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CAN POTENTIAL MISMEASUREMENT OF THE DIGITAL ECONOMY EXPLAIN THE POST-CRISIS SLOWDOWN IN GDP AND PRODUCTIVITY GROWTH?

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ABSTRACT / RÉSUMÉ

The digital economy has created some new measurement challenges for macroeconomic statistics and may have exacerbated some older ones, raising some concerns about the scope and estimation of GDP. Against a backdrop of slowing rates of measured productivity growth, this has raised questions about the conceptual basis of GDP and output, and whether current compilation methods are adequate to capture them (known as the mismeasurement hypothesis). In response to these concerns the international statistics community has reinforced efforts to investigate these concerns, chiefly under the vehicle of OECD-IMF collaboration and a newly formed Advisory Expert Group working under the auspices of the OECD's Committee for Statistics and Statistical Policy. This paper is intended to provide momentum to these on-going efforts and to address immediate concerns about the potential scale of GDP mismeasurement in key areas where mismeasurement is often suspected. Notwithstanding the need for further work in some areas, notably with regards to cross-border transactions as well as potential mismeasurement in other macro-economic statistics, such as the consumer prices index, this paper concludes that even if mismeasurement is occurring, its scale is not sufficient to explain the widespread slowdown in measured GDP growth or multi-factor productivity growth. Nevertheless it's important to note that this is a backward looking exercise. Even though the distortionary impact of any potential mismeasurement is currently thought to be small the growing size of digitised transactions could point to larger impacts in the future.

Keywords: Productivity, GDP, mismeasurement, prices, digitalisation

JEL Classification:E1, E22, E24, E30

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L'économie numérique a créé de nouveaux défis de la mesure des statistiques macroéconomiques et en a peut-être exacerbé d'autres plus anciens, soulevant des réserves à la fois sur la portée et l'estimation du PIB. Dans un contexte de ralentissement de la croissance de la productivité mesurée, cela a poussé à se poser des questions sur les bases conceptuelles du PIB et de la production, et à se demander si les méthodes de compilation actuelles sont adéquates pour les appréhender (appelé l'hypothèse d'erreur de mesure). En réponse à ces préoccupations, la communauté statistique internationale a conjugué ses efforts pour investiguer, principalement sous la direction du couple OCDE-FMI ainsi que d'un nouveau Groupe de conseil d'experts travaillant sous les auspices du Comité de l'OCDE pour les statistiques et la politique statistique. Ce document entend donner un élan à ces efforts continus et à répondre aux inquiétudes actuelles concernant l'ampleur de l'erreur de mesure du PIB dans des domaines importants où elle est susceptible d'exister. Nonobstant le besoin de travail complémentaire dans certains sujets, notamment les transactions transfrontalières ainsi que l'erreur de mesure potentielle dans d'autres statistiques macroéconomiques, telles que l'indice des prix à la consommation, ce papier conclut que même si erreurs de mesure il y a, leur ampleur n'est pas suffisante pour expliquer le ralentissement généralisé de la croissance du PIB mesuré ou celle de la productivité multi factorielle. Néanmoins, il est important de noter qu'il s'agit d'un exercice de recherche en arrière. Même si l'impact de distorsion de n'importe quelle erreur de mesure potentiel est actuellement considéré comme minimal, la taille croissante des transactions numérisées peut conduire à des impacts plus importants dans le futur.

Mots clés : productivité, PIB, erreur de mesure, prix, numérisation

Classification JEL : E1, E22, E24, E30

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Executive Summary

The digital economy has created some new measurement challenges for macroeconomic statistics and may have exacerbated some older ones, raising concerns about the scope and estimation of GDP. Against a backdrop of slowing productivity growth, this has raised questions about the conceptual basis of GDP and output, and whether current compilation methods are adequate to capture them ("the mismeasurement hypothesis"). The international statistics community has reinforced efforts to investigate these concerns, chiefly under the vehicle of OECD-IMF collaboration and a newly formed Advisory Expert Group working under the auspices of the OECD's Committee for Statistics and Statistical Policy. This paper is intended to provide momentum to these on-going efforts and to address immediate concerns about the potential scale of GDP mismeasurement in key areas where mismeasurement is often suspected.

The paper necessarily restricts itself to potential mismeasurement in key areas of GDP where concerns have been raised. Further work to be conducted in the coming year will consider other macro-economic indicators, including cross-border transactions, in particular with respect to current guidelines for determining economic ownership of intellectual property assets, and consumer prices. The present focus is to address the immediate concerns about the potential scale of GDP mismeasurement, and the absence of information that is fuelling the mismeasurement hypothesis. The paper does this by producing a range of illustrative estimates based on the limited data that are available, including unofficial data, and on assumptions. Some of the assumptions deliberately stretch the bounds of plausibility, as the objective is to illustrate the largest conceivable consequences for GDP growth of possible mismeasurement in areas where digitalisation is thought to have created or exacerbated biases.

The key conclusion from the analysis presented in the paper is that even if suspected mismeasurement is occurring, it is not of sufficient scale, at least for now, to significantly depress measured GDP growth or multi-factor productivity growth, nor to explain the recent, near-global slowdown in productivity and GDP growth. Indeed, adjustments to prices to correct for potentially overlooked quality improvements would reduce estimated GDP growth in the case of imports.

Nevertheless, further work is clearly needed on measuring and reporting the contributions of digitalisation to GDP and other macroeconomic statistics. Digitalisation is not sufficiently present within the classification systems currently used to estimate and report on economic activity, inhibiting the ability of policy makers and other interested stakeholders to assess the size and growth of the digital economy and its impact on households. Furthermore, even though the value of free services funded by advertising is already indirectly included in estimates of household consumption, their direct contribution to consumer welfare merits further investigation, and consideration for satellite accounts. In addition, the rise of the 'sharing' and 'gig' economies, raise important issues for labour market policies. Better understanding of the digital economy in macroeconomic statistics is also important as effects not yet investigated could turn out to be significant. Even though the distortionary impact is currently thought to be small, new evidence could reveal larger impacts.

Taken together, the above considerations reinforce the need for further work concerning price and output volume measurement, and statistics on the size of key aspects of the digital economy. They also reinforce the need for research on complementary accounting frameworks, or satellite accounts, and on the development of statistics on the Digital Economy at large, including measures to shed light on the benefits for consumer welfare. Such accounting frameworks and measures will support the broader objective of capitalising on the opportunities (and managing the challenges) arising from digitalisation.

The main provisional findings in this note are as follows:

- Price changes for products that are internationally traded can be expected to be similar across countries. However, significant differences exist across countries in the observed official rates of price change in information and communication (ICT) equipment and software prices of ICT goods in Spain for example have shown modest change over the last two decades, in contrast to falls of between 70 and 90% in Australia, Canada, Germany, the Netherlands, UK, and US.

- Nevertheless, correcting for potential mismeasurement of price indices in these areas does not translate into significant changes to recorded GDP growth. Upper bound estimates based on strong assumptions point to revisions to GDP growth rates of around 0.2% per annum in most economies, significantly below the normal margin of error seen in estimates of quarterly GDP growth rates. Similarly, in the more in-depth analysis performed for the United States, the estimated effect of mismeasurement of ICT equipment and software was between 0.1 and 0.2% per year in the last decade. At the upper limit, Byrne and Corrado (2017) estimate their adjusted ICT price indexes would add about 0.22 percentage points to output growth for the United States.

- However, much depends on whether adjustments are made to import price indices. If price mismeasurement in ICT products **only** affected imports, the corrections could work to reduce official estimates of GDP by around 0.1% of GDP.

- The results do not help to explain the recent productivity slowdown. The longstanding wide variation across countries in ICT price indices indicates the potential measurement error pre-dates the slowdown period, and the in-depth analysis for the US shows that the productivity measurement error was just as large in the earlier period. In addition, although investment growth is noticeably higher when adjustments are made for potential price measurement, these adjustments have little effect on multi-factor productivity growth, and only help to attenuate the slowdown in labour productivity.

- Mismeasurement of investment due to the partial use of automobiles as fixed assets in the sharing economy is relatively small. At most, total investment would increase by 0.04% in the case of the United Kingdom if Uber drivers' expenditures on automobiles were recorded as investment, and the impact on broad productivity measures would be negligible.

- If free media funded by advertising were added to household consumption expenditures, the largest estimated impact would be in the United States. There, the average growth rate of GDP in 2011-2013 would increase by 0.07 percentage points, driven mainly by web portals.

- The value of free digital services provided by Wikipedia, one of the most popular websites, is insignificant relative to GDP; the estimates range from 0.0004% of global GDP to as much as 0.0094% of World GDP. With very extreme and unrealistic assumptions, this could rise to 0.1% of global GDP.

- Although growing, small amounts of cross-border transactions facilitated by digital (e-commerce) transactions remain small; ranging between 1-3% of total trade – and many countries include estimates in their official statistics on GDP.

1. Background

1. The digital economy has created some new measurement challenges for macroeconomic statistics and may have exacerbated some older ones, raising some concerns about the scope and estimation of GDP. In response to these concerns the international statistics community has reinforced efforts to investigate these concerns, chiefly under the vehicle of OECD-IMF collaboration and a newly formed Advisory Expert Group (AEG), working under the auspices of the OECD's Committee on Statistics and Statistical Policy. A joint OECD-IMF issues paper provided to G-20 Sherpas in June 2016, framed that collaboration by describing some key measurement and conceptual concerns arising from digitalisation and recommending some actions. The key conclusion of the paper, and an earlier supporting paper of the OECD (Ahmad and Schreyer, 2016) was that the conceptual basis for GDP (the 2008 System of National Accounts, SNA) is still sound.

2. These earlier works highlighted that in many areas where concerns were raised, the digital economy's output is captured in estimates of GDP, and that other key concerns relating to a decoupling between measures of consumer surplus and household consumption reflect confusion between measures of consumer welfare and household consumption in GDP. To address these concerns, there is growing support for the development of satellite accounts that present new statistics as complements to those on GDP.

3. One, often raised, concern is that data assets are not being measured, and that this omission could have masked the contribution of the digital economy to productivity growth. However, before concluding that a supplementary or expanded measure of data assets is needed, it is worth pausing to consider which kinds of data would actually qualify as assets. To be an asset, data must have enforceable rights of economic ownership and be a store of value. Much of the data used as intermediate inputs in targeted online advertising, such as digital tracks of online behaviour, loses value very quickly. Flows of short-lived data used as intermediate inputs into the production of outputs such as targeted online advertising are already captured in the national accounts as part of the value of the output.

4. Another important take-away from the earlier work was that the lack of visibility of the digital economy and digitally-enabled activities within official statistics may, at least in part, be fuelling perceptions of mismeasurement. It is clear in this respect that further development of statistical classification systems may be needed: today's classification systems do not separately distinguish digitalised activities, and digitalisation itself remains an ill-defined concept.

5. One area that is not fully examined in this paper, but which will be investigated as part of planned initiatives, concerns globalisation, particularly cross-border transactions in intellectual property. Guidance continues to be developed regarding the rules to determine economic, as oppose to legal, ownership, with the recent work by the Task Force on Global Production building on earlier work of the Expert Group on the Impact of Globalisation on National Accounts (GGNA).[2] Transfers of intellectual property from one country to another, whether for fiscal optimisation or for economic reasons, can have a significant impact on GDP and productivity. However, with consistent recording in all countries, these effects would net out at the global level, and hence should not cause *global* slowdowns in productivity and GDP growth.

[2] See Guide to Measuring Global Production: www.unece.org:8080/fileadmin/DAM/stats/publications/2015/Guide_to_Measuring_Global_Production__2015_.pdf and The Impact of Globalization on National Accounts: www.unece.org/fileadmin/DAM/stats/groups/wggna/Guide_on_Impact_of_globalization_on_national_accounts_FINAL21122011.pdf.

6. All of these areas are being investigated as part of the work-plan of the OECD and IMF, and the AEG, but robust analysis of the scale of the problem will take some time and will require statistical agencies to develop new source data. As an interim contribution to the debate, and also to assuage concerns in some areas and to provide the basis of priority action in others, this paper pulls together available information from a variety of sources to quantify the potential scale of the mismeasurement. It investigates the following key areas: *i)* potential mismeasurement that may arise from inadequate price indices, in particular in the measurement of Information and Communication Technology (ICT) products; *ii)* potential mismeasurement of investment, capital stock, and, in turn, multifactor productivity due to partial use of vehicles owned by households as business assets; *iii)* quantifying the value of free and subsidised consumer products financed by advertising and data acquisition; *iv)* quantifying the value of a free good, such as Wikipedia, produced by volunteers; and *v)* reviewing country practices and quantifying small amounts of cross-border transactions facilitated by digital trade (e-commerce).

2. Prices and volumes

7. A key challenge presented by digitalisation is in the area of measuring price change.[3] Inadequate adjustment for quality change may affect the distinction between price and volume changes when estimating growth of output and capital inputs. This concern is especially pertinent for the measurement of ICT products, which tend to undergo frequent changes in quality and specifications. When technological progress is rapid, standard methods may undervalue the quality improvements embodied in new models, leading to overestimation of the growth of quality-adjusted prices and underestimation of output volume growth.[4]

8. This is not a new issue: Fifty years have passed since quality improvements in computers were first identified as a particular challenge for price measurement by Chow (1967). Services also present difficult challenges, particularly those that are subject to rapid changes in characteristics. Communication services have especially benefitted from digitalisation, with significant technological progress in recent years. Price measurement of communication services is further complicated by the great variety of pricing plans and bundles, and, in some cases, funding models involving data collection and/or advertising.

9. Recent studies finding evidence of overestimation of price change in official price indices for ICT and software have revived the discussion of price mismeasurement.[5] The OECD and IMF will explore these issues in future work. In anticipation of those results, this section provides an approximate indication of the potential scale of mismeasurement of growth by applying a simple approach that requires only currently available national data. The simple approach replaces one set of price indices by another in the

[3] Price indices are constructed by comparing prices of sampled products between two periods in time. Two conditions have to be fulfilled to obtain reliable estimates of the index for a product group: the products in the sample must be representative of a whole product group, and they must be comparable between the two periods. One challenge is customisation that is enabled by digitalisation. With products (in particular, services, but increasingly also goods) becoming more unique, controlling for quality differences is becoming more complicated. The Eurostat-OECD Methodological Guide for Developing Producer Price Indices for Services (SPPI, 2014) provides detailed advice on this issue by product, highlighting a number of approaches that could be used for measuring price changes in specialised products (contract pricing, model pricing, component pricing, hedonic methods). Yet implementing these approaches to measuring quality changes remains challenging.

[4] The standard matched models' method for handling the replacement of an old model by a new one assumes that their quality-adjusted prices are the same if they are observed selling side by side.

[5] See, for example, Byrne, Oliner and Sichel (2015), Byrne, Fernald, and Reinsdorf (2016), and Byrne and Corrado (2016, revised January 2017).

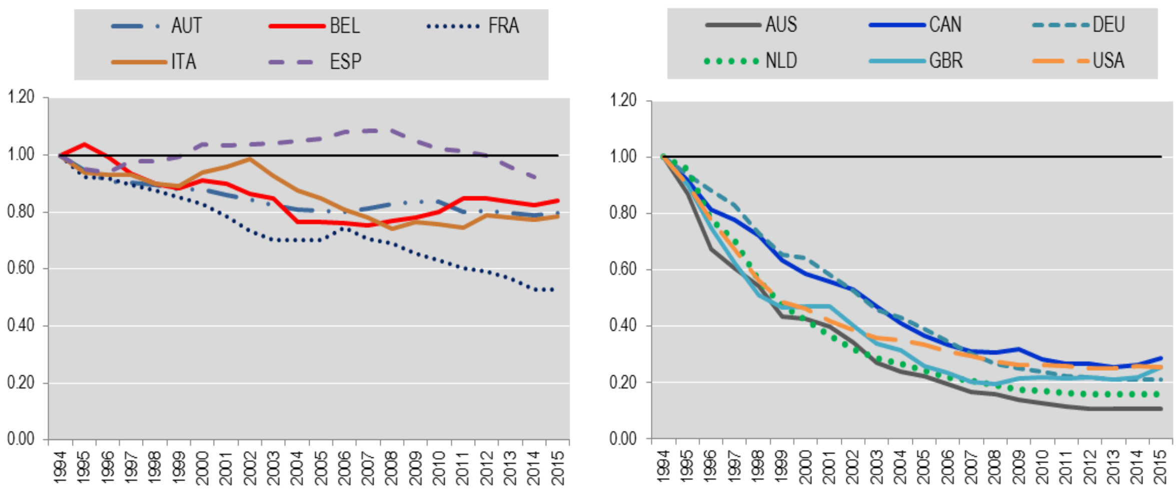
framework of national accounts (see Annex 1 for a detailed exposition). This analysis is followed by a review of more detailed results that are available for the US.

2.1. Cross country comparison of prices

10. A simple first indication of the possible scale of price mismeasurement can be constructed by comparing measured price changes across countries for three kinds of products: ICT equipment, software and databases, and communications services. Particularly during a period of relatively low global inflation, we can assume that price movements are broadly similar across countries for globally traded goods, after allowing for pass through of exchange rate movements. This assumption can usually be expected to hold for commodities, and is not unreasonable for computers and other ICT equipment. However, common behaviour of prices is a strong assumption in the cases of communications services and software, where significant investment is generated on own-account (i.e. through the in-house production of software). Nevertheless, notwithstanding other factors that may cause price divergences across countries, a simple comparison is of use, and the evidence would seem to point to significant differences across countries; see Figures 2.1 to 2.3.

Figure 2.1: Price indices for investment in computer hardware and telecommunications equipment

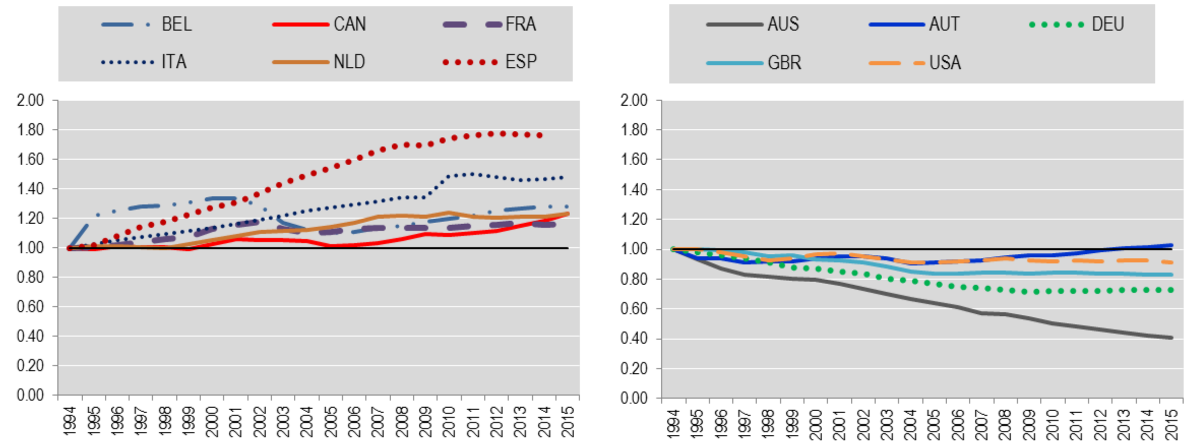
National price indices, selected OECD countries, 1994=1.00



Source: OECD National Accounts Statistics and OECD Productivity Database, February 2017.

Figure 2.2: Price indices for investment in computer software and databases

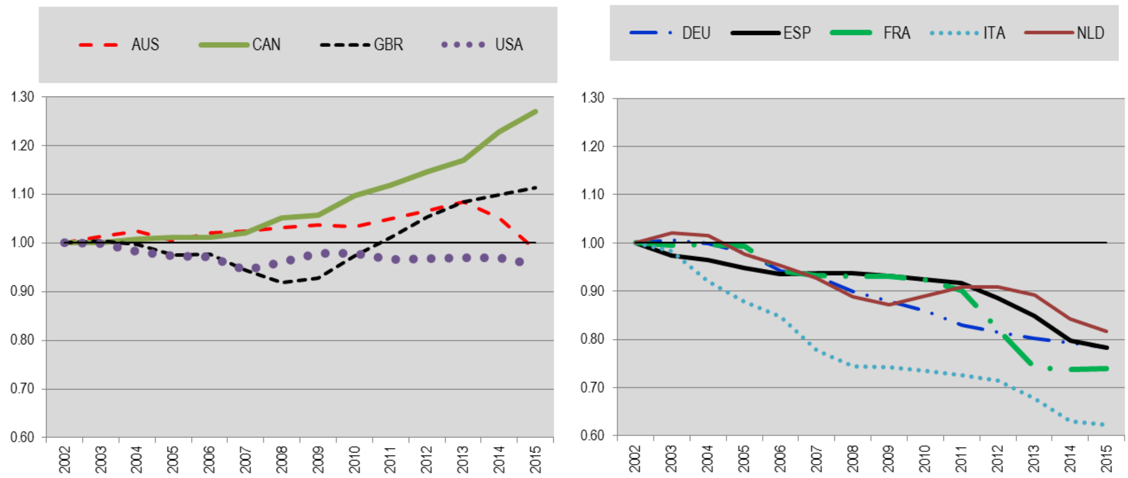
National price indices, selected OECD countries, 1994=1.00



Source: OECD National Accounts Statistics and OECD Productivity Database, February 2017.

Figure 2.3: Price indices for consumption of communication services

National price indices, selected OECD countries, 2002=1.00



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

11. Many of the differences across countries in the measured price change since 1994 (or 2002 in the case of communications services) are substantial (Figures 2.1 to 2.3). To illustrate the potential scale of mismeasurement, prices of computers and telecommunications equipment show little change over the two decades in Spain, and declines of between 70 and 90% in Australia, Canada, Germany, the Netherlands, UK, US. In Italy and Austria, prices fall by only around 20% over the two decades, but remain broadly flat in the second decade.

12. The large differences in price movements for software also point to different index construction and quality adjustment procedures. Investment in software includes significant in-house production, where countries may be generating price indices using a cost-of-production approach. Wages are the most important component of the deflator for this software, and wages of software writers are unlikely to have diverged as much as the price indices for software. Software prices in Spain, for example, rose by

around 80% over the period, but they fell by 60% in Australia, and ranged between +25% and -25% for almost all the other countries.

13. For communication services – where, admittedly, local factors, such as competition and deregulation are likely to play a significant role in price changes – prices rose by around 30% in Canada over the last decade but fell by close to 40% in Italy. Australia and Spain also offer interesting contrasts between the communication services indices and the ICT equipment indices: the price index for communication services rose almost continuously until 2013 in Australia and fell continuously in Spain, whereas the ICT goods index fell rapidly in Australia and was nearly flat in Spain.

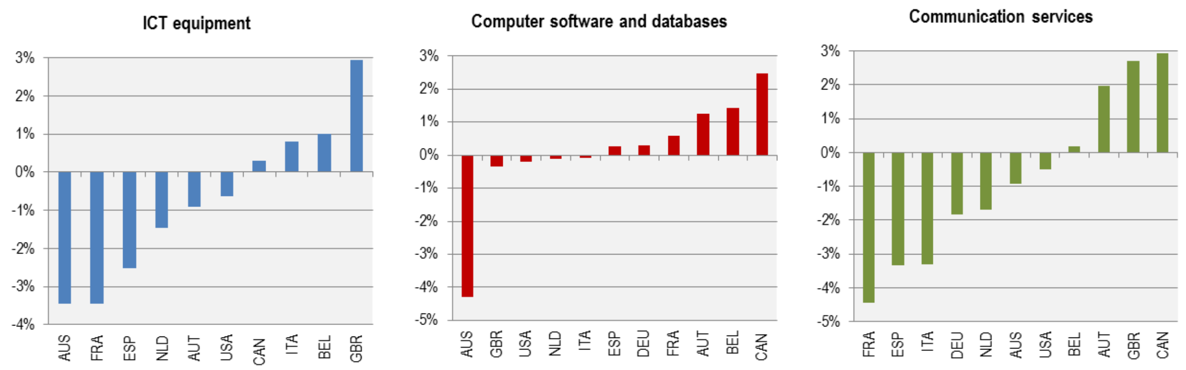
2.2. Growth in ICT investment and consumption of communication services

14. Although the divergences in the price indices are not proof of mismeasurement, they can be used to derive upper and lower bounds that indicate the scale of the potential mismeasurement of growth in investment or output caused by deflators. To do this, we replace a country's own price index for a given product with the lowest and highest price index from any country, with an adjustment for the differences in general inflation rates. The range between the upper and lower bounds for the investment and communication services growth rates probably overstates the range of uncertainty caused by potential price mismeasurement because factors other than measurement error in prices contribute to the variance of countries' reported price changes.

15. For the purposes of this interim report, we focus on a more recent period (as illustrated in Figure 2.4). This figure provides a simplified illustration of the price changes in 2010-2015, confirming the pattern of divergences across countries and hence potential mismeasurement.

Figure 2.4: Price indices for investment in ICT assets and consumption of communication services

Average annual growth rate in%, 2010-2015 (or latest available year)



Notes: Data reported for Spain for ICT equipment and computer software and database correspond to the period 2010-2014. Data reported for Austria for Communication services correspond to the period 2011-2015.

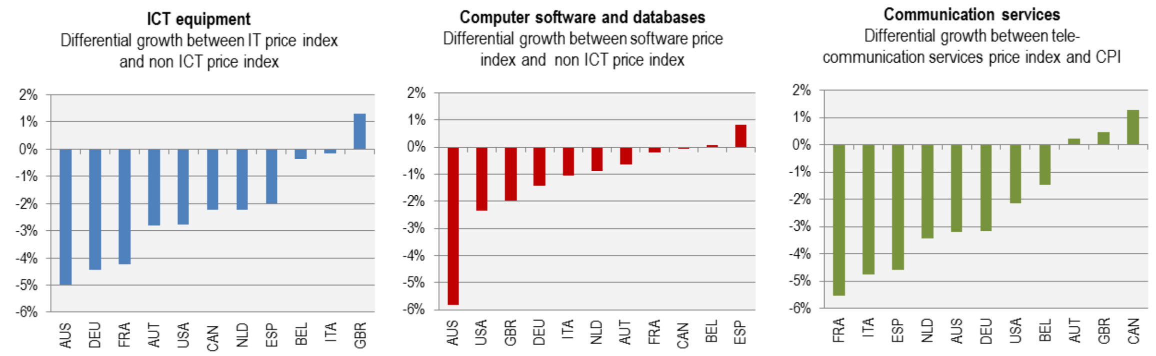
Source: OECD National Accounts Statistics, OECD Productivity Database, OECD Prices and Purchasing Power Parities database, Australian Bureau of Statistics, US Bureau of Economic Analyses and Statistics Canada, February 2017.

16. Rather than simply replacing a country's own price index for IT investment or communication services with the maximum or minimum price index, we use deviations from a broad price index as a way of removing the effects of differences in underlying general inflation. For example, the upper bound index for ICT equipment in Canada is calculated by adding the deviation of the ICT equipment index from non-ICT, non-residential investment in the United Kingdom (the maximum country) to the index for non-ICT,

non-residential investment in Canada.[6] Figure 2.5 presents the upper and lower bound price movements adjusted for underlying inflation.

Figure 2.5: National price indices, investment in ICT assets and consumption of communication services

Difference in average annual growth in %, 2010-2015 (or latest available year)



Notes: Data reported for Spain for ICT equipment and Computer software and database correspond to the period 2010-2014. Data reported for Austria for Communication services correspond to the period 2011-2015.

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

17. Table 2.1 below, illustrates the impact of this approach on growth in investment in ICT equipment and software. The first column of numbers in each of the tables shows the average annual growth rate of the volume of investment in the product over the five-year period (2010-2015) actually reported by the country. The next column shows the lower bound estimate of investment volume growth implied by the upper bound price index. That price index is calculated by adjusting the country's observed measure of general price inflation by the minimum deviation, across all countries, between the product's price change and general inflation (for example, if country A reported a price change of 1 in the specific product and general inflation of 6, and the minimum deviation between the specific product and general inflation across all countries was -2 because general inflation was 3 and the product's price change was 1 in country Z, then the upper bound measure of price change for the product in country A would equal 6-2).

18. The third column of numbers in each of the tables is calculated using an analogous approach, but this time using the maximum observed value of product-specific inflation minus general inflation (for example, if the maximum difference was observed in country Y, with general inflation of 4 and product inflation of -6, the difference of 10 applied to country A's general inflation rate produces an inflation rate of -4). A further alternative for estimating investment growth is provided in the last column, which takes the actual US price indices adjusted for relative price differences (see Annex 1).

6 See Annex 1. For calculations relating to investment categories, the underlying measure of inflation used to generate price relatives is the observed measure of inflation in all categories on non-ICT non-residential investment: i.e. transport equipment, other machinery and equipment and weapons systems (excluding ICT equipment), non-residential construction, research and development (R&D), and other intellectual property products (excluding R&D and computer software and databases). For calculations relating to communication services, the price relative takes general consumer price inflation. Note that for investment measures, some distortions will be introduced reflecting differences in the composition of investment across countries. Similar distortions, albeit likely to be smaller, will be introduced for measures of communication services, although measures of inflation will include some ICT categories and communication services.

Table 2.1: Growth rate of investment, volume

Average annual growth rate in %, 2010-2015 (or latest available year)

A. ICT Equipment

Country	Growth rate of investment in ICT equipment			
	Using national ICT price index	Using adjusted ICT price indices		
		Lower bound growth	Upper bound growth	US harmonised growth
Australia	2.0%	-4.3%	2.0%	0.6%
Austria	3.8%	-0.3%	6.0%	4.8%
Belgium	1.3%	-0.4%	5.9%	4.7%
Canada	-0.1%	-3.7%	2.6%	1.4%
France	4.7%	-0.9%	5.4%	4.2%
Germany	6.2%	0.4%	6.8%	5.5%
Italy	-2.3%	-3.7%	2.6%	1.4%
Netherlands	3.1%	-0.5%	5.9%	4.6%
Spain	2.1%	1.6%	5.5%	4.5%
United Kingdom	8.1%	8.1%	14.4%	13.2%
United States	1.3%	-2.8%	3.5%	

B. Software

Country	Computer software and databases			
	Using national software price index	Using adjusted software price indices		
		Lower bound growth	Upper bound growth	US harmonised growth
Australia	9.2%	2.6%	9.2%	5.2%
Austria	3.9%	2.5%	9.2%	5.3%
Belgium	1.3%	0.5%	7.2%	3.3%
Canada	-0.5%	-1.4%	5.3%	1.4%
France	3.9%	2.8%	9.5%	5.6%
Germany	3.2%	0.9%	7.6%	3.7%
Italy	2.6%	0.8%	7.4%	3.5%
Netherlands	3.8%	2.2%	8.8%	4.9%
Spain	3.7%	3.7%	10.4%	6.5%
United Kingdom	4.9%	2.1%	8.8%	4.9%
United States	5.1%	2.0%	8.6%	

Notes: ICT equipment includes computer hardware and telecommunication equipment. Data for Spain correspond to the period 2010-2014.

Source: OECD calculations based on OECD National Accounts Statistics and OECD Productivity Database, February 2017.

19. Table 2.2 below provides a similar range of estimates for communication services, except in this case an alternative estimate based on US price indices adjusted for relative price differences is not provided as prices in communication services are in general not internationally determined (although mobile telephone charges within Europe have increasingly been the subject of European Commission regulations in recent years).

Table 2.2: Growth rate of household final consumption of communication services, volume average annual growth rate in%, 2010-2015 (or latest available year)

Country	Communication services		
		Using adjusted consumer price indices for communication services	
	Using national consumer price index for communication serv.	Lower bound growth	Upper bound growth
Australia	2.9%	-1.6%	5.2%
Austria	-3.0%	-4.6%	3.0%
Belgium	-0.2%	-2.9%	3.9%
Canada	1.7%	1.7%	8.5%
France	2.0%	-4.8%	2.0%
Germany	3.5%	-0.9%	5.9%
Italy	-0.1%	-6.7%	1.2%
Netherlands	1.8%	-2.9%	3.9%
Spain	1.1%	-4.8%	2.0%
United Kingdom	0.2%	-0.6%	6.2%
United States	4.8%	1.4%	8.1%

Notes: Data reported for Austria correspond to 2011-2015. Data reported for Italy correspond to 2010-2014.

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

2.3. Impacts of different prices on GDP growth

20. The impact of a measurement error in ICT or communication deflators on GDP depends on whether the affected products are for final or intermediate uses, and on whether they are imported or domestically produced. For example, if all ICT investment goods were imported and the deflators used for imports and investment were consistent (assuming no import tariffs or distribution margins), then any corrections made to the price indices for ICT investment would have no impact on overall GDP; the changes to volumes of ICT investment would be offset by corresponding changes to imports of ICT products. Similarly, if all communication services were domestically produced and consumed by businesses, then any increases in the volume of output of the communications services sector arising from improvements to the communications price indices would be entirely offset by corresponding increases in the intermediate consumption of the sectors using the services; so again GDP would be unaffected by improvements in price measurement. In this latter case, the only changes that would occur in the accounts would be in the distribution of value-added across sectors.

21. Nevertheless, all of the above presupposes complete coherence in deflation methods across the accounts, something that can only be assured through compiling national supply and use tables (SUTs) in volume terms or similar steps to achieve consistency. Many countries do not produce these SUTs, so, in the next table, three scenarios[7] are investigated (see also Annex 2 for a more detailed exposition). The first assumes that import prices are measured well, so that the adjustments made to the price indices affect only volume estimates of final demand. The second takes a more extreme view that assumes that only import prices are mismeasured, and that final demand prices are measured well. This is an unlikely scenario, but is shown in order to provide extreme, albeit unrealistic, bounds of the possible effect on growth rates. The

7 As it has not been possible to determine in this interim report the actual deflators used for import prices, scenarios two and three, necessarily assume that the observed price indices for imports are the same as the observed price indices for investment (for ICT goods) or consumption (for communication services).

final approach gives results in between these two extremes by adjusting both the final demand and the import price indices.

22. Table 2.3 presents results on the implied adjustments to GDP growth for each product category when alternative price indices are used as the deflator. Following the same approach as in the earlier discussion, for each scenario, upper and lower bound price indices, and a US adjusted price index (except for communication services) are applied.

23. Table 2.4 aggregates over all products. It only shows the growth rate adjustment implied by the lower bound price indices because the usual mismeasurement concern is that the official price indices under adjust for quality change. Under our rather strong set of assumptions, the result for Belgium shows that overall growth rates could be adversely affected by price mismeasurement by as much as 0.4% per year. However, the implied adjustments to growth are only around 0.2% for most countries. While measurement errors of this magnitude would be significant, it is important to note that these are very much upper bound estimates, and that the true scale of mismeasurement is likely to be considerably lower. The assumption of no coherence between import prices and final consumption prices is unlikely to hold, especially in countries producing supply and use tables in volumes, and factors other than mismeasurement may have contributed to the price index differences.

Table 2.3: GDP growth, using different price indices

Average annual growth rate, 2010-2015 (or latest available year)

A. ICT equipment

Country	GDP growth, unadjusted	Adjusted GDP growth minus Unadjusted GDP growth								
		Scenario I: M=0			Scenario II: FD=0			Scenario III: FD and M from SUT		
		Lower bound growth	Upper bound growth	US harmonised growth	Upper bound growth	Lower bound growth	US harmonised growth	Lower bound growth	Upper bound growth	US harmonised growth
Australia	2.761%	-0.085%	0.000%	-0.018%	0.075%	0.000%	0.016%	-0.010%	0.000%	-0.002%
Austria	1.047%	-0.173%	0.092%	0.041%	0.112%	-0.059%	-0.026%	-0.061%	0.033%	0.015%
Belgium	0.996%	-0.066%	0.177%	0.130%	0.047%	-0.129%	-0.095%	-0.020%	0.049%	0.036%
Canada	2.148%	-0.107%	0.084%	0.046%	0.091%	-0.071%	-0.039%	-0.016%	0.013%	0.007%
France	0.943%	-0.158%	0.022%	-0.013%	0.117%	-0.016%	0.009%	-0.041%	0.006%	-0.003%
Germany	1.572%	-0.309%	0.030%	-0.036%	0.198%	-0.019%	0.023%	-0.111%	0.011%	-0.013%
Italy	-0.641%	-0.041%	0.129%	0.096%	0.032%	-0.081%	-0.059%	-0.009%	0.048%	0.037%
Netherlands	0.748%	-0.223%	0.177%	0.100%	0.097%	-0.078%	-0.044%	-0.126%	0.099%	0.056%
Spain	-0.235%	-0.009%	0.057%	0.040%	0.006%	-0.040%	-0.028%	-0.003%	0.017%	0.012%
UK	1.978%	0.000%	0.198%	0.160%	0.000%	-0.167%	-0.135%	0.000%	0.031%	0.025%
US	2.072%	-0.142%	0.076%	-	0.075%	-0.040%	-	-0.067%	0.035%	-

B. Software

Country	GDP growth, unadjusted	Adjusted GDP growth minus Unadjusted GDP growth								
		Scenario I: M=0			Scenario II: FD=0			Scenario III: FD and M from SUT		
		Lower bound growth	Upper bound growth	US harmonised growth	Upper bound growth	Lower bound growth	US harmonised growth	Lower bound growth	Upper bound growth	US harmonised growth
Australia	2.761%	-0.094%	0.000%	-0.057%	0.008%	0.000%	0.005%	-0.085%	0.000%	-0.052%
Austria	1.047%	-0.039%	0.138%	0.035%	0.009%	-0.033%	-0.008%	-0.029%	0.105%	0.027%
Belgium	0.996%	-0.017%	0.138%	0.047%	0.004%	-0.032%	-0.011%	-0.013%	0.105%	0.036%
Canada	2.148%	-0.012%	0.074%	0.024%	0.002%	-0.015%	-0.005%	-0.009%	0.060%	0.019%
France	0.943%	-0.025%	0.135%	0.042%	0.003%	-0.017%	-0.005%	-0.022%	0.118%	0.036%
Germany	1.572%	-0.031%	0.061%	0.007%	0.011%	-0.021%	-0.002%	-0.020%	0.040%	0.005%
Italy	-0.641%	-0.024%	0.061%	0.011%	0.003%	-0.009%	-0.002%	-0.020%	0.052%	0.010%
Netherlands	0.748%	-0.053%	0.157%	0.034%	0.012%	-0.035%	-0.008%	-0.041%	0.122%	0.026%
Spain	-0.235%	0.000%	0.103%	0.044%	0.000%	-0.016%	-0.007%	0.000%	0.086%	0.037%
UK	1.978%	-0.057%	0.078%	-0.001%	0.007%	-0.010%	0.000%	-0.049%	0.068%	-0.001%
US	2.072%	-0.055%	0.061%	-	0.005%	-0.005%	-	-0.051%	0.056%	-

C. Communication services

Country	GDP growth, unadjusted	Adjusted GDP growth minus Unadjusted GDP growth					
		Scenario I: M=0		Scenario II: FD=0		Scenario III: FD and M from SUT	
		Lower bound growth	Upper bound growth	Upper bound growth	Lower bound growth	Lower bound growth	Upper bound growth
Australia	2.761%	-0.044%	0.023%	0.002%	-0.001%	-0.042%	0.022%
Austria	0.617%	-0.017%	0.064%	0.003%	-0.011%	-0.014%	0.053%
Belgium	0.996%	-0.057%	0.085%	0.016%	-0.023%	-0.042%	0.062%
Canada	2.148%	0.000%	0.128%	0.000%	-0.007%	0.000%	0.121%
France	0.943%	-0.105%	0.000%	0.010%	0.000%	-0.095%	0.000%
Germany	1.572%	-0.059%	0.031%	0.007%	-0.004%	-0.052%	0.027%
Italy	-0.641%	-0.088%	0.011%	0.011%	-0.001%	-0.078%	0.009%
Netherlands	0.748%	-0.076%	0.033%	0.011%	-0.005%	-0.065%	0.028%
Spain	-0.235%	-0.103%	0.016%	0.011%	-0.002%	-0.092%	0.014%
UK	1.978%	-0.012%	0.088%	0.002%	-0.015%	-0.010%	0.073%
US	2.072%	-0.071%	0.071%	0.000%	0.000%	-0.071%	0.071%

Notes: Data reported for Austria (communications) correspond to 2011-2015 and Spain (ICT goods and software) correspond to 2010-2014. Data reported in grey identify the countries of which price indices are the upper and lower bounds.

Source: OECD National Accounts Statistics, OECD Prices and Purchasing Power Parities database, OECD Productivity database, OECD Supply and Use Tables database, Australian Bureau of Statistics (ABS), Bureau of Economic Analysis (BEA), Statistics Canada, Office for National Statistics (UK), February 2017.

Table 2.4: GDP growth, aggregate impact of ICT assets and communication services using lower bound price indices

Average annual growth rate in%, 2010-2015 (or latest available year)

Country	GDP growth, unadjusted	Adjusted GDP growth minus Unadjusted GDP growth		
		Scenario I: M=0	Scenario II: FD=0	Scenario III: FD and M from SUT
Australia	2.761%	0.023%	-0.001%	0.022%
Austria	1.047%	0.294%	-0.103%	0.191%
Belgium	0.996%	0.400%	-0.184%	0.216%
Canada	2.148%	0.286%	-0.093%	0.194%
France	0.943%	0.157%	-0.034%	0.123%
Germany	1.572%	0.122%	-0.044%	0.077%
Italy	-0.641%	0.200%	-0.091%	0.109%
Netherlands	0.748%	0.367%	-0.118%	0.250%
Spain	-0.235%	0.176%	-0.058%	0.117%
UK	1.978%	0.365%	-0.193%	0.172%
US	2.072%	0.208%	-0.046%	0.162%

Notes: Data reported for Austria (communications) correspond to 2011-2015 and Spain (ICT goods and software) correspond to 2010-2014.

Source: OECD calculations based on OECD National Accounts Statistics, OECD Prices and Purchasing Power Parities database, OECD Supply and Use Tables database, Australian Bureau of Statistics (ABS), Bureau of Economic Analysis (BEA), Statistics Canada, Office for National Statistics (UK), February 2017.

24. One additional observation is worth making here. Concerns related to mismeasurement have, at least in part, been driven by the on-going debate over the productivity slowdown. Whilst all of the adjustments to GDP described above translate almost directly into adjustments to labour productivity, the implications for multi-factor productivity (MFP) are more complicated. For ICT goods and software, the upward adjustments to growth also increase estimates of capital stock and inputs of capital services. The offsetting output effects and input effects are likely to make the adjustments to MFP estimates much

smaller than those for labour productivity. A more detailed assessment of the impact of price adjustments on MFP will be developed in future reports of the OECD and IMF.

2.4. Country case: Measurement error in deflators for ICT equipment and software in the US

25. Results that allow a detailed assessment are already available for the US. Rather than generating upper and lower bound estimates based on the range of measures of price change in a broad set of countries, this assessment uses alternative deflators constructed from detailed hedonic price indices from the country itself to make point estimates of the measurement error.

26. The growth rate differences between the official deflators in the US national accounts and the alternative deflators of Byrne, Fernald, and Reinsdorf (2016) are summarised in Table 2.5. For software, a more recent estimate from Byrne and Corrado (2017), which implies a larger measurement error, is also shown. Measuring quality change in software is difficult, so estimates of price change for software are subject to more than the usual amount of uncertainty.

Table 2.5: Growth rate differences between US official deflator and alternative deflator

	1995-2004	2004-2014
Computers and peripherals		
Average growth rate of official deflator	-19.3%	-6.6%
Difference between official deflator and alternative deflator[a,b]	8.0%	12.0%
Communications equipment		
Average growth rate of official deflator	-5.4%	-2.7%
Difference between official deflator and alternative deflator[a]	5.8%	7.6%
Other IT systems equipment		
Average growth rate of official deflator	-0.6%	0.5%
Difference between official deflator and alternative deflator[a]	8.3%	5.4%
Software		
Average growth rate of official deflator	-1.1%	0.1%
Difference between official deflator and alternative deflator	1.4%	0.9%
Difference between official deflator and alternative deflator of Byrne and Corrado (2016)		3.9%

Source: a. Alternative deflator from Byrne, Fernald and Reinsdorf (2016, table 1), b. Sichel (2016) finds a difference for computers and peripherals in 2007-2014 of 6.7% per year.

Effects on measurement of productivity, investment and GDP

27. The alternative deflators for computers and communication equipment increase the average growth rate of labour productivity for US private business in 2004-2014 by 0.13% per year. Adding specialized computer equipment, and also software as estimated by Byrne and Corrado (2017), increases the effect on labour productivity to about 0.2% per year.[8] However, the effect on multi-factor productivity is approximately zero because of the increase in the estimate of inputs of capital services.

28. Byrne and Corrado (2017) find that their alternative deflators for software and ICT equipment imply an upward revision to the growth rate of ICT investment of 5.8% per year. Multiplying by the average share of ICT products in US private fixed investment in 2004-2014 (22.5%) implies an upward revision of 1.3% per year to the annual growth rate of private fixed investment. The relatively high weight of imported ICT equipment helps to explain the large estimated measurement error in the deflator for

8 Use simplifying assumptions, Byrne and Corrado (2016) estimate that the effect on labor productivity correcting the measurement errors in the deflators would be 0.22% per year.

investment. The US import indices for ICT products have higher growth rates than the producer price and consumer price indices for those products, which leads to a finding of larger measurement errors in the import indices.

29. The effect on the US GDP growth rate implied by the Byrne and Corrado (2017) indices is, of course, much smaller than the effect on investment, as in this case only domestic production is included. The weight of ICT equipment and software in GDP is only around 3.6% in 2004-2014, and software, which has a relatively small measurement error, predominates within this aggregate. The overall effect on the annual growth rate of US GDP is therefore between 0.1 and 0.2% per year.

2.5. Summary assessment for price mismeasurement

30. The experiments with minimum deflators from other countries for ICT equipment, software and communication services indicate that measurement errors in GDP growth could range up to 0.2% per year. However, this finding should be interpreted with caution, as it depends on strong assumptions. A more detailed analysis using hedonic price indices for the US finds a measurement error of less than 0.2% per year.

31. Note that even the estimates based on detailed hedonic indices for the US should be interpreted with caution because they require assumptions and because hedonic price indices can be sensitive to decisions about the specification. Taking the result implied by the hedonic indices that official methods tend to overestimate price change as correct, it is worth considering the likely causes of the overestimation. Some are longstanding issues in the price index literature, such as failure to incorporate new goods quickly, use of list prices rather than transactions prices, and reliance on non-hedonic, “matched models” methods. Others have only recently become an issue. The characteristics considered in hedonic regressions or other methods for quality-adjusting the official ICT prices may include ones that have lost their relevance and exclude ones that have become important. Finally, increased delays in the timing of the markdowns in the prices of old models, and the increased importance of hard-to-measure software and specialised ICT equipment have made measurement more difficult.

32. These results do not help to explain the productivity slowdown, because similar measurement errors may have been present in the period before the slowdown and because the upper bound of the possible measurement error is much smaller than the productivity slowdown experienced by many economies since the mid-2000s (indeed, Byrne, Fernald and Reinsdorf, 2016, find empirical evidence that the measurement error was just as large in the past). Also, the effects on multi-factor productivity are much attenuated because inputs of capital services are subject to the same sort of adjustment as output. On the other hand, improvements to the price indices for ICT equipment and software could have a substantial effect on the growth rate of investment.

3. Using consumer durables as business assets: the case of automobiles

33. The digital economy has increased the importance of peer-to-peer transactions, with platforms such as Airbnb intermediating the renting out apartments/houses, and platforms such as Uber intermediating the provision of taxi services by households to other households. As noted in the earlier paper provided to the G-20, in practice, the measurement framework used by national accountants already covers the output of these activities. Actual compilation practices also appear to include them at least partially, albeit not in a way that allows for a separate articulation of their size. Estimating the size (and impact on growth) of these activities will be the subject of further work.

34. However even if the output of these services is reasonably well captured in current estimates of GDP, at least for taxi-services, the underlying fixed assets (vehicles) used in the provision of these services

are often not correctly recorded as fixed assets.[9] This affects the current official estimates of the capital stock, and, in turn, multifactor productivity.

35. The SNA states that expenditures on consumer durables that are also partly used for commercial purposes should be split between investment and household final consumption expenditure in proportion to their usage for business and personal purposes.[10] While the principle behind this split is clear enough, it is hard to do in practice. The evidence provided by a recent OECD survey[11] suggests that in most countries, car purchases by Uber-drivers are currently recorded as household consumption of consumer durables rather than investment.

36. This section attempts to provide some indication of the impact of potential misclassification on productivity estimates using basic information on the number of Uber drivers and the number of registered cars. The section ends by also providing an estimate of the value-added generated by Uber drivers in the economy; but as noted above, because of the way that statistical offices generally measure low scale 'informal' activities, this does not necessarily mean that the value-added is currently missing from official estimates of GDP.

37. Table 3.1 presents the number of Uber drivers and the number of registered passenger cars in Australia, France, the United Kingdom and the United States.[12] Although individuals may own more than one car, the information provides a proxy of the share of overall cars owned by Uber drivers. Clearly shares will differ across countries depending on local market factors, regulatory measures, and presence in the market, which is apparent from the table. In the UK and the US for example – the two countries where Uber has been active for the longest time – the estimated share of cars owned by Uber drivers are around four times the shares in France.[13]

Table 3.1: Number of Uber drivers in relation to car owners (2014-2015)

Country	# of Uber drivers	# of registered passenger cars	Estimated share of Uber drivers
Australia (2015)	12 680	16 655 368	0.08%
France (2015)	12 000	37 780 000	0.03%
United Kingdom (2015)	40 000	34 906 000	0.11%
United States (2014)	160 000	131 138 925	0.12%

Source: For number of Uber drivers: Australia - Deloitte Access Economics (2016), Number referring to August 2015 for Sydney, Melbourne, Brisbane and Perth; France – Frenchweb article (15 January 2016), www.frenchweb.fr/insiders-combien-de-nouveaux-chauffeurs-uber-en-france-en-2015/223293, United Kingdom – The Guardian (28 October 2016); United States – Hall and Krueger (2015). For number of registered passenger cars: Australia – ABS; France – Comité des constructeurs français automobiles (CCFA); United Kingdom – ONS; United States – BEA, Table 7.2.5B-Motor Vehicle Output.

9 See Ahmad and Schreyer (2016).

10 2008 SNA paragraph 9.60.

11 Only eight OECD countries make some distinction between a car purchased for business or personal use. In many cases this is done using information on car registration. Follow-ups with these eight countries however indicated that no corrections are currently made for dual use (see Wistrom and Bournot [2016]).

12 For Australia it concerns 'passenger vehicles', 'campervans', 'light commercial vehicles' and 'light rigid trucks'. For the United States it concerns 'autos' and 'light trucks'.

13 See Hall and Krueger (2015).

38. Information[14] on the average use of cars by US households for personal use (7 hours per week), and median commercial use by an Uber driver (15 hours per week) are available for the US, which can be used to derive a split of the value of an Uber driver's vehicle into household consumption and investment.[15]

39. Further the same information suggests that Uber drivers use their car 3.14 times (22 hours) more intensively than regular households (7 hours), from which it can be assumed, albeit heroically, that they replace their cars 3.14 times more often. Therefore their share of car purchases in a given year is likely to be higher than their share of the total number of passenger cars.[16] Combining this information with official estimates of consumption on motor vehicles by households provides the basis of the estimated investment in motor vehicles by Uber drivers, shown in Table 3.2 below, helping to illustrate its relatively small contribution to investment: at most 0.61% of investment in motor vehicles in the US for example reflected Uber drivers, equivalent to only 0.03% of total investment. So even allowing for growth and other operators it is unlikely that the contribution would be significantly higher than 0.1% of total investment.

Table 3.2: Estimated value of Uber car purchases: By household final consumption expenditures (HFCE) and investment (GFCF)

	AUS 2015	FRA 2015	UK 2015	US 2014
Total value of Uber car purchases, national currency, mln	50.8	43.6	200.3	1 608.9
Of which HFCE,	16.2	13.9	63.7	511.9
Of which GFCF	34.6	29.8	136.6	1 097.0
As per cent of total GFCF on cars	0.46%	0.19%	0.69%	0.61%
As per cent of total HFCE on cars	0.18%	0.08%	0.28%	0.28%
As per cent of Total GFCF	0.01%	0.01%	0.04%	0.03%
As per cent of Total HFCE	0.00%	0.00%	0.01%	0.00%

Source: Author's calculations.

40. Because of the increased investment, capital stock measures also increase. Table 3.3 below presents illustrative results of capital stock estimates in 2014 for the United States assuming that consumption patterns are stable, with a range of service lives (using a geometric depreciation technique). For comparison purposes, the table also shows comparable estimates for the total economy stock of fixed assets for machinery and equipment and weapon systems.

14 Bean (2016).

15 Additional information on the average use of Uber cars for commercial purposes by Uber drivers are available for London and Brisbane, which turn out to be higher than the median reported in the Bean report.

16 The following shares are estimated to be 0.19% for Australia, 0.08% for France, 0.29% for UK, and 0.30% for US.

Table 3.3: Value of the stock of fixed assets, United States 2014

	Service life			
	3 years	**4 years**	**5 years**	**6 years**
Value of fixed assets of Uber cars (in bln US $)	1.58	2.06	2.53	3.00
Value of fixed assets of Machinery and equipment and weapon systems	7 182.1	7 182.5	7 183.0	7 183.5

Source: Author's calculations for Uber cars and OECD Annual National Accounts Statistics.

41. Table 3.4 below illustrates the impact of these increases in capital stock on US productivity measures in 2015, using data for five-year service lives. The results show that the impact of Uber on productivity measures will be very small. Furthermore, some of this effect may be offset by incorrect treatment of the leases of cars used to drive for Uber. These leases may be included in household consumption when they should be treated as intermediate inputs used by the peer-to-peer taxi services industry. A significant number of Uber drivers lease their vehicles.

Table 3.4: Impact of different recording of Uber cars on United States productivity data, 2015

	Excluding Uber cars as assets	Including Uber cars as assets	Difference
Growth in capital services for transport equipment	5.494%	5.534%	+0.040%
Growth in capital service for all assets	2.019%	2.021%	+0.002%
Growth in multi-factor-productivity	0.613%	0.613%	-0.000%

Source: Author's productivity database and OECD calculations.

42. Table 3.5 shows that the share of Uber driver's compensation in the US as well as their return on capital (capital services) is rather negligible at 0.019% of GDP in 2014.

Table 3.5: Share of Uber drivers' compensation and capital services in the United States, 2014

	Income of average Uber driver		
	Benenson	**Hall and Krueger**	**OECD.stat**
Average compensation of employees excl. employers' social contributions (in $)	-	-	19 969
Capital services (in $)	-	-	632
Average earning of Uber drivers (in $)	14 280	16 420	20 601
Total earnings of Uber drivers (in bln $)	2.284	2.627	3.296
As % of GDP	0.013%	0.015%	0.019%

Source: Author's calculations based on average earnings of Uber drivers from Benenson (2015) and Hall and Krueger (2015); number of Uber drivers from Hall and Krueger (2015); compensation of employees and number of employees in the transport sector from the OECD Annual National Accounts statistics; average number of hours worked STAN database.

4. Free and subsidised consumer products

43. Free digital products for consumers – such as apps for smart phones, email, search engines, and much of the content on the Internet – are frequently put forward as examples of output that goes unnoticed in GDP figures despite its contribution to consumer welfare. Although these services are included in GDP in an indirect way, as part of the prices paid for the items that are advertised, this indirect approach means that estimates of household consumption do not explicitly capture these benefits; rather they are captured indirectly through higher costs of advertised products.

44. As noted in the earlier report to the G-20 Sherpas, free services funded via advertising are not a new phenomenon. Households have long been accustomed to receiving free media services (television and radio) funded via advertising. In this sense, the exclusion from GDP of households' consumption of the free services of firms such as Google (which generates around 90% of its revenue from advertising) is no different than the longstanding treatment of broadcast television TV companies. The debate that occurred with the emergence of broadcast television has recently resurfaced because digitalisation has increased the scale and visibility of the issue. A new twist has also been added to his debate because of the emergence of new data- driven business models involving the acquisition of large amounts of information on consumers' preferences, characteristics and spending patterns.

45. As noted above, the System of National Accounts does not really exclude the activities of businesses that provide free services and get their revenue from advertisers: Ultimately, consumers pay for the costs incurred to provide these services through higher prices for the products that are advertised, or through eventual upgrading to paid, premium services. Nevertheless, there is a growing recognition that estimates of the value of free services received by households would be useful, as a means of providing improved insights on consumer welfare through a system of satellite accounts. As an example of a question that these accounts could address, the global nature of the services provided means that there may be cross-border flows and distributional impacts, as one group of consumers 'pays' may pay all the costs incurred by providers of the free services while all consumers enjoy the benefits.

46. The two modes of funding free online services, advertising and data acquisition, are considered separately below.

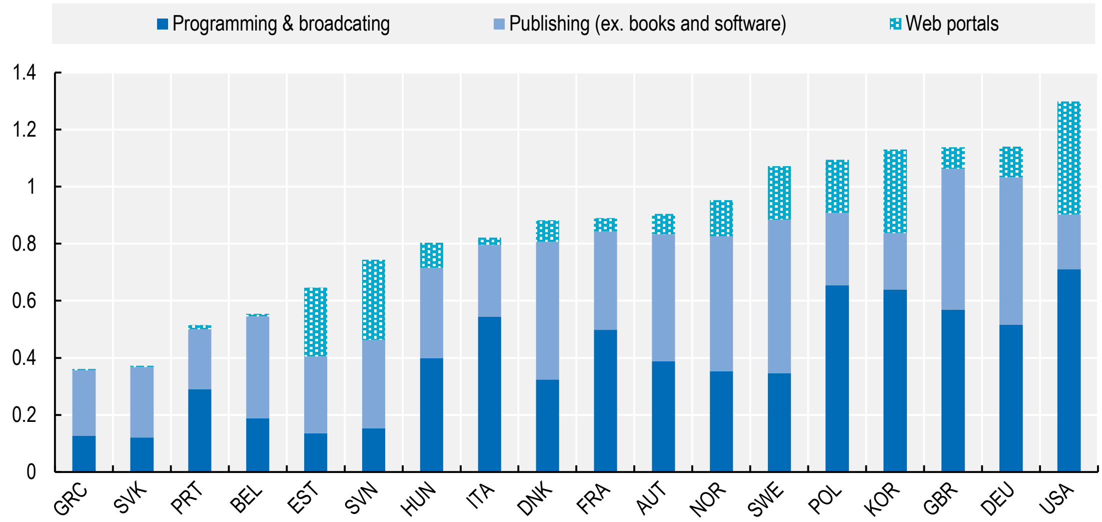
4.1. Financing via advertising

47. To give an indication of the magnitude of the issue, Figure 4.1 below shows the total turnover of media industries financed primarily by advertising revenue.[17] However, some of this revenue corresponds to explicit payments made by households already included in household final consumption expenditures (e.g. subscription fees for newspapers or cable television fees). Therefore, in order to avoid double counting, an adjustment using detailed data obtained from the US Census Bureau is made, and applied to all countries.[18]

48. The total turnover (excluding explicit payments made by households) for the 'media' related activities as a share of GDP varies across countries from a low of 0.4% of GDP in Greece to 1.3% of GDP in the United States in 2013 (figure 4.1).

Figure 4.1: Turnover (net of payments by households) of "media" industries, 2013

Percentage of GDP



Notes: For publishing (excluding books and software) industry (ISIC 5812, 5813, 5819): EST, TUR: 2013 refers to 2012; For web portals (ISIC 6312): TUR: 2013 refers to 2012.

Source: OECD SDBS database, OECD Annual National Accounts database and US Census Bureau data.

49. The dynamics differ across the various media industries. For the programming and broadcasting industry a little more than half of the countries experienced declines in inflation-adjusted turnover. The largest declines were in Greece and Belgium (contracting over 20% per year on average), whereas the United States, Sweden, and the United Kingdom experienced moderate growth of more than 3% per year between 2008 and 2013. In the publishing industry excluding books and software, almost every country

17 Radio and television broadcasting, publishing excluding books and software, and web portals (includes operation of search engines and websites that act as portals to the Internet). A portion of the software publishing industry should also be included, such as free game apps that are supported by advertising but detailed information is not available in the OECD SDBS database to make an estimate.

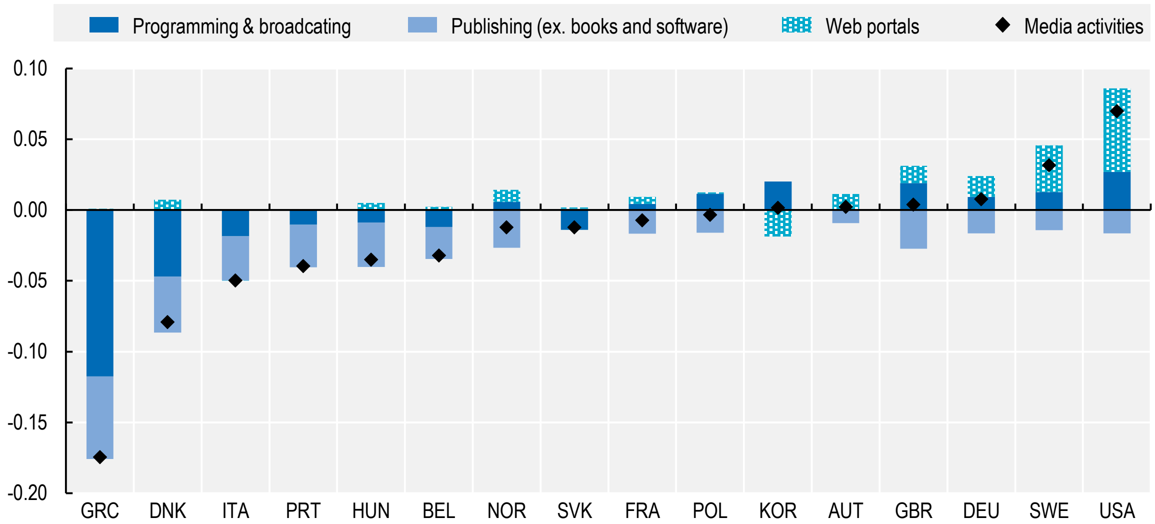
18 For directory & mailing list (5812) it is assumed that 40% is from subscriptions/sales; for Newspapers & periodicals (5 813) it is assumed that 33% of the revenue is generated by subscriptions/sales; for other publishing activities (5 819) it is assumed that 50% is from subscriptions/sales; for Radio/television (60) it is assumed that 5% is from subscriptions/sales; for Web portals (6 312) it is assumed 0% of revenue is generated by subscriptions/sales.

with the exception of Belgium and Slovakia experienced a decline in inflation-adjusted turnover. The industry that saw the strongest growth in most countries was the web portals industry. In the United States, the country with the largest share relative to GDP (at 0.4%), inflation-adjusted turnover for the web portals industry increased at an average annual growth rate of 20.6% between 2010 and 2013.

50. A simple approach to assigning a value to the free products that are provided to households is to assume that it equals the revenue that the producers of these products receive from advertisers. Figure 4.2 illustrates the impact of this assumption on average annual GDP growth from 2009-2013. The United States shows the most positive impact. There, the addition of an estimated value of free products to household consumption would contribute an extra 0.07 percentage points to economic growth on average over the period 2009-2013 (mainly driven by the web portals industry). Greece shows the opposite effect however, with average growth declining by 0.17 percentage points per annum (driven by contractions in programming and broadcasting and publishing excluding books and software industries).

Figure 4.2: Estimated impact of media activities on GDP growth

Average 2009-2013, percentage points



Notes: Data for BEL, KOR and POL refer to 2012-2013, for FRA, GRC to 2010-2013 and for the USA to 2011-2013.

Source: OECD calculations based on data from OECD SDBS database, OECD Annual National Accounts database and US Census Bureau data. The GDP deflator was used for deflation purposes.

4.2. Financing via data and databases

51. Brick-and-mortar stores have long had customer loyalty programs in which consumers disclose information on their identity and purchasing behaviour in exchange for discounts. Consumers may similarly disclose information on their digital identity to gain access to certain free online services, and they passively disclose behavioural information whenever they use a free online service, albeit perhaps without awareness that they are doing so. When consumers are aware of the data gathering, we can infer the existence of an implicit transaction between the consumer and the producer who provides the free digital services. Many producers of free digital services use the information gathered on their users to

provide better services to them and to produce services for advertisers who wish to reach targeted audiences. Some providers of free digital services also sell information on their users to data brokers.[19]

52. The types of data that are personal, or potentially personal, include the following sub-categories:

- **Digital identities:** Basic information on individuals that either remains unchanged or that gets modified only sporadically over the course of a lifetime. Identity includes, for example, name, gender, residence, language, education level, marital status, household composition. Digital identity also includes e-mail addresses. This type of information is provided by a voluntary basis in exchange for free digital services (e.g. Facebook or LinkedIn).

- **Behavioural:** Users' presence online allows the accumulation of information on their behaviours of value to marketers who seek to use customised or targeted advertising. **Digital footprints** include observed data recording online activities of individuals such as location, websites visited (as in Clickstream Data), product or services purchased, travel. Users are not necessarily aware of the collection of such data. Google Search or YouTube are examples of free digital service providers that can scrutinise, collect and store, information on users' online activity with no obligation for the users to register, and hence no obligation to disclose their digital identity. Data collectors and data brokers may also analyse data from a variety of sources to infer user's **preferences**, lifestyle and interests.

53. Digital identity data are generally long-lived, while behavioural data are generally short-lived. The distinction between long-lived data and short-lived data matters because there are strong arguments to include expenditures to acquire long-lived data as investment, as opposed to intermediate consumption, which is currently the case in the accounting framework.[20] At present these costs are included as intermediate input, as are expenditures on behavioural data, used in the production of advertising and other services. Thus the value of both long-lived and short-lived data is already included in the output of the producer of the free digital services, as measured by advertising revenue, other sales of services, and investment in self-produced intellectual property assets and software.

54. In the alternative framework in which benefits to households of free digital services are added to GDP, households' consumption of free digital services could be measured by the value of the user data that the service providers collect. Note, however, that adding the advertising revenues to the value of the data would result in double counting of most of the value of the data. Estimates of the free services to households based on the value of their data plus the advertising revenues may involve significant double-counting.

4.2.1. Data valuation based on transactions with users of online services

55. Estimates of the value of data on users of online services are of interest for analytical purposes. One analytical question concerns the value that users put on their data, as measured by their willingness to pay to keep their data private, or the price that they would accept to reveal their data.

56. It appears that most users of online services are willing to provide their personal data for very little. Beresford, Kubler and Preibusch (2012) ran an experiment in which one online vendor of DVDs in Germany asked for sensitive personal information (date of birth and income) and another, otherwise

[19] Sales to data brokers appear to be relatively small. Exapik and DataWallet are two of the companies operating in this sphere. Facebook and Google do not sell user data.

[20] This reflects a recognition that recording long-lived data as an asset in the conceptual framework would also lead to the capitalisation of other forms on knowledge, such as human capital.

identical vendor did not. Both vendors attracted equal numbers of purchasers when their prices were identical. When the online vendor that required buyers to provide sensitive personal information charged one euro less, it got 93% of the market even though all the buyers claimed that they placed a high value on privacy.

57. Additional evidence that consumers have a low willingness to pay for privacy of their data is the failure of paid online services that offer privacy protection to gain a significant market share. Nevertheless, some are willing to pay at least a modest amount to keep their data private. For instance, clients of FastMail pay USD 3 per month for an advertising-free, no-tracking email service as an alternative to a free service such as Gmail.[21] Although privacy protection is bundled with freedom from advertising, the price of basic FastMail service can be taken as an indication of the amount that some consumers are willing to pay to keep their basic personal information private.

58. Another approach considers the amount that consumers have accepted from companies such as Exapik, DataWallet or Datacoup for the right to access their digital identity and footprints. Although the number of consumers selling data to these companies is small, the prices can give an indication of the value of users' data. The amount paid may vary depending on the level of completeness of the information users are prepared to disclose. In some cases, consumers sell information on online purchases from their credit cards together with their digital identities, so that the company purchasing the data can track their online presence. For example, Datacoup pays USD 8 per month to access a person's digital identity and footprints.

59. The scant information available suggests a range from USD 3 to 8 per month for the price of personal data in transactions between consumers and businesses, depending on the level of information disclosed. The remaining problem is how to distinguish the value of a one-off disposal of digital identity (as is the case when new users enrol on Facebook) from the value of a recurrent flow of information on the digital footprints tracking users' online activities. As providing an email address affords only limited opportunities for tracking, we will assume that customers of FastMail are paying to protect the privacy of their digital identity. Also, as tracking digital footprints is the main focus of Datacoup, we will assume that its payments represent the price of digital footprint data.

60. Table 4.1 provides an estimate of the value that Facebook's new and ongoing users might assign to their personal information based on prices that users of online services have paid to protect, or accepted to reveal, their data. New users and active users in 2016 are broken down by geographical area (columns A and B), and the values of their identity and tracking data are calculated using prices of USD 36 and USD 96 dollars, respectively (columns C and D). Note, however, that if Facebook actually began to charge these prices and at the same time stopped collecting and using personal data, the number of users would drop, perhaps by 85%.[22] The participants in the German experiment who were willing to exchange their sensitive personal information for one euro may be representative of most Facebook users.

61. Assuming that the USD 36 annual basic fee that users pay to FastMail is a suitable proxy for the highest price that users would be prepared to pay to protect their identity, the upper bound value of the

21 The fee includes the use of 2 GB storage per user, personal support, no ads, no tracking, full mobile sync with push: mail, contacts and calendars (www.fastmail.com/pricing/). This compares to 15 GB of storage space offered for free by Google (Gmail, Google Photo and Google Drive all together).

22 In a 2013 survey of Facebook users by Greenlight, only 15% of respondents said that they would be prepared to pay Facebook to see no ads, with 8%, saying they would pay USD 10 per month. See PR NewsChannel (2013), www.prnewschannel.com/2013/07/25/greenlight-poll-shows-facebook-users-would-be-willing-to-pay-10-to-see-no-ads-at-all/. But answers to survey questions about hypothetical willingness to pay are not necessarily good predictors of people's actual behavior.

digital identity data that Facebook users provide to Facebook is USD 9.7 billion in 2016. Assuming that the USD 96 per year paid by Datacoup represents the lowest price that consumers would accept to sell their digital footprints gives an upper bound estimate for the value of these data of USD 168.7 billion. The upper bound for the total value of the worldwide data acquired by Facebook in 2016 (digital identities + footprints) is therefore USD 178.4 billion in 2016.

Table 4.1: User valuation approach: Value of Facebook user data, 2016

Area	Number of new users (Millions)	Number of active users (Millions)	Value (Millions of USD)			
			Digital identity	Digital footprint	Total	Total Users willing to pay (15%)
	A	B	C	D	E	F
Worldwide	269	1 757	9 684	168 672	178 356	26 753
US & Canada	12	227	432	21 744	22 176	3 326
Europe	26	341	936	32 736	33 672	5 051
Asia-Pacific	133	620	4 788	59 472	64 260	9 639
Rest of the World	97	570	3 492	54 672	58 164	8 725

Source: Authors' calculations based on data from Facebook, FastMail and Datacoup.

62. To give some sense of perspective, for the US and Canada the total value of USD 22.2 billion amounts to around 0.1% of GDP, meaning that any impact on growth rates from including these free services in the accounts is likely to be negligible. Moreover, the estimates assume that all users are prepared to pay even though the evidence suggests that this is very unlikely. Indeed, if we assume, as noted above that only 15% of users are prepared to pay (column F in Table 4.1) – in itself an upper-bound – the impact of including free services would be closer to 0.01% of GDP. Moreover, there are additional reasons why these figures should be viewed as an upper bound. Firstly, the prices may be influenced by transactions costs, or other costs of received ads and being tracked, such as slower page loading times. Secondly, there is considerable heterogeneity in the values that users assign to personal information, depending on the users' characteristics and the type of information (e.g. wealthier users may assign a higher value to information on their income or patients affected by specific pathologies may assign a higher value to the information on the health status), and also on the context in which data are used. Assigning the same value for all types of data for all types of users is an extreme simplification.

4.2.2. Data valuation by business

63. Very limited information is available on the value that companies assign to users' data. Anecdotal evidence suggests that companies tend to assign a negligible value to digital identities and a higher value to information on consumers' preferences and digital footprints. According to an article in the Financial Times, information on age, gender, or residence was worth a mere USD0.0005 per person in 2013.[23] But information on what individuals are seeking to buy is more valuable. Data on potential auto buyers, for instance, are worth about USD 0.0021 a person. Knowledge that a woman is in her second trimester of pregnancy could add another USD 0.11 to the value of her data. Information on specific health conditions or on the use of prescription drugs is worth USD 0.26 per person.

23 Emily Steel (2013) Financial worth of data comes in at under a penny a piece Financial Times www.ft.com/content/3cb056c6-d343-11e2-b3ff-00144feab7de.

64. The Financial Times has also released a web-based interactive calculator that reveals the value of different kinds of user data.[24] The calculator is based on the analysis of industry pricing data from a range of sources in the United States. It is far from being exhaustive, however, as it omits the details of the thousands of bits of information that data brokers track, analyse and sell.

65. Maximum values of data on different aspects of digital identity and behaviour covered by the interactive calculator are shown in Table 4.2. Demographic and family information are grouped together under 'digital identity', and the other types of information are categorized under 'digital footprints'.

Table 4.2: Maximum user data values based on Financial Times simulator (USD), 2016

Information		Maximum value (USD)
Digital identity (DI)	Demographic	0.3699
	Family	0.1597
	Total	0.5296
Digital footprint (DF)	Consumer	0.0411
	Activities	0.3668
	Property	0.1958
	Health	4.0180
	Total	4.6217
Total (DI + DF)		5.1512

Source: Author's calculations based on Financial Times. Adjusted to 2016 prices.

66. Many of the variables in digital footprint change rapidly enough so that repeated observations during the same year would all be valuable, while a few change slowly enough so that having data from prior years would reduce the value of data collected in the current year. Nevertheless, we will make the simplifying assumption that the footprint data are all observed once per year and that their value is not diminished by the availability of similar information from prior years. In addition, we assume that Facebook is able to observe all of the variables, and that privacy laws do not impede them from collecting the health variables. Finally, although the most valuable data is on consumers with activities and health conditions that are uncommon, to get a crude estimate of the maximum possible value of the data collected by Facebook, we will assume that everyone has the value-maximizing attributes.

67. Under these strong assumptions, the value of the digital identity data of Facebook would amount to only USD 142 million per year (269 million new users * USD 0.5296) and the value of the digital footprints data would only be USD 8.1 billion (1 757 million active users * USD 4.6217) in 2016. The total value is around USD 8.3 billion in 2016, a tiny fraction of the valuation given in Table 4.1. Excluding the health information, the value of Facebook's data, worldwide, would amount to just USD 1.2 billion (269 million new users * USD 0.5296 + 1 757 million active users * USD 0.6037). Allowing for the possibility of collecting some kinds of digital footprint information multiple times per year would increase this estimate slightly, but, on the other hand, relaxing the assumption that the prices charged in low income countries would be the same as they are in the US would decrease the estimate.

24 Steel, Locke, Cadman and Freese (2013) How much is your personal data worth? *Financial Times*, www.ft.com/cms/s/2/927ca86e-d29b-11e2-88ed-00144feab7de.html?ft_site=falcon#axzz2z2agBB6R.

Table 4.3: Business valuation approach: Value of Facebook users' data in 2016

Area	Number of new users (Millions)	Number of active users (Millions)	Value (Millions of USD)		
			Digital identity	Digital footprint	Total
	A	B	C	D	E
Worldwide	269	1 757	142	8 120	8 263
US & Canada	12	227	6	1 047	1 053
Europe	26	341	14	1 576	1 590
Asia-Pacific	133	620	70	2 863	2 934
Rest of the World	97	570	51	2 632	2 683

Source: Author's calculations based on Facebook and Financial Times.

68. When this 'company approach' is extended to include some other major providers of free digital services, the results suggest (Table 4.4) that the value of user data as a share of GDP is around 0.02% at the global level (although this excludes other major providers of free digital services such as those in China (Tencent and Baidu). The value of user's data in this case, as a share of GDP has gradually expanded over the last few years – excluding Gmail, increasing from 0.01% in 2013 to 0.015% in 2016 (Table 4.5). Nevertheless, it is clear that the impact of including free services consumed by households on estimated GDP volume growth consumption would be very marginal.

Table 4.4: Relative share of user's data to the global economy, for selected providers, 2016

World		Facebook	Twitter	Instagram	LinkedIn	Total without Gmail	Gmail	Total
Average of the number of Monthly Active Users - MAUs (Millions)	Total	1 757	315	525	106	2 703	975	3 678
	New users	269	14	200	6	489	50	539
	Old users	1 488	301	325	100	2 214	925	3 139
Users data value (Millions of USD)	Total	8 263	1 461	2 532	493	12 749	4 533	17 282
	New users	1 386	72	1 030	31	2 519	258	2 777
	Old users	6 877	1 389	1 502	462	10 230	4 275	14 505
Users data value/GDP ratio (Percentage)		0.010%	0.002%	0.003%	0.001%	0.015%	0.005%	0.020%

Source: Author's calculations based on Facebook, Twitter, LinkedIn, Statista and Financial Times.

Table 4.5: Evolution of the share of user data to the global economy, for selected providers, 2013-2016

World	2013	2014	2015	2016
Facebook	0.007%	0.008%	0.008%	0.010%
Twitter	0.001%	0.002%	0.002%	0.002%
Instagram	0.001%	0.001%	0.002%	0.003%
LinkedIn	0.000%	0.001%	0.001%	0.001%
Total	0.010%	0.011%	0.013%	0.015%

Source: Author's calculations based on Facebook, Twitter, LinkedIn, Statista and Financial Times.

4.2.3. Data valuation by the shareholders

69. In addition to the annual flows of user data, the question of the value of the stock at a point in time is of analytical interest. To estimate a value of the stock of user data we focus on the value of a company when acquired. Two relevant examples are WhatsApp and Instagram at the time they were acquired by Facebook. Among the assets of those companies was the dataset on registered individuals. Although online services are subject to network effects that make customer relationships particularly durable and valuable, to derive an upper bound value for user data, we will assume that the data itself was the main asset of the acquired businesses. Under this strong assumption, the stock of data on each user registered with WhatsApp was worth around USD 30, with a similar value derived for Instagram users (2012) and Minecraft users, when acquired by Microsoft.

70. Of note is also the work by Tristan Louis (2013) who estimated the value of an individual user for Facebook, LinkedIn, Yahoo and Google, based on the results available from the official quarterly financial reports (for 2013 Q2) and other information freely sourced from the Internet.[25] For each company, the author reported the value of the market capitalisation, the number of users and the revenue of the latest quarter. These were used to estimate the 'per user valuation', as well as the average revenue per user (i.e. ARPU). Table 4.6 repeats the exercise for 2016 (limited to Facebook and Twitter).

Table 4.6: Estimates of the stock of user data value based on market capitalisation and revenues. Facebook and Twitter, 2016

Company name	Facebook	Twitter
Market capitalisation - Dec 2016 (Billions of USD)	330	12
Number of users (Millions of USD)	1 757	315
Revenue (Billions of USD)	28	3
Per user valuation (USD)	188	37
Average Revenue Per User - ARPU (USD)	16	8

Source: Financial reports for Facebook and Twitter; market capitalisation from ycharts.com

71. The key measure here is annual revenue per user, USD 16 for Facebook and USD 8 for Twitter (the difference between Facebook and Twitter could reflect the difference in their abilities to capture commercially valuable information and to deliver advertising). These revenue numbers are not consistent with the high valuations calculated above under the users' valuation approach, which implied upper bounds ranging from USD 36 to USD 132 per user. However, the valuation based on the Financial Times interactive calculator of USD 4.70 or less per user seem consistent with the average revenue per user.[26]

72. The results above on advertising revenue and the value of user data illustrate the complexities entailed in trying to include valuations of free products to consumers in household final consumption, using either advertising revenues or data values. Furthermore, if both approaches were used in combination, there would be a significant amount of double counting. And either of these approaches would need to consider the implications of the on-going discussions of counting advertising expenditures

25 Tristan Louis (2013) How Much Is A User Worth?, www.forbes.com/sites/tristanlouis/2013/08/31/how-much-is-a-user-worth/#7efb15f292a9.

26 This approach is explored in OECD (2013), "Exploring the economics of personal data: A survey of methodologies for measuring monetary value", *OECD Digital Economy Papers*, No. 220, OECD Publishing, http://dx.doi.org/10.1787/5k486qtxldmq-en.

as part of a newly recognized investment in brands in the SNA and the discussions of when data should be recorded as an asset.

5. Free assets produced by volunteers

73. Viewing advertisements and providing data are not the only ways that consumers are able to receive free services. ’Public goods’ created using donations of labour and funds can also provide consumers with access to free services. Wikipedia, a volunteer-written and edited encyclopaedia built collaboratively using wiki software is a well-known example.

74. The SNA framework values services provided for free by volunteers at zero, and as a non-profit institution serving households, the output of Wikipedia would be measured by its actual expenses; about USD 200 million in 2011. When the output is largely produced by volunteers, this approach may drive a larger wedge between measures of household final consumption and material well-being. This section investigates approaches to determine an equivalent market value of the services of Wikipedia, and presents them in relation to their size to overall (global) economic activity to provide some indication of their economic importance.

75. Two simple approaches are investigated: estimating the advertising revenue that Wikipedia could generate if it allowed advertising on its pages, and estimating the revenue it could generate if it charged its users a subscription fee, as in OECD (2013).[27]

5.1. If Wikipedia sold advertising

76. To make an estimate of the potential revenue that Wikipedia could hypothetically generate from advertising, we use available information on Google’s highly successful advertising network. This network is split into two arms, the search network and the display network. When advertising on the search network, businesses place text ads in the search engine results. On the display network, businesses instead place display ads on a network of sites across the internet. Partly by design, the click-through-rates (clicks an ad receives divided by the number of times an ad is shown) and cost per click tend to be higher on the Google search network than on Google display network.

77. Information on the average click-through-rates (1.91% on the search network and 0.35% on the display network) and the average cost per click (USD 2.32 on the search network and USD 0.58 on the display network) multiplied by number of page views can yield an estimate of advertising revenue that Wikipedia could earn.[28] Using this method, in 2016, Wikipedia would yield USD 373.1 million, 0.0004% of World GDP, using the lower amount for display network (183.8 billion page views * 0.35 click-through-rate * USD 0.58 cost per click) and USD 8.1 billion, 0.0094% of World GDP, using the higher amount for the search network (183.8 billion page views * 1.91 click-through-rate * USD 2.32 cost per click). Results are shown in Table 5.1 below. The search network estimates should, however, be viewed as an extreme upper bound estimate, as consumers using Wikipedia’s search activities are not searching for specific retail products. Indeed, even the estimates relating to the display network model should be viewed as ’upper-bounds’, not least because they are not adjusted for differences in currencies’ purchasing power.

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[28] Information on click-through-rates and costs per click was obtained from a report based on a sample of 2,367 US-based WordStream client accounts in all verticals (representing USD 34.4 million in aggregate AdWords spend) who were advertising on Google AdWords’ Search and Display networks in Q2 2015. ‘Averages’ are technically median figures to account for outliers. All currency values are posted in USD, www.wordstream.com/blog/ws/2016/02/29/google-adwords-industry-benchmarks.
Information on number of page views is sourced from Wikimedia at:
https://stats.wikimedia.org/wikimedia/squids/SquidReportPageViewsPerCountryOverview.htm.

Table 5.1: Number of page views and estimated advertising revenue

		2010	2012	2013	2015	2016
Number of page views (millions)		*143 397*	*152 096*	*160 685*	*153 330*	*183 796*
World GDP (GDP USD, current prices, constant		*65 058 816*	*73 355 559*	*76 787 466*	*83 300 939*	*86 905 866*
Revenue (USD millions)	Display network CTR = 0.35% CPC = 0.58	291.1	308.8	326.2	311.3	373.1
Value/ World GDP Ratio		0.0004%	0.0004%	0.0004%	0.0004%	0.0004%
Revenue (USD millions)	Search network CTR = 1.91% CPC = 2.32	6 354	6 740	7 120	6 794	8 144
Value/ World GDP Ratio		0.0098%	0.0092%	0.0093%	0.0082%	0.0094%

Source: Author's calculations based on data from Wikimedia, WordStream, and OECD Economic Outlook database.

78. Although the failure to consider purchasing power parities (PPPs) of local currencies is partly mitigated by the fact that 68% of page views in 2016 occurred in North America and Europe, Africa and Asia experienced much more rapid growth between 2010 and 2016 than regions with high PPPs. As a result of the compositional shift to regions with low PPPs, if the structure of imputed revenues is adjusted for purchasing powers, imputed revenues actually declines by nearly 10% between 2010 and 2015, see Table 5.2.

Table 5.2: Number of page views and estimated advertising revenue, adjusted for price level differences

		2010	2012	2013	2015	% change between 2010 and 2015
Revenue (USD millions)	Display network CTR = 0.35% CPC = 0.58	266.9	274.5	280	240.4	-9.90%
Revenue (USD millions)	Search network CTR = 1.91% CPC = 2.32	5 826.8	5 992.9	6 111.5	5 247.9	-9.90%

Source: Author's calculations based on data from Wikimedia, WordStream, and PPPs from World Development Indicators.

5.2. If Wikipedia charged fees

79. Another way to estimate the value of Wikipedia is to consider what might happen if users were charged a fee for using the service. For example, users of the online encyclopaedia Britannica pay USD 85 per annum.

80. In 2016, the number of unique devices that accessed Wikipedia was an average of 1.2 billion devices a month across the various Wikipedia language sites. If we assume that each device represents one unique user (which is likely to be an overestimate of users, as many users have multiple devices), this would generate USD 103.4 billion, around 0.1% of global GDP. However, this is a very extreme upper-bound, produced only to illustrate that, even with heroic assumptions – i.e. all users would be prepared to pay – the imputed market-value of services provided by Wikipedia would not be large enough to have a significant impact on GDP.

6. Cross-border trade

81. As mentioned in the earlier paper provided to the G-20 Sherpas, measurement of trade presents some significant challenges in areas such as intra-firm transactions in data, digital services, and intellectual property (which may be affected by tax considerations). It is important to note that these challenges do not necessarily equate to mismeasurement, but they do present significant difficulties for interpretation of GDP and trade statistics. The large jump in Irish GDP estimates, reflecting the relocation of some US firms to Ireland, is a case in point.

82. There are also some questions about how to record and classify ICT-enabled cross-border services. For example, do Uber's cross-border transactions represent business services or transport services? Should these flows, where they are cross-border, be recorded as the full cost paid by the consumer, with a corresponding payment made by Uber to the drivers, or just the net receipts received by Uber? Differences in the classification of the service make little difference to estimates of GDP but they do matter within trade rules. On the other hand, differences in classification as a service or primary income do matter for GDP. For example, cross-border flows from Uber's affiliates to the parent might be recorded as payments for services received (and so as an import, reducing GDP), or they might be recorded as payments of primary income (which would have no impact on GDP).

83. To find out how countries are addressing these issues, the OECD recently sent a survey to delegates of its Working Party on International Trade in Goods and Services (WPTGS). So far, only eight countries have reported that they are able to identify foreign-owned digital intermediaries resident in their economy, while five have reported that they are able to identify payments to non-resident digital intermediaries. Most countries noted that resident digital intermediaries would be in the business register, and so included in GDP, but that separately identifying them was difficult. Responses indicated the need for further investigation to determine how cross-border services transactions of such intermediaries are being classified in their trade statistics.

84. Progress on these and similar challenges, such as cross-border transactions incurring no cost[29], will take time. They go beyond the scope of this interim report, but the work is being actively pursued by the Inter-Agency Task Force on International Trade Statistics, chaired by the OECD and WTO, with support from the G-20 Trade and Investment Working Group. Where some, albeit limited, progress has been made is in the estimation of small amounts of transactions below customs' thresholds, where there is a concern that cross-border e-commerce may have led to greater scope for under-estimating trade. The WPTGS survey revealed significant cross-country differences in the operational threshold in use, ranging from zero in Turkey, to USD 2 500 in the United States, but that the overall scale remained relatively small between 1-3% of total. However, it appears that not all OECD countries make explicit adjustments for this trade, and further work will be undertaken to investigate this problem. Less is known about the scale of small amounts of transactions in services enabled by the gig economy and delivered across the border. Unrecorded digital exports by residents working in the gig economy could plausibly be significant in some developing economies.

29 Of the 16 WPTGS members who provided a response to a conceptual question in the above-mentioned survey on non-monetary data transactions, 15 were of the view that a monetary value should not be imputed for no-cost transactions.

7. Conclusions and way forward

85. Although further investigation in some areas is needed, the analysis presented in this paper indicates that any potential mismeasurement caused by digitalisation does not explain the recent productivity slowdown, nor cause significant downward bias in estimates of GDP growth. Adjustments for potential mismeasurement of prices of ICT products can be expected to add no more than 0.2% per annum to GDP growth rates and the impact on estimates of multifactor productivity growth is likely to be significantly smaller. Similarly, imputing values for free media products, and adding these to estimates of household consumption is also likely to have a minimal impact on GDP levels (at most 0.1% of GDP), with negligible impacts on GDP growth rates.

86. Nevertheless, despite the relatively small impact, the current debate on mismeasurement has also highlighted the lack of statistics that explicitly reveal the role of digitalisation in production and consumption, including satellite accounts that reveal benefits of digitalisation for consumer welfare. In response, the OECD has created an Advisory Group on Measuring GDP in a Digital Economy that will be chaired by the United States Bureau of Economic Analysis, with participation of a number of countries and international organisations, including the IMF. This group will form the key vehicle to generate follow-up reports to the G-20. The key objectives of this Advisory Group will be to advance the measurement agenda but it will also act as a forum and focal point to share ideas and experiences, and to develop best practice. The results of the Advisory Group's work will feed into the G-20 work streams, as well as the OECD's report on "Going digital: Making the transformation work for growth and well-being".[30]

87. It is clear that further work is needed on measuring and reporting the contributions of digitalisation to GDP and other macroeconomic statistics. Digitalisation is not sufficiently present within the classification systems currently used to estimate and report on economic activity, making it difficult to assess the size and growth of the digital economy and its possible contributions to consumer welfare. In addition, the employment impacts of digitalization, including the rise of the 'sharing' and 'gig' economies, raise important issues for labour market policies. Working on a more explicit view of the digital economy in macroeconomic statistics is also important because further investigation could uncover significant measurement challenges in activities that have not been fully investigated in this interim report but whose economic size could grow and create measurements biases in the future.

30 The OECD's Going Digital project is a multidisciplinary, cross-cutting initiative that aims to help policymakers better understand the digital transformation that is taking place across different sectors of the economy and society as a whole. To enable evidence-based policies, better measurement of the digital transformation is needed. The project was officially launched on 12 January 2017 at a conference organised jointly by the OECD and the German Federal Ministry of Economic Affairs and Energy in Berlin. This conference served to provide information on the Going Digital project, as well as to kick-off the German G-20 Presidency´s digital agenda.

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ANNEX 1: SENSITIVITY ANALYSIS FOR PRICE INDICES

Replacing one country's price index by that of another country implies assuming away differences in the composition of production or consumption as well as differences in market structure and competition. Both can have significant impact on the aggregate ICT price or communication price, thus the use of different price indices remains at best an approximation of an upper and lower bound impact shown in section 2. There are several possibilities for transposing another country's deflator to other countries' accounts as discussed in Schreyer (2002). The method chosen in this paper is to use the chosen country's deflator adjusted for domestic inflation.[31] This method is used in creating the upper and lower bound price indices as well as the US 'harmonised' deflator. To control for domestic inflation, the following assumption is made: the relative price change of the ICT product under consideration should be the same across countries. The relative price is expressed as follows:

In the case of ICT equipment and software investment, the adjustment is made using the following the formula:

(1) $P^{i,X} = \frac{P^{i,REF}}{P^{NICT,REF}} * P^{NICT,X}$

where i corresponds to one of the two ICT assets (ICT equipment or computer software and databases), X refers to any country under analysis, REF corresponds to the reference country chosen for the upper or lower bound (i.e. the country in which the price index increased (declined) relative to the non-ICT investment price the most over the period 2010-2015), and $NICT$ corresponds to all non-ICT non-residential investment assets.[32]

Therefore, the rate of change of the ICT price index of a country other than the reference country is then given by: $\Delta \ln(\tilde{p}_{ICT}^{Other}) = \Delta \ln(p_{NICT}^{Other}) + \Delta \ln(p_{ICT}^{REF}) - \Delta \ln(p_{NICT}^{REF})$. Therefore, as an example, if ICT prices in the reference country rise by 10% per year less than prices for non-ICT goods, this carries over to other countries.

Similarly, for the consumer price of communication services, the adjustment for domestic inflation follows:

(2) $P^{cs,X} = \frac{P^{cs,REF}}{CPI^{REF}} * CPI^{X}$

where cs stands for communication services, X refers to any country under analysis, REF corresponds to the reference country chosen for the upper or lower bound (i.e. the country in which the price index increased (declined) the most over the period 2010-2015), and CPI stands for Consumer Price Index (all items). Note that the CPI includes the effects of ICT prices and so does not fully correct for relative price mismeasurement across countries, although the effects are not expected to be significant.

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31 There are two other methods discussed in Schreyer (2002). This first uses the reference country's deflator unadjusted for domestic inflation. The underlying hypothesis is that nominal prices of ICT and communication services products change at the same rate in different countries. The second adjusts the reference country's deflator with the exchange rate. This is a plausible approach if the prices of the underlying products are in effect determined internationally.

32 Non-ICT non-residential investment assets comprise transport equipment, other machinery and equipment and weapons systems different from ICT equipment, non-residential construction, research and development (R&D), and other intellectual property products different from R&D and computer software and databases.

An additional test is conducted by replacing national price indices with those used in the United States based on the assumption that the differences between price changes for ICT capital goods and non-ICT capital goods should be the same across countries in reference to the United States.[33] This is referred to as 'US harmonised' in the tables in section 2.

[33] The rate of change of the harmonised price index in a country other than the United States is given by: $\Delta \ln P_{i,t}^{Other} = \Delta \ln P_{NICT,t}^{Other} + \gamma_{i,t}^{US}$ where i stands for a type of ICT product, $NICT$ stands for non-ICT non-residential capital assets, and $\gamma_{i.t}^{US} = f(\Delta \ln P_i^{US} - \Delta \ln P_{NICT}^{US})$, this is, $\gamma_{i.t}^{US}$ is the series of predicted values of a polynomial regression aiming to eliminate short-term fluctuations in relative ICT price changes in the US.

ANNEX 2: SENSITIVITY ANALYSIS FOR GROWTH SIMULATIONS

To obtain an order of magnitude of the impact of different price assumptions for ICT and communication products on the rate of change of volume GDP, we carry out the method proposed by Schreyer (2002).

It consists in evaluating a 'multiplier' by which price index adjustments of ICT and communication products would carry over to measured GDP growth rates. In a simple accounting framework, where GDP in current prices is the sum of final demand (FD: comprising private and government consumption, gross capital formation and exports) minus imports (M):
(3) $GDP_t = FD_t - M_t$

This can be further decomposed as follows to differentiate between ICT products and non-ICT products, indexed with a superscript (N)ICT:
(4) $GDP_t = FD_t^{NICT} + FD_t^{ICT} - M_t^{NICT} - M_t^{ICT}$

The logarithmic rate of change of volume GDP can be represented as a weighted average of the rate of change of volume final demand and volume imports. Weights are in current prices, representing the ratio of final demand to GDP and the ratio of imports to GDP. As shown in the paper applying a different price index to ICT products is tantamount to using a different rate of volume growth of ICT components in final demand and import components.

The effect of the price adjustment of ICT products on GDP growth is measured as (note that a similar equation is used to calculate the impact for communication services):[34]

(5) $\frac{d \ln GDP_t}{dt} - \frac{d \ln G\widetilde{D}P_t}{dt} = \left(\frac{FD_t^{ICT}}{GDP_t} - \frac{M_t^{ICT}}{GDP_t}\right) . \left(\frac{d \ln FD_t^{ICT}}{dt} - \frac{d \ln \widetilde{FD}_t^{ICT}}{dt}\right)$

where:

- $\frac{d \ln GDP_t}{dt}$ is the growth rate of measured volume GDP
- $\frac{d \ln G\widetilde{D}P_t}{dt}$ is the growth rate of adjusted volume GDP
- $\frac{d \ln FD_t^{ICT}}{dt}$ is the growth rate of measured final demand of ICT products, deflated with the measured (national) price index
- $\frac{d \ln \widetilde{FD}_t^{ICT}}{dt}$ is the growth rate of adjusted final demand of ICT products, deflated with the adjusted ICT price index.

The first term on the right-hand side of equation (5) acts as a multiplier to the quantity adjustment. Before interpreting this multiplier, it is practical to explicitly formulate a supply and demand balance for the ICT product. Total supply of the ICT product is the sum of domestic gross output of the ICT product (Q_t^{ICT}) and imports (M_t^{ICT}). Demand is the sum of final demand (FD_t^{ICT}) and intermediate consumption: $Q_t^{ICT} + M_t^{ICT} = IC_t^{ICT} + FD_t^{ICT}$ or $FD_t^{ICT} - M_t^{ICT} = Q_t^{ICT} - IC_t^{ICT}$, where IC_t^{ICT}) reflects intermediate consumption.

34 To see all the steps to get to equation 5, see Schreyer (2002).

It is now straightforward to interpret the multiplier above. The multiplier:

- equals zero (has no impact on aggregated GDP) if final demand equals imports of the ICT products $FD_t^{ICT} = M_t^{ICT}$;
- is largest (and positive) in size when imports are zero, i.e. when the ICT product is produced only domestically ($FD_t^{ICT} = Q_t^{ICT} - IC_t^{ICT}$);
- is negative when imports exceed final demand ($FD_t^{ICT} < M_t^{ICT}$). The negative multiplier is largest in absolute terms when the product is exclusively used for intermediate consumption, and when there is no domestic output: $M_t^{ICT} = IC_t^{ICT}$.

The second term on the right-hand side of equation (5) is the quantity adjustment, and represents by how much prices (and therefore quantity change) are adjusted. It can be shown that:

(6) $\left(\frac{d \ln FD_t^{ICT}}{dt} - \frac{d \ln \widetilde{FD}_t^{ICT}}{dt}\right) = \left(\frac{d \ln \tilde{P}_t^{ICT}}{dt} - \frac{d \ln P_t^{ICT}}{dt}\right)$

where:

- $\frac{d\, ln\, P_t^{ICT}}{dt}$ is the change in the measured (national) price index
- $\frac{d \ln \tilde{P}_t^{ICT}}{dt}$ is the change in the any alternative ICT price index

Information on final demand and imports of ICT products are available in national supply and use tables (see table A2.4 for details of the product categories used in each country), providing the basis to estimate the impact of changes on price measures on GDP as set out in (5). However, this assumes that price mismeasurement, where it occurs for a particular product, happens in the same way for both imports and final demand. As such two additional assumptions are investigated that provide upper and lower bound estimates of adjustments to growth.

- the impact of the price adjustment only flows through to final demand (i.e. the $\frac{M_t^{ICT}}{GDP_t}$ is assumed to be 0 for the purposes of the multiplier).[35] This can be viewed as an upper bound multiplier and is presented as scenario I in the following tables.

- the impact of the price adjustment only flows through to imported intermediate products (i.e. the $\frac{FD_t^{ICT}}{GDP_t}$ is assumed to be 0 for the purposes of the multiplier).[36] This can be viewed as a lower bound multiplier and is presented as scenario II in the following tables.

Scenario III below reflects the central estimate using information on imports and final demand from national supply and use tables.

Tables A2.1 to A2.3 show estimates for the multiplier described above, i.e. the factor by which an adjustment of the volume or price indices of ICT equipment, computer software and databases, and communication services translates into a change in total GDP growth. For example, in the multipliers for ICT equipment table A2.1, the figure of 0.0284 for France (scenario I, representing the upper bound multiplier) shows that a 10% upward adjustment of the volume index for ICT equipment (or a 10%

35 This is not to say that imports of ICT products are zero. It simply means that the contribution to the growth rate of GDP is only determined by the share of ICT final demand in GDP.

36 This is not to say that final demand of ICT products is zero. It simply means that the contribution to the growth rate of GDP is only determined by the share of ICT imports in GDP and that all imports flow to intermediate consumption.

downward adjustment of the price index) would lead to a 0.0284 * 10% = 0.284% shift in GDP growth rate.

Not surprisingly, scenario II, the lower bound multiplier, produces negative multipliers. This reflects the case of imported intermediate products: when their price index is adjusted downwards, the imported intermediate volume increases and this translates into a negative effect on measured volume GDP change.

Similarly Scenario I produces only positive multipliers, Scenario III, also produces only positive multipliers but smaller than scenario I because some of the impact is mitigated by imports (which are a subtraction).

Table A2.1: Estimates of multipliers for ICT equipment

Percentage

Country	Multipliers in different scenarios for investment in ICT equipment		
	Scenario I: M=0	Scenario II: FD=0	Scenario III: FD and M from SUT
Australia	0.0135	-0.0119	0.0016
Austria	0.0416	-0.0270	0.0147
Belgium	0.0386	-0.0275	0.0111
Canada	0.0298	-0.0255	0.0043
France	0.0284	-0.0210	0.0074
Germany	0.0534	-0.0342	0.0192
Italy	0.0267	-0.0176	0.0091
Netherlands	0.0631	-0.0275	0.0356
Spain	0.0217	-0.0156	0.0061
UK	0.0312	-0.0264	0.0048
US	0.0343	-0.0182	0.0160

Notes: The table reports average ratios computed with available data for each country between 2010 and 2015. The product category for European countries is Computer, electronic and optical products (CPA 26). The goal for non-European countries was to use an equivalent product category. Given the role of the Netherlands as an international transit hub the multipliers exclude the impact of re-exports.

Source: OECD Supply and Use Tables database, Australian Bureau of Statistics (ABS), US Bureau of Economic Analysis (BEA), Statistics Canada, Office for National Statistics (UK), February 2017.

Table A2.2: Estimates of multipliers for computer software and databases

Percentage

Country	Multipliers in different scenarios for investment in Computer software and databases		
	Scenario I: M=0	Scenario II: FD=0	Scenario III: FD and M from SUT
Australia	0.0141	-0.0013	0.0128
Austria	0.0255	-0.0059	0.0196
Belgium	0.0227	-0.0051	0.0176
Canada	0.0129	-0.0026	0.0103
France	0.0236	-0.0027	0.0209
Germany	0.0139	-0.0048	0.0091
Italy	0.0125	-0.0018	0.0106
Netherlands	0.0313	-0.0069	0.0244
Spain	0.0188	-0.0030	0.0158
UK	0.0203	-0.0027	0.0176
US	0.0174	-0.0015	0.0159

Notes: The table reports average ratios computed with available data for each country between 2010 and 2015. The product category for European countries is Computer programming, consultancy and related serv., Information serv. (CPA 62_63). This does not include packaged software which is included in the publishing industry (CPA 58). The goal for non-European countries was to use an equivalent product category.

Source: OECD Supply and Use Tables database, Australian Bureau of Statistics (ABS), US Bureau of Economic Analysis (BEA), Statistics Canada, Office for National Statistics (UK), February 2017.

Table A2.3: Estimates of multipliers for communication services

Percentage

Country	Multipliers in different scenarios for consumption of Telecommunication services		
	Scenario I: M=0	Scenario II: FD=0	Scenario III: FD and M from SUT
Australia	0.0098	-0.0005	0.0093
Austria	0.0112	-0.0020	0.0092
Belgium	0.0210	-0.0058	0.0152
Canada	0.0188	-0.0010	0.0178
France	0.0162	-0.0014	0.0148
Germany	0.0133	-0.0016	0.0118
Italy	0.0149	-0.0018	0.0130
Netherlands	0.0163	-0.0024	0.0139
Spain	0.0176	-0.0019	0.0157
UK	0.0146	-0.0026	0.0120
US	0.0207	0.0000	0.0207

Note: The table reports average ratios computed with available data for each country between 2010 and 2015.

Source: OECD Supply and Use Tables database, Australian Bureau of Statistics (ABS), US Bureau of Economic Analysis (BEA), Statistics Canada, Office for National Statistics (UK), February 2017.

Table A2.4: Product categories used in constructing the multipliers

	IT equipment	Software and Database	Communications services
OECD SUT database	Computer, electronic and optical products	Computer programming, consultancy and related serv., Information serv.	Telecommunications services
AUS	Mainframe and super-computers Computer file servers and other multiple-user computer hardware Laptops, notebooks, personal digital assistants and other portable computers Desktop computers (PCs) Computer peripheral devices (incl monitors, keyboards, mice, joysticks, speakers, drives and burners) Printing and photocopying machinery and parts Other computer hardware, computer peripherals and accessories nec Line telephone and telegraph equipment (excl headphones and parts) Mobile phones and other phones nec (excl parts) Telecommunication equipment parts (incl parts for mobile phones and satellite receivers)	Internet Service Providers, Internet Publishing and Broadcasting, Websearch Portals and Data Processing Computer Systems Design and Related Services	Telecommunication Services
CAN	Parts of computers and computer peripheral (except printed circuit assemblies) Computers and computer peripheral equipment Telephone apparatus Other communications equipment Televisions and other audio and video equipment Navigational and guidance instruments Measuring, medical and controlling devices Unrecorded magnetic and optical recording media Printed and integrated circuits, semiconductors and printed circuit assemblies Other electronic components	General purpose software Data processing, hosting, and related services Subscriptions to Internet sites and contents Advertising space on the Internet Other information services Custom software design and development services Own-account software design and development services	Wired telephone services Wireless telephone services Cable, satellite and other program distribution services Internet access services
UK	Computer, electronic and optical products	Computer programming, consultancy and related services Information services	Telecommunications services
US	Computer and electronic products	Data processing, internet publishing, and other information services Computer systems design and related services	Broadcasting and telecommunications

Note: Australia makes more detailed product breakdowns available in 5215.0.55.001 Australian National Accounts: Input-Output Tables (Product Details), this information was used in the calculation of the ICT equipment multiplier. For the US communication services multiplier, broadcasting was excluded using information from the 2007 benchmark Input-Output table.

ANNEX 3: WHAT IS DIGITAL DATA?

The European Union's Data Protection Directive (95/46/EC) defines personal data as any information relating to an identified or identifiable natural person or data subject. The types of personal data can include the following sub-categories:[37] [38]

- **Digital identities** and **milestones in personal life-** Basic information on individuals that either remains unchanged or that gets modified only sporadically over the course of a lifetime. Such a set of information include, for instance, name, gender, residence, language, education level, marital status, household composition. This type of information is typically bartered by users on a voluntary basis in exchange for free digital services (e.g. Facebook or LinkedIn).

- **Behaviours-** Users' presence online allows the accumulation of information on their behaviours that, once elaborated, can become of value particularly for marketers interested to customised advertising. Behaviours can be broken down in two sub-categories**:**

    - **Digital footprints-** Include observed data recording online activities of individuals such as location data (e.g. when using cell phones), websites visited (Clickstream Data), product or services purchased, travel. Users are not necessarily fully aware of the existence of such set of data. Online service providers can collect and store detailed information about users' online activities that may be of great interest to them as well as to third parties. Google Search or YouTube represents two examples of free digital service providers that can scrutinise, collect and store, information on users' online activity with no obligation for the users to register and hence no obligation to disclose their digital identity.

    - **Derived data-** Information about users' preferences, lifestyle and interests can be inferred from the analysis of digital identities and footprints. This can be elaborated at the individual level or aggregate. Individuals are rarely aware of the existence of derived data and most likely ignore their value. It appears, however, that the main interest of providers of free digital services lies precisely in the elaboration of derived data as it represent the pillar for customised advertising.[39]

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[38] World Economic Forum (2011) Personal Data: The Emergence of a New Asset Class http://www3.weforum.org/docs/WEF_ITTC_PersonalDataNewAsset_Report_2011.pdf.

[39] For a description of recent evolution of the online advertising markets see:

J. Estrada-Jiménez et al., (2017), "Online advertising: Analysis of privacy threats and protection approaches", Computer Communications, http://dx.doi.org/10.1016/j.comcom.2016.12.016 and

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