POLICY MAKING IN THE DIGITAL AGE

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Digital Economy Measurement and Digital Policy

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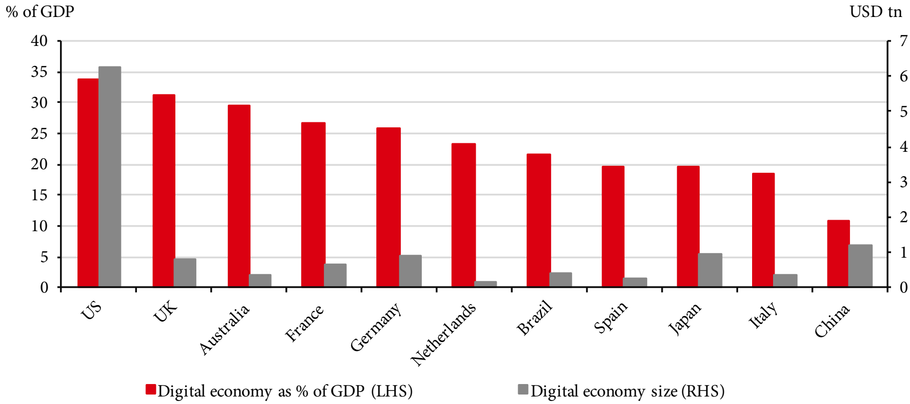
INTRODUCTION

The digital economy refers to the global network of economic and social interactions facilitated by digital technology – most notably the Internet. There is evidence to suggest that the digital economy is a significant source of economic activity in many major economies (Figure 1). Despite this, there is an ongoing debate within

Figure 1. Contribution of the digital economy to economic activity[1]



Source: "Digital Disruption: The Growth Multiplier," Accenture 2017 the economics profession between "techno-pessimists" such as Gordon (2012) and "techno optimists" such as Brynjolfsson and McAfee (2014) regarding the significance of the digital revolution for economic growth – the latter believe that technology will play a large role in driving unprecedented growth in the global economy, while the former believe that the boost to productivity growth from the information and communication technology revolution has already been and gone. The digital economy's lack of visibility in official statistics has made this debate difficult to resolve. There are currently no internationally agreed-upon definitions of the digital economy and digital trade for national accounting purposes. However, such definitions are crucial if policymakers are to account for the significant economic and welfare benefits generated by the digital economy.

1. Digital economic activity here includes spending on digital skills, digital equipment, software, and intermediate digital goods and services. Because intermediate production is included, it is not strictly comparable to gross value added in GDP, which is measured net of intermediate inputs.

IS THE DIGITAL ECONOMY MISMEASURED?

Stiglitz, Sen and Fitoussi (2009) observe that Gross Domestic Product (GDP) is predominantly a measure of market production. With some exceptions, most forms of non market or home production are considered beyond the GDP "production boundary". A consequence of this exclusion is that GDP declines when private or home-based production is substituted for market production. Bean (2016b) and Coyle (2017) argue that digitisation has facilitated greater substitution of home for market production in recent times. This reflects the rapid growth in digitally disintermediated online travel, employment, banking and other financial services where individuals are encouraged to perform services for themselves with the aid of digital platforms; the development of open source software such as Linux and Apache; the increase in online video sharing and the production of content for social media, wikis and blogs; and other new phenomena such as self-checkouts at supermarkets.

While GDP statistics may have been overstated in the 20th century due to the shift from home based production activities to market activities, this trend may have reversed to some extent in the 21st century. No comprehensive estimates of this substitution effect currently exist, although estimates of the value of individual examples of the voluntary household production of free digital products, the sharing economy, and digitally disintermediated services performed by customers tend to be relatively modest where available. Nonetheless, taken collectively, these could represent a significant contribution to digital mismeasurement.

To facilitate comparisons of the "real" change in the quantity of production over time, GDP needs to be separated into changes in quantity and price. To isolate these effects, the components of nominal GDP must be deflated using relevant price indexes to obtain estimates of "real" GDP. The process of decomposing output into changes in price and quantity results in a range of known measurement challenges.

First, it is often difficult to separate price movements into "pure" nominal changes and those related to changes in product quality or characteristics. Failing to adjust prices for quality changes will result in upward-bias in price indexes and subsequent under-measurement of real GDP. This is of particular concern in the digital economy context, as computers, smartphones and software have experienced rapid improvements in performance and functionality over recent decades.

Second, real GDP can be underestimated when new products or services are not introduced into the measurement sample in a timely manner. For example, Hausman (2003) found that the United States Bureau of Labor Statistics did not include mobile phones in their price indexes until 15 years after their release.

During this period of omission, the price of mobile phones declined precipitously.

Finally, price indexes can be upwardly biased when different stores sell identical products at different prices. Specifically, when a new outlet enters the market and sells a particular product at a lower price than other retailers, current statistical practices assume this price reduction reflects a real reduction in the quality of service provided, and therefore no net price reduction. This form of bias is referred to as outlet substitution bias, and may have increased in recent years due to the entry of online retailers. Thus, there are compelling reasons to believe that digitisation may be exacerbating these known measurement challenges.

In fact, economists have found evidence that inadequate price adjustments in response to improvements in the quality of Information and Communications Technology (ICT) products (such as computers, communications equipment and software) have led to under-measurement of the digital economy and economic growth (see Byrne, Fernald and Reinsdorf (2016); Ahmad and Schreyer (2016); Syverson (2017); and Groshen et al. (2017)).[2] For example, Groshen et al. (2017) find that United States (US) real GDP growth was under-measured by 0.23 percentage points in 2000, declining to 0.15 percentage points in 2015, due to these adjustment failures. While the inadequate price adjustment of the limited range of ICT products considered in these papers is not highly significant for GDP growth estimates due largely to the offsetting effects of the investment and import price indexes, they nonetheless have the potential to contribute to substantial mismeasurement of Consumer Price Index (CPI) inflation.

2. At the upper-end of the spectrum, Byrne and Corrado (2017) estimate their adjusted ICT price indexes add about 0.22 percentage points to US real GDP growth. While most of the decline in mismeasurement identified by the authors occurred before 2005, the more gradual decline between 2010 and 2015 suggests that weak investment growth post-crisis may also be contributing to the decline in mismeasurement.

These modest mismeasurement findings may also be a result of not fully accounting for the transformative changes in the quality and functionality of some more recent innovations such as tablets and smartphones. Varian (2017) notes that mobile phones now provide the functionality of cameras, GPS, landline telephones, gaming machines, eBook readers, computers, movie players, audio players, maps, password generators, fitness monitors, alarm clocks, web browsers, calculators, recording devices, video cameras and many other functions. The failure to fully adjust the prices of smartphones for these quality improvements will result in the mismeasurement of price indexes. For instance, Byrne, Dunn and Pinto (2016) estimate that mismeasurement of price declines for tablets alone is biasing US labour productivity downward by 0.1 percentage points per year. Byrne and Sichel (2017) also point out that prices for many ICT products, such as industrial robots, electro-medical instruments, and defense and aerospace equipment, remain completely unstudied. Meanwhile, Feldstein (2017) has argued that failing to account for the consumer welfare benefits of new products may be a greater source of digital mismeasurement than inadequate quality adjustment.

Syverson (2017) also suggests that digital mismeasurement alone cannot explain the entire post-2004 labour productivity slowdown in the US (worth approximately $US 9,300 per person in 2015), even if estimates of the consumer welfare benefits of the Internet are taken into account. Using the method of Goolsbee and Klenow (2006), Syverson estimates these consumer welfare benefits at only around $US 3,900 per person in the US in 2015, well short of the per capita cost of the observed labour productivity slowdown. While acknowledging the conceptual differences between GDP and consumer welfare, recent research is challenging this conclusion.

Table 1 reports survey responses from Brynjolfsson, Eggers and Gannamaneni (2017), in which participants were asked how much they would need to be paid to forego access to various free digital services. The median annual consumer surplus from free digital goods studied in the US amounted to a highly significant two thirds of median household disposable income per person in 2016. Despite being subject to hypothetical and selection biases, the numbers suggest that recent changes in GDP per capita

Table 1 Survey-based Estimates of Median Annual Consumer Surplus from Free Digital Goods in 2016 (USD)	
Search engines	$16,629
E-mail	$6,896
Digital maps	$2,790
Online videos	$936
E-commerce	$771
Social Media	$188
Messaging	$145
Music	$144
Total	**$28,499**
Official household disposable income per capita	$43,469

Source: "Using massive online choice experiments to measure changes in well-being," by Brynjolfsson, E., Eggers, F. and Gannamaneni, A., MIT Working Paper, 2017

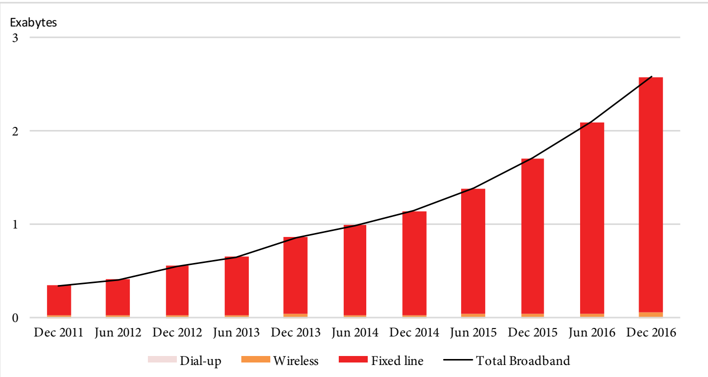
Note: The most recent official data from Australia suggests that the average number of hours spent online for personal use in a typical week per Internet user was around 10 hours per week in 2014–2015. If one were to value this time based on average hourly earnings data for May 2017, the total would be around A$20,400 (US$15,200) per annum. However, other sources report higher levels of Internet use in Australia. For example, Quiggin (2014) reports estimates of time spent actively engaged in the Internet economy of 3 hours per day, and Roy Morgan Research (2016) report the average Australian aged over 14 spends 19 hours per week using the Internet, 13 hours of which occurs in the home. The higher estimates of Internet use reported by Quiggin and Roy Morgan Research place the value of time use associated with the Internet more in line with the estimates of Brynjolfsson, Eggers and Gannamaneni (2017). For instance, 21 hours of weekly use implies a value of around A$43,300 (US$32,275) and 19 hours per week a value of A$39,200 (US$29,200) per annum. The fact that official ABS data indicates that 15 to 17 year olds are spending 17.8 hours online for personal use on average in a typical week suggests there may be some scope for estimates of the welfare benefits of the Internet based on time-use to increase in future years.

may be significantly understating changes in living standards. The welfare value of the Internet is also evident in data concerning the time people spend online—recent data from Australia suggests that valuing the amount of personal time users spent on the Internet (10 hours per week) using average hourly earnings would result in a total of $US 15,200 per person per annum. There is evidence to suggest that this is a lower bound, as other sources report higher levels of Internet use in Australia, and Australian Bureau of Statistics (ABS) data on the Internet usage of 15 17 year olds (17.8 hours per week) seems to indicate that there may be some scope for estimates based on time-use to increase in the future (Figure 2).[3]

The provision of free digital services in unlimited quantities is a unique (and arguably critical) aspect of the digital economy. However, these same attributes present fundamental measurement challenges for statisticians. Nevertheless, using Nakamura and Soloveichik's (2015) method of valuing free media based on the value of advertising expenditure, Byrne, Fernald and Reinsdorf (2016) find that free digital services such as Facebook imply

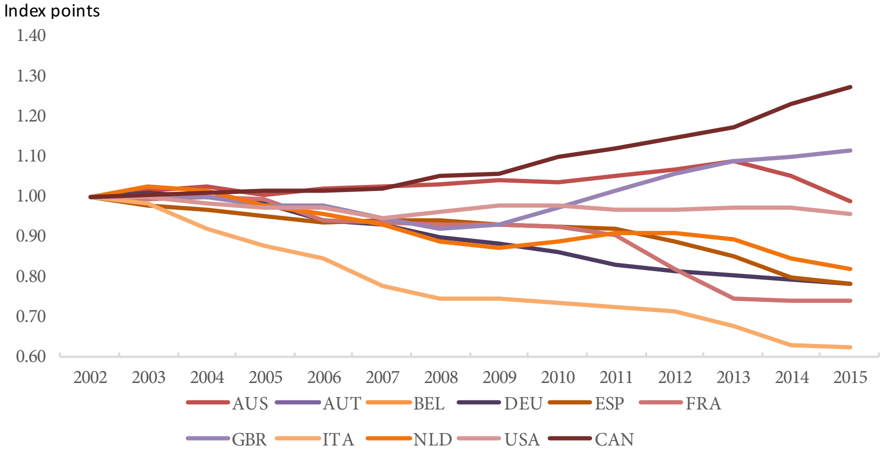
3. At the upper-end of the spectrum, Byrne and Corrado (2017) estimate their adjusted ICT price indexes add about 0.22 percentage points to US real GDP growth. While most of the decline in mismeasurement identified by the authors occurred before 2005, the more gradual decline between 2010 and 2015 suggests that weak investment growth post-crisis may also be contributing to the decline in mismeasurement.

Figure 2. Volume of data downloaded (Australia)



Source: "Volume of data downloaded by access connection," Australian Bureau of Statistics, 2017

Figure 3. Price indexes for telecommunication services (2002=1.0)



Source: "National Consumer Price Indices (CPIs)," OECD, 2017

Note: The significant differences in price indexes for telecommunication services between countries, something that is also apparent for computer and software price indexes, highlights the need for a more consistent and comparable approach to measuring the digital economy internationally.

an upward revision to post 2004 US labour productivity growth of only 0.0065 percentage points per annum on average. Bean (2016b) however argues this represents an extreme lower bound for digital mismeasurement related to free digital services. Not all free digital services are subsidised by advertising; for instance, Facebook and Google also earn income from the analysis of user data, and many, such as Wikipedia, are provided completely for free. Modest estimates of growth in the value of free digital services are also difficult to square with the fact that physical data flows have been increasing exponentially, suggesting that the consumption of digital services is actually growing extremely rapidly. For instance, Figure 3 indicates that over the five years through December 2016, the volume of data downloaded in Australia has grown at a staggering average rate of 50 per cent per annum.[4]

So how might "data on data" help improve measurement of digital services for national accounting purposes? The ABS (2017) recommends the "unit value approach" for deflating telecommunications services. For telephone calls, this means price is derived by dividing total revenue received by the number of call minutes. Extending the same treatment to pricing fixed and mobile broadband services would suggest dividing total revenue for these services by data use.[5] This would imply a rapid decline in the price index for telecommunications services in Australia in recent years. However, as Figure 4 demonstrates, the telecommunications price index was actually increasing between 2002 and 2014. This, in essence, showing that real GDP growth has been understated.

Given the rapid growth in data flows, potential adjustments to the CPI and real rates of growth based on data use could be significant. For example, Bean (2016a) deflated telecommunications services in the United Kingdom (UK) by the growth rate in consumer Internet traffic and found that annual real GDP growth would have been 0.7 percentage points higher on average over the preceding decade.[6] In a more detailed study, Abdirahman, Coyle, Heys, and Stewart (2017) find upward bias of the UK telecommunications services price index of between 35 and 90 per cent between 2010 and 2015 depending on the method used. The lower bound corresponds to deflating mobile and fixed broadband services using data flows; and the upper bound deflating all telecommunication services using data flows. Coyle and Mitra-Kahn (2017) report that the upper bound methodology would add as much as 1.5 percentage points per annum to UK real GDP growth between 2010 and 2015. While some may argue that deflating all telecommunications services using data usage is overly aggressive and sits uncomfortably with existing statistical

4. This is consistent with the prediction of Gantz and Reinsel (2012) that digital information should double every two years between 2015 and 2020. Cisco (2017) also predict that Australian consumer Internet traffic will grow at an average compound annual growth rate of 28 per cent between 2016 and 2021, slightly above the global average of 27 per cent.

5. Text messages and phone calls can also be priced on a per bit basis.

6. Van Ark (2016) also reports private data from the US suggesting price declines of 25 per cent per annum for broadband services since the turn of the century. Other ICT services are experiencing similar trends, with cloud services in the US experiencing price declines of 30 per cent per annum on average over the same period. .

practices, deflating fixed and mobile broadband services in this manner would materially increase estimates of digital productivity and economic growth.[7]

Digital businesses also make significant investments in intangible assets not fully captured in company and national accounts. Though data is the defining asset of the digital economy, Ahmad and Schreyer (2016) note that the SNA 2008 (System of National Accounts), which includes in GDP investment in intangible assets such as research and development (R&D), database creation, computer software, and literary/artistic originals, only seeks to measure the cost of physically producing and maintaining a database, rather than the inherent

Table 2 Price -to-book ratios

Apple	6.54
Amazon	22.16
Microsoft	7.26
Facebook	7.15
Alibaba	9.18
Microsoft	6.28
Tesla Motors	10.87
Google	4.53
Baidu	4.93
Atlassian	11.56

Source: Bloomberg and Yahoo Finance (accessed 05/12/2017)

7. In the Australian context, applying the Bean (2016a) methodology to all telecommunications services would require making data usage assumptions for phone calls and text messages. Given that some measures of data use are averaging 15 percentage points a year higher than the data use assumption adopted in the Bean Review (2016a), this could imply higher estimates of growth mismeasurement if all telecommunications services were treated as data services and deflated using data flows. On the other hand, only deflating fixed and mobile broadband services using data flows and incorporating these on a revenue weighted basis into the telecommunications services price index would lead one to expect a lower increment to growth in real GDP. For instance, in the UK, Abdirahman et al. (2017) found fixed and mobile broadband revenues represented around 40 per cent of telecommunications revenue in 2015, implying a 40 per cent revenue weight in the bundle of telecommunications services. However, a reservation regarding this approach is that fixed and mobile broadband services are relatively underweighted in telecommunications services revenues, and over-weighted in terms of data volumes. For example, in the UK in 2015, fixed and mobile broadband services contributed 99.6 per cent of data flows. In the event that fixed line rental charges and other price differences between voice, text and data services are competed away over time, we would expect mismeasurement estimates using the two different approaches to converge over time. .

value of data itself. Indeed, it is likely that the only time the value of a database is fully reflected in GDP is when it is sold as part of a going concern whereby the value is captured as purchased goodwill. However, in many countries, including Australia, even this is not captured in national accounts. For a long time, economists such as Corrado, Hulten, Sichel (2005) have argued that expenditures on services like employee training and the development of firm-specific human capital, strategic planning, improving firm management and organisational processes, and developing brand equity should be included as investment in company and national accounts. This is on the basis that any expenditure that reduces current consumption with a view to generating future benefits should be regarded as investment. The disparity between share market and book valuations for a range of leading international technology companies suggests that unmeasured intangible investments such as these are critically important in the digital economy (Figure 5).

Van Ark et al. (2010) found that between 1995 and 2006, GDP growth rates would be 0.1 to 0.2 percentage points higher in a number of advanced economies if the broader definition of intangible assets proposed by Corrado, Hulten, Sichel (2005) was adopted in national accounts. However, more recently Byrne, Fernald and Reinsdorf (2016) have found that under-measuring intangibles had no impact on US growth rates between 2004 and 2014. This may be due in part to multinational profit-shifting activity related to intangibles. Adjusting for the transfer pricing activity of US multinationals alone, Guvenen et al. (2017) find that US labour productivity growth from 1994 to 2004 is 0.1 percentage points higher per year and 0.25 percentage points per year higher between 2004 and 2008.[8] Beyond 2008 they find no mismeasurement of labour productivity growth which may be attributable to cyclical factors. They find the greatest mismeasurement in industries that undertake significant R&D activities or produce information technologies.[9] While recent estimates of

8. Productivity growth from 2006 to 2008 was also almost a percentage point higher after accounting for profit shifting.

9. While no similar exercise has been conducted for Australia, IMF (2014) analysis suggests that the reallocation of multinational profits on the basis of the location of assets and/or payroll costs would increase Australian GDP in a similar manner.

mismeasurement of economic and productivity growth related to intangibles have been small, unmeasured intangible investment arguably still results in the material understatement of the level of investment, GDP and labour productivity.[10]

WHAT ARE THE CONSEQUENCES OF DIGITAL MISMEASUREMENT FOR POLICY?

Measurement challenges are making evidence-based digital policymaking more difficult. Important policy debates concerning digital infrastructure, online competition policy, digital trade, taxation, ICT security, opening public data, privacy rights and restrictions to the free flow of information online are currently being conducted largely without the benefit of official statistics. A more comprehensive understanding of data flows, how and where value is created in the digital economy, the value of investment in data, and cross border flows related to digital services and intangibles would provide valuable information to assess the costs and benefits of various policy interventions.

The rapid growth in free digital products and services could be contributing to the weakness in inflation currently observed in many developed economies, making life more difficult for central banks. Mismeasurement may also have important consequences for monetary policy. Jacobs, Perera and Williams (2014) have suggested that Australian CPI inflation could be overstated by up to 1.2 percentage points per annum relative to that derived using a true cost-of-living index due to new products, incomplete quality adjustment and substitution bias. As discussed above, digitisation is potentially exacerbating these sources of bias. If inflation is upwardly biased in unanticipated ways, this could increase the risk of central banks underestimating the degree of excess capacity in their economies, and adopting inappropriately tight monetary policy settings. Blanchard, Cerutti and Summers

10. In the Australian context Fox and Elnasri (2017) found total Corrado, Hulten and Sichel (2005) defined intangible investment of A$82 billion for Australia in 2012–2013, of which A$47.3 billion at the time was not included in national accounts. While some criticise the Corrado, Hulten and Sichel (2005) methodology as relying on some 'heroic' assumptions, work by Bucifal and Bulic (2016) which reduces reliance on arbitrary assumptions actually suggests that the number for intangibles not capitalised in the national accounts for Australia in 2012–2013 could be around A$4 billion higher. Consideration should be given to developing broader measures of intangible investment in the context of developing digital satellite accounts

(2015), Ball (2014), and Anzoategui et al. (2016) suggest that this could have adverse long term consequences for growth in potential output and productivity.

The digital economy may also present challenges for fiscal policy. To the extent that home production and free digital products and services are substituting for market production, this translates to a reduction in tax revenue for governments, eroding both consumption and income tax bases. Further, upward bias in measured inflation has consequences for government spending where program funding is indexed to inflation. The Boskin Commission (1996) famously argued that CPI measurement bias in the US could contribute US$148 billion to the deficit by 2006, making it the fourth largest federal government spending program behind social security, health care and defence.

CONCLUSIONS

The digital economy is large, rapidly growing and provides significant welfare benefits to consumers in many major economies. Despite this, it lacks visibility in official statistics. While GDP was never intended to be a measure of welfare, policymakers tend to view it as a proxy. Significant welfare benefits generated by the digital economy currently fall outside the GDP production boundary, suggesting that growth in GDP per capita may be becoming a less reliable guide to improvements in living standards. While recent studies suggest mismeasurement of GDP growth related to some ICT products, intangibles and software has been relatively modest, mismeasurement related to digital services could be more substantial and warrants further investigation. Better evidence concerning the substitution towards home production due to digitisation is required, and more regular time use surveys incorporating questions on digital time use would be helpful in this regard. Digital mismeasurement could ultimately be a story of many individually small sources of mismeasurement adding up to a more significant whole. The poor visibility of the digital economy in official statistics remains a challenge to evidence based digital policymaking, while digital mismeasurement could be sending misleading signals to macroeconomic policymakers.

Core macroeconomic statistics need to adapt more quickly to the changing structure of the digitally enabled global economy. Increasing research effort concerning the measurement of ICT products and services, intangibles, the value of data and data flows, and the substitution of market for digital home production should be priorities, especially given the promise that new digital measurement techniques hold for resolving broader economic measurement challenges.[11] Satellite accounts are appropriate vehicles to experiment and progress incremental reforms. Many countries are already moving in the right direction. The US Department of Commerce (2016) is conducting a three-year review to improve the measurement of cross-border data flows, define the digital economy, and provide initial estimates of the digital economy's contribution to GDP. The United Kingdom has established the Economic Statistics Centre of Excellence tasked with undertaking research to improve new economy measurement. Given the scale and rapid growth of the digital economy in most developed economies, improving digital measurement will remain important for policy makers globally as well.

11. For example, Cavallo and Rigobon (2016), Cavallo (2017) and Redding and Weinstein (2016) highlight the promise of online data and Big Data techniques for addressing broader measurement challenges regarding new goods and quality change.

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