it is clear that this position is not a constant now as new entrants push into this market in more substantial ways, meaning statisticians needs to continue to keep up to date with market dynamics.

3.3.4. CPC 84.1 Telecommunications, specifically 84.12 fixed telephony and 84.13 mobile telecommunications services

The following options for telecommunications were considered:

- A traditional SPPI, including suitable quality adjustment, such as hedonic adjustments according to the key factors of quality, as per the US approach[40], or
- A SPPI derived from a data usage unit value index, as derived by Abdirahman, Coyle, Heys and Stewart (2017)[41], where all data services are converted into data and a unit value index is derived for this homogenous product based on quantities of data usage.

Beneath this, in relation to **information and communication services**[42], 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:

- **Pure bundles**[43], 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.

[40] Annex C provides a description of the hedonic methods applied by the US Bureau of Labor Statistics.
[41] Abdirahman et al (2017) presents two options, one a traditional SPPI composed of a basket of products and one a data usage unit value index. Abdirahman et at (2020) provides a bridging structure explaining the factors which lead to these returning markedly different valuations.
[42] Detailed in Annex A
[43] 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.'*

    - 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**[44] 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 should be allocated to COICOP 08.3.0.4 'Bundled telecommunication services'.

The data usage unit cost index SPPI is recommended because, in terms of a traditional SPPI the main conceptual issue arises, as is already observed, not from the traditional challenge of when one good replaces another good, but rather when two different goods combine and become one good.

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. More detail is given in Annex B.

This challenge reflects the absence of perfect competition which is a prerequisite for many traditional methods and assumptions that higher prices reflect higher consumer valuations for the product, or additional services[45], as opposed to merely reflecting either an absence of information or sticky consumer purchasing patterns.

Two matters therefore are worth considering from a conceptual viewpoint.

- Is a unit cost index a valid deflator for this product, and
- How might future changes in this sector make this a positive approach to take?

[44] 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.*

[45] If one uses the parallel of water, 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 to the different usage of the water but to guarantees of provision. To quote Eurostat (2016) (pp81-82)

"ESA 2010 par.10.16 says that price discrimination only applies when different prices are charged for identical products sold under exactly the same circumstances. An example would be sales of electricity to a small business and to a private house at a particular hour of the day — whilst the product is exactly the same, and the small business may not benefit from any bulk discounts, it is often the case that the business is charged at a different rate (business tariff) from the household."

Whilst generally viewed negatively, unit value indices have a place in deflators, as explained in Eurostat's Prices and Volume Handbook (2016):

'The classification of methods can differ from product to product. What is considered a good method for one product can be a less good, or even unacceptable, method for another. For example, the use of unit value indices can only be accepted if the products concerned are homogeneous.'[46]

Clearly, telecommunications, if we consider this as the transmission of bits of data, that is digital transmission of a series of zeros and one, are the ultimate homogenous product. Clearly in terms of informational content the value may vary, but this is not reflected in the telecommunications product: a ground-breaking economics blog may have the same number of bits transmitted as a cat-video, but have an utterly different value to the end-user. However, the value should accrue to the content creator, not the telecommunications provider.[47] The same approach is recommended as an A method for electricity in Eurostat (2016)[48]

Eurostat (2016) goes on to outline when a unit value index may not deliver unbiased results:

"While complete and thus representative coverage of the observations is guaranteed, the problem in this method is the heterogeneity of the products, which can cause a large variability in the index. Furthermore, any changes in the composition of the products can influence the unit value index resulting in a price change although such changes should in fact be included in the volume component. It is not possible to adjust unit value indices for quality changes in the products in the same way as can be done for price indices."[49]

Clearly, if we conceptualise transmission as a basic homogenous product not subject to quality change then this treatment appears to conform to the expected standards to be the preferred approach.[50] Eurostat (2016) notes:

"A number of methods have been studied and a unit value approach has been shown to be feasible and to provide acceptable results."[51]

The second conceptual aspect is future-proofing and ensuring the propose approach remains robust to changes in the product which may occur in the future. In this area we can clearly see a risk: with a traditional SPPI, using weights to bring together the different prices for the different products, keeping pace with the changes in the market would be a challenging task as goods change to reflect the common underlying data-nature of the product?

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[46] Page 10

[47] In the same way that soft drinks manufacturers use water in their product, but we wouldn't say the value of the water has changed once it becomes a soft drink.

[48] Page 82: *"The A method here is to deflate value of output by the available PPIs, assuming that they satisfy the standard conditions set out in section 2.3, and take full account of any 'standing charges' (payments unrelated to consumption) levied by the companies. A fully equivalent approach, which would also be an A method, is to directly use the quantity data available on products, providing the quantity data is sufficiently detailed (i.e. it identifies the quantities delivered by tariff and customer)."*

[49] Page 29.

[50] Eurostat (2016) considers this method an A rated method for electricity, but despite telecommunications transmission having the same characteristics, it is rated a B Method in this field. This guidance recommends is it also considered an A method for telecommunications.

[51] Page 100.

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 chips 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). Whilst there are barriers to this process presently (such as fixed line charges and the bundling of older technologies into equipment), experience has taught us that digital technologies develop quickly to overcome such challenges.

There are other methods which can be considered if these optimal methods are unavailable.

"The use of CPIs, adjusted to basic prices, for the output consumed by households (for example television cable services) would also be an A method… The use of PPIs where their coverage does not exactly match the products or where there is no adjustment for quality is a B method… The use of volume indicators that reflect the full range of outputs is a B method. The use of detailed CPIs to deflate output other than that consumed by households can be a B method if price developments can be shown to be similar for households and businesses. However, CPIs are unlikely to be suitable for the full range of telecommunication services, because of the availability of discounts and the different range of products consumed by businesses. Using detailed CPIs for business purchases where it is known that businesses receive discounts or purchase a different range of products than households would be a C method."[52]

3.3.5. Other goods and services of a non-digital nature

The key conceptual issues relating to other goods and services of a non-digital nature which have been affected by digitalisation relates to whether the changes observed should be characterised as:

- A version of the existing product, subject to a change in quality or
- A new product, which is a close substitute to the existing product.

In many ways this continues to be a version of the 'new good' debate which has existed in the price statistics literature since the earliest papers. In this context, the clearest indicators that the digitally affected product should be treated as a different product are:

- Is it regulated in a different fashion, such as its relationship to pricing constraints (e.g. regulated taxi fees) or tax regimes (hotel taxes)?
- Whilst being freely accessible to anyone with the correct technology, is its customer base effectively segregated from other customers, as observed by different price movements or purchasing patterns?
- Is the digitally affected product routinely customised in a standardised way such that, whilst the customisable element could be perceived as a minor component it has become a core component of the user's expectation of the user experience, such that it functions in a sufficiently different way to be considered a new good?

[52] P100 Eurostat (2016)

In all such cases the standard guidance in relation to new goods in price statistics and aggregation should be applied.

3.4. Recommended Approach – Practical Aspects

3.4.1. CPC 45.2 Computing machinery and parts and accessories thereof, particularly 45.22 (laptops) and 45.23 (PCs)

Eurostat (2016) is clear about how to address the challenges around these products that:

> *"Due to the rapid turnover of models, for PCs price observation should be at least monthly. Preferably, price collection is carried out directly from the manufacturers or retailers. However, at least for the consumer market, price collection through magazines or the internet can also provide reliable enough data. If computers are sold together with software, this software needs to be recognized as a characteristic of the computer in the hedonic model."*[53]

In relation to data availability, Eurostat (2016) also notes a second practical concern, which in part gave rise to the guidance in this document to explore international options, suitably exchange rate adjusted:

> *"Several countries rely on magazine prices, either for their PPIs or their CPIs. Data for larger systems are less widely available and their collection is more difficult. Catalogue prices are less likely to give an accurate reflection of market prices and the smaller quantities may make monitoring of actual transactions difficult."*[54]

3.4.2. CPC 47.222 Telephones for cellular networks or for other wireless networks

The practical issues around telephones mainly relate to the speed with which models are updated, both in terms of the model version, but also through software updates. In most instances software updates do not lead to a change in the price of the product, being built into the price at the point of contracting. However, in some instances contracts, including bundled contracts can be subject to revision, and the usual techniques should be applied to address this.

3.4.3. CPC 47.8 Packaged software, 83.141 Software produced under contract for others, 83.143 Software originals, and 83.49 Online games and online software

Eurostat (2016) captures two key practical issues:

- Software can be purchased via the internet at lower prices than in a physical retailer. Outlet substitution bias therefore is a risk that requires addressing in survey design so different outlets can be distinguished when constructing price indices.
- For businesses, the price of the software often depends on the number of user licences purchased rather than the actual number of copies of the software.
- Where firms have significant monopoly or near-monopoly positions this can make data collection easier, even if it may make this data less useful in terms of less directly displaying quality change through price movements.

Eurostat (2016) also presents an important practical issue:

[53] P77 Eurostat (2016)
[54] Section 4.3.3. (p77)

"Software packages are continuously being developed. New versions with more functions than the previous one are frequently brought on the market. These appear often in the form of upgrades, which should be seen as a different product [rather] than a complete version of the package."[55]

That is, the upgrade does not 'rewrite' the whole of the pre-existing software, but rather complements it. This does raise some issues, as presumably the upgrade has no independent value if accessed without the base programme, but the advice is to see each upgrade as distinct, at least in terms of the characteristics loaded into a hedonic regression or in an overlapping sample. However, this is incredibly hard to do in practice when it may not be clear what are the particular attributes which have been changed or which drive value. Expert guidance is one route to understanding this.

Eurostat (2016) also makes two valuable and connected points around the practical issues of assembling appropriate PPIs.

"The business market for packaged software is quite different from the consumer market. For example, businesses buy licenses in large quantities and can therefore obtain discounts. Hence, although a CPI can be used to deflate household consumption of software, it will be a C method for the deflation of output. There are also two different groups of business purchasers, those that buy software for inclusion in their own products which is intermediate consumption (e.g. a computer manufacturer who bundles software with their hardware) and that purchased for use directly within the business (capital formation). The prices for these business purchases will be different and PPIs need to reflect this adequately for them to be considered suitable as an A method."[56]

In addition, it is also important for PPIs to be informed by discounting behaviour. Large purchasers may be able to negotiate significant discounts so the price collection needs to be designed in a way which is able to capture this dimension of price variance.

Finally, whilst the relevant price statistics for game (or other apps) downloads from an *appstore* will be for consumer expenditure classified under COICOP "software" (09.1.3) or "games" (09.3.1), for the producer side the relevant service producer price index (SPPI) will usually be defined for the whole industry, based on the ISIC classification. This means that specific price indices at product level for deflation are usually not available. It is unclear if and how app programming or software publishing in app stores is included in the overall (national) price index, for example for J58 'publishing activities'[57].

[55] Page 97.
[56] Pages 99-100.
[57] Where the firm is domestic, research from the gaming industry in Finland[57] shows some app developers, over time, changed their main activity and hence their classification from 'Computer programming, consultancy and related services' (ISIC J62) to 'Publishing services' (ISIC J58) showing the inherent tension in trying to place all firms in a single category where the nature of their product may rapidly change..

3.4.4. CPC 84.1 Telecommunications, specifically 84.12 fixed telephony and 84.13 mobile telecommunications services

The major practical challenges with being able to deliver a data usage unit value index is accessing data quickly enough from telecommunications providers. To overcome this, it is possible to work with regulators who in some countries already have access to this data, or to deal with telecommunications providers directly.

As a regulated sector, it is important to ensure that the data received is 'real' and not 'constructed' to meet a regulatory requirement which has little real world meaning. An example from the UK related to fixed charges for mobile and fixed line telephony services. These data are provided to the regulator to meet a historical data need, but had to be generated within accounting systems by the companies as they do not reflect the way they view or operate their system (particularly for mobile networks, but as data becomes the predominant use of landline provision, in terms of fixed line charges either). As such as a data artefact it is clear this should be accounted for when collecting data.

3.4.5. Other goods and services of a non-digital nature (e.g. taxi or accommodation services)

The most significant practical challenge is how to maintain international consistency given different countries may experience different industries being subject to change from digitalisation, and in terms of how this is manifest.

The obvious answer is for each country to follow clear principles and apply these so the treatment is correct given the circumstances the country faces, as opposed to a common approach applied in different countries even if this does not fit all those countries institutional models or forms. The most immediate example relates to Uber and the way different legal jurisdictions have approached the question of whether it employs the drivers, and hence is a taxi services provider, or doesn't employ the staff and is just an intermediary. The following section goes into this in more depth, but clearly each country should place such firms as appropriate in their economic context.

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

In the majority of instances, the sections above do not require changes to the SNA itself but can be viewed as additional supplementary guidance which provide further detail to support successful implementation of the SNA. As Chapter 15 2008 SNA, which address prices and volumes, makes clear:

"This chapter aims to do no more than introduce the most important concepts and considerations of the application of index number theory to the derivations of volume series within the SNA."[58]

[58] Para 15.9

As such the guidance has been structured to provide options and a view on which of these hold the strong conceptual and practical merit. In only one areas are updates justified:

3.5.1. Non-market output

Finally, in relation to the impact of digitalisation, we should not forget the public sector. This does not refer to the activity of the public services, but rather to their recording. Chapter 15 of the SNA covers the issue of measurement of non-market output, but paragraph 15.123 then sounds a note of caution:

"15.123 It is recommended these volume indicators be tested for a substantial period of time with the aid of experts in the domain prior to their incorporation in the national accounts. Expert advice is particularly relevant in the areas of health and education, which usually dominate the provision of individual services. Further, the consequences of the estimates including the implications for productivity measures should be fully assessed before adoption. Unless and until the results of such investigations are satisfactory, it might be advisable to use the second best method, the "input method"."

Given the improvement in data management systems and the demand for more evidence in policy-making, alongside the developments in techniques in this area[59] it seems an appropriate time to revise this paragraph to now read:

"15.123 It is recommended these volume indicators are tested with the aid of experts in the domain prior to their incorporation into the national accounts, and the impacts fully assessed, in line with other revisions.*

4. Price deflation and volume estimation of new digital goods, services, and assets

4.1. Existing Material

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 'NW-A3000 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[60]).

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

[59] See Foxton, Grice, Heys, and Lewis (2019) for a summary of UK methods.
[60] An interesting example of the impact on tangible goods of intangible services. The iPod was supported by superior open-code software and online shop facilities. Other players had superior tangible (sound quality) attributes, but the iPod came to dominate the market.

low weights to enable the price change to be tracked and contribute correctly 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.

This section addresses volume estimates in a supply and use tables framework and two specific new product types which deliver challenges currently. These are digital intermediaries and cloud computing.

Both of these present particular challenges because of their classification within the ISIC structure. This is currently open to debate. 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.[61] This paper reserves itself to considering the measurement of these items without reference to the classification structure, and will take of these in turn.

4.1.1. Volume estimates in a supply and use tables framework

Section 2.1 above describes the method implemented by the Australian Bureau of Statistics (ABS) for preliminary experimental estimates of digital activity (see ABS (2019)). This method extracts digital activity from the existing supply and use tables (SUT) framework in current prices.

ABS also undertakes volume estimates for digital activities by estimating SUTs in previous year's prices. Starting point are standard SUTs in previous year's prices, which are derived by applying a set of deflators (PPIs and CPIs). Once the tables in current and previous years' prices are balanced, product level implicit deflators (IPD) for intermediate use and output for each product in the SUTs can be derived, i.e. IPD = CP/PY.

The digital activity satellite account uses the SUTs derived IPDs and applies them to digital products to deflate current prices to compile volume measures. A double deflation of output and intermediate consumption is undertaken. Volume estimates of value added are estimated on the basis of chain-linked volume indices.[62] This method keeps the digital activity satellite accounts in balance. If different deflators were applied, the tables would need to be rebalanced.

The industry level estimates (in current prices and volumes) are derived by aggregating the product level estimates.

This is a general approach, which can be applied also to new digital products, as long as they are identified in the supply and use tables framework.

4.1.2. The measurement of digital intermediaries (platforms)

[61] Annex D summarises the classification issue.
[62] See Appendix B and C of ABS(2019), available at: https://www.abs.gov.au/websitedbs/D3310114.nsf/home/ABS+Chief+Economist+-+Full+Paper+of+Measuring+Digital+Activities+in+the+Australian+Economy

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[63] each focusing on different characteristics.

In 2008 SNA no explicit definition of intermediary services is provided. Examples of existing intermediation services in 2008 SNA - before the rise of digitalisation - can be found mainly for real estate agents (CPC 722 'Real estate services on a fee or contract basis') and travel agency and reservation services (CPC 855 'Travel arrangement, tour operator and related services'). The main characteristic of the intermediation activity is that economic ownership of the subject of intermediation is not taken over, and that 'capacity risk' is not taken on[64].

Intermediation services are also common for financial and insurance activities, in particular when provided by auxiliaries. However, financial intermediation has different characteristics from intermediary services listed before as concerns taking over of economic risks. An interesting parallel is that for financial intermediaries SNA found a solution to measure output as a combination of explicit fees and implicit fees – known as FISIM. Also for digital intermediary services different combinations of explicit fees and implicit or secondary sources of income are possible.

Digitalisation has significantly impacted the business models of existing intermediary services. Secondly, digitalisation allowed establishing intermediation services for economic activities where they did not exist before (or were not economically relevant). Digital intermediary services have in common perception reached an economic importance that requires to reflect these properly in economic statistics. This will finally be reflected in updated classifications of economic activities and products. The updated classifications can be expected to resolve at least some of the current problems of definition and statistical source data for current price and volume estimates. However, this cannot be expected within the next years.

A broad definition published by the OECD is that digital intermediaries are; *"an online entity providing a digital service that facilitates interactions between two or more distinct but interdependent sets of users (whether firms or individuals) who interact through the service via the Internet*" (*OECD, 2019b*).

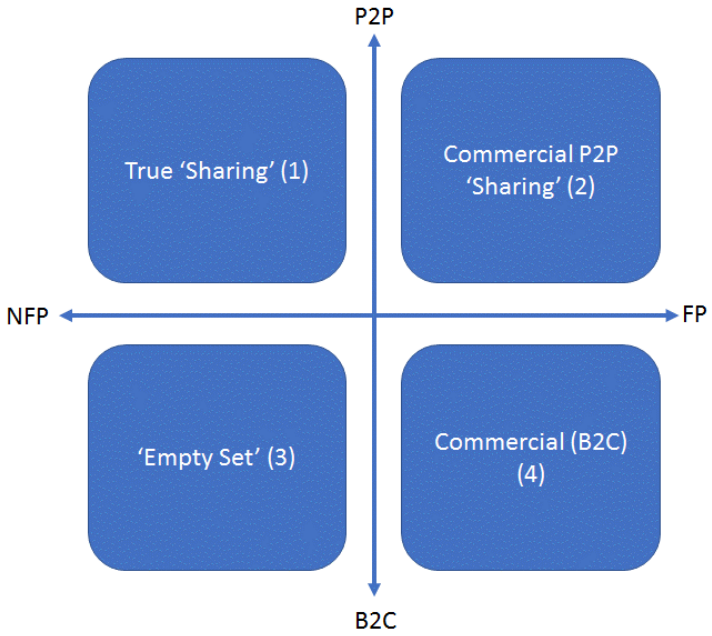
As will be outlined below in relation to the national accounts production boundary, it is important to distinguish between those platforms that charge an explicit fee to the producer or consumer and those that do not. Therefore, as published in the handbook on measuring digital trade, digital intermediaries are defined as;

[63] For example, sharing platforms and collaborative platforms, just to mention a few.
[64] A wholesaler who purchases fifty items, but can only sell on 25 has taken on the capacity risk for the remaining 25. An intermediary never purchases themselves but only facilitates the sale of the item and has not taken on economic ownership of the item or the capacity risk. See Murphy (2017) for a strong articulation.

"*Online interfaces that facilitate, for a fee, the direct interaction between multiple buyers and multiple sellers, without the platform taking economic ownership of the goods or services that are being sold (intermediated)"* (OECD-WTO-IMF, 2019).

A mapping of the different digital platform types can be found in Codagnone and Martens (2016):

Figure Four: 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 such companies have gained in many countries, while numerous other of such platforms exist and are growing in importance.

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, determining by country the need to introduce it into the CPI samples, but statisticians need to consider the following:

- Airbnb in most countries has an impact on the CPI only through the presumably downward effect its existence has on hotel prices.
- The inclusion of Airbnb in the CPI would be to introduce a new product and would have no direct price impact on traditional hotels.
- The presumably lower prices of Airbnb would be seen as a lower quality services than the traditional hotels, which is a contentious assumption.
- Statisticians need to consider the impact of Airbnb on the imputed rental price of owner-occupied dwellings. For example, if one room in a home is rented out through Airbnb, should this room be excluded in the calculation of the imputed rental price, and does this affect the weight of owner-occupied housing in the CPI?

Equally how to treat the intermediation function is also challenging. Statistics Canada (2019b) presents provisional estimates of private short-term accommodation in Canada, using data acquired from a third-party market research firm that specializes in providing data analytics for private short-term accommodation rental platforms. The acquired data included web scraped listing information, in addition to derived or modelled revenue data for all properties within the geographic boundaries of Canada, and concluded that digital intermediary platforms provide intermediation services to both hosts and guests since they charges fees to both parties.

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, alongside equivalent data relating to traditional taxi transactions, which might be equally challenging as both need to be reported in a similar fashion to allow differences in the quality of the services to be identified, 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.

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.[65]

4.1.3. The measurement of digital 'cloud computing' services

As touched on in section 2.1.1, 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, and similarly for disappearing goods.
5. Trade implications[66]: 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.

4.2. Options Considered

4.2.1. Digital Intermediaries

Business Prices

As business statistics on digital intermediaries are still under development, separate SPPIs cannot be expected to be available at this stage. The practical difficulty therefore is to identify available price indices for digital intermediary services. 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).[67]

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[65] The accepted treatment of monetary transactions involving digital platforms is that the payment from the end consumer shall be recorded as paid to the producer rather than to the platform. In most cases this payment will be imputed as the actual monetary transaction usually occurs between the consumer and the platform and then between the producer and the platform. This amount paid by the consumer usually includes the cost of the product as well as an amount that is kept by the platform for facilitating the transaction (the digital intermediary service payment). While this amount is explicit between the producer and the platform, it is usually not explicitly charged to the consumer. This will mean that for Digital Intermediary Platforms (not taking ownership of the products they intermediate), estimates of turnover (sales) that are digitally ordered should reflect only revenues related to the intermediation services they provide and not include the value of the products intermediated. Handbook of Digital Trade (OECD-WTO-IMF, 2019)

[66] These are not considered in this paper, as the globalisation group is better placed to cover these.

[67] Uber seems to make some information available. For Australia, it appears that the Uber fee percentage is

Consumer Prices

Consumer prices are observable. Hiemstra (2019)[68] attempts to measure the volume of Airbnb Services in the Dutch national accounts. As no specific price index for intermediation services like Airbnb exists, the pragmatic solution was to use the CPI for hotel services as a proxy for deflating Airbnb output.

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. If the intermediary service is charged as a fixed amount, the measure of the price change is straightforward. If the fee is calculated as product of the value of the underlying service and a percentage fee, changes in both elements need to be combined for the price index. The calculation of prices and volumes can, in principle, follow the methods described for ad valorem taxes in chapter 3.10 or the description for real estate agents in chapter 4.12.1 of the Eurostat handbook on price and volume measures (see Eurostat (2016)).

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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)[69]. In principle price statistics should react to a higher volatility with observing prices in a frequency corresponding to the price changes. This is of course a challenge when confronted with dynamic pricing techniques. Section 5 below tackles this issue in greater depth.

However, if a CPI is used, the outlet substitution problem clearly presents itself, and controlling for this to ensure quality differences are accounted for will be required. 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. It should be noted that Uber will likely be included in consumer price indices for taxi services. The HICP, for example, uses COICOP as its classification

27.5% in May 2020: https://www.drivetax.com.au/how-much-will-i-actually-make-from-uber-driving/
Similarly, in the USA, it seems to be 25%: https://www.uber.com/gh/en/drive/basics/tracking-your-earnings/

[68] The presentation of the 2019 NTTS event on the digital economy are available here: https://ec.europa.eu/eurostat/cros/content/slides-digital-economy-event_en

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

structure and thus classifies transactions by purpose. COICOP does not have categories for reservation services.

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.

A Eurostat task force identified the following potential solutions, specifically using the example of the firm Uber to illustrate the range of alternatives:

- Option A1: Treat Uber as a taxi company with self-employed drivers
- Option A2: Treat Uber as a taxi company with employees
- Option B: Treat Uber as providing intermediation services to the taxi driver
- Option C: Treat Uber as providing intermediation services to the household
- Option D: Treat Uber as providing intermediation services to both the taxi driver and the household
- Option E: Treat Uber as an intermediation company that produces taxi services
- Option F: Treat Uber as a merchanter of services

These options are considered in more depth below, and detail is provided in Annex D.

Implied Deflators

An alternative approach was implemented in experimental statistics developed by the Australian Bureau of Statistics (2019)[70] presented in section 2.1.3 above, which deflates digital products in a supply and use table framework. Though, the approach does not cover digital intermediaries it could be applied to these in a similar manner[71]. Estimates of value added by digital activities in volume terms were generated using double deflation on a chain volume basis. Deflation used implicit price deflators derived from the ratio of current prices and prices in the previous year after balancing in their standard supply-use framework. To derive the constant price digital output and intermediate consumption, each of the underlying products was deflated with the corresponding price movement.

Price and volume measures

4.2.2. Cloud Computing

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.

[70] https://www.abs.gov.au/websitedbs/D3310114.nsf/home/ABS+Chief+Economist+-+Full+Paper+of+Measuring+Digital+Activities+in+the+Australian+Economy

[71] See Annex B and C

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 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 mis-measurement 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.

- *Price deflation of new digital products*[72]

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.

- *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.

4.3. Recommended Approach – Conceptual Aspects

4.3.1. Digital Intermediaries

The 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.

4.3.2. Cloud Computing

This guidance recommends quality adjusted price indexes to deflate values developed using hedonic models which capture the variety of attributes.

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

There are no great conceptual problems with dealing with cloud computing service prices and volumes. The problems are primarily practical, around understanding the use of different products in order to determine appropriate definitions of quantities and their corresponding prices. It is essential to quality adjust these prices in order to correctly deflate these services for volume measures in the national accounts.

4.4. Recommended Approach – Practical Aspects

4.4.1. Digital Intermediaries

To ensure the correct treatment of digital intermediary platforms a typology needs to be developed to facilitate their classification and hence how to record their transactions in the national accounts. This will depend on the ISIC Review and where these services are classified.

Statisticians should look to develop SPPIs but will need to collect additional data on the intermediation component of charges.

Where CPIs are used, these need to be reviewed for outlet substitution bias and appropriate quality adjustments needs to be applied. This may be a difficult process as different populations may view the same product differently: some consumers will prefer the hotel experience whereas others may prefer the informality and home comforts of staying in a domestic home setting, as per a Airbnb service, and hence whilst one will view Airbnb as a quality improvement others will view it as an inferior product. Consumers might be expected to self-select according to these desires, as per with other goods so the key question is considering the weights each product (traditional hotels v domestic room-rental) has in the basket.

Implied deflators will be derived for business prices, consumer prices or both, and statisticians should ensure they understand and have checked the relevance of the original source data.

4.4.2. Cloud Computing

The key requirement is to identify appropriate data sources for these services so regular, routine collection can take place. Either direct access to data from cloud computing companies or via surveys are needed in order to understand the use of different products. These will inform the determination of appropriate definitions of outputs from the cloud computing industry and their use as intermediate inputs. Once these are determined, through the web-scraping of prices and an understanding of the relevant characteristics of each product, it becomes feasible to construct quality adjusted price indexes for deflation purposes for calculating volumes for the national accounts. Rapid changes in this industry means that the services provided and used may change even within a year, requiring the sourcing of rapid data collection and updating in order to avoid missing the price and volume impacts of new products.

Where cloud computing is imported or exported, these products should be brought into scope of the relevant import or export series.

Where cloud computing is used as part of final consumption, these products should be brought into scope of the relevant CPI series.

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

4.5.1. Digital Intermediaries

The SNA presently does not define what an 'intermediary' is. We recommend that such a definition would be a useful addition.

Reviewing the alternative options, we would recommend the amendment of paragraph 6.21, (as shown by the underlined text) to carry this definition:

"Margin services result when one institutional unit facilitates the change of ownership of goods, knowledge-capturing products, some services or financial assets between two other institutional units. Margin services are provided by wholesalers[, ~~and~~] retailers[, intermediaries,] and by many types of financial institutions. Margin services resemble change-effecting services in that they are not separate entities over which ownership rights can be established. They cannot be traded separately from their production. By the time their production is completed they must have been provided to the consumers.[Intermediaries are defined as institutional units who facilitate the sale or exchange of a good or service, for a fee, without taking economic ownership of the good or service that are being sold. Digital intermediaries deliver this through digital means."

It is important that any definition would need to work alongside paragraph 4.101, which defines 'financial intermediaries' as:

"Financial intermediaries are institutional units that incur liabilities on their own account for the purpose of acquiring financial assets by engaging in financial transactions on the market."

Finally, 2008 SNA para 24.52 which defines imputed rental from owner-occupied housing should be considered in light of the actual rental accrued via room rentals, such as through the Airbnb model. For example, if one room in a home is rented out through Airbnb, should this room be excluded in the calculation of the imputed rental price? Also, the impact on the weight of owner-occupied in the CPI should be assessed.

4.5.2. Cloud Computing

Cloud computing is a service, and like the treatment of many other services, it is not the theoretical framework that is the problem, it is lack of data, and understanding of this data which is required for implementation, alongside confirmation of where in the relevant classifications the different components of cloud computing should be placed.

Nevertheless, similar to the arguments presented above a definition of cloud computing services should be included in the SNA, probably in section 6F, where the output of different industries are described in detail.

5. Addressing rapid change in e-commerce price data

5.1. Existing Material

In recent years there has been some discussion and analysis of the digital economy which has centred on e-commerce and the diverging pricing patterns of products available to buy online. The price flexibility of online retailers means that online prices tend to move differently than in-store prices. Online prices can adjust to the market price quickly in response to changing market forces. In addition, online retailers can monitor demand based on consumer behaviour on their websites.

Using this information, online retailers can optimise profits with algorithmic pricing using parameters for calendar effects; weather; competitor prices; and more. The use of algorithmic pricing, which can result in rapidly changing prices, poses challenges in terms of the measurement of consumer price inflation. Because prices are collected on a monthly basis for most consumer goods and services, the CPI represents a monthly snapshot of price changes. Prices that rapidly change create considerable volatility over the reference month.

The inability to capture and aggregate price volatility at the lowest levels of the CPI within the pricing month introduces the potential for significant month-to-month volatility in the headline CPI, which may distort the measure of pure price change reported in the monthly CPI.[73] To overcome this measurement problem for CPI the general approach is to calculate unit prices (revenue divided by quantity) for scanner data, and in the absence of quantity data for web scraping calculate average price across the reference month. A few examples of country practices to address this challenge are discussed below.

5.1.1 *International*

The Consumer Price Index Manual: Concepts and Methods (ILO et al 2004), contains comprehensive information and explanations on compiling a CPI. The Manual provides an overview of the methods and practices national statistical offices (NSOs) should consider when making decisions on how to deal with the various problems in the compilation of a CPI. In most countries many, if not the majority of the prices used to compile the CPI are collected by field officers who observe point-in-time prices at sampled retail businesses. They also discuss discounts, special offers and volume-selling items with the respondent. The regular visits to outlets enable the field officers to monitor market developments and observe quality change.

Scanner data sets contain variety quantities sold and revenue received by the retailer for these varieties for some period. This information enables NSOs to calculate a price for an individual variety by dividing a variety's revenue by the quantity sold. This unit value price represents

[73] There may be a need to assess whether rapid online price changes may also affect the calculation of other price indices such as the export and import price indices since transactions on many online websites such as Amazon and Ebay may take places between buyers and sellers who are located in different economic territories. Another issue to consider is whether rapidly changing prices will also result in similarly changing quantity weights. If yes, this could imply the need to frequently update the weights to calculate the CPI or other price indices.

the average price experienced by consumers over a period. For a homogeneous item, the unit value more accurately reflects prices paid by consumers over the whole period than point-in-time pricing (Balk, 1998). Unit values contain discounts and the effects of these discounts on the quantity of varieties sold. The period for which unit values are calculated is important in terms of the accuracy of the unit value. Diewert, Fox and de Haan (2016), for example, argue that unit value prices used for constructing the CPI should be for the same period as the index to be constructed, rather than for a sub-period.

5.1.2 *Germany*

Thousands of online prices are collected each month by the German Federal Statistical Office (FSO) for the German consumer price index (CPI) and the harmonised index of consumer prices (HICP). Blaudow and Burg (2018) try and understand the challenge of dynamic pricing. It was limited to products and online retailers that were included in the CPI/HICP sample and used web scraping to collect prices. The unit value price over the entire month is the target price, but if the price changes on average more than once each month, the traditional methods for price collection could lead to the inclusion of less representative prices (outliers) compared with the unit value. Given that quantity data is unavailable for web scraped prices an average of prices scraped at regular intervals (for example, every hour as in the study) is calculated. While this is straightforward, it is questionable whether all scraped prices are representative and therefore suitable for the calculation of price indices. Consumers may face prices at a level at which a purchase is unlikely, therefore calculating average prices over time based on scraped prices requires the elimination of such outliers and the imputation of missing prices.

5.1.3 *Canada*

Analysis conducted by Statistics Canada (Mitchell 2019) identified that prices collected from online-only retailers exhibited more volatility than prices collected either in physical stores or in the online versions of these stores. The frequency of monthly price changes, as measured by the proportion of non-zero price changes from one month to the next, was higher for online-only retailers in most product categories. As online retailers have fewer barriers to price adjustment than physical stores they can adjust prices as frequently as market forces dictate.

As e-commerce becomes an increasingly important, online pricing dynamics will assume greater relevance to the measurement of consumer prices. The analysis highlights that prices collected online move differently than those collected in physical stores, and this divergence, in the short-term, has the potential to distort conventional understanding of monthly inflation. This effect will increase as e-commerce continues to grow. Challenges emerge in interpreting inflation dynamics based on a CPI that was designed to capture a monthly snapshot of prices, rather than prices that change as frequently as those in the online world.

One way to address the challenges of pricing in a digital economy is to update price collection methods to mirror the actual consumption patterns. Ideally, the proportion of the sample collected online would mirror the actual consumption habits as closely as possible, with the goal of measuring the movement of prices consumers face. This would require expansion of the online sample to include a greater variety of outlets and products. Weighting the sample of

a given commodity to reflect the actual consumption habits of consumers with respect to method of purchase would require the development of a data source from which to create expenditure weights at the commodity level.

5.1.4 Australia, The Netherlands and New Zealand

The dynamic nature of scanner data causes problems for traditional index methods and as a result many NSIs have introduced unweighted indices into production. To try and maximise the information on scanner datasets the Australian Bureau of Statistics (ABS), Statistics Netherlands (CBS) and Statistics New Zealand (SNZ) have each implemented the use of multilateral index methods for some components of their CPIs. After years of research these methods are accepted by the price statistics community as the most appropriate approach to compile price indices that use scanner data.

While bilateral index methods compare prices across two time periods, multilateral index methods make price comparisons across three or more time periods. Multilateral methods use all matched products, and weight products by economic importance. They are free of 'chain drift' and yield transitive price comparisons. Three families of multilateral methods exist:

- Dummy Variable Regression
- Gini, Eltetö and Köves, and Szulc (GEKS)
- Geary-Khamis (GK)

A detailed description of the methods is given by Ivancic, Diewert and Fox (2011)

While empirical results show little difference between different multilateral methods the choice depends on the characteristics of input data. Multilateral methods require extension methods for production. The choice of window length should be at least one year and it is this choice that can create the biggest difference in results.

5.2. Options Considered

The options considered are:

- Use of multi-lateral index methods to accommodate scanner data into price indices
- Unit values using scanner data calculated over an appropriate time period, appropriately adjusting the weights of on-line versus physical sales to reflect actual purchasing patterns.
- An average of prices web-scraped at regular intervals through the time period.

5.3. 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…).

5.4. 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.

5.5. 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.

Annex A: Deflation of existing 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)
- Papa, A., Murray L., Murphy B, Holocsy, I.H., Blang, D., Puchter, C, Kalko, J. (2018)

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.[74] 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.[75] However, from the perspective of economic theory, the price index should answer a subtly different question: How

[74] Equally, there is not really an index number problem in that case.
[75] Conversely, the Paasche will form a lower bound, looking back from today's basket of goods.

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 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[76]) 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".[77] 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[78]), 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

[76] 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.
[77] Adelman & Griliches (1961)
[78] This figure relates to the Consumer Price Index

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.

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.

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 (a simple sum of all 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. 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.

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. 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, then the market volume of apples sold and

'consumed' is still six, 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. Whilst data may be 'carried forward' or 'pre-paid', pricing models will be based on algorithms designed around the cost of producing the data which companies expect to be used.

- Data usage also has the advantage that regulations and companies can provide this information, whereas the sum of data 'purchased' in terms of contracted volumes may not be universally available and hence unfeasible.
- 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.
- On the basis data is homogenous, this approach is equivalent to using volume metrics directly to calculate the volume of output of the telecommunications industry.

Understanding the empirical implication of data usage unit value indices as a deflator of telecommunications services.

In reviewing the empirical impact of the data usage unit value approach compared to alternative measures, there are two empirical strategies which can be applied:

- Understanding the differences in behaviour between the unit value index and traditionally compiled services producer price indices, and
- Understanding whether the issues identified in the UK research are also experienced by other countries?

Differences in behaviour between the unit value index and traditionally compiled services producer price indices

Following the initial research in Abdirahman et al (2017) concerning the derivation of the data usage unit value index, further work, which has been presented at the OECD, IMF and Voorburg City Group, has been undertaken to understand the wide discrepancy between alternative measures – a standard SPPI shows a decline in prices of 36% between 2010 and 2017, whereas the data usage unit value index delivers a price fall of 96% in the same time. This has identified two core drivers for these differences, which broadly come down to the treatment of line rental costs and the transition from weighting according to prices towards volume.

- In the UK, fixed costs are now rarely presented outside of a bundle to consumers. Indeed on some products, firms report they only calculate and report these for regulatory purposes, suggesting it is a perverse judgement to included these in the basket as a separate component when consumers no longer observe these items in this way. Allocating revenue from the fixed component on landline and mobile contracts back to the core services experienced by consumers (calls, SMS texts and data) using either price or volume weights helps bring the two measures closer together. There is clearly a vital element in designing deflators that the underlying price indices need to reflect the economic reality of the product under observation.

- The data usage index value converts SMS texts and calls into their data equivalents, and calculates a unit cost index based on the overall usage of data. It therefore uses a standard weight applied to each byte of data. The SPPI uses weights derived from the relative prices to estimate the share of the basket for each product. The more one moves towards weighting by volume of data used the more one moves into line with the data usage approach, whilst still taking account of the price differences of the different products.

Applying these two adjustments provides a range of alternatives delivering price falls of between 58% and 84% between 2010 and 2017. However, volume weighting does suggest that, particularly in recent years traditional call services are becoming a negligible component of the basket, which may raise questions.

Are the issues identified in the UK research are also experienced by other countries?

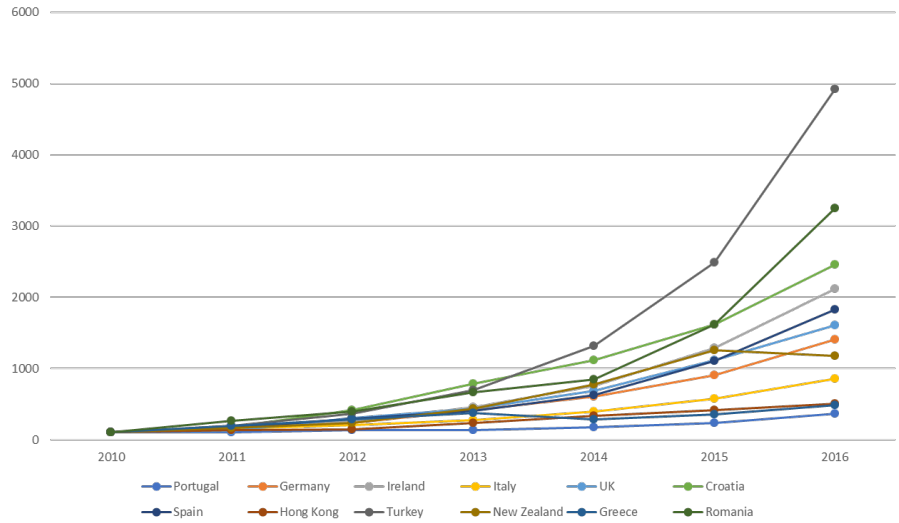
Whilst Abdirahman et al have broadly undertaken their research in the UK context, it is also possible to gather consistent data on multiple countries from the UN's International Telecommunications Union[79], from which Data Usage based price indices were calculated for 11 other countries alongside the UK, noting the absence of the USA from these data:

- Portugal
- Germany
- Ireland
- Italy
- New Zealand
- Greece
- Spain
- Hong Kong
- Croatia
- Turkey
- Romania

Figure A1 presents evidence on mobile phone data traffic, which is equivalent to that used in Abdirahman et al (2017), whilst figure A2 presents equivalent data for fixed line communications, which is also consistent with the Abdirahman study.

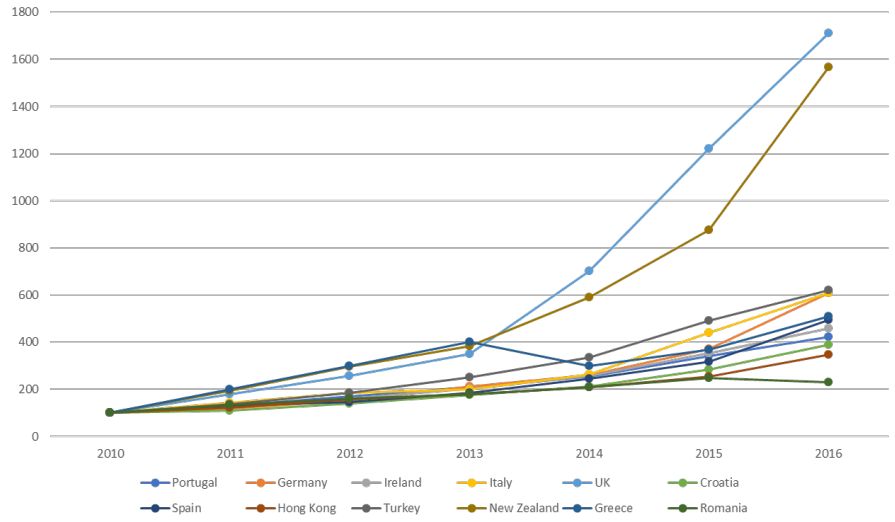
[79] www.itu.int

Figure A1: Mobile Data Traffic Index (2010 = 100)



Source: ITU

Figure A2: Fixed Line Data Traffic (2010 = 100)

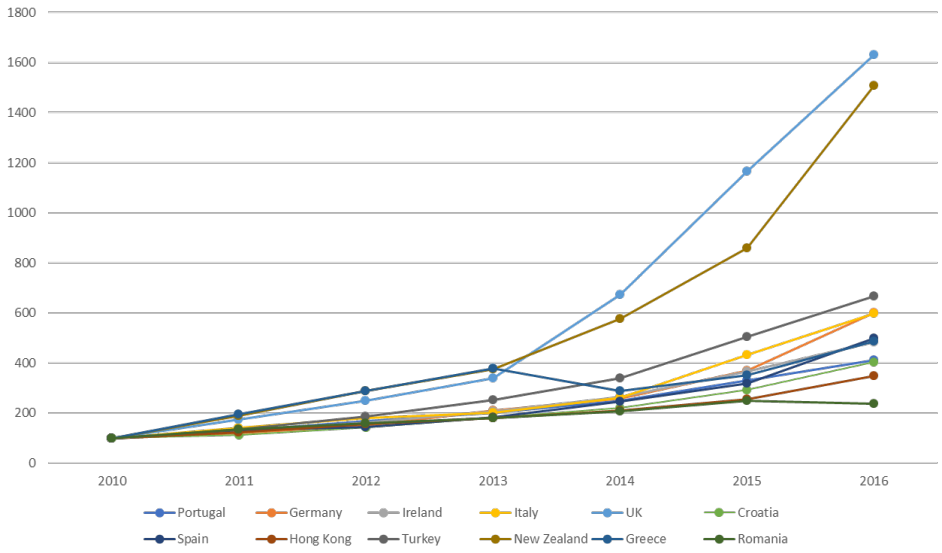


Reviewing these we see different countries with markets possibly in different models, with Turkey, Romania and Croatia showing the largest increases in mobile traffic, albeit with all countries experiencing strong growth of between several times, or a factor of 50. In terms of landline traffic, the UK and New Zealand show the strongest growth here of 15-17x over a six year period. In the UK much of this increase is traffic is experienced, perversely through mobile devices uses wifi hotspots or other such connections. Again, to the consumer it is becoming increasingly difficult to differentiate or observe the distinct nature of these services.

Combining these in figure A3, we can observe that fixed line data traffic dominates the combined market, but with every country in the sampling at least doubling data traffic in this period. This is a global phenomenon and it is necessary for national accountants to ensure their

statistics reflect this, including the magnitude of this change in consumer patterns of demand. Once again this is most significant in the UK and New Zealand.

Figure A3: Total Data Traffic Index (2010 = 100)



The ITU also provides commensurate revenue data, as presented in figure A4, allowing the creation of data usage unit value indices. It is immediately apparent that globally changes in revenues have both been significantly lower than data traffic growth, and indeed in many countries have trended negatively whilst data traffic has rapidly grown, particularly in Portugal, Ireland, Greece and Italy.

Figure A4 : Total Revenue Indices (2010 = 100)

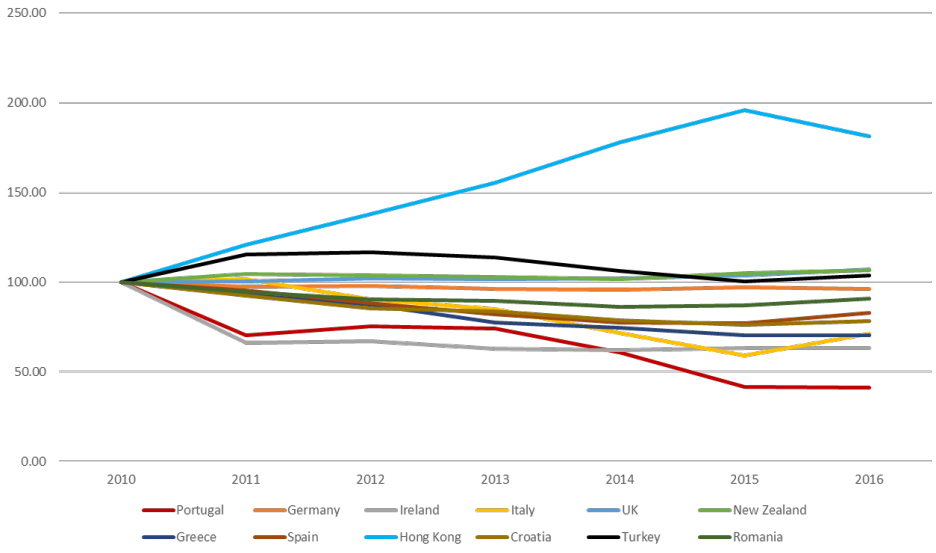
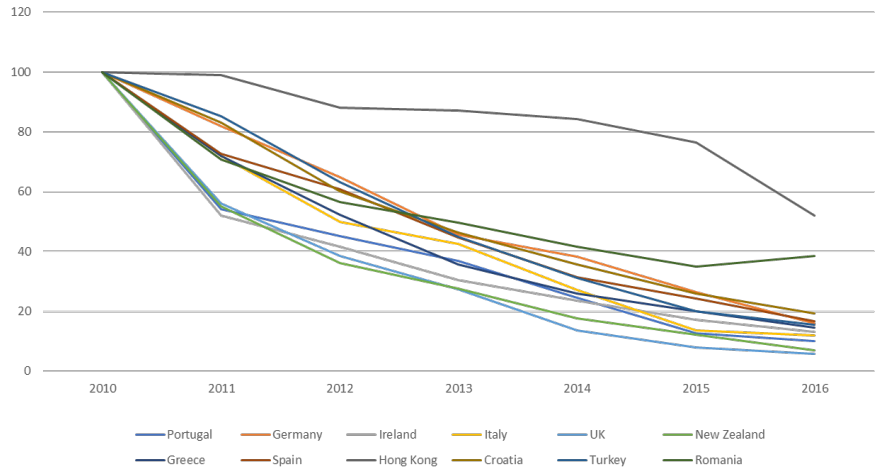


Figure A5: International Data Usage Price Indices (2010 = 100)



The combined effect of these data volume and revenue data is to deliver unit costs indices with a broad degree of similarity, with deflators showing significant declines in a short period of time. The main exception is Hong Kong which showed a much flatter decline. We are yet to determine possible reasons for this but we suspect that this may be because Hong Kong started from a higher technological base, whilst looking at the total revenue for the industry, Hong Kong's has nearly doubled between 2010 and 2016 which explains why the deflator is not falling as steeply (see next slide), which suggests it may simply be an outlier.

Nevertheless, the stark commonality between countries, with almost all reporting rapid decreases to deflators of between 50-70% by 2013 and 80-96% by 2016, compared to 2010. Caution is obviously necessary where major countries (France, USA, China) are missing from the current sample. Nevertheless, whilst some countries (Hong Kong / Rumania) show deviations from the trend, even here the price index has fallen between 45-60% in seven years, reinforcing that this is a trend which merits appropriate treatment in the national accounts on a global basis.

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*[80] *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."

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.

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

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[81] 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.
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

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

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.

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.

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

Table A1: Main industrial classifications for Telecommunication services

ISIC (Rev. 4)	NACE (Rev. 2)	NAICS (v. 2017)	ANZSIC (v. 2006/Rev. 1)	Class (Group)
6110	6110	5173	5801	Wired telecommunication activities
6120	6120	5173	5802	Wireless telecommunication activities
6130	6130	5174	5809	Satellite telecommunication activities
6190	6190	5179		Other telecommunication activities

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 equipment, 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.

Annex B: Biases in traditional SPPI approaches

A simple example illustrates the potential scale of the bias in the traditional SPPI 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[82] 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, 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	1,000	10	1	10	110	1,010	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

[82] 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.

alternatives, and conversely). In the data usage unit value index approach, 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.

Annex C: 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[83] within Producer Price Index (PPI) data from December 2016, applied to the following divisions:

- Wired telecommunications carriers: Internet access services[84]
- Telecommunication, cable, and internet user services: Internet access services[85]

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

[83] https://www.bls.gov/ppi/broadbandhedonicmodel.htm
[84] PCU5173115173116
[85] WPU3741

	Coefficient	Standard Error	t-statistic	P-value	Variance Inflation Factor
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:

'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.'*

Annex D: Classification issues around digital intermediaries

Most sharing businesses have complex and non-traditional legal structures and business models. This makes classifying the economic activity and agents very challenging. Sharing businesses perform an important facilitation process which must be appropriately accounted for within the SNA. The facilitation activity is distinct from the actual goods or services exchanged between producers and consumers. As a result, even where the national accounts may capture the economic activity, it may not be classified appropriately.

The majority of the economic agents providing the final services consumed are within the household sector. Household production is mixed with corporate production and characterized as business activity. Since most of the producers are households engaging in non-traditional production activities, traditional data sources are likely not picking up this activity.

Large proportions of the economic activity are with economic agents in different countries. Most sharing businesses are not incorporated or registered in the territories where they conduct their business, thus they are classified as non-residents in the national accounts. As a result, their economic activity is out of scope of business surveys of the territories in which they operate.

For example, 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 2008 SNA[86], 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'"[87].

[86] UN et al (2009). *System of National Accounts*, New York
[87] 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.

Some guidance was provided by UNSD in 2017, which commenced by noting that:

"ISIC Rev. 4. does not have a generic industry or section for agency for intermediation between service providers and service consumers that is equivalent to wholesale trade or retail trade" (Murphy, 2017).

Due to this, the guidance suggested that these intermediary platforms should be classified *"to the ISIC class of the activity being performed – if there is a separate class in ISIC for the agency service or default to the ISIC class of the change producing service if there is not a separate class"* (Murphy, 2017).

While this provided a classification for some well-known platforms providing services related to travel and accommodation, the UNSD also noted that not all industries have a separately identified agency class, meaning many DIPs were "defaulted" to the industry where the goods or services they were intermediating are classified, thus confounding platforms with other businesses and defying the initial purpose. Additionally, some platforms intermediate goods and services that transcend multiple industries, making classification harder.

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

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 CPA 79	30	50	CPA 49 CPA 79		30	50
			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 CPA 49	20	30	-20 20	CPA 47 CPA 49		50
				value added	20	30

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

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