MEASURING THE DIGITAL ECONOMY

February 2018

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MEASURING THE DIGITAL ECONOMY

February 28, 2018

EXECUTIVE SUMMARY

Digitalization encompasses a wide range of new applications of information technology in business models and products that are transforming the economy and social interactions. Digitalization is both an enabler and a disruptor of businesses.

The lack of a generally agreed definition of the "digital economy" or "digital sector" and the lack of industry and product classification for Internet platforms and associated services are hurdles to measuring the digital economy. This paper distinguishes between the "digital sector" and the increasingly digitalized modern economy, often called the "digital economy," and focuses on the measurement of the digital sector. The digital sector covers the core activities of digitalization, ICT goods and services, online platforms, and platform-enabled activities such as the sharing economy.

Available evidence suggests that the digital sector is still less than 10 percent of most economies if measured by valued added, income or employment. Digitalization has penetrated many activities, and, indeed, almost the entire economy could be included in the "digital economy" broadly defined. However, it is more realistic to focus measurement efforts on a concrete range of economic activities at the core of digitalization. While the term "digital sector" refers to a concrete perimeter of economic activities, the term "digital economy" is often used to indicate that digitalization (e.g., the use of Internet) has spread across all sectors of the economy, from agriculture to warehousing.

Next, the paper considers the question of the measurement error in GDP growth and productivity statistics. Insufficient adjustment for quality change in constructing the deflators for digital products, and gaps in measuring the sharing economy and activities of online platforms are two sources of underestimation. The available research suggests that the effect of under-measurement of the digital sector on estimates of US labor productivity growth is no more than 0.3 percentage points, smaller than the post-2005 slowdown in the growth in productivity of 1–2 percentage points.

Largely symmetric effect on price statistics, yielding a slight overestimation of inflation. The implied understatement of growth and productivity has been widely discussed in the last years. However, a symmetric effect on the measurement of inflation has been notably overlooked. If growth has been understated due to

insufficient downward adjustment of price indexes in the presence of high quality increases in digital products and services, inflation must generally have been overstated by a roughly similar amount. This implication is particularly relevant for the assessment of the monetary policy stance in economies that have suffered deflationary pressures while experiencing a rapid digital transformation.

Free digital services that are self-produced, volunteer-produced, or produced by platforms that sell advertising and collect users' data, have been proposed for direct inclusion in the definition of GDP, but a change in the conceptual framework of GDP to directly include "free digital services" in consumption would not be warranted. GDP is a measure of market- and near-market production valued at market prices, and, as such, is well-suited to address key policy questions. However, some free services enabled by digital products represent quality improvements that could be captured in real consumption by quality-adjusting the deflator. Also, research on expanding the measure of investment to include collection of data may imply a modification of the GDP production boundary.

Indicators of welfare from free digital products can, and should, be developed in the context of measurement of nonmarket production outside the boundary of GDP. Productivity gains in households' time use for nonmarket production may be increasing welfare in ways not measured by consumption or GDP. Therefore, the old debate about measuring household non-market production is now even more pertinent. International and national institutions need to accelerate efforts to develop indicators of welfare growth from non-market production beyond the boundary of GDP.

Recommendations for overcoming the measurement challenges posed by digitalization include improving access by national statistics compilers specifically to administrative data and generally "Big Data." For administrative data, this entails close cooperation of national government agencies, while in the broader case of Big Data, the cooperation should extend to partnerships between the private and the public sectors, including international organizations.

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*The Statistics Department (STA) established in January 2017 a group on the Digital Economy led by Gabriel Quirós, with wide staff participation, comprising Serkan Arslanalp, Evrim Bese Goksu, Diane Kostroch, Jose Carlos Moreno-Ramirez, Margarida Martins, Silvia Matei, Stephanie Medina Cas, Peter van Oudheusden, René Piché, Tamara Razin, Marshall Reinsdorf, Carlos Sánchez-Muñoz, Patrizia Tumbarello, Louis Venter, and Mari Ylä-Jarkko. Kathie Jamasali provided excellent editing assistance.
This paper has benefited from the discussions on the same topic at the 5th IMF Statistical Forum, in November 2017.

CONTENTS

Glossary

AE	Advanced economy
BOP	Balance of Payments
CPC	Central Product Classification
CPI	Consumer Price Index
DPI	Digital Price Index
EDI	Electronic Data Interchange
GDP	Gross domestic product
GSMA	Groupe Spéciale Mobile Association
ICT	Information and Communications Technology
IMTS	International Merchandise Trade Statistics
IIP	International Investment Position
ISIC	International Standard Industrial Classification
MFS	Monetary and Financial Statistics
MNE	Multinational Enterprise
NSO	National Statistical Office
NPISH	Nonprofit institutions serving households
OECD	Organisation for Economic Cooperation and Development
P2P	Peer-to-peer
PPI	Producer Price Index
TFP	Total Factor Productivity

INTRODUCTION

1. Since the start of 2000s, a new fast-growing phenomenon is changing our societies: digitalization. The digitalization of the economic activity can be broadly defined as the incorporation of data and the Internet into production processes and products, new forms of household and government consumption, fixed-capital formation, cross-border flows, and finance. The rapid pace of change has led to concerns about possible under-measurement of economic activity and economic welfare associated with digital products. The questioning of the existing measure of GDP has been further motivated by the puzzle of low productivity growth at a time of rapid technological change. Internet platforms and smartphones have given consumers access to many new services since their dramatic growth in the mid-2000s, while GDP and productivity exhibited slow growth in advanced economies (AEs).

2. Measurement of the digital economy in GDP and productivity statistics has become a topic of much discussion. Some commentators have attributed the productivity slowdown to mismeasurement of the digital economy in GDP, advancing a wide of range of criticisms, from the "exclusion" of free digital products in the conceptual framework, to the mismeasurement of improved digital products, globalized production and new forms of financial services (i.e., Fintech). The possible growth measurement problems can be grouped into three categories: *the conceptual boundaries of GDP, prices of new and improved digital products,* and *unrecorded digital sector output*. Section III provides conceptual background on GDP and welfare, including the role of deflation, and considers the GDP boundary questions. The price measurement issues are discussed in sector IV, and potentially unrecorded output is discussed in section V.

3. However, digitalization also raises measurement issues and new data needs for external, monetary, and financial sector statistics. Improved measurement of digital products and transactions could improve measurement of inflation, balance of payments developments affecting external sector stability, and financial stocks and flows of relevance for countering money laundering and tax evasion. Section VI discusses measurement challenges and data gaps in the balance of payments (BOP). Section VII briefly considers the three main Fintech products that have implications for monetary and financial statistics (MFS).

4. This paper provides a more in-depth discussion of these issues than the June 2017 informal briefing to the Executive Board on measuring the digital economy. It also considers a broader range of issues and assesses the current state of play in measurement of the digital sector in macroeconomic and financial statistics, recommending steps to overcome the measurement challenges posed by digitalization.

DEFINITION AND SIZE OF THE DIGITAL SECTOR, PRODUCTS, AND TRANSACTIONS

5. There are no agreed definitions of digital sector, products or transactions, let alone the digital economy. In official statistics, the latest version of the United Nations' *International Standard Industrial Classification* (ISIC) defines an *Information and Communications Technology (ICT) sector*[1] and a *Content and Media Sector*. Similarly, the *Central Product Classification* (CPC) includes ICT products, and content and media products. However, revisions to these classifications have not kept up with the recent growth of digital activities and products. Coverage of "online platforms" (e.g., Google, Facebook, Alibaba) and their products is incomplete.[2] Also, platform-enabled services" (e.g., Airbnb) are not explicitly covered. Another open question is the treatment of data as a product—under current international guidelines, databases are products, but not data itself.

6. The "digital economy" is sometimes <u>defined narrowly</u> as online *platforms*, and *activities that owe their existence to such platforms,* yet, in <u>a broad sense</u>, *all activities that use digitized data are part of the digital economy: in modern economies, the entire economy*. If defined by use of digitized data, the digital economy could encompass an enormous, diffuse part of most economies, ranging from agriculture to R&D. For example, Ostroom *et al*. (2016) estimated that in the Netherlands in 2015, businesses with an online presence accounted for 87 percent of turnover and 86 percent of employment in the business sector. But when the Internet economy was defined more narrowly as online stores, online services and Internet-related ICT services, its turnover share was 7.7 percent, and its share of business employment was 4.4 percent.

7. Rather than attempting to cover the broad, unclear concept of the "digital economy," this paper focuses on a *digital sector* comprising the producers at the core of digitalization: *online platforms*, *platform-enabled services*, and *suppliers of ICT goods and services*.[3] Platform-enabled services include the *sharing economy*, whose main components are peer-to-peer short-term property rentals and peer-to-peer labor services (e.g., Uber). *Collaborative finance* (e.g., peer-to-peer lending) may also be included in the sharing economy. Platform-enabled services to businesses in the "gig economy" include crowdsourcing platforms (e.g., Freelancer, and Upwork).

8. Estimates of the size of the digital sector can be sensitive to the choice of definition, as illustrated by the discussions of the rapid growth of digitalization in China at the 5th IMF Statistical Forum. Measured by the combined value of ICT production and integrated digital inputs

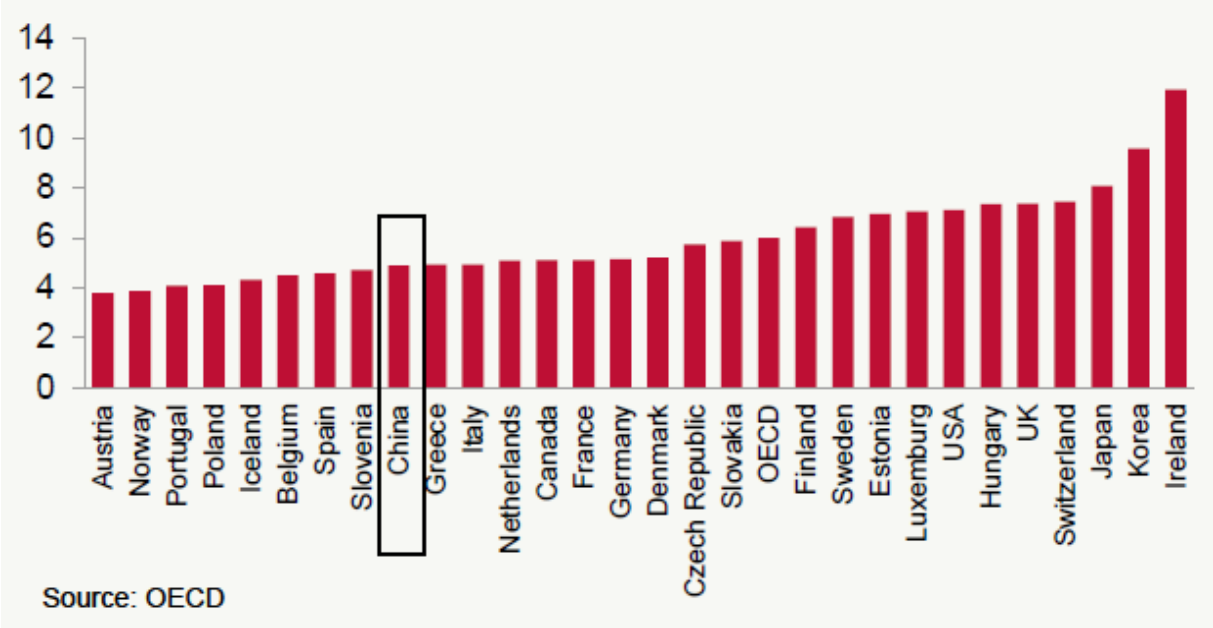
[1] Manufacturing of semiconductors, computers and communications equipment, software publishing, telecommunications, computer programming, data processing, and web portals.

[2] Platform products covered by the CPC include searches, content and media, and e-commerce. But matching services and cloud computing are not covered.

[3] For convenience, we speak of ICT services as a separate category from online platforms. However, they overlap, as the *web portals* classification within ICT services contains several types of online platforms.

to the rest of the economy, China's digital economy amounted to 30 percent of GDP in 2016 (Tencent, 2017). However, when measured by value added of industries in the ICT sector, China's digital sector was 5 percent of GDP in 2012 (Figure 1).[4]

Figure 1. ICT Sector Shares of GDP based on Value Added, 2012



Source: Garcia Herrero and Xu (2017).

9. As an indication of the size of the digital sector in AEs, Table 1 provides illustrative estimates for the United States in 2015. Staff estimates of output of ICT equipment, semiconductors and software amount to 2.8 percent of GDP. Telecommunication services (including landline telephones) and other ICT services are 3.3 percent of GDP. Services of online platforms, including distribution margins of e-commerce platforms, were estimated to amount to 1.5 percent of U.S. GDP. Platform-enabled services appear to amount to 0.2 percent of GDP. Except for ICT equipment, parts and software, the estimates are based on output rather than value added, so their sum of 8.3 percent of GDP, reflects some double-counting.

10. The size of the U.S. digital sector could, arguably, be expanded, as shown in the lower panel of Table 1. The figures give an indication of possible sizes, and should not be interpreted as implying that adjustments to GDP are warranted. First, although estimates of what free digital products supplied by volunteers would sell for if they were priced as commercial products are highly speculative, extrapolating the estimates in Greenstein and Nagle (2014) of the value of an open source (free) software product in the United States suggests that production of open source

[4] See Garcia Herrero and Xu (2017). Another example of sensitivity to definitions comes from an analysis of firms in the United Kingdom. In 2010-2012, Nathan and Rosso's (2015) expanded classification for the ICT sector includes firms accounting for 8.9 percent of business employment, while the current official classification is estimated to put 3.7 percent of business employment in the ICT sector.

software could be worth a third of pre-packaged commercial software, or $35 billion in 2015. Also, Ahmad and Reinsdorf (2017) estimate that Wikipedia's worldwide annual revenue if it sold advertising might be $6 billion, part of which would come from the United States. A hypothetical value of volunteer production is therefore 0.2 percent of GDP. Second, Nakamura, Samuels and Soloveichik (2017) value free media funded by advertising at about 0.1 percent of GDP. Third, Byrne, Corrado and Sichel (2017) argue that fixed capital formation by platforms that make their own servers is overlooked; this could amount to 0.3 percent of GDP. Finally, apportioning the worldwide output of U.S. multinational enterprises (MNEs) based on indicators discussed below shifts some of their foreign output back to the United States (Guvenen *et al*., 2017). A conservative estimate of the digital portion of this output is 0.4 percent of U.S. GDP. (Other compilation challenges that could be sources of underestimation are discussed below.)

Table 1. Possible Size of the Digital Sector in the United States, 2015

Product group	Percent of GDP
Included in GDP (on a value-added basis):	
ICT equipment, semiconductors and software	2.8
Telecommunication and Internet access services	3.3
Data processing, and other information services	0.7
Online platforms, including e-commerce platforms	1.3
Platform-enabled services, (e.g., the "sharing economy")	0.2
Total (with incomplete adjustment for double counting of output)	**8.3**
Conceptually not included in GDP, or missed for procedural reasons:	
Wikipedia and open source software	0.2
Free media from online platforms funded by advertising	0.1
"Do-it-yourself" fixed capital formation of online platforms	0.3
Output of MNEs attributed to tax havens	0.4
Total (with incomplete adjustment for double counting of output)	**1.0**

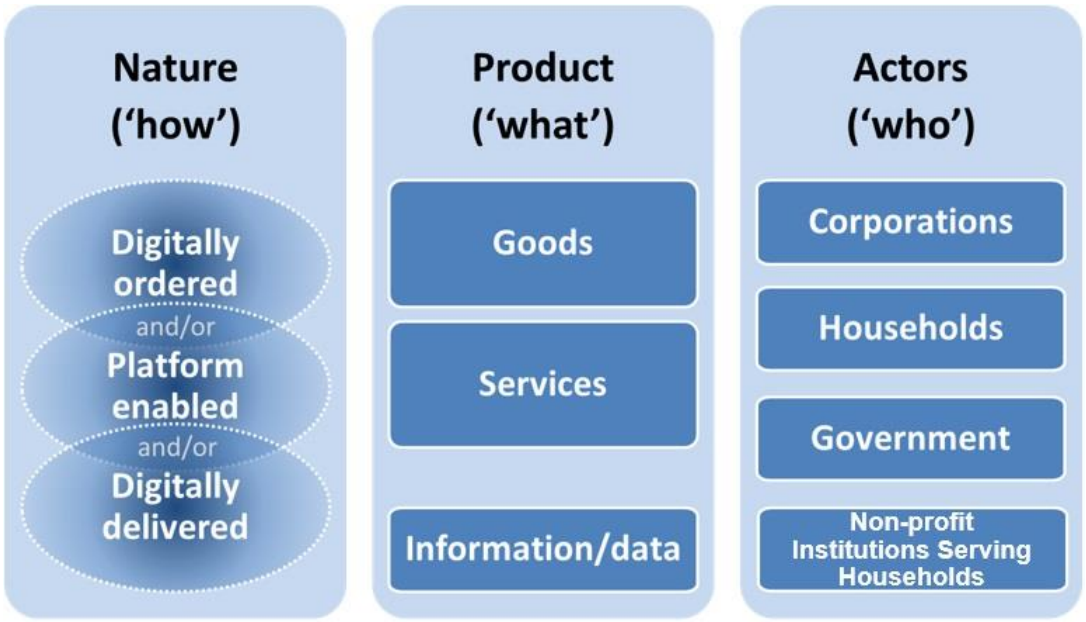
Source: Staff estimates based on official U.S. data, Nakamura, Samuels and Soloveichik (2017), Byrne, Corrado and Sichel (2017), and Guvenen *et al.* (2017).

11. The relevant weights for gauging sensitivity of estimates of GDP growth to mismeasurement of the digital sector are smaller than the GDP shares in Table 1 because some of the output is used for intermediate consumption. ICT services are particularly likely to be used for intermediate consumption. Mismeasurement of the output of the digital sector used for intermediate consumption by business would not matter for estimation of GDP, which equals final consumption, plus capital formation, plus net exports.

12. Defining *digital transactions* is an alternative to defining the digital sector. OECD advisory expert groups on a digital economy satellite account in national accounts and on digital trade in balance of payments statistics take this approach (Ahmad and Ribarsky, 2017, and Fortanier and Lopez Gonzalez, 2017). The possible criteria for distinguishing digital transactions (Figure 2) include *how* the transaction is made (digitally ordered, enabled or delivered), *what* is transacted

(goods, services or data), and *who* is involved (consumer, business or government). The expert groups' current working definition of digital transactions includes products that are *digitally ordered*, *digitally delivered*, or *platform-enabled*.

Figure 2. The Three Dimensions of Digital Transactions



Source: Fortanier and Matei (2017).

DIGITALIZATION AND THE CONCEPTUAL FRAMEWORK OF GDP: WELFARE, GLOBALIZATION AND PRODUCTIVITY

A. GDP Versus Welfare

13. GDP is a measure of production, specifically market and near-market production valued at market prices.[5] Three approaches, which, conceptually, yield the same answer, are used to estimate this production. GDP may be estimated by: (a) aggregating the value added of all resident producers (and adjusting for taxes and subsidies on products), (b) adding final expenditures on household consumption, capital formation, government consumption, and net exports (C + I + G + X–M), or (c) adding the income from production distributed to the suppliers of labor and capital or paid as taxes.

[5] Free services of governments and nonprofit institutions serving households are valued at the cost of production.

14. The controversy over GDP has been largely fueled by concerns that welfare gains from digital products—particularly when they become "free"—are being neglected. Free products may be produced by volunteers, by consumers themselves ("self-service"), or by platforms funded by advertising and the collection of user data. They have inspired proposals to change the definition of output in (a), or consumption in (b), neglecting the implications for income in (c). If a free digital product is added to output and consumption, GDP compilers would have to impute two transactions that raise the gross income of the consumer and producer of that product. The producer would provide imputed income to the consumer as a transfer, or possibly a purchase of ad-viewing services, which would be used to purchase the free product. However, imputed income that the consumer simultaneously receives and returns differs in important ways from actual money income, and imputed producer revenue differs in important ways from actual revenue.

15. Nominal GDP is not—and should not be confused with—a measure of welfare. The total welfare from water is enormous because water is essential to life; yet water is abundant enough to have a low price, and so consumption of water is small. However, welfare growth is measured by growth of real consumption (or, with adjustments, real GDP), as discussed in Annex 1.

16. The total welfare from digital products includes consumer surplus, but consumption, as recorded in GDP, does not. The consumer surplus may be big. Thus, comparisons of the total welfare from digital products to household consumption or GDP may give an exaggerated impression of the scale of the potential mismeasurement. Online discrete choice experiments in Brynjolffson *et al.* (2017) found that the median amounts that Internet users in the United States would accept to agree to forego digital products are large (Table 2). If household consumption in U.S. GDP were adjusted to include the total consumer surplus of Internet users, its level would increase by about 30 percent.

Table 2. Median Annual Consumer Surplus from Free Digital Goods, Internet Users in the United States in 2016
(U.S. dollars)

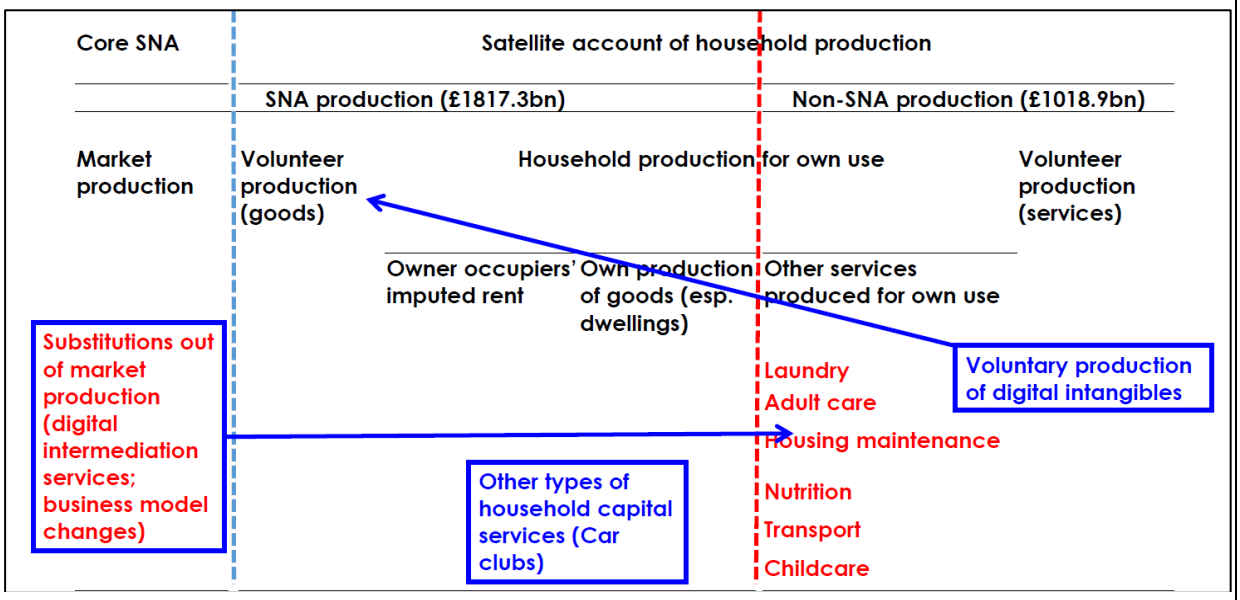
Digital Product	Willingness-to-Accept
Search engines	$14,760
E-mail	6,139
Digital maps	2,693
Online videos	991
E-commerce	634
Social media	205
Messaging	135
Music	140
TOTAL	**25,697**
Memo: Household disposable income per capita in U.S.	*43,469*

Source: Brynjolfsson, Eggers, and Gannamaneni, 2017.

17. "Real GDP" statistics are calculated by deflating nominal values by a price index. The characteristics of the deflator for household consumption are key, both for measuring the contribution of household consumption to real GDP and for using real household consumption as a measure of welfare. The interpretation of aggregates such as real household consumption depends on the weights assigned to the individual goods that household consume. The market prices used in national accounts yield the weights that make growth of aggregate real consumption a measure of overall welfare growth, and the productivity statistics a measure of technology/efficiency change under the usual assumptions. Proposals to use hypothetical shadow prices to value free digital products to capture their effects on welfare growth or productivity growth are inconsistent with the underlying conceptual frameworks for measuring those concepts.

18. GDP was not designed to be a comprehensive measure of production. The production boundary of GDP as defined in the *System of National Accounts* (*SNA*) includes a specific part of overall production, consisting of market and near-market production (Figure 3). Volunteer services are outside the boundary, along with households' nonmarket production of services for own consumption, such as cooking, laundering, childcare, and home maintenance. Nonmarket services of volunteers or for own consumption amounted to 36 percent of overall production (and 56 percent of GDP) in the United Kingdom in 2014 (Office for National Statistics – ONS, 2016a).

Figure 3. Nonmarket Production of Services and the SNA Production Boundary (United Kingdom, 2014)



Source: Bean (2017).

19. Shifts of market production to outside the GDP boundary have been cited as a source of downward distortion in GDP in the digital age. Online information has reduced search and matching costs, and enabled households to substitute services that they produce for market services; for example, households can be their own travel agent (Bean, 2017). Free digital replacements (such as Skype as a replacement for long distance calls) can also be viewed as enabling households to eliminate expenses via do-it-yourself production (Coyle, 2017). Finally, the Internet enables volunteers to supply online content and open source software.

20. Nevertheless, the shifts go in both directions. The gig economy has reduced transaction costs to hire for tasks such as driving or assembling a furniture kit. Online shopping has shifted the tasks of finding the item on the shelf and transporting it home to market producers. Furthermore, shifts across the production boundary caused by technology, social change, or economic development also occurred before the digital age. Discussions of the effects of the digitalization on the production boundary must consider the broader context of household non-market production, and shifts between market and non-market production driven by social and economic change, not just technological change.

21. The view that shifts to self-service enabled by digital replacements reduce and distort GDP ignores consumers' behavior and confuses the roles of nominal and real GDP. Free digital replacements change the composition of GDP, not its level, as households are likely to spend the money saved on something else. It could be said that GDP stays flat while welfare grows. But this criticism of GDP assumes a role for nominal GDP that it does not have. The question should be whether real GDP captures the welfare gain, i.e., whether the deflators capture increases in quality of digital products. Accuracy of deflation is critical for measuring productivity, as productivity gains often have downward effects on prices.

22. Capturing the welfare in GDP from free digital replacements is primarily a price and volume index problem, not as a production boundary problem. As discussed below, adjustment of prices for quality change is a key step to measure welfare. Most capabilities of digital products that eliminate a household expense can be treated as a quality change in some priced item. For example, a smartphone camera that is good enough to replace a camera bought separately is a quality attribute of the smartphone. Nevertheless, digital products from volunteers, and uses of digital products as inputs in household production for own consumption, raise some important production boundary questions.

23. Changing the definition of GDP in any fundamental way would create more problems than it would solve. Different questions require different concepts. The current definition of GDP is well-suited for key policy questions involving income, employment, monetary policy, potential government revenue, investment and productivity. Nonmarket household production does not generate spendable income, or income that can be used to fund investment and easily taxed. Putting nonmarket production in GDP could mask important developments in market output, such as the start of a recession. Another consideration is replicability and objectivity. The current definition of GDP can be estimated from observable transactions and market prices. In contrast,

assumptions and subjectivity may drive the monetary values assigned to volunteer services, nonmarket services for own consumption, and free on-line services.

24. Indicators "beyond GDP" can help us to understand the welfare effects of digitalization. Rapid increases in free digital services and household non-market production made possible by digitalization have widened the gap between GDP growth and household welfare growth. Measures of nonmarket production and other welfare indicators "beyond GDP" are discussed in Stiglitz, Sen and Fitoussi (2009). These sorts of indicators could address questions such as the impact of digitalization on the welfare of different segments of the population, and how digitalization has changed the way households use their time.

25. Proponents of modifications of the GDP production boundary argue that these marginal changes in definition would enable GDP to better capture the welfare from the digital sector. One proposal is to apply the current treatment of owner-occupied dwellings to consumer durable goods, including digital devices. To capture the welfare gains from digitalization in household consumption statistics, Byrne and Corrado (2017) would include services of consumer durables in household consumption, with an adjustment for intensity of utilization. This approach also increases the weight given to quality changes in digital devices. During periods of rapid uptake of devices such as smartphones and tablets, and rapidly rising time spent online, the effect on household consumption growth could be significant. The main impediments to this approach are practical problems, including resources and source data, and the possible obscuring of business cycle developments (imputed services of durables would be smooth).

26. Proposals to change the treatment of free media funded by advertising and collection of users' data also merit further research. The *SNA* treats free platforms whose revenue comes from advertising as suppliers of advertising services, and assumes that the viewers pay for the free media as part of the prices of the advertised products. Nakamura *et al.* (2017) would expand the measure of the output of these platforms to include imputed media services consumed directly by the viewers, with the value of the services inferred from their cost of production. However, there are some outstanding questions raised by this and similar proposals.[6] Free services to attract platform users is a more general phenomenon than advertiser-funded media, and the broader implications need to be understood. Another question for research is whether expenses to attract platform users and collect data on them should be treated as an investment in data. Data as a product or asset should be part of the research agenda.

[6] The quantitative impact may be small. Valuing the free media based on advertising revenue implies increases in the level of nominal GDP in OECD countries in 2013 that range from 0.4 percent of GDP in Greece to 1.3 percent of GDP in the United States (Ahmad *et al.*, 2017). For growth, the effects are close to zero, or even negative. As discussed above, approaches that try to quantify the benefits as perceived by consumers yield larger estimates; however, such estimates are not suitable for inclusion in a measure of market and near-market production.

B. Globalization

27. Geographical boundaries are another kind of boundary problem, as GDP is defined as production occurring within a country's economic territory. Digitalization has made it easy to fragment global production processes, and to separate the locations of production and consumption of services. Furthermore, intellectual property assets, which play a large role in many digital enterprises, are easily redomiciled. Consequently, the global production of a multinational enterprise (MNE) may be spread across different countries in a way that makes the production location an ambiguous concept.

28. Relocations by MNEs for tax reasons may generate concerns about whether the reported location of production best describes where the production really took place, and about the meaning of BOP and international investment position (IIP) statistics. These relocations may be accomplished by moving the MNE headquarters (often via a corporate inversion), by implementing a holding company structure, or by selling intellectual property and other moveable assets to an overseas affiliate. Relocations of MNEs are not limited to digital enterprises, but they affect the measurement of the digital sector because many digital enterprises have headquarters or intellectual property assets in a tax-advantaged jurisdiction.

29. Revisions to the estimates of the 2015 GDP, BOP, and IIP of Ireland drew attention to the potential for relocations to significantly affect these statistics. Yearly GDP growth was revised from 7.8 percent to 26.3 percent, goods exports were revised up by €50 billion, and the net IIP was revised from –€150 billion to –€532 billion. Indirect and direct effects of relocations of intellectual property assets play a large role in the revisions. Another round of effects could occur if U.S. MNEs repatriate assets and subsidiaries in response to the recent changes in U.S. tax law, or if countries change from a residency-based approach to a destination-based approach to international taxation.

30. In cases where relocations of MNEs cause GDP, BOP and IIP data to give an incomplete picture, dissemination of additional detail on the transactions of the MNEs, and of alternative approaches, may help to fill in the missing information. To provide additional insight into the purely domestic portion of its economy, Ireland developed a modified concept of gross national income that excludes factor income of redomiciled companies and depreciation of relocated assets, and a modified current account balance. However, modified concepts must be well-documented and provide meaningful insight.

31. The effects of MNE relocations on measurement of digital output and digital trade vary. Output of digital products may be understated in high-tax countries that host significant operations of digital MNEs. Although there is no research that specifically looks at the digital sector, researchers have used an apportionment technique for inferring the location of overall production of MNEs to provide a perspective on tax-driven distortions in locations of MNEs' production. Guvenen *et al*. (2017) apportion the worldwide income of MNEs headquartered in the United States to locations where they have operations based on a combination of labor inputs and sales to unaffiliated

entities, with results implying an increase of 1.7 percent in the estimate of U.S. GDP level in 2012.[7] U.S. productivity growth increases by 0.1 percentage point in 1994–2004, and 0.25 percentage points in 2004–2008, with no change thereafter. The upward revision to U.S. GDP could also imply an upward revision to net exports of goods and services. These estimates include all industries; digital enterprises may account for less than half of the total.

C. Productivity

32. Productivity is a measure of changes in the ability of producers to transform inputs into output. Only market producers are within the scope of the productivity statistics. Overstated deflators for ICT products have been identified as causing underestimation of real output and, hence, productivity. Nonmarket output does not fall within the domain of standard measures of productivity. Digitalization has improved the ability of households to use their own time and other inputs to produce nonmarket services for own consumption, thereby increasing welfare. Measures of these welfare gains would help to understand the positive effects of digitalization. However, development of such measures is hampered by lack of appropriate time-use data.

33. Measurement of productivity and real GDP are closely linked. Productivity is calculated as the growth of market output as measured in GDP less the growth of inputs, either labor, or, in the case of *Total Factor Productivity* (TFP), labor and capital combined. Adjustments to real GDP to better capture output of digital products have a slightly magnified effect on the growth rate of aggregate labor productivity. This is because the base on which the percentage change in productivity is calculated includes only the market production part of GDP. However, in the case of TFP, adjustments to output of fixed capital goods, such as computers, may have virtually no effect because capital is also an input.

34. The backdrop to the measurement debate is the sharp slowdown in productivity in most AEs that has persisted since the global financial crisis. Some have attributed the productivity slowdown to mismeasurement of the digital economy. Growth of the market output of the digital sector probably *is* underestimated because measures of ICT prices under adjust for quality improvements, but ICT output is too small for its measurement to have much impact on estimates of aggregate productivity in most AEs.[8] The slowdown in the productivity growth rate in AEs is more than 1 percentage point (Adler *et al*., 2017), and almost 2 percentage points in some cases. In contrast, the underestimation of labor productivity growth caused by under adjustment for quality change in ICT goods and services is generally under 0.3 percentage points—or less, if the

[7] An indication that the estimate of 1.7 percent of GDP for the size of the distortion may be too high is that it is almost as large as the net sales of foreign affiliates reported in the ownership-based framework of the U.S. current account. Net receipts from sales of foreign affiliates amounted to 1.8 percent of GDP in 2012 (Hossio, 2018).

[8] Output of ICT goods and services is about 6 percent of U.S. GDP in Table 1. Almost half of this is software, whose growth rate appears to be underestimated only slightly, perhaps by 3 percentage points or less. Quality improvement in computers and semiconductors seems to be underestimated, perhaps by as much as 10 percentage points, but their weight in the market output covered by the productivity calculations is just 0.5 percent.

mismeasurement before slowdown began is considered. Effects on TFP are likely to be smaller.

35. Productivity was also underestimated before the slowdown began. Nevertheless, a small role for mismeasurement in the labor productivity slowdown cannot be ruled out. An increasing share of fixed capital formation is taking place in capital products whose quality change is hard to measure, such as software and R&D. Future research may find that the quality improvements in software have been substantially underestimated – existing software indexes tend to imply a slower pace of quality improvement than has traditionally been the case for hardware indexes.

PRICE INDEX COMPILATION CHALLENGES AND STATE OF PLAY

36. Having discussed the conceptual framework of GDP, including the distinction between GDP as a measure of market production and a measure of welfare, this section turns to the compilation challenges for price indexes used to deflate digital components of GDP and to measure inflation. Four challenges posed by the digital economy are: capturing the fast-changing quality of digital goods and services; handling introductions of new products; measuring e-commerce; and measuring the sharing economy.

A. Quality Adjustment and Price Indexes

37. Quality improvements conceptually represent increases in real output. To prevent quality change from being mistaken for price change in calculating the index for a product, either the prices of different models must be adjusted for their quality difference before they are compared, or a technique that avoids comparisons of different models must be used. The latter approach is more common. The "matched models" technique excludes non-matching observations from the index calculations. Suppose that the model replacement occurs in a month in which overlapping prices of the old and new models are collected. The change in the old model's price enters the calculation of the change in the index in the overlap price month, and in the next month, the change in the new model's price enters the calculation of the change in the index. This technique assumes that the quality change is reflected in the price differential between the new and old models if they are sold side-by-side; in other words, the price index remains unchanged regardless of any change in the quality-adjusted price when the new model replaces the old one.

38. Table 3 illustrates the mechanics of quality adjustment using the observed case of two iPhones. After the new model (the iPhone 7) was launched in 2017 at $650, sellers started to discount the price of the iPhone 6 by $100 to $450. The price difference between the two models, $200, is considered as the value of the quality increase brought by the new model. With no quality adjustment, the price index would equal 118.2 (650/550), while with the quality adjustment it is 81.8. In 2017, output of iPhones is 10.2 percent in nominal terms while its real output growth is 34.7 percent, i.e., after deflating nominal output by the indicated quality-adjusted price index: 81.8.

Table 3. Illustration of Quality Adjustment for iPhone in Price and Volume Indexes

	2016	2017
iPhone 6s 32GB, Transactions price (US dollars)	550	450
iPhone 7 32GB, Transactions price	N.A.	650
Quality adjustment, iPhone 7 vs iPhone 6s		200
Quality-adjusted iPhone 7 price		450
Quality-adjusted Price Index for iPhones	100	81.8
iPhone Nominal Output, Western hemisphere ($ US billions)	54.9	60.5
Nominal Value Index		110.2
iPhone Sales, in constant prices of 2016	54.9	73.9
Volume index	100	134.7
Volume index with no quality adjustment	100	93.2

Source: Staff calculations based on prices observed in April 2017 and Apple's 2016 *Annual Report*.

39. New Goods: Truly novel goods occasionally appear that cannot be compared to any existing good, even after quality adjustment. Some have argued that the omitted welfare gains from the appearance of smartphones and online platforms are large. However, the potential role of this problem in the productivity slowdown is limited, as the gains from major digital innovations were concentrated in a relatively short period when uptake of the new inventions was rapid, and they may have been less important than gains from past inventions.[9] The gains from the initial appearance of truly novel goods are difficult to quantify (Box 1).

40. Nevertheless, delays in bringing new goods into the index basket could be a cause of overstatement of price change. Avoiding such delays may require a rethinking of compilation procedures and access to new data sources. A change in international guidelines on price index compilation practices (which allow updating of the basket structure every 5 years) could help. Research on innovative quality adjustment procedures for new goods may be helpful; it may be possible to compare goods that serve the same function by pricing the function.

41. For new models of existing digital goods, quality adjustment generally is possible. The IMF and the OECD conducted a survey on price index compilation practices in 2017. There were 43 responses, 33 of which came from OECD countries. Just three countries make no adjustments for quality changes in ICT and high-tech products. For types of products where new models appear on a regular basis, such as automobiles and computers, most compilers use explicit quality adjustment procedures to handle replacements of models in the index. Nevertheless, quality adjustment is a

[9] Data on advertising revenues in Nakamura *et al.* (2016) imply that broadcast television was a more important innovation in the 1950s than online media in the 2000s, and judging by viewing time, television remains more important (Nielsen, 2016). Gordon (2016) also discusses examples, such as air conditioning.

resource-intensive task, and procedures may need frequent updating. Furthermore, quality adjustment for software is particularly challenging.

42. Compilers in AEs update the consumer price index (CPI) variety samples annually, and make interim sample updates to bring in replacements for old models that have disappeared or become unrepresentative. These practices help to capture the price changes that occur early in the life cycle of new models and varieties and ensure that the samples remain representative. However, sample updating practices for producer price indexes (PPIs) vary.

43. New models or varieties may not be subject to quality adjustment if they enter the index as part of a sample rotation. In a sample rotation, the entire sample is replaced. Both the new and old samples are priced in an overlap month, and in the next month the price changes in the new sample are used to calculate the change in the index. When new models of a product with rapidly advancing technology come into an index during sample rotations, price change may be overstated.[10] In general, challenges in quality adjustment mean that price change is likely to be overestimated for products incorporating advances in ICT technology. The combined effects of all sources of underestimation of quality change in digital products on the measurement of consumer inflation in an average OECD economy may be around 0.3 percentage points (Box 2).

44. Quality improvements in ICT goods and services may be significantly underestimated in some cases. Price indexes for ICT equipment (Figure 3a), software (Figure 3b), and telecom services (Figure 3c) can vary greatly between countries. Although differences in national conditions are plausible for communication services, they are unlikely to explain the discrepant behavior of prices of computers and telecom equipment, because they are internationally traded. Focusing on the ICT indexes, Ahmad *et al.* (2017) adjust for differences in general inflation rates and compare the adjusted growth rates over 2010–15. The adjusted indexes for Germany and France fall more than 4 percent per year, while those for Belgium, Italy and the United Kingdom rise or are flat, and those for the remaining countries fall by 2 to 3 percent per year. In the case of telecom services, research in the United Kingdom has confirmed that price change is being overstated: Abdirahman *et al.* (2017) find a 7-percentage point overstatement of the price growth rate in 2010–2015.

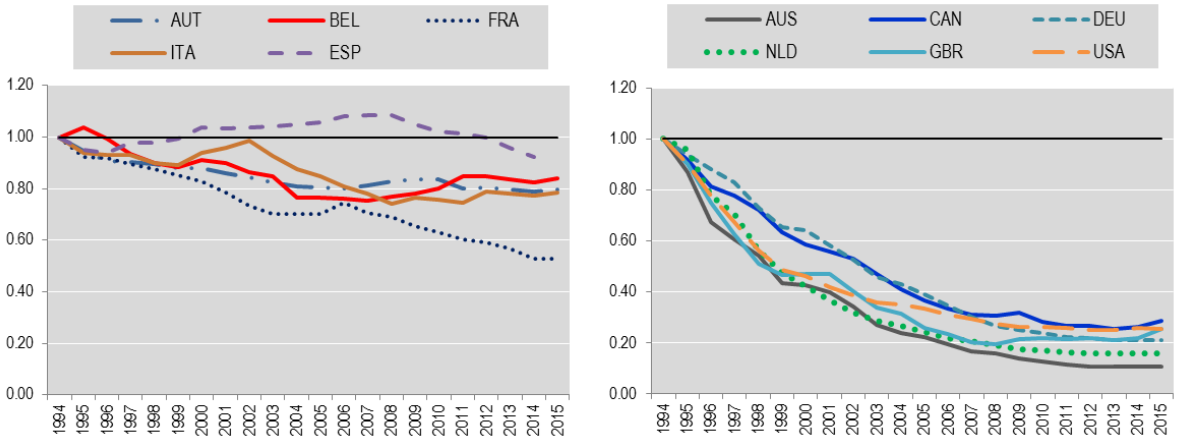
45. If Internet access is viewed as a product, growth in online content and faster connection speeds would represent quality improvements, but other changes in the online environment imply quality declines. Increases in hacking, trafficking of stolen information, and ransomware attacks, have increased losses from security breaches and forced more defensive expenditures on cybersecurity.

46. To measure price indexes for digital products accurately, national statistics offices (NSOs) must quality-adjust prices of key digital products, drawing on the experience of other countries. NSOs should also consider innovations in data sources, data collection, and index

[10] Research on a CPI for televisions found that neglected quality improvements in models that entered during sample rotations caused price growth to be overestimated by 2 percentage points (Moulton, Moses and Lafleur, 1998).

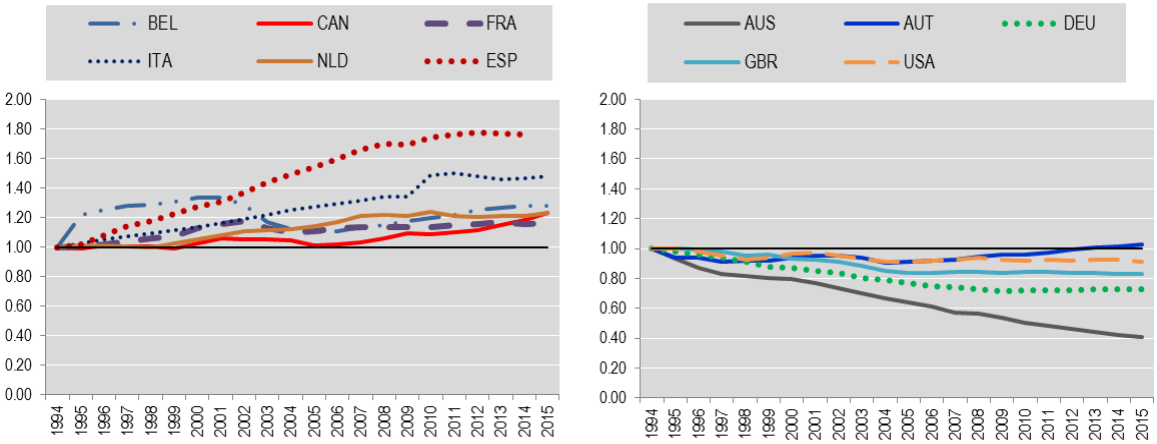
calculation to allow new varieties and suppliers to be incorporated as soon as they start to become important. Up-to-date samples of varieties and suppliers will enable the deflators for digital products to match the composition of the digital product aggregates in the national accounts, improving the estimation of real GDP. Development of indexes well-suited to deflating national accounts aggregates may also require close collaboration price statisticians with national accounts compilers[11].

Figure 3a. Price Indices for Investment in Computers and Telecommunications Equipment
Selected OECD countries, 1994=1.00



Source: Ahmad, Ribarsky and Reinsdorf (2107), based on OECD National Accounts Statistics and Productivity Database.

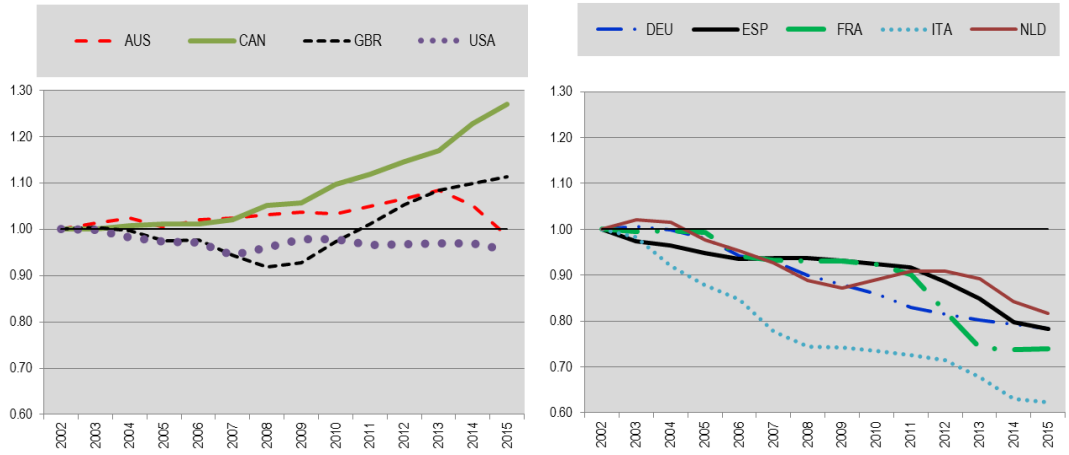
Figure 3b. Price Indices for Investment in Computer Software and Databases
Selected OECD countries, 1994=1.00



Source: Ahmad, Ribarsky and Reinsdorf (2017), based on OECD National Accounts Statistics and Productivity Database.

[11] The recommendations of Voorburg Group and the Ottawa Group provide a good basis.

Figure 3c. Price Indices for Consumption of Communication Services
National price indices, selected OECD countries, 2002=1.00



Source: Ahmad, Ribarsky and Reinsdorf (2107), based the data from OECD Prices and Purchasing Power Parities database, Australian Bureau of Statistics, U.S. Bureau of Economic Analyses, and Statistics Canada, February 2017.

Box 1. The New Goods Problem

New goods occasionally appear that are too unlike any existing good for a quality adjustment to be possible. Welfare gains from new goods have been an important driver of rising living standards. The impact of mobile phones in many developing countries is an example.

The discussion of the impossibility of measuring welfare gains from truly innovative new goods has a long history. Even before GDP was invented, Keynes (1930) illustrated the problem with an example of comparing admission to the cinema to admission to the gladiator games of ancient times. Truly novel new goods often enter price indexes during a change in the base year as part of the new item structure. The welfare gains when the new good first appears are not captured—nor are the welfare losses when existing goods disappear.

In theory, the consumer surplus from the appearance of a new good may be captured by appropriately weighting the difference between the new good's reservation price and its post-entry price. The reservation price—the price at which demand would become zero—can be treated as the pre-entry price of the new good because unavailability of the good is the same from a welfare perspective as if it had existed, but been priced high enough to drive demand to zero. Nevertheless, reservation prices are more appropriate for an experimental welfare indicator than for the CPI or GDP deflator. The consumer surplus from the appearance of a new good is not spendable in the same way as money saved from an actual price decline. Moreover, estimating a reservation price requires strong assumptions that make the results non-replicable.

It may be possible to capture most of the welfare gains without imputing a reservation price by bringing the new good into the index as soon as it appears. Important new goods typically undergo price declines in the early part of their life. By including these early price declines, the index may capture most of the welfare gains. This is often difficult to achieve in practice, however. A third of the respondents to an IMF-OECD survey on price index compilation practices update their CPI basket structure at intervals of 2 years or longer. Many countries update their PPI structure at 5-year intervals.

Box 2. Effects of Digitalization on Measurement of Inflation and the Cost of Living

Three kinds of effects on the cost of living from new and improved digital products may not be captured in the CPI and the deflator for household final consumption. ICT goods and services often undergo quality improvements that are hard to measure. Second, new free and inexpensive digital products that allow consumers to achieve the same function for less are replacements for non-digital products. Third, e-commerce has given consumers access to more varieties, and online search results and product reviews provide information to select varieties that best match their tastes and needs.

Reinsdorf and Schreyer (2017) calibrated upper bounds for the potential impact of these effects on the deflator for household consumption using weights in an average consumption basket for OECD countries in data from the OECD's purchasing power parities program. Based on prior research (Byrne and Corrado, 2017, and Moulton *et al.,* 1998), they assumed that underestimation of quality improvements causes the indexes for ICT equipment and telecommunication services to overstate the growth rate of their prices by 5 percentage points, and the indexes for other goods that incorporate digital technology, such as televisions and automobiles, to overstate growth of their prices by 2 percentage points. Based on the weights of the affected items in the 2015 consumption basket, the deflator for household consumption would overestimate inflation by 0.28 percentage points.

Next, based on an analysis of detailed expenditure patterns in the OECD data, they assumed that the indexes for household consumption categories containing items with free or inexpensive digital, or sharing economy, replacements (taxis, music and video recordings, newspapers, and film developing) overstate the rate of change in the cost of living by 5 percentage points. (Telecommunication services and photographic equipment are excluded here because they were already included in the 5-percentage point adjustment for unmeasured quality change.) They further assumed, also, that the indexes for categories that are weakly affected by digital replacements (books, postal services, travel formerly arranged through travel agents, etc.) overstate the rate of change in the cost of living by 2 percentage points. The effect on the deflator for household consumption is 0.18 percentage points with the weights of 2005, falling to 0.11 percentage points with the weights of 2015.

All in all, the marginal benefits of expanded access to variety and better variety selection are relatively small at the product level, but they could still be significant at the aggregate level because many products are affected. If the rate of change in the cost of living were overstated by 0.3 percentage points for items with expanded access to variety online, or with online information enabling better variety selection, the impact on the deflator for household consumption would be 0.06 percentage points. This sort of inferred cost of living effect is probably not appropriate to include in the official CPI, but it would be relevant for a broader welfare indicator.

Adding the 2015 bounds for the three effects gives an upper bound of 0.45 percentage points for the combined overstatement of the rate of change in the cost of living. For comparison, the productivity slowdown has reduced growth by more than 1 percentage point in the AEs.

B. Coverage of E-Commerce and the Sharing Economy

47. Online retailers are replacing street stores for goods that are easily shipped. ONS data show that non-gasoline retailers the United Kingdom in 2017 made more than 16 percent of their sales online. Eurostat data on the European Union in 2016, show that 66 percent of household Internet users made online purchases, and for business with 10 or more employees, sales over the Internet to consumers were 2.7 percent of turnover, and all other e-commerce sales were 15.6 percent of turnover.

48. Prices may be lower online, and the CPI may fail to capture the decline in the average price paid caused by substitution to online shopping. Cavallo (2017) finds that prices from Amazon are, on average, 5 percent lower than prices at offline stores. If substitution to online shopping has reduced the average price paid, the effect on the cost of living would not be fully captured in the CPI. As discussed below, online prices tend to be under-represented in CPI samples, and about half the respondents to the IMF-OECD survey on price compilation practices reported that they treat price differentials between outlets as quality changes.

49. Adequate coverage of e-commerce in price samples is important because online prices may have a different growth rate. Evidence that online prices are declining relative to the prices in the U.S. CPI comes from a comparison with the Adobe *Digital Price Index* (DPI) over 2014–2017. The DPIs fall by 1 percent per year, on average, relative to corresponding CPIs (Goolsbee and Klenow, 2018). However, procedural differences may contribute to this result, and the years examined could be atypical. Data from many countries collected in the *Billion Prices Project* generally show similar rates of change in online and offline prices (Cavallo and Rigobon, 2016).

50. E-commerce prices appear to be under represented in CPI and Producer Price Index (PPI) samples. About 70 percent respondents to the IMF-OECD survey of price compilation practices have e-commerce prices in their CPI (Table 4). However, there are many gaps in the coverage of products frequently purchased online, such as clothing and footwear. In the PPI, coverage of e-commerce is limited. Lags in reflecting fast-changing purchasing patterns are a major contributor to the general problem of under-representation of e-commerce prices.

Table 4. Countries Including E-Commerce in Price Indexes
(Sample of 43 countries; Percentages in parenthesis)

	Domestic e-commerce		Cross-border e-commerce	
	CPI	**PPI**	**CPI**	**PPI**
Africa	1 (16.7)	0 (0.0)	0 (0.0)	0 (0.0)
Asia-Pacific	4 (66.7)	4 (80.0)	2 (33.3)	3 (60.0)
Europe	21 (91.3)	7 (33.3)	8 (34.8)	3 (14.3)
Middle East & Central Asia	1 (50.0)	0 (0.0)	0 (0.0)	0 (0.0)
Western Hemisphere	3 (50.0)	2 (33.3)	2 (33.3)	1 (16.7)
All Regions	**30 (69.8)**	**13 (35.1)**	**12 (27.9)**	**7 (18.9)**

Source: IMF-OECD survey of NSOs.

51. Sharing economy suppliers should be included in the CPI with weights that reflect their importance in consumers' spending patterns. Also, in cases where substitution to a lower priced replacement product in the sharing economy has been significant, estimates of the effect on the cost of living would be important for understanding the welfare change, and, possibly, for improving the accuracy of the CPI. If the replacement product from the sharing economy is a close substitute for the original product (e.g., Uber and taxis), it may be reasonable to let CPI reflect the change in the average price paid for the service.

52. Progress on including sharing economy prices in the CPI and PPI may not reflect their importance in the economy. Only three respondents to the IMF-OECD survey (Australia, Germany and the United States) include these prices in their CPI, and none in the PPI. The measurement error in the indicators of price and output growth depends, in part, on the relative size of the sharing economy, which still tends to be small. Many survey respondents regarded the sharing economy as relatively unimportant in their country.

COMPILATION CHALLENGES AND STATE OF PLAY IN NATIONAL ACCOUNTS

A. E-Commerce and Free Products from Online Platforms

53. In 2016, the OECD surveyed countries on national accounts compilation practices regarding the digital economy. The 29 responses generally showed slow progress in developing estimates of the digital sector. In 2017, the IMF extended the survey to some non-OECD countries, with 11 responses. Many of these responses indicated that measuring the digital sector was not a priority. Commonly cited impediments to progress were a lack of resources and unavailability of source data. Notably, however, Malaysia is developing an ICT satellite account that includes online platforms.

54. Only a third of the countries responding to OECD and IMF surveys collect data on online purchases, and just five collect separate data on cross-border e-commerce transactions. However, most respondents to the IMF survey viewed e-commerce as important in their country. Ghana, India, Jamaica and Malaysia reported that they include data on e-commerce in compilation of their national accounts.

55. Proposals to impute viewers' consumption of free online media funded by advertising and collection of data are under discussion. However, just one country has developed experimental estimates, and no other respondent to the OECD survey reported plans to do so. Only eight respondents agreed with the view that free products funded by advertising should be included in household consumption or in a new category of final consumption.

56. The surveys also indicate that no country has data to impute production by volunteers of free online content/media, or of free software, nor does anyone have information on who consumes these free products. The lack of coverage of open source (free) software is a statistical concern because inputs of open source software can affect the measurement of TFP and of commercial software production. Nevertheless, some open source software may already be captured by methods used to compile GDP. GDP compilers often base part of their software production estimates on input costs, including earnings of software coders. Commercial enterprises may pay coders to write open source software as a way of generating sales of support services or of upgrades to premium versions (the so-called "freemium" business model). The software may also be a kind of advertisement for the enterprise.

B. The Sharing Economy

57. Sharing economy suppliers of short-term property rental services or labor services may be informal, i.e., unregistered and untaxed. National accounts procedures for informal rental and labor activity tend to reflect conditions before the emergence of the sharing economy. Household surveys help to measure the labor activity, but survey respondents often neglect to report their sharing economy work unless the questionnaire includes explicit questions on the topic (Abraham *et al*., 2017). Nevertheless, countries are making progress on bringing platform-enabled rentals and labor services into tax, regulatory and reporting regimes. This should help improve the measurement of the sharing economy in GDP.

58. Platforms such as Airbnb have enabled rapid growth of short-term rentals in some economies, particularly those with a tourism industry, suitable housing stock, and a favorable legal environment. Just six of the countries in the OECD survey capture rentals of property through digital intermediaries, and in the IMF survey, only India reported that it captures these rentals. Information used for the estimates may come from tax data, or be collected directly from the digital intermediary. Nevertheless, relative to GDP, the scale of the rental activity is limited; press reports of Airbnb's revenue forecast for 2017 of $2.8 billion suggest worldwide host revenue of perhaps $30 billion. Furthermore, GDP already includes an imputation for services of owner-occupied dwellings that captures part of the value of the peer-to-peer rentals.

59. The state of play is slightly better for labor services, such as Uber. In about half the countries where they are legal, GDP compilers include sharing economy transportation services in estimates of self-employment income based on tax data (8 countries) or labor force surveys (7 countries, with some using both). India, Malaysia and Ghana capture some of these earnings through labor force surveys.

60. Intermediation fees retained by the platforms are challenging to measure. Only five countries in the survey reported that they currently capture these fees. Often, the intermediation services are supplied by a foreign platform that does not report its cross-border transactions, or the available data lack detail on the intermediation fee component of revenue.

C. Lags and Data Gap Concerns

61. International guidelines recommend updating of the benchmark year of the national accounts at least every five years. In between the benchmark years, estimates of the output of each activity are adjusted using indicators of their growth. The growth of the online platform sector in many countries has been so rapid that updating of the national accounts benchmark year at five-year intervals may result in underestimation of the size of the sector.

62. The composition of the available deflators often lags the composition of the aggregates that they are used to deflate. The varieties and detailed weights in PPIs or CPIs are likely to reflect production or purchasing patterns of a previous year, while the composition of the national accounts aggregate reflects current patterns. For example, the deflator might contain only laptops while tablets have become predominant in spending, and sharing economy expenditures may enter GDP compilation before they enter the CPI or PPI. Better correspondence between the composition of the deflators and the composition of national accounts aggregates would be an important step to measure growth more accurately, particularly in the case of the rapidly changing digital sector.

63. Data users need more extensive and more granular statistics on the scale and structure of the digital activity to understand economic developments in a digitalized economy. Alternative classifications will help; for example, an estimate of employment in e-commerce retailing may have to include establishments classified in warehousing. Also, estimates of the scale and relative importance of digital sector activities are needed to analyze the potential mismeasurement of growth and productivity. Ahmad and Ribarsky (2017), discuss work on developing guidelines for a digital economy satellite account.

COMPILATION CHALLENGES AND STATE OF PLAY IN EXTERNAL SECTOR STATISTICS

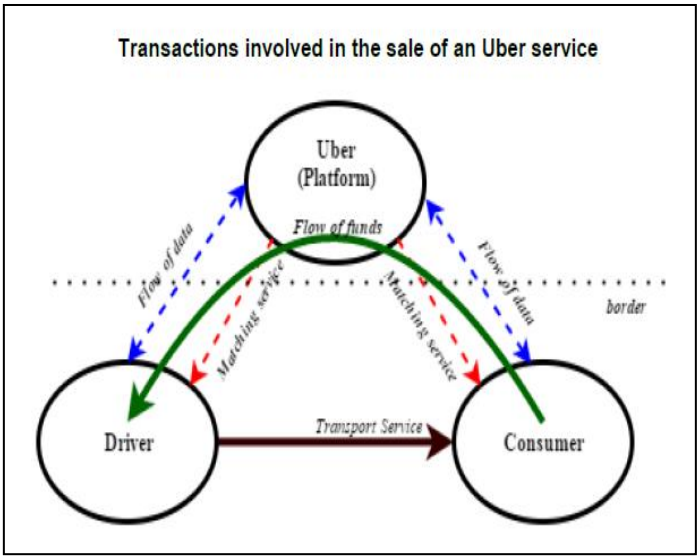
A. Digital Trade

64. Digital trade is growing in importance, raising measurement concerns and data dissemination needs. International organizations involved in trade statistics have responded with several initiatives, including a project on cross-border e-commerce, and reinforced collaboration on guidelines for measuring and classifying digital trade. A preliminary measurement framework for digital trade considers the dimensions and types of transactions in Figure 1. Data sources and methods for capturing new business models, such as Uber, Airbnb, Facebook and Spotify, are being developed.[12]

[12] A draft handbook on measuring digital trade may be available for comments in late 2018.

65. Digital trade includes cross-border transactions that are digitally ordered, platform-enabled, or digitally delivered. Digitally-ordered trade involves cross-border e-commerce in both goods and services. The elements of a platform-enabled transaction are illustrated by an Uber ride example in Figure 4. Questions include whether to classify the platform's matching service in transport services or business services, and who is the user of the service.[13]

Figure 4. International Flows of Data and Services in a Platform-Enabled Transaction

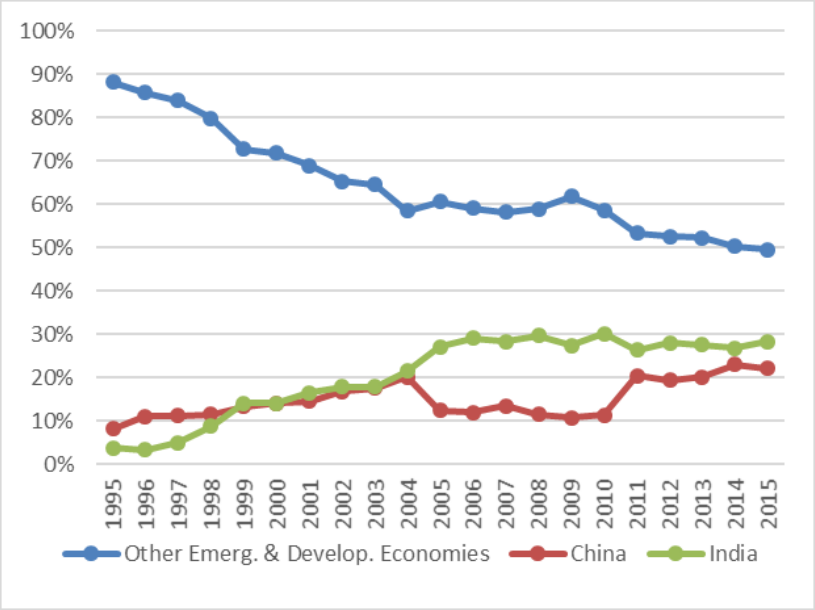


Source: Fortanier and Lopez Gonzalez (2017).

66. Digital delivery involves products delivered via digital downloads or web streaming, such as software, media and cross-border data flows (e.g., advertisements). As a step towards developing estimates of digitally-delivered services, UNCTAD has developed guidelines on ICT and ICT-enabled trade in services, defining "ICT-enabled services" as comprising digitally-delivered services consumed remotely. In 2014, ICT services and (potentially) ICT-enabled services accounted for 54 percent of overall services exports and 48 percent of services imports in the United States, and 56 percent of services exports to non-EU countries, and 52 percent of services imports from non-EU countries in the EU. In contrast, in emerging market and developing economies in 2014, ICT services and (potentially) ICT-enabled services accounted for just 33 percent of services exports and just 27 percent of services imports (Figure 5). China and India play leading roles.

[13] See Statistics Canada (2017) for a discussion of practical difficulties in estimating cross-border intermediation services, and the consumption of the platform-enabled services by non-residents or by residents while abroad.

Figure 5. Share of ICT and ICT-Enabled Services in Emerging and Developing Economies, Credit



Source: IMF BOP data base.

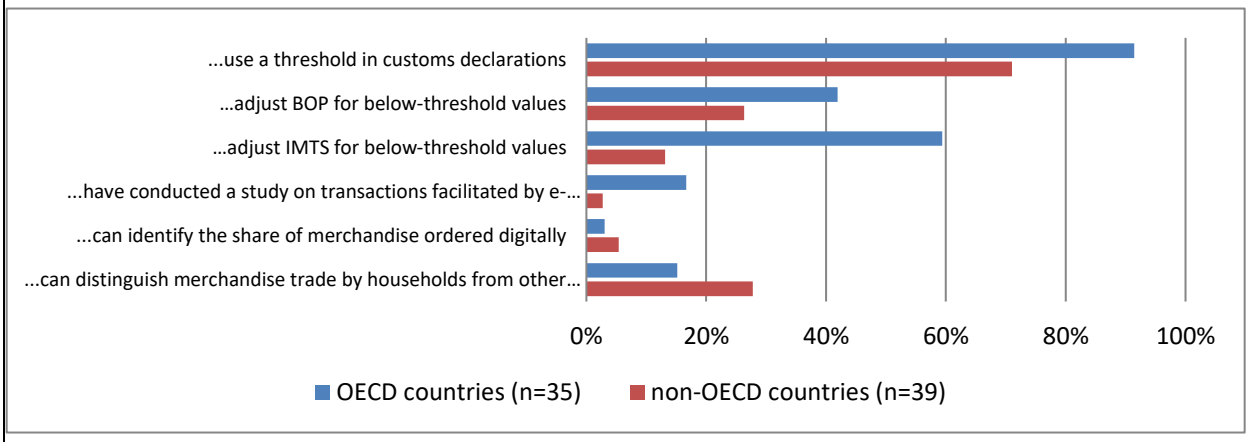
67. Digitally-delivered services raise some conceptual and practical questions, including the boundary of what is included. Also, free media funded by advertising (which should be captured in trade statistics) may involve international flows of unpriced data on which the advertising depends. Platforms often produce services with unpriced cross-border data flows as intermediate inputs. These data flows have economic importance, but little progress has been made on measuring them.

68. In 2017, the OECD and IMF surveyed BOP compilers on practices for measuring digital trade and payments, with responses from 74 countries. Although aspects of digital trade are well-measured in some countries, the results highlight the practical measurement challenges, particularly gaps in the available source data.

69. Digital ordering, digital payments, and digital delivery of services, have fostered the growth of small transactions below customs reporting thresholds. Most countries have a reporting threshold for small transactions (Figure 6), but the sizes of the reporting threshold and the adjustment practices vary. More than half of OECD countries include an estimate of the below-the-threshold transactions in their international merchandise trade statistics (IMTS). However, a minority of non-OECD countries responding to the IMF survey do so. The largest estimate of the share of below-the-threshold trade among the countries responding to the IMF survey was about 15 percent. (U.S. estimates were 2.2 percent of goods imports and 0.8 percent of goods exports in 2015.) To avoid underestimation, merchandise trade statistics must incorporate adjustments for unreported small transactions that reflect their growth in the digital era.

70. Low transaction costs have led to a growing importance of cross-border e-commerce both for businesses and for consumers. Electronic Data Interchange (EDI) has also reduced costs for business-to-business transactions. E-commerce is an important driver of recent merchandise trade growth. In Russia, the share of e-commerce in imports grew from 2.5 percent in 2016 to 4.2 percent in the first quarter of 2017. However, few countries have separate estimates of cross-border e-commerce.

Figure 6. Percentage of BOP Respondents who…



Source: OECD and IMF surveys of BOP compilers.

71. Services such as software, e-books, music and e-learning are frequently delivered via digital downloads. Responses to the OECD-IMF survey indicated that digital downloads are covered by the source data in most OECD countries, and almost half of non-OECD countries; however, they may not be separately identifiable. Eleven countries indicated that household consumption of cross-border services could potentially be captured through credit card data, and other sources, including administrative data, are also under consideration.

72. Many survey respondents viewed trade in digitally delivered services as under-reported, particularly on the import side. Some data discrepancies support this view. Luxembourg's services exports to EU countries substantially exceed the imports recorded by its trading partners; as an example, it has been argued that Spotify, which supplies digitally-delivered music, is captured in Luxembourg's export data, but not in the data of the importing countries.[14]

73. Only three of the surveyed countries are researching methods to measure trade in sharing economy services. Overlooked exports of gig economy services could be significant in some emerging market and developing economies. However, almost a third of OECD countries, and

[14] Spotify is headquartered in Sweden, but has a Luxembourg holding company.

almost a quarter of non-OECD countries, reported that sharing economy services are implicitly included in cross-border trade totals.

74. Intermediation services of non-resident platforms (as in Figure 5) are rarely measured. Only 15 percent of OECD countries, and 6 percent of non-OECD countries, can identify payments to nonresident digital intermediaries. Other countries, such as Thailand, are developing estimates.

75. Foreign-owned digital intermediaries are of interest for policy purposes, but separate estimates of their transactions are generally hampered by the absence of classification codes to identify them on the business register. Most respondents to the OECD and IMF surveys believe that the business register (or similar file) includes the foreign-owned digital intermediaries. However, in three-quarters of OECD countries, and nearly 90 percent of non-OECD countries, they cannot be easily identified.

76. Cross-border data flows that do not result in a monetary transaction may indirectly support revenue-generating activities, as in the case of a social networking platform with revenue from advertisers. Measures of these unpriced data flows would have policy relevance. However, none of the respondents to the OECD survey have done research on measures of unpriced data flows. Most were opposed to including imputed values of the cross-border data flows in balance of payments statistics, for both conceptual and practical reasons.

B. Digital Payments and Measurement of Cross-Border Remittances

77. Standard methods for capturing cross-border payments in BOP statistics may omit some payments using digital technologies. The effects could be particularly important for the measurement of international remittances. As is reflected in the large discrepancies between global receipts and global payments (Table 5), remittances are one of the hard-to-measure items in the balance of payments.

Table 5. Global Totals of Remittance Receipts and Payments
(Billions of U.S. Dollars)

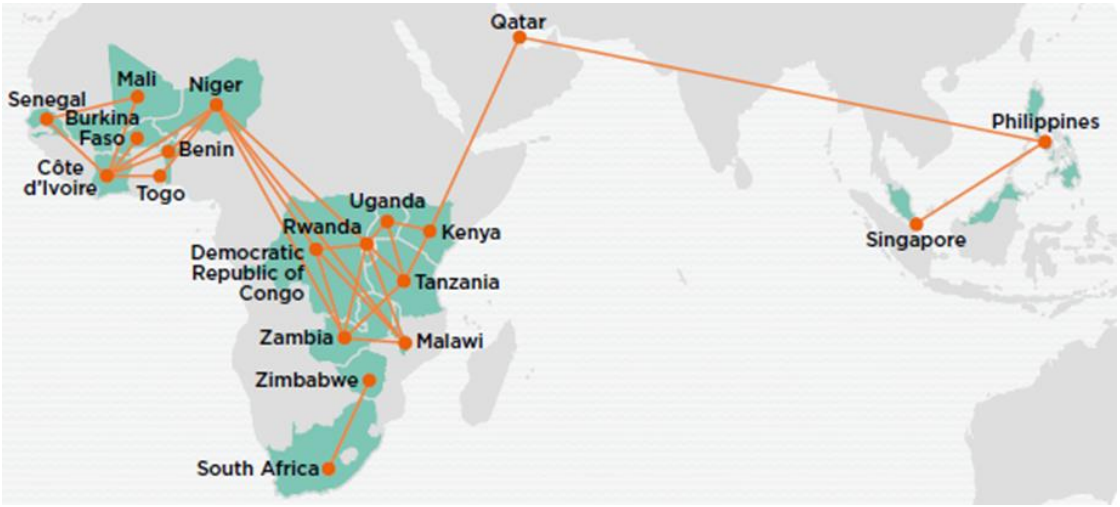
	2009	2010	2011	2012	2013	2014	2015
Credit	397.3	424.2	472.6	496.1	525.4	555.9	550.8
Debit	303.3	302.9	340.6	356.3	390.4	400.5	386.0
Discrepancy	**94.0**	**121.3**	**132.0**	**139.8**	**135.0**	**155.4**	**164.8**

Source: IMF Balance of Payments Statistics

78. Households increasingly use digital platforms to make remittances. Mobile money (whose importance in developing countries is discussed below) has a significant share of the cross-border transfers, especially between neighboring countries where the service is available. Mobile money may offer savings on transactions costs for remittances exceeding 50 percent (GSMA, 2016a),

and are available even in remote areas. Many corridors for mobile money remittances were already active as of 2015 (Figure 7).

Figure 7. Active Corridors for Cross-border Remittances via Mobile Money



Source: GSMA (2016b). Year-end data for 2015.

79. New digital channels, including mobile money, online platforms, and Bitcoin, may have exacerbated longstanding problems of gaps in the source data for estimating remittances. Common data sources for estimating remittances include reports on cross-border transactions from banks and money transfer operators (Western Union, Money Gram, etc.), and household surveys. In a survey of central banks on cross-border migrant remittance flows conducted by the World Bank in 2008–2009, just 43 percent of remittance-receiving countries indicated that they collect information on remittances through informal channels—cash brought in pockets and unregistered agents.

80. Some international mobile money transfers are probably captured by existing procedures because they pass through banks that have partnered with the mobile money operator. However, others are made directly by the mobile phone operators (Bank of Uganda, 2017). Currently, in countries where mobile money is widely used for remittances (e.g., Uganda, Kenya, Philippines), no data are collected from telecommunication companies on the cross-border remittances executed via their network, and no adjustments are made for remittances through such channels.

81. Data accuracy could improve as digital transfers replace informal mechanisms and digital transfer platforms are brought into the regulatory and reporting regimes. Measuring mobile money remittances is an area of research, and proposals exist for addressing the data gaps by surveying the telecommunication companies involved in digital transfers. Surveys of telecommunication companies should not be expensive to conduct.

DIGITALIZATION AND CHALLENGES FOR MONETARY AND FINANCIAL STATISTICS

82. The financial sector has long been an intensive user of digital technology, with the recent digitalization of financial services being termed "fintech." Fintech includes a wide range of innovative uses of technology. As in other sectors, new technologies in finance are both an enabler, helping incumbents to increase efficiency and respond to customer needs, and a disruptor, bringing new business models that compete with existing ones. Fintech raises questions of classification and measurement in monetary and financial statistics (MFS), including on marketplace lenders, e-money, and digital currencies based on distributed ledger technologies (which, for convenience, we term "digital currencies").

A. Marketplace Lending Platforms

83. Marketplace lending platforms facilitate peer-to-peer (P2P) credit transactions or lend their own funds. P2P platforms primarily match borrowers with individual investors, but they may also allow banks and other institutional investors to invest in loans. Some marketplace lenders have arrangements with a bank to securitize their loans (e.g., SoFi and Prosper).

84. Marketplace lenders operate in many countries (Figure 8), with large lending volumes in China, the United States, and the United Kingdom. They have improved access to credit and lowered the cost of credit for small and medium enterprises (SMEs) and households, by operating in underserved areas and using credit scoring models that consider non-traditional types of information. However, because they are less regulated than conventional financial intermediaries, marketplace lenders may not be subject to reporting requirements. This may delay their inclusion in MFS data, as statisticians may have to survey them directly to obtain the necessary information.

Figure 8. Distribution of Digital Marketplace Lending

Note: only countries with significant volumes are highlighted.

Source: Lending Club 2015.

85. MFS compilation guidelines classify P2P lending platforms as financial auxiliaries because in most cases, they do not assume credit risk, and they rely on fees collected from users for their income (IMF, 2016). The loans made by households with the assistance of these auxiliaries are currently not included in MFS. However, to provide a full picture of credit developments, households' P2P lending may need to be reported as supplementary information, and their loans to SMEs should be included in the integrated sectoral financial accounts of the *SNA*.

86. Marketplace lenders that extend credit from their own funds are a measurement concern. These marketplace lenders should be included in the financial sector as financial intermediaries, but the information to do so may be unavailable.

B. E-Money

87. E-money is defined as a monetary value, represented by a claim on the issuer, that is electronically stored on a card, device or server, and used for payments to third parties. It includes mobile money, widely-accepted pre-paid cards, and web-based products. However, many digital instruments or services used for payments do not qualify as e-money. Digital currencies (discussed below) are not e-money, and neither are credit and debit cards, as no monetary value is stored on them. Also, excluded from e-money are mobile phone payment applications (such as scanning a QR code) that are linked to an account at a financial institution, and pre-paid cards that can be used at only certain stores.

88. Although e-money has a low share in the money supply and in payment transactions (Table 6), as an accessible substitute for transferable deposits, it plays an important role in financial inclusion. Mobile money, a form of e-money stored in mobile phone accounts, is widely used in many emerging and developing economies. As of 2015, the number of mobile money accounts approached or exceeded the number of bank accounts in 21 African countries (Table 7), and it was present in more than 90 countries (Figure 9). Among the benefits of mobile money for financial inclusion is greater access to financial services for women.

89. The accuracy of existing MFS appears to be largely unaffected by e-money. To safeguard the claims on e-money issuers, regulations generally require the issuers to mirror the value of the outstanding e-money in an escrow account at a regulated financial institution. Some mobile money operators also offer non-payment services. This also poses no measurement problems, because they must partner with a regulated financial service provider covered by reporting requirements, or obtain a license that brings their business into the regulatory regime. However, mobile money does have implications for data dissemination, as data are needed to analyze the effects on financial inclusion. It may also create opportunities to improve accuracy of other kinds of statistics on transactions of households using data from the providers of mobile money services.

Table 6. Share of E-money Transactions in Noncash Payments in 2015

Advanced Economies		Emerging and Developing Economies	
Country	**Percent of Value of Transactions**	**Country**	**Percent of Value of Transactions**
Austria	0.01	Albania	0.02
Belgium	0.01	Brazil	0.01
Cyprus	0.02	Bulgaria	0.02
France	0.00	Croatia	0.00
Germany	0.00	Dominican Republic	0.01
Greece	0.07	Egypt	0.14
Ireland	0.02	India	0.05
Italy	0.21	Maldives	0.04
Korea, Republic of	0.00	Namibia	0.18
Malta	0.03	Nigeria	0.94
Netherlands	0.00	Russian Federation	0.13
Norway	0.00	Samoa	0.16
Portugal	0.08	Thailand	0.02
Singapore	0.24		
Slovenia	0.00		
Sweden	0.00		
Switzerland	0.03		

Notes: Total non-cash payments equal the sum of debit card payments, credit card payments, direct debits, credit transfers, checks, and e-money payments. Data cover 2015 or most recent year available.

Sources: CPMI (2016), GPSS (2017), and IMF staff calculations.

Figure 9. Availability of Mobile Money Services Around the World

Source: GMSA (2017).

Table 7. Mobile Money Share of Accounts

Percent of Total Number of Accounts at Mobile Phone Companies and Commercial Banks

Afghanistan	6.04	Guyana	2.21	Pakistan	25.40
Armenia, Republic of	7.65	Indonesia	16.48	Philippines	19.61
Bangladesh	30.60	Jordan	1.85	Qatar	12.79
Benin	**50.95**	Kenya	47.34	**Rwanda**	**84.84**
Botswana	**51.19**	**Lesotho**	**65.16**	Samoa	21.16
Burkina Faso	47.76	Liberia	27.13	**Senegal**	**65.00**
Cambodia	14.33	**Madagascar**	**65.21**	Seychelles	1.02
Cameroon	**79.62**	Malawi	19.73	Solomon Islands	20.43
Chad	0.95	Malaysia	1.27	South Africa	9.99
Congo, Republic of	**63.43**	**Mali**	**63.61**	Swaziland	39.99
Cote d'Ivoire	**78.10**	Mauritius	21.71	**Tanzania**	**87.40**
Dominican Republic	11.25	Mexico	7.93	Togo	15.01
Egypt	12.33	Mongolia	10.47	Tonga	37.55
Fiji	40.80	Morocco	0.01	**Uganda**	**81.89**
Gabon	5.72	Mozambique	42.42	Vietnam	6.24
Ghana	**53.31**	Myanmar	0.61	**Zambia**	**65.29**
Guatemala	6.93	Namibia	33.13	**Zimbabwe**	**91.51**
Guinea	**51.63**	**Niger**	**76.41**		
Guinea-Bissau	0.24	Nigeria	13.75		

Notes: Total number of accounts includes mobile money accounts and deposit accounts at commercial banks (or number of depositors if number of accounts is unavailable). Data cover 2015 or most recent year available.

Sources: Financial Access Survey (2017a), and IMF staff calculations.

C. Digital Currencies

90. A digital currency is a means of payment that only exists electronically. Cryptocurrencies such as Bitcoin are the best-known type of digital currency.[15] Over 1,300 digital currencies exist, and in early 2017, there were between 2.9 and 5.8 million unique active users of digital currency wallets (Hileman and Rauchs, 2017). Digital currencies also have the potential to affect the measurement of liquidity in the financial system if they become widely accepted as medium of exchange.

91. Several central banks are investigating issuance of digital currencies, on which data are not reported at present. In addition, private digital currencies raise measurement issues for financial, macroeconomic and balance of payments statistics because the residency of the holders is unavailable.

92. Existing digital currencies do not qualify as money in the current MFS framework. At present, they are classified as nonfinancial assets in MFS compilation guidelines. According to the internationally-accepted MFS framework, Bitcoin is not classifiable as money because it is not issued

[15] As of March 2017, Bitcoin's total market capitalization was US$25 billion, compared with US$1.5 trillion of U.S. dollar currency in circulation. But in February 2018 its capitalization was almost $150 billion.

or authorized by a central bank or government, is not widely accepted as a medium of exchange, and exhibits excessive price volatility to be considered a store of value. If and when digital currencies become widely accepted as a medium of exchange, consideration will be given to their inclusion in a broader measure of liquidity.

POLICY IMPLICATIONS AND RECOMENDATIONS

93. Slow productivity growth is a genuine phenomenon requiring policy responses, not a measurement error in the statistics. The arguments that attribute the poor growth of productivity since the financial crisis to measurement error reflect misconceptions about the purpose and scope of GDP and productivity statistics and exaggerated impressions of the weight in GDP of the potentially mismeasured products. Where research and data exist, as in the United States, they indicate that underestimation of digital sector output could subtract 0.3 percentage points from the productivity growth rate, compared to a 1- to 2-percentage point slowdown in productivity growth rates.[16] The impact in other countries may be lower or higher, depending on the extent of digitalization of the economy and statistical capacity.

94. Largely symmetric effect on price statistics, yielding a slight overestimation of inflation. Under adjustment for quality change, and lags in bringing new products and suppliers into price index samples, often result in overstatement of price change for digital products that embody advancing technology. The implied understatement of growth and productivity has been widely discussed. However, if growth has been understated, inflation must generally have been overstated by a roughly similar amount, an implication that has been usually overlooked in the debate on the potential mismeasurement of digitalization. This implication is particularly relevant for the assessment of the monetary policy stance in economies which have suffered deflationary pressures while experiencing a rapid digital transformation, in the last decade.

95. The rapidly growing digital sector and digital transactions present measurement challenges that may affect the quality and relevance of the data used for surveillance. Even though mismeasurement of the digital economy plays only a minor role in the productivity slowdown, digitalization has exacerbated some weaknesses in compilation methods and created new data needs in a broad range of macroeconomic statistics. There may also be a need to consider adjustments to the GDP production boundary, including a treatment of data as an asset or product, and alternative treatments of relocations of MNEs in national accounts and BOP statistics.

96. Addressing these challenges requires development of, and international agreement on, updated or improved definitions, classifications and measurement techniques. Under the articles of agreement, the Fund is well-positioned to promote international cooperation and research on these issues, as it is to "*act as a centre for the collection and exchange of information on monetary and financial problems, thus facilitating the preparation of studies designed to assist*

[16] Furthermore, mismeasurement was also present before the slowdown began, and did not increase.

members …" (Art. VIII, Section 5). International organizations should work to update classification systems for digital activities and products to support needed measurement improvements, and to develop guidelines and recommendations on measuring digital transactions. The Fund must also be ready to respond to requests from member countries for technical assistance on measurement of the digital economy.

- *Recommendations:*
  a) Improve coverage of digital platforms and services linked to digital platforms in the main classification system; and
  b) Develop aggregate classifications covering the digital sector, digital products and digital transactions.

97. National statistical offices require additional resources, and better access to source data, to be able to implement compilation improvements and data enhancements. International guidelines and recommendations are necessary, but not sufficient. Resources are needed to improve compilation methods and disseminate additional indicators, including possible new indicators of welfare and nonmarket production linked to digitalization. NSOs also must be able to access the source data needed to compile macroeconomic and financial statistics. Declining survey response rates, and emerging new economic sectors and products, make it essential for statistical agencies to expand the use of administrative data and new data sources linked to digitalization, or "Big Data." Government agencies should be encouraged to share data needed for statistics, a strategic public good. National and international organizations should facilitate access to Big Data through partnerships with global firms.

- *Recommendations*:
  a) Endow national statistical offices with sufficient resources to measure digital products and to develop indicators of welfare effects of digitalization; and
  b) Ease access by national statistical compilers to administrative data, and Big Data, promoting sharing administrative data with statistical agencies, as well as partnerships between the private and public sectors, including international organizations.

98. The fundamental conceptual framework of GDP remains valid, but how digitalization has affected welfare is a policy-relevant issue. The definition of GDP should continue to be market and near-market production at market prices where these exist. Anchoring GDP to market activity allows a consistent framework of three closely-linked macro-indicators: *Value Added* (or non-duplicated Output), *Income*, and (final) *Expenditures*. However, rapid increases in free digital services and household non-market production made possible by digitalization have widened the gap between GDP growth and household welfare growth. Indicators "beyond GDP" are needed to understand the welfare from nonmarket production enabled by digitalization.

99. This paper's analysis of the issues raised by digitalization for each area of statistics also implies some technical recommendations. *For price statistics,* the main compilation challenges are improving quality adjustment procedures for ICT goods and services, timely inclusion of new digital product varieties and suppliers in the detailed indexes, and timely inclusion of new digital products in the basket and weighting structures of the high-level index. Methods for adjusting the

prices of new products for quality change have been developed, but they often have substantial input data requirements, resource requirements, and statistical capacity requirements.

- *Recommendations:*
  a) Statistical agencies should focus on quality-adjusting a selective list of products drawing on quality adjustment work of other countries;
  b) International organizations should develop compilation approaches fit-for-use by compilers facing severe resource and data sources constraints; and
  c) Statistical agencies should consider innovations in data sourcing and collection, and processing to include new digital products in index compilation as soon as they become important.

100. ***For national accounts*****,** key compilation challenges involve deflation, and complete coverage of digital platforms and platform-enabled activity. Improved quality adjustment procedures for products benefitting from advances in digital technology are part of the solution for deflators. More rapid and extensive access to source data, updated classifications, and adjustments for missing data are elements of the solution for coverage gaps.

- *Recommendation:*
  a) National accounts compilers and price statisticians should work collaboratively to align the composition of the deflators for digital products with the composition of the aggregates that need to be deflated by ensuring that the deflators reflect the current mix and sourcing of digital products and, where possible, by using datasets containing prices and quantities to simultaneously calculate deflators and nominal values.

101. ***For external sector statistics,*** measurement challenges include growth of small transactions and of cross-border services and payments using digital platforms.

- *Recommendations:*
  a) Statistical agencies should update assumptions concerning small transactions facilitated by digital ordering and digital delivery of services;
  b) Enhance collection of information on cross-border services provided by, or through, online platforms; and
  c) Develop methods for estimating international payments via new kinds of digital channels, such as remittances via mobile money.

102. ***For monetary and financial statistics****,* in the future the new liquidity and credit generated by fintech could become important.

- *Recommendations:*
  a) Add marketplace lending platforms that lend their own funds to credit statistics, and report supplementary data on peer-to-peer lending; and
  b) Investigate methods for compiling statistics on digital currencies.

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Annex I. Link Between Consumption and Welfare Growth

1. The level of consumption, measured by price times quantity, *understates* welfare because it excludes the consumer surplus. In the diagram below, the initial position of the demand curve implies a quantity consumed at price p of q_0, making consumption equal to the area of rectangle c. Consumer surplus, defined as the excess of the willingness-to-pay over the amount paid, is given by the part of the area under the demand curve that is above the price line, the triangle labeled s. Welfare is measured by the area under the demand curve out to q_0, c+s.

2. The growth of real consumption equals (or approximates) the welfare growth. Assume that income growth causes the demand curve to shift to the right, so that the quantity consumed becomes q_1. The price is constant, so nominal consumption growth, given by $(c+\Delta c)/c$, equals real consumption growth, q1/q0. Welfare growth, given by $(c+\Delta c+s+\Delta s)/(c+s)$, also equals real consumption growth.

3. The weights used to calculate aggregate growth of real consumption are based on prices as the measure of value. These weights allow aggregate growth to approximate the welfare growth.

Effect of Increase in Income on Consumption and Welfare