# Economic Measurement in the Digital Era: Measuring the Unmeasurable

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## Highlights

- The digital economy's rapid ascension has coincided with a notable slowdown in economic and productivity growth in most advanced economies that predated the 2008 financial crisis.
- Due to the lack of observable market prices for most digital products, traditional macroeconomic aggregates might not be capturing the full extent of the digital economy. This raises the question of whether a sizable share of economic output is being mismeasured.
- The research available today indicates that economic mismeasurement, while it exists, is likely insufficient to explain the recent slowdown in economic and productivity growth.
- Thus far, economic mismeasurement is unlikely to have a material impact on monetary and fiscal policies, but this storyline could change as the digital economy grows larger.

In most advanced economies, the rise of the digital economy has coincided with a noticeable slowdown in economic and productivity growth that predated the global economic downturn of 2008. This overlap, alongside the digital economy's distinctive characteristics (i.e., digital goods and services that are often free to consume and therefore excluded from traditional economic measurement) has given a renewed salience to concerns about the accuracy of traditional economic indicators.

While there is little doubt that economic mismeasurement exists, the consensus is that it is relatively small, and importantly, not materially worse than it has been in the past. It is therefore insufficient to fully explain the economic and productivity slowdown of recent years. Still, most modern economic indicators were designed at a time when economic activity consisted largely of goods production. The shift to an increasingly digitally-based services economy exacerbates long-standing measurement challenges, while also bringing new ones to light.

## The price is (mostly) right

Measurement challenges can be grouped into price and quantity issues. The two are interrelated. Let's start with a discussion of challenges in measuring prices and inflation. Notionally, inflation should represent the evolution of living costs for an average consumer in a given economy. Central banks around the world monitor it diligently and rely on its stability as a measure of success in achieving their objectives. Governments routinely use it for indexation purposes, including social benefits and income tax systems, while businesses may use it to make cost-of-living adjustments to wages and salaries. For financial markets, a country's inflation rate provides important information about the relative purchasing power of its currency and the riskiness of investing in its financial markets. Therefore, given its importance, it's critical that measures of inflation are as accurate as possible.

The most commonly used measure of inflation is growth in the consumer price index (CPI). While the methodology used to calculate the index has undergone numerous improvements over the years, the underlying principles have remained consis-

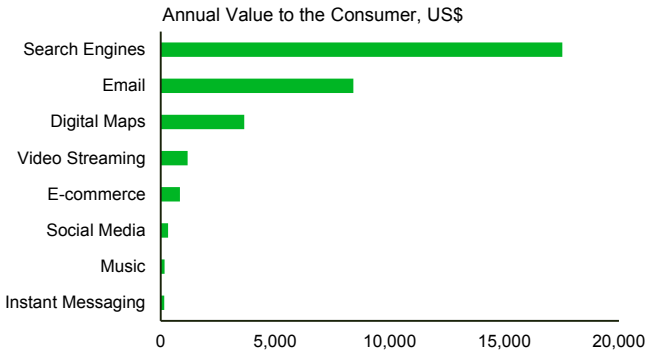
tent. Based on household consumption habits, a basket of *market* goods and services is priced and the fluctuations in the price of this basket are tracked over time. Consumption patterns tend to change as tastes evolve and new goods and services become available. So, statistical agencies are faced with the task of regularly updating the consumption basket contents and component weights to keep them as current as possible.

The challenge with digital goods and services is that their pricing structure is often very different from traditional goods and services. If we consider some of the most popular digital products available today, many are free – or quasi free – to consume. The price of using such products is sometimes described as a person's willingness to barter their personal data and attention for exposure to targeted advertising and marketing materials from content providers. But, due to an absence of monetary transactions, prices for many of these digital services are not reflected in the CPI.

Researchers from the Massachusetts Institute of Technology's Initiative on the Digital Economy recently attempted to estimate how much these digital products are worth by surveying consumers about the amount of money they were willing to accept in order to forego using them. They had concluded that search engines proved most valuable, followed by email at a distant second. Somewhat surprising, e-commerce and digital streaming services proved least valuable (see Chart 1).[1]

Finding a price for digital goods and services is only half the battle. Measuring their price *changes* is just as challenging. Digital products have the same features that render the price changes of other high-tech goods difficult to capture. The prices of goods such as mobile phones, computers and home electronics are prone to considerable drops following their introduction, which could lead to what economists refer to as "new product bias." In essence, if the CPI basket is not updated quickly enough it will fail to capture some of these price declines, resulting in an overstatement of the reported CPI. The extent to which this can happen depends on the relative share of these new products in the spending profile – the larger the share, the bigger the bias.[2]

**Chart 1: Search Engines Most Valuable Free Digital Goods for Consumers**




Note: The annual value to the consumer represents the median willingness-to-accept monetary value to stop using the listed digital goods for a year in 2017.
Source: Brynjolfsson, Eggers and Gannamaneni (2017), TD Economics

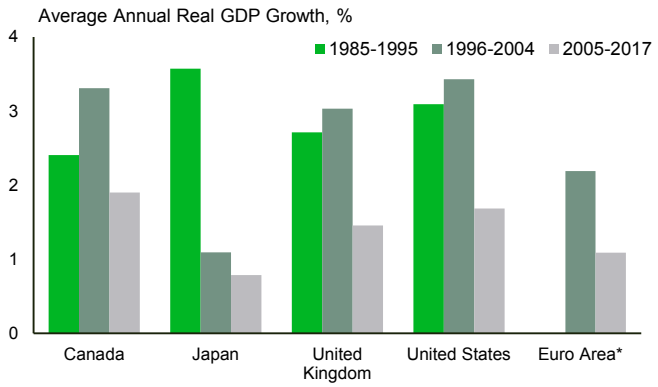
Finally, there is ongoing improvement in digital goods. This quality change is another source of possible measurement bias. In order to measure inflation correctly, price movements resulting from a change in quality need to be removed from inflation measures. As such, improvements in the quality of goods and services could exert an upward bias on the CPI over time if prices are not corrected. Statistical agencies use a variety of techniques to correct for quality change[3], but with digital products, such changes tend to occur at a rapid pace.

## Bygone days of robust growth?

Digital goods and services pricing issues also impact quantity measures; most notably, economic activity and productivity. Gross domestic product (GDP), a summary measure of a country's economic output, is an aggregation of the value of goods and services that are generated within a country's borders over a specific time period. There are different methods for estimating GDP, but the expenditure-based approach, which consists of summing the total amount spent by the different sectors of the economy on goods and services, is most common. Under this approach, consumer spending is usually the largest contributor to GDP. As with the CPI, the consumption of unpriced digital goods and services is not included in these calculations. Notably, the process of measuring output where a monetary value is not directly observable has become increasingly intricate, but there is still a concern that as the digital economy expands, a share of economic output is being overlooked by the national income and product accounts.

In real terms, the issue is exacerbated by the possibility of inflation mismeasurement. When it comes to measuring

**Chart 2: Remarkable Slowdown In Economic Growth**




* Data unavailable for 1985-1995 time period.
Source: OECD, TD Economics

economic performance, either over time or between different countries, real GDP – the constant dollar volume of economic output – is the preferred metric. Real GDP is calculated by removing inflation from current dollar (or nominal) GDP.[4]

Considering the challenges of measuring inflation accurately, and especially of correcting for changes in quality, mismeasurement in the context of real GDP is what economists are most concerned about. The combination of underestimated nominal GDP and overestimated inflation could suggest a persistent underestimation of real economic growth. This is particularly relevant considering that the rise of the digital economy appears to overlap a slowdown in real GDP growth in most advanced economies (Chart 2).

This slowdown, which preceded the onset of the Great Recession, garnered a lot of attention due to its timing and persistence. Much of this slowdown appears to be on the productivity side of the equation. Employment (and labour hours more generally), while hit hard during the Great Recession, have not experienced as dramatic a slowdown especially relative to underlying population growth over this longer time period.

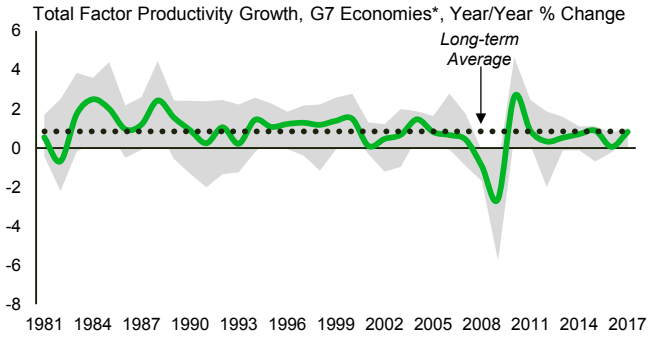
Productivity, in simple terms, measures how efficiently units of input are transformed into units of output. As such, it is typically calculated as a ratio of economic output (such as real GDP) to inputs, such as labour and capital. Therefore, if real GDP is underestimated due to uncounted output and/or overestimated inflation, productivity will be underestimated as well, assuming errors in the measurement of inputs are less significant. Productivity itself can be further decomposed between the inputs themselves and how well these inputs are used together, often referred to as total factor productivity (TFP). In growth terms, TFP is the share of real GDP growth that is not explained by changes in inputs such as labour and capital. As such, it is often used as a proxy measure for less observable drivers of economic growth such as technological innovation, improved efficiencies, and greater education and training.[5]

Looking at the world's most developed economies as a group, TFP growth has slowed to below-trend levels for a little over a decade now (Chart 3). Slowing productivity growth is problematic since it is the key driver of improvements in living standards. These low productivity growth numbers, however, have been described by many observers as aberrant in an era of booming technological innovations and digitalization. A number of theories have been put forward to explain why productivity growth has slowed. One that has garnered considerable attention is that the productivity gains are not being captured in the data.

## Elsewhere lies the answer (for now)

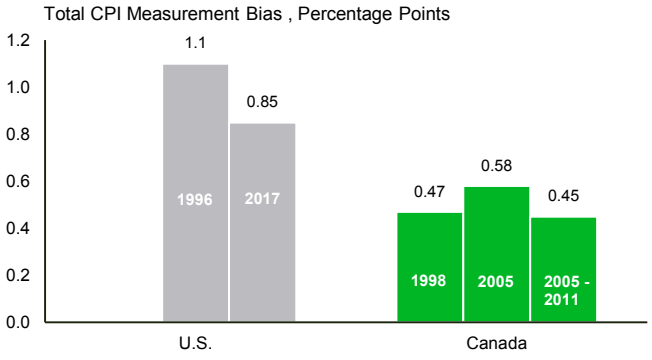
With all these factors in mind, how acute is the economic mismeasurement problem? For the CPI, economists and statisticians generally acknowledge that there are limitations and measurement biases that are inherent to how the CPI is computed. However, it is important to note that biases related to the introduction of new products have arguably been more pronounced in the past. The automobile, for example, represented a product whose price both de-

**Chart 3: Advanced Economies Experienced Below Average TFP Growth in Recent Years**




* G7 economies include the U.S., Japan, Canada, France, Germany, Italy and the United Kingdom, all weighted by their respective purchasing power parity share; Index (2010 = 100).
Source: The European Commission's AMECO database, IMF, TD Economics

**Chart 4: Overall CPI Measurement Bias Could Be Decreasing**




Source: Bank of Canada, Moulton, Brent R. (2018), *"The Measurement of Output, Prices and Productivity: What's Changed Since the Boskin Commission?"*, Hutchins Center on Fiscal and Monetary Policy at the Brookings Institution, TD Economics

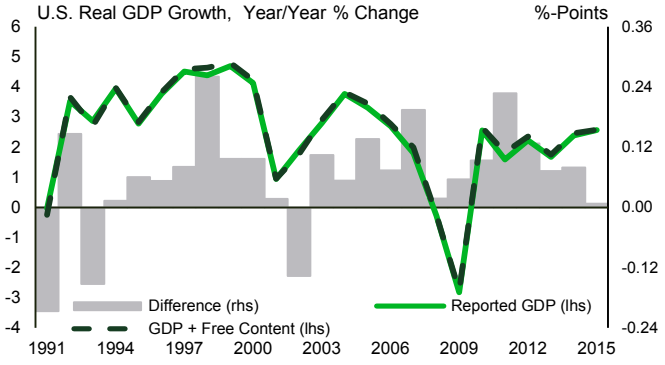
creased rapidly upon its introduction and whose market penetration increased relatively quickly. By the time new automobiles were introduced into the CPI in 1940, it is estimated that more than 1 in 2 households living in cities already owned a car in the U.S.[6] Moreover, used automobiles were not introduced into the CPI until the early 1950s. The swath of household appliances and electronics invented in the immediate post-war period through to the 1960s present a similar story. Room air conditioners, for instance, were first introduced into the CPI in 1964, even though they were widely sold in the U.S. as early as 1951.[7] The issue of quality improvement is also longstanding and not clearly more acute today than it has been over history considering the progress that has been achieved in calculating and computing CPI.

Indeed, these biases could have overstated inflation on average by around 0.45 percentage points per year in Canada between 2005 and 2011, according to a Bank of Canada study.[8] This was down slightly from an estimate of 0.6 percentage points in 2005 (Chart 4). In the U.S., the scale of measurement biases in the CPI is less evident. In 1996, a Congress-commissioned study asserted that CPI was upwardly biased by about 1.1 percentage points per year. Following this report, substantial changes to the CPI methodology were implemented, but official communication on the scale of these biases has since been scarce. A recent independent analysis from the Hutchins Center on Fiscal and Monetary Policy at the Brookings Institution places the upward bias in the U.S. CPI at about 0.85 percentage points currently.[9] The author also finds that the upward bias in PCE inflation – which is the U.S. Federal Reserve's preferred inflation target and is the more relevant metric for the calculation of economic growth – shrank from 0.95 percentage points per year in 1996 to 0.47 percentage points currently. All things considered, while CPI may be upwardly biased, the bias appears to be decreasing in both Canada and the U.S. relative to past periods (Chart 4).[10]

At the same time, estimating the scale of potential GDP and productivity mismeasurement in the context of the digital economy is not easy, seeing as definitions are still being determined and measurement frameworks are still being researched. On the bright side, research on the topic has accelerated in recent years, leading to the development of a number of experimental methodologies. Estimates tend to vary in scale, but most find that while mismeasurement does exist, it is not sufficient to explain the slowdown in real GDP and productivity growth.

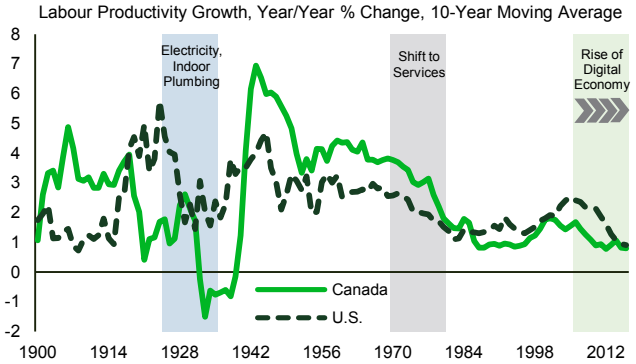
In the U.S. for example, researchers from the Federal Reserve Bank of Philadelphia and the Bureau of Economic Analysis have attempted to estimate the value of free content based on their production costs and then re-estimate GDP with it included.[11] They find that the inclusion of free digital content does have a positive impact on real GDP growth, although this is partially offset by a decline in other forms of free content, such as free newspapers. The overall impact, however, appears to be quite small (Chart 5). Using their methodology, on average real GDP growth and private sector TFP growth would be higher by 0.08 and 0.07 percentage points, respectively, every year between

**Chart 5: Addition Of Free Content Unlikely To Have Substantial Impact On Growth**




Source: Based on Nakamura, Leonard I. and Samuels, Jon and Soloveichik, Rachel H., *"Measuring the 'Free' Digital Economy within the GDP and Productivity Accounts"* (2017-10-23). FRB of Philadelphia Working Paper No. 17-37, TD Economics

**Chart 6: Productivity Statistics Could Lag Innovation and Structural Shifts**




Source: Bergeaud, A., Cette, G. and Lecat, R. (2016): *"Productivity Trends in Advanced Countries between 1890 and 2012,"* Review of Income and Wealth, vol. 62(3), pages 420–444,TD Economics

1995 and 2014. In fact, the Brookings Institution research previously discussed finds that economic mismeasurement is smaller today than it was twenty years ago. The author's estimates show that in 2017, the level of U.S. real GDP (excluding government, nonprofit, farm and owner-occupied housing) was understated by 0.43 percentage points less than it was in 1996.

By most accounts, economic mismeasurement appears likely insufficient to explain the slowdown in economic and productivity growth that occurred after 2005. In view of this, a number of other potential explanations have been put forth, including how productivity statistics have often lagged the diffusion of major breakthroughs and structural shifts in the past (Chart 6). In addition, limitations in workers' abilities to quickly adapt and take full advantage of rapid innovation cycles could be limiting the short-to-medium-run productivity benefits.[12]

## Navigating the Policy Implications

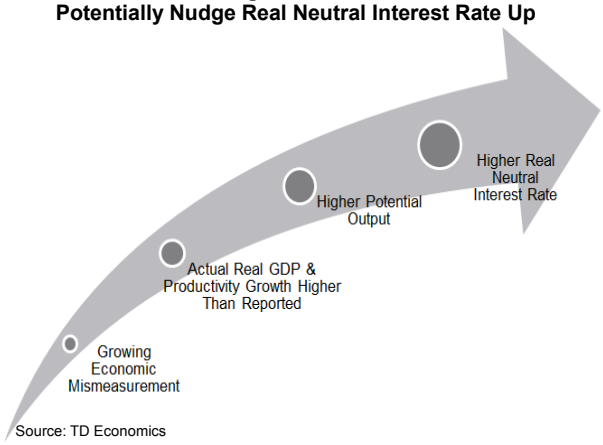
Should mismeasurement in the context of inflation, real GDP and productivity become worse, the resulting implications could be substantial. Inaccurate readings could result in policy missteps, including missed opportunities. For governments, accurate data is critical to analyzing returns to policy changes often meant to improve longer-run economic performance. This includes tax reform and research and development funding. Inaccurate data could alter or prematurely end such reforms and spending initiatives.

In a similar vein, central banks routinely use all three indicators to design and adjust monetary policy. In most developed countries, central banks operate under an "inflation targeting" framework, aiming to keep inflation within a relatively narrow range.[13] This requires an accurate read of inflation in order to minimize the risk of policy errors, where monetary policy is set too loose or too tight relative to the economy's actual needs.

If economic activity is being underreported due to understated productivity growth, this poses two somewhat contradictory challenges for the central bank. On the one hand, higher potential growth could mean the economy is operating with more slack than thought (and with less intrinsic inflationary pressure) and therefore requires more accommodative monetary policy in the near-term. On the other hand, higher potential growth may also imply a higher neutral interest rate required to keep the economy on an even keel. This would imply that the central bank has more room to raise interest rates once economic activity has reached its potential.

In short, given that monetary policy is set with respect to theoretical concepts estimated from measured economic data, the possibility of greater mismeasurement makes the job of regulating the pace at which the economy expands more difficult. However, as long as the level of mismeasurement is small and relatively stable, it should not materially impact monetary and fiscal policies. Of course, this storyline could change as the digital economy grows larger.

**Chart 7: Growing Mismeasurement Could Potentially Nudge Real Neutral Interest Rate Up**




Source: TD Economics

## Bottom Line

Most economists would agree that mismeasurement, in the realm of macroeconomic variables, does exist. At this stage, its scale appears to be relatively small, and in some instances, has been decreasing. The research available to date indicates that mismeasurement is not sufficient to explain the recent slowdown in real GDP and productivity growth. Policymakers and statistical agencies recognize this, and there had been a push in recent years to investigate ways of improving statistical classification systems and compilation methods in order to get a better grasp of how big the digital economy is and how to best measure it.

In Canada, Statistics Canada is working on a series of projects to better understand the digital economy, and had recently published the results of a Digital Economy Survey, which will be used to fill important statistical data gaps related to the digital economy.[14] In the U.S., the Bureau of Economic Analysis had recently released preliminary estimates towards the construction of a digital economy satellite account that could eventually lead to a comprehensive measure of the contribution of the digital economy to GDP.[15] On a wider scale, the OECD and the IMF are working jointly to coordinate efforts on understanding how the digital economy is affecting macroeconomic statistics.[16] To be sure, there is still a long way to go considering that research on the topic is still ongoing and most initiatives are still at the experimental stage. If successful, such efforts could help reduce measurement errors in the future and keep macroeconomic indicators from becoming obsolete.

## Endnotes

1. Brynjolfsson, Erik, Eggers, Felix & Gannamaneni, Avinash (2017), "Using Massive Online Choice Experiments to Measure Changes in Well-being".
2. The CPI basket weights are updated every 2 years in the U.S. by the Bureau of Labor Statistics (BLS) and in Canada by Statistics Canada. It is worth noting that new products can periodically enter the CPI basket either as a substitution for an existing product or, as is more generally the case, during a sample rotation or update. The BLS carries out such a rotation every 4 years, while Statistics Canada uses the biennial CPI basket updates as an opportunity to review and update the basket contents and the outlets they source their prices from.
3. Hedonic models are one such technique. They rely on the assumption that the value of an item could be broken down into different contributing factors, which individual relative values could be estimated through regression analysis. In doing so, statistical agencies can estimate the price of an item assuming a constant set of characteristics, which then enables them to distinguish between price changes induced by characteristics changes and pure price changes.
4. The preferred measure of inflation in the GDP context is called the GDP deflator. Like the CPI, the GDP deflator is a measure of price changes; unlike the CPI, the GDP deflator's scope encompasses all the goods and services that are produced within a country's borders (therefore excluding imports) and is not limited to consumer-purchased products. Additionally, the GDP deflator is not based on a fixed basket of goods and services.
5. As a residual, TFP encompasses any "unexplained" source of real GDP growth. This also includes measurement errors, if any.
6. Costa, Dora (2001), "Estimating Real Income in the United States from 1888 to 1994: Correcting CPI Bias Using Engel Curves" https://www.econ.ucla.edu/costa/cpibias.pdf
7. Committee on Finance, United States Senate (1996), "Final Report of the Advisory Commission to Study the Consumer Price Index" https://www.finance.senate.gov/imo/media/doc/Prt104-72.pdf
8. Sabourin, Patrick (2012) "Measurement Bias in the Canadian Consumer Price Index: An Update" https://www.bankofcanada.ca/wp-content/uploads/2012/08/boc-review-summer12-sabourin.pdf
9. Moulton, Brent R. (2018), "The Measurement of Output, Prices and Productivity: What's Changed Since the Boskin Commission?", Hutchins Center on Fiscal and Monetary Policy at the Brookings Institution. https://www.brookings.edu/wp-content/uploads/2018/07/Moulton-report-v2.pdf
10. For both countries, the estimates presented here are not specifically related to the digital economy, but rather represent the extent of the potential bias at the scale of the entire economy.
11. Nakamura, Leonard I. and Samuels, Jon and Soloveichik, Rachel H., "Measuring the 'Free' Digital Economy within the GDP and Productivity Accounts" (2017-10-23). FRB of Philadelphia Working Paper No. 17-37. https://www.philadelphiafed.org/-/media/research-and-data/publications/working-papers/2017/wp17-37.pdf?la=en
12. Another view is that productivity often peaks before recession hits. Usually, this is when input resources become scarce, forcing firms to become more creative on how to use them. This would generally result in an increase in TFP, and thus productivity growth.
13. The Bank of Canada is an early adopter of inflation targeting, which it started implementing in 1991, second only to the Reserve Bank of New Zealand. The Bank of Canada's current inflation target is a "2 per cent midpoint of an inflation-control target range of 1 to 3 percent", as measured by the year-over-year increase in the total CPI. By contrast, the U.S. Federal Reserve officially communicated in January 2012 for the first time that it judges that "inflation at the rate of 2 percent (as measured by the annual change in the price index for personal consumption expenditures, or PCE) is most consistent over the longer run with the Federal Reserve's statutory mandate."
14. https://www150.statcan.gc.ca/n1/daily-quotidien/180829/dq180829b-eng.htm
15. Kevin Barefoot, Dave Curtis, William A. Jolliff, Jessica R. Nicholson, and Robert Omohundro (2018), "Defining and Measuring the Digital Economy", Bureau of Economic Analysis, https://www.bea.gov/system/files/papers/WP2018-4.pdf
16. Ahmad, N., J. Ribarsky and M. Reinsdorf (2017), "Can potential mismeasurement of the digital economy explain the post-crisis slowdown in GDP and productivity growth?", OECD Statistics Working Papers, No. 2017/09, http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=STD/DOC(2017)9&docLanguage=En

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