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Overlooking the online world: Does mismeasurement of the digital economy explain the productivity slowdown?

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Introduction

Starting in the mid-2000s, advanced economies have seen a slowdown in productivity (OECD 2019a). In Canada, the growth in labour productivity declined from an average annualized quarterly rate of 1.52 percent in the period 1995–2004 to 0.83 percent in 2005–19 (**Chart 1**).[1, 2] For countries in the Organisation for Economic Co-operation and Development (OECD), growth in labour productivity fell from an average of 1.9 percent in the period 2000–05 to 1.0 percent in 2005–10 and 0.8 percent in 2010–15 (OECD 2019a).[3, 4]

At the same time as this drop, we have seen enormous technological advances that are thought to be improving productivity. For example, the recently widespread use of artificial intelligence to detect disease, classify legal codes and translate languages is expected to free up workers' time for tasks that improve business and, by extension, increase productivity.

Several authors (Brynjolfsson, Rock and Syverson 2017; Macdonald, Anderson and Kimbel 2000) try to reconcile the paradox of enormous technological improvement and falling productivity by arguing that official productivity statistics are failing to measure the productivity gains from technological advances. This note investigates whether mismeasurement of productivity improvements from technological innovation could be at the heart of the lower productivity numbers in Canada over the last 15 years.

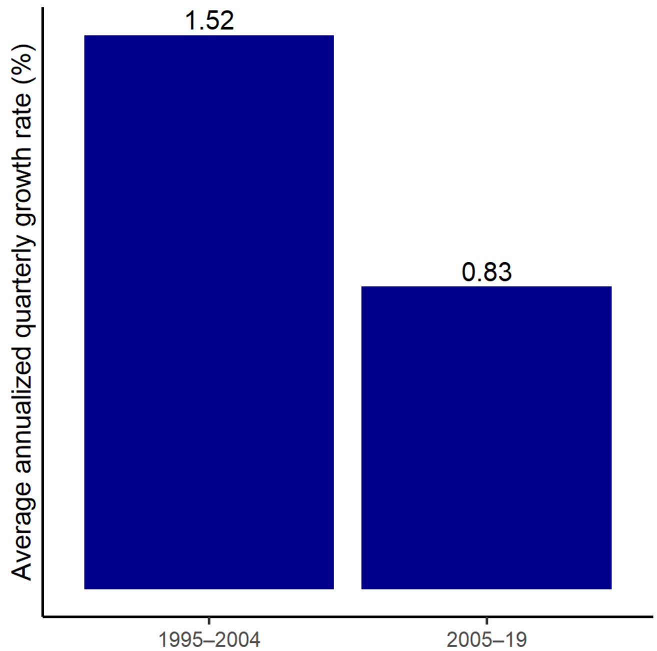
[1] Unless otherwise specified, this note uses the geometric average in all calculation of averages involving growth rates.

[2] The average growth rates for the two periods are statistically different at the 10 percent level. See the appendix for subsector heterogeneity in labour productivity.

[3] For manufacturing, the slowdown was highest in Finland, South Korea and Czech Republic among OECD countries. Meanwhile, for business sector services, the slowdown was more marked in Estonia, Greece and Latvia (OECD 2017).

[4] Research in the early 2000s found that during the dot-com bubble of 1995–2000, an increase in labour productivity in the United States was driven largely by investment in digital technology (Jorgenson, Ho and Stiroh 2008). Looking at Europe, Bloom et al. (2010) did not find a comparable increase in labour productivity for information and communication technology during this period.

Chart 1: Average labour productivity growth



Sources: Statistics Canada Table: 36-10-0207-01 and authors' calculations

One of the potential explanations for the productivity paradox is the mismeasurement hypothesis. According to this hypothesis, reported declines in productivity growth are illusory because existing output measures fail to include goods and services powered by new technologies (see Brynjolfsson and McAfee 2014; Hatzius and Dawsey 2015; and Syverson 2017 for more details). Mollins and St-Amant (2019) suggest that mismeasurement could be driving the decline in the contribution of the information and communication technology (ICT) sector to growth in labour productivity in Canada since 2008.[5]

In this note, we estimate the "missing output" for Canada—that is, the output that would exist today if labour productivity had not slowed down. Further, we test the mismeasurement hypothesis by performing four independent exercises based on:

1. the measurement error in the ICT sector
2. the consumer surplus associated with internet technologies
3. the gap between nominal income-based gross domestic product (GDP) and expenditure-based GDP
4. the value of data and databases in the economy[6]

[5] For example, when information technology firms create their own cloud services in-house, these might not be included in measures of investment (Byrne, Corrado and Sichel 2017).

[6] We should not add these calculations together since they are not mutually exclusive and encompass similar sectors of activity.

This approach attributes mismeasurement to the creation and expansion of digital platforms offering goods and services at low to no direct cost to consumers over the last 15 years. The missing output calculations and first three exercises extend Syverson's (2017) recent work for the United States to the Canadian context.

We estimate that if labour productivity had continued growing at the same rate as before 2005, Canada's real GDP in 2019 would have been $228 billion (in chained 2012 dollars) higher.[7] While this number is far smaller than the US$2.71 trillion that Syverson (2017) finds for the United States, both numbers constitute a similar percentage of 2019 GDP for these countries (10.8 percent for Canada and 12.6 percent for the United States).

Similar to Syverson (2017), we find that for the three related exercises (ICT mismeasurement, internet consumer surplus and GDP comparisons), the mismeasurement hypothesis cannot account for most of the productivity slowdown. Apart from the three calculations specified, Syverson (2017) finds that OECD countries with higher ICT intensity did not face a bigger slowdown in labour productivity growth from 2005 to 2015. This is contrary to what would be expected if ICT mismeasurement was causing the slowdown.[8]

In addition to Syverson's (2017) approach, we use an alternative leisure definition for calculations of the internet consumer surplus, and we add another mismeasurement exercise to calculate the impact of adding data and databases to gross output. For the new data exercise, we use existing Statistics Canada estimates of the value of data-related activities based on their cost of production. Again, we find that the results cannot explain most of the productivity slowdown.

Background: The mismeasurement hypothesis

Are data and free digital goods and services driving mismeasurement?

These days, consumers can obtain many digital goods and services (DGS) for free through the internet (Goldfarb and Tucker 2019). Some online platforms charge consumers nothing and make their revenue from advertising (such as Instagram and Facebook); others offer free and paid versions (such as Spotify, LinkedIn and Dropbox). These platforms may increase the consumer's utility (e.g., playing a free game app) or help users be more

[7] Calculations were made with data extracted in October 2020 using preliminary 2019 estimates found at Statistics Canada. The data were later revised on February 12, 2021. Our results are robust to these revisions.

[8] Syverson (2017) measures ICT intensity through broadband access (consumer side) and ICT share of real GDP (producer side).

productive (e.g., using a budgeting app). Since DGS are often received for free or at prices that are highly discounted, national accounting may be failing to capture DGS through expenditure measurements.[9]

While certain free DGS are supported by advertising, Brynjolfsson et al. (2020) argue that measuring advertising expenditures would only quantify a fraction of the welfare that these goods and services contribute to households. In response, many researchers have constructed alternative measures of GDP that include the consumer surplus that DGS generate. Brynjolfsson et al. (2019) suggest focusing on the consumer benefits rather than costs of digital technologies and create GDP-B.[10] Byrne and Corrado (2019) propose another measure and estimate that the additional consumer surplus yielded by online content delivery services contributed over half a percentage point to US real GDP growth from 2007 to 2017.[11] Hulten and Nakamura (2017, 2019) expand GDP by calculating it using an output-saving model meant to better capture improvements in living standards from free DGS. Overall, current research shows that DGS have a big economic impact that is under-accounted for.

Another possible driving factor for mismeasurement of GDP is the fact that the value of firms' data is not included in national accounts. There is international debate around whether data should be classified as a service, an input or an asset in national accounting. A report by the OECD (2015) recommends treating data as a capital good, where the amount used in production is counted in national accounts through its depreciation rate. However, this is challenging since the bits of data recorded and stored do not depreciate the same way that, for example, a machine accumulates wear and tear or a piece of software is no longer supported on a new operating system. Despite not physically depreciating, data are costly to store, and regulations may require companies to dispose of data after a certain length of time.[12]

Apart from possibly reducing GDP mismeasurement, treating data as a capital good can also help explain certain business models and the expansion of free DGS. Characterizing data as

[9] While we focus on the mismeasurement of the numerator of labour productivity (GDP), mismeasurement can also occur in the denominator, total hours worked. A potential factor for mismeasuring total hours worked is the expansion of the gig economy. Kostyshyna and Luu (2019) find that gig workers in Canada, those who engage in non-standard or informal work arrangements, represented approximately 700,000 full-time equivalent jobs between the third and fourth quarter of 2018. Across borders, the gig economy can take the form of outsourcing micro tasks to people in other countries. Some papers estimate this online outsourcing industry to have been worth US $4.8 billion worldwide in 2016 (Kuek et al. 2015).

[10] Brynjolfsson et al. (2019) find that incorporating Facebook into GDP-B has led to about 0.05 to 0.11 percentage points higher growth labour productivity-B per year, on average, since 2004.

[11] Likewise, Brynjolfsson, Eggers and Gannamaneni (2018) find through running an online choice experiment that losing access to all search engines and email would lead to a yearly disutility equivalent to US$500–US$1,000 less in earnings.

[12] If we assume data have a depreciation rate of less than a year, this equates to treating them as an intermediate input. For example, Drake-Brockman (2018) suggests data should be treated as an intermediate input.

a capital good, Farboodi and Veldkamp (2020) build a model to explain firms' incentives for data collection. In this model, new firms with a small amount of data increase their productivity when they collect more data. Meanwhile, larger firms with already established databases and sales and production models see diminishing marginal returns from additional data. Their model can explain why some young firms will offer digital platforms for free to help them acquire new data.

Alternative hypotheses for mismeasurement

Mismeasurement can also be caused by the failure of statistical agencies to capture falling prices or improved quality of DGS. With technological innovation, certain products get destroyed and replaced (Aghion et al. 2019), while others are dramatically improved in quality, such as the change from the cellphones of the early 2000s to the smartphones of today. However, the literature for this hypothesis fails to find evidence that this is the leading cause of the productivity slowdown for advanced economies (Byrne and Sichel 2017; Nakamura, Samuels and Soloveichik 2017).

Another explanation for the productivity paradox is the uneven distribution of the gains of technology, where superstar firms have used technological changes to increase their industry concentration (Aghion et al. 2019; Autor et al. 2020; Decker et al. 2017). In these cases, the gains from technology are already present but only attainable for a select number of high-productivity firms. This alternative hypothesis establishes that new technologies take time to implement. As a result, the new digital economy is still in the "installation phase," and the productivity improvements will be realized later, during the "deployment phase" (Brynjolfsson, Rock and Syverson 2017; van Ark 2016).[13]

Results

Calculating the missing output

In Canada, quarterly labour productivity growth between 1995 and 2004 was on average 0.38 percent (or 1.52 percent at the annual rate). This number fell to an average of 0.21 percent (or 0.83 percent at the annual rate) between 2005 and 2019.

To calculate the missing output, we investigate a counterfactual scenario where quarterly labour productivity continued to grow at its pre-2005 rate, the year the slowdown began. We estimate that if labour productivity growth had continued at the same rate, or 0.17 percentage points higher per quarter, Canada's output at the end of 2019 would have been 10.8 percent higher ($1.0017^{60} = 1.108$) than it currently is. Using the value of real

[13] GDP measurements are not meant to include the potential future stream of revenue for data and DGS. This is reflected in many start-up tech companies (e.g., Uber) that have high valuations but that are only expected to become profitable over longer time horizons.

GDP in the fourth quarter of 2019 ($2,114 billion in chained 2012 dollars, at market prices), this implies approximately $228 billion additional output in real terms.[14]

For the mismeasurement hypothesis to explain this productivity slowdown, the measurement error for new technologies would need to be at or around this level—implying that current GDP measures would be missing hundreds of billions of dollars of incremental output. For most of the exercises that follow, we compare the magnitude of our estimates with this missing output figure of $228 billion.

Mismeasurement in the ICT sector

Potentially, the expansion of new DGS that are not accounted for in the SNA are driving mismeasurement of the digital economy. If the increase in size and mismeasurement of the digital economy were responsible for the productivity slowdown, then the ICT sector—which represented about 88.5 percent of Canada's digital economy in 2017—should account for most of the missing output (Statistics Canada 2019a).[15]

In this counterfactual exercise, we assume that the mismeasurement of the digital economy falls within the ICT sector and evaluate the plausibility of attributing the $228 billion of missing output to this sector. **Chart 2** shows GDP for the ICT sector with and without this additional output in 2019.[16]

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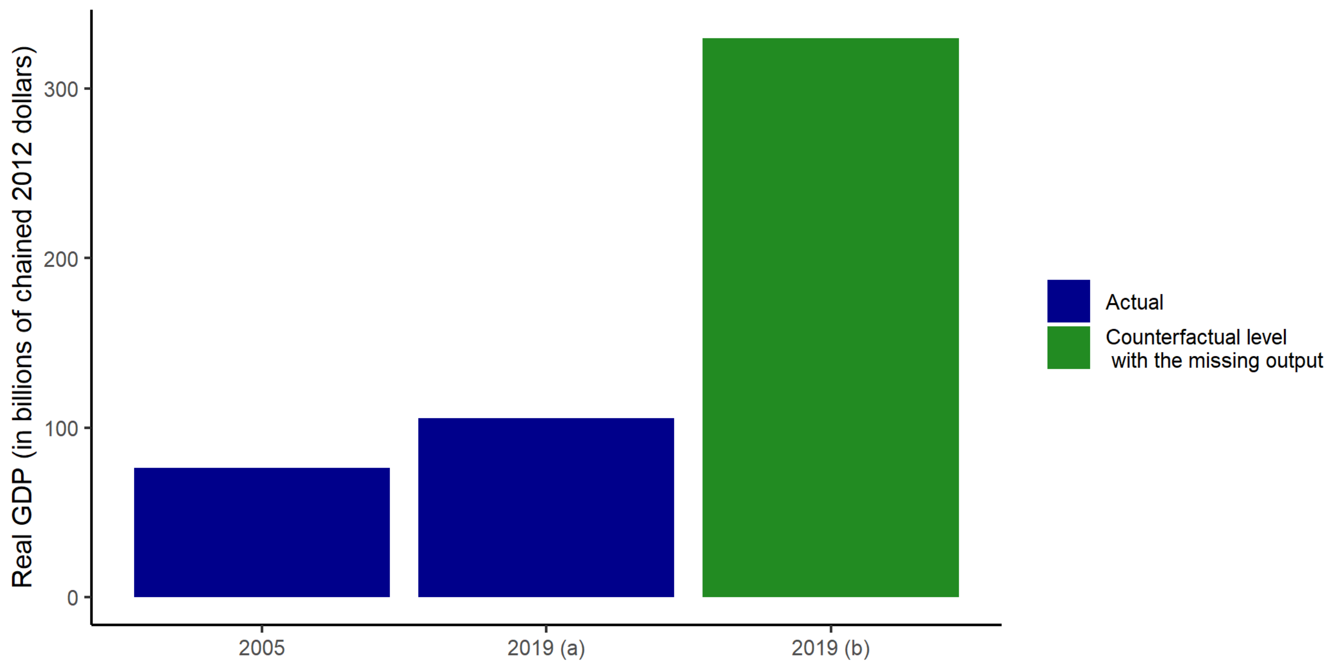
[14] GDP growth rates are calculated in real terms using Statistics Canada Table: 36-10-0207-01. Numbers shown are rounded for ease of viewing.

[15] Authors calculations are based on calculations from Statistics Canada.

[16] We define the industries included in the ICT sector as in Syverson (2017): North American Industry Classification System (NAICS) 334 (Computer and electronic product manufacturing), NAICS 51 (Information and cultural industries) and NAICS 5415 (Computer systems design and related services). This allows us to use more years of data than Statistics Canada's definition of the ICT sector, which has GDP data for that sector beginning in the first quarter of 2007 (Statistics Canada Table: 36-10-0449-01).

Chart 2: Level of real GDP in the ICT sector with and without the missing output



Note: ICT is information and communication technology. GDP is gross domestic product. Blue bars (a) display actual ICT output values, while the green bar (b) shows the size of the ICT sector if it included the missing output.

Sources: Statistics Canada Table: 36-10-0434-03 and authors' calculations

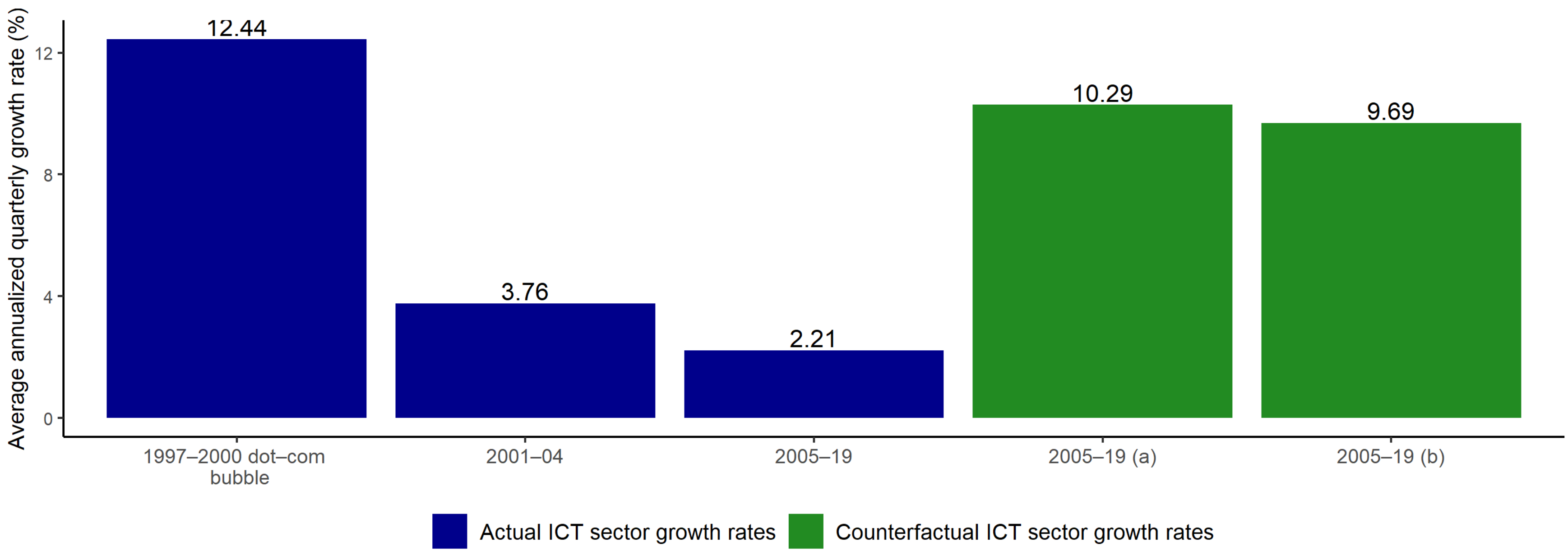
In 2004, before the productivity slowdown in Canada, real GDP for the ICT sector was $75.93 billion (chained 2012 dollars) in the fourth quarter. By the last quarter of 2019, this number grew to $105.46 billion (**Chart 2**), representing a 38.9 percent increase, or a 2.21 percent average annualized quarterly (AAQ) growth rate, over this period. If we attribute the missing $228 billion of real output to the ICT sector, then this implies the sector had to grow by 339.2 percent between 2005 and 2019—an AAQ growth rate of 10.37 percent for 15 years (**Chart 3**, see a). Even attributing only 88.5 percent (the size of the ICT sector relative to the digital economy), the implied annualized growth rate would have had to be 9.77 percent (**Chart 3**, see b). Thus, to account for the missing output, the ICT sector would have had to grow at an annualized rate five times greater than its measured rate for a duration of 15 years.

To put these results in perspective, growth rates of this magnitude have never been observed in any Canadian sector or subsector for such an extended period. From 2005 to 2019, the top-growing subsector for GDP was air transportation, which had an AAQ growth rate of 6.18 percent. From 1997 to 2004, the observed AAQ growth rate in the ICT sector was 7.38 percent, but this was largely driven by the dot-com bubble (ICT sector growth rates of 12.44 percent during the dot-com years of 1997–2000 and 3.76 percent afterwards in 2001–04 in **Chart 3**). Hence, the ICT growth rate including the missing output is less than the ICT growth rate during the dot-com period. However, the ICT dot-com growth rate lasted only three years, from 1997 to 2000, whereas to encompass the missing output, this growth rate would have had to last for 15 years.

In sum, to explain the missing output, the ICT sector growth rate would have had to be five times larger than its measured rate, larger than the growth rate of all subsectors during the same period and comparable in size to the dot-com period, and it would have had to last for an unprecedented period. Hence, we conclude that it is highly unlikely that the mismeasurement of the ICT sector's output can account for most of the slowdown in labour productivity growth.

Chart 3: Comparing ICT sector growth rates with their counterfactual growth rates

when attributing the missing output to the ICT sector



Note: ICT refers to information and communication technology. 2005–19 (a) refers to the counterfactual ICT sector growth with all the missing output, and 2005–19 (b) refers to the counterfactual growth with 88 percent of the missing output.

Sources: Statistics Canada Table: 36-10-0434-03 and authors' calculations

Consumer surplus of internet-linked technologies

Since several new digital platforms are offered to consumers at low monetary cost, researchers have suggested methods to estimate their value that are alternative to GDP. For instance, Goolsbee and Klenow (2006) argue that the predominant cost of consumption of these platforms is the leisure time consumers spend using them. They estimate consumers' demand curve for the internet by using a utility model in which they relate consumption of these platforms to the opportunity cost of time spent on the internet. Following this method, we compute the related consumer surplus in 2005 and 2019 to examine whether its increase matches the missing output during this period.

Table 1 shows our calculations for the consumer surplus generated by these DGS.

We first calculate the value of leisure by multiplying hourly after-tax wages by the number of hours spent enjoying leisure per year.[17] Using Statistics Canada's General Social Survey on Time Use, we find that Canadians spent an average of 2.8 hours a day in 2005 and 3.7 hours a day in 2019 on screen-time-related activities, including use of technology, watching videos and playing videogames.[18]

Next, we add the value of leisure to per capita net employee compensation to calculate "total income." Drawing on Goolsbee and Klenow's (2006) work, we take consumer surplus to be 3 percent of this total income figure.[19]

Finally, we multiply consumer surplus by the number of Canadians with internet access in a given year to find the internet-derived consumer surplus for all of Canada.[20, 21, 22] We

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[17] We calculate hourly wages after-taxes per capita by dividing per capita net compensation (employee compensation minus personal income taxes) by the number of hours that people spend working in a year, according to the General Social Survey on Time Use (Statistics Canada Table: 45-10-0014-01). The average number of hours spent in paid work is an average for all the days in the week, including weekends, and does not include paid breaks and lunches. This survey was directed at a random sample of non-institutionalized individuals over the age of 15 and thus includes employed, unemployed and retired individuals. We extrapolated 2019 figures using the average growth rate in average weekly hours from the Survey of Employment, Payrolls and Hours and actual hours worked between 2015 and 2019 from the Labour Force Survey.

[18] Using the figure for 2015, we sum active and passive leisure because these include computer and television time, respectively. For 2005, we sum active leisure outside of active sports and passive leisure outside of reading books (as e-books were not widespread in 2005). We extrapolated the 2019 figure using the growth rate between 2005 and 2015.

[19] Goolsbee and Klenow (2006) find that the consumer surplus of internet in the United States could be as high as 3 percent of full income. They define full income as the sum of actual income and the value of leisure time.

[20] We interpolate data on internet usage from Statistics Canada Table: 22-10-0058-01 (2005) and Table: 22-10-0083-01 (2018) to get the 2015 figure and use the annual average 2005–18 growth rate to extrapolate to the 2019 figure.

[21] We deflate the consumer surplus using the final consumption expenditure deflator from Statistics Canada Table: 36-10-0223-01. This allows us to compare all our numbers in chained 2012 dollars.

[22] Data are converted to per capita terms using population figures listed in Statistics Canada Table: 17-10-0005-01. For 2005 and 2019, the population of Canada was 32,243,753 and 37,589,262, respectively.

estimate the additional surplus from the internet between 2005 and 2019 to be $26.47 billion in chained 2012 dollars (the difference between $48.15 billion in 2019 and $21.68 billion in 2005) for internet-specific leisure. If Canadians were charged for apps and websites, then this number would represent an estimate for changes in expenditure on internet-derived DGS during this period.

Table 1: Consumer surplus calculations*

	2005	2019
Daily number of hours of leisure	2.8	3.7
Hourly after-tax wages (per capita)	$12.75	$20.17
Annual value of leisure (per capita, current prices)†	$13,025.48	$27,041.41
Compensation of employees‡ (in millions, current prices)	$692,608	$1,170,867
Population of Canada	32,243,753	37,593,384
Net compensation (per capita, current prices)	$16,281.85	$23,560.51
Total income (per capita, current prices) = net compensation + value of leisure	$29,307.33	$50,601.91
Consumer surplus (per capita, 2012 chained dollars) = 3% of deflated total income	$990.11	$1,371.33
Percentage of people with home internet access	67.9%	93.4%
Total consumer surplus (billions of chained 2012 dollars) = % internet access x population	$21.68	$48.15

* Numbers calculated in the table are shown rounded to the second decimal. Calculations are based on the exact numbers.

† "Current prices" refers to current in their year of observation.

‡ Compensation of employees from Household sector, current accounts Statistics Canada Table: 36-10-0224-01

Syverson (2017) uses a different definition of leisure for his analysis of the United States. Referring to the American Time Use Survey, he defined leisure as time outside of sleep, personal care and paid work.[23] Applying this definition, we find that Canadians would have

[23] Syverson (2017) assumes that all leisure time is screen time. Syverson's definition of leisure also includes time spent eating and drinking, performing household chores and in education. Our more precise definition of leisure time does not include these categories.

spent on average 10 hours a day on leisure activities; the resulting additional surplus is an upper bound of $51.3 billion, which is less than one-quarter of the missing output.[24]

In sum, the $26.47 billion change in consumer surplus represents 11.6 percent of the $228 billion in missing output. This means that the mismeasurement of free internet DGS is insufficient to explain most of the slowdown.

Comparison of income-based GDP and expenditure-based GDP

Since DGS are often offered for free (or at prices that are highly discounted), comparing the income and expenditure sides of national accounting can shed light on potential mismeasurement. If consumption of DGS obtained through the internet is mismeasured, then income should exceed expenditure because workers would be getting paid to produce goods and services that are not captured in consumer spending.

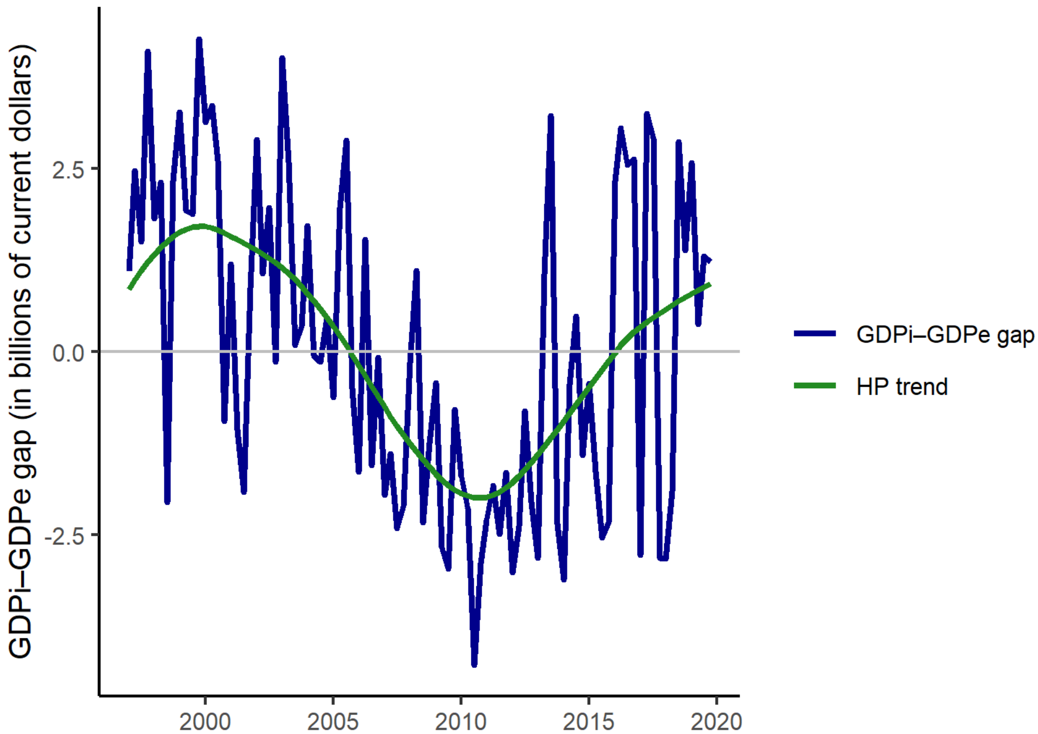
Chart 4 shows the difference between the nominal quarterly GDP based on income (GDPi) and GDP based on expenditure (GDPe). Because the data are quite volatile, we use a Hodrick-Prescott (HP) filter to smooth the time series. Between 2005 and 2016, the smoothed GDPi–GDPe gap was negative. This result is inconsistent with the hypothesis that labour earnings can capture the missing output. Starting in the second quarter of 2016, GDPi has exceeded GDPe, as shown in the smoothed GDPi–GDPe gap.[25] While the data are volatile, we are potentially starting to see evidence of workers getting paid for free DGS.

However, because this trend reversal has been observed only in the last three years, the GDPi–GDPe gap during the entire period studied (2005–19) does not support the mismeasurement hypothesis.

[24] Syverson (2017) also uses disposable income instead of net employee compensation to calculate total income.

[25] We also examine the labour share of income. Other than a jump during the global financial crisis, it has remained stable between 2005 and 2019.

Chart 4: Gap between quarterly income-based GDP and expenditure-based GDP



Note: GDPi is gross domestic product based on income. GDPe is gross domestic product based on expenditure. HP stands for Hodrick-Prescott. HP filter lambda = 1600. "Current dollars" refers to current in the year of observation.

Sources: Statistics Canada Table: 36-10-0221-01 and Table: 36-10-0222-01 and authors' calculations

Some missing pieces from the SNA: Estimates of the value of data and databases

Following international standards, the value of data is not yet included in Canada's measurements of national accounts. While data are excluded, some activities related to data, such as data science, are included in the SNA through reporting on research and development (R&D). In a 2019 study, Statistics Canada (2019c) produced experimental estimates on the value of data, databases and data science. According to this study, parts of these three components are somewhat included in the SNA, as follows:

1. Data science is mostly included through R&D expenditures.[26, 27]
2. Databases are captured through gross fixed capital formation in software, although they are thought to be highly underestimated under the current methodology.[28, 29]
3. Data are not included in the SNA since, as was mentioned above, there is no international convention for doing so.[30]

We use Statistics Canada's (2019c) estimates on the value of data and its improved estimates on the value of databases.[31] As shown in **Chart 5**, in 2018 the value of data and databases was estimated to be between $17 billion and $26 billion in current prices. Statistics Canada calculated these values through the labour costs incurred in producing data and databases plus associated non-direct labour and other costs, such as the costs of the associated human resource management and financial control, electricity, building maintenance and telecommunications services.[32] Hence, these estimates represent only the input costs related to data and databases and not their potential future stream of revenue. Some papers estimate this revenue to be large. For example, Li, Nirei and Yamana (2019) estimate that the value of Amazon's data in 2017 for the United States can account for 16 percent of Amazon's market valuation and has an annual growth rate of 35 percent.

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[26] In the Statistics Canada (2019c) study, data science is defined under "research and development" as in the 2008 SNA; "the value of expenditures on creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and use of this stock of knowledge to devise new applications."

[27] The collection of data on R&D is sampled on a small set of firms that are more likely to be research-intensive (Statistics Canada 2019c).

[28] In the Statistics Canada (2019c) study, databases are defined as in the 2008 SNA: "Databases consist of files of data organized in such a way as to permit resource-effective access and use of the data. Databases may be developed exclusively for own use or for sale as an entity or for sale by means of a license to access the information contained. The standard conditions apply for when an own-use database, a purchased database or the license to access a database constitutes an asset."

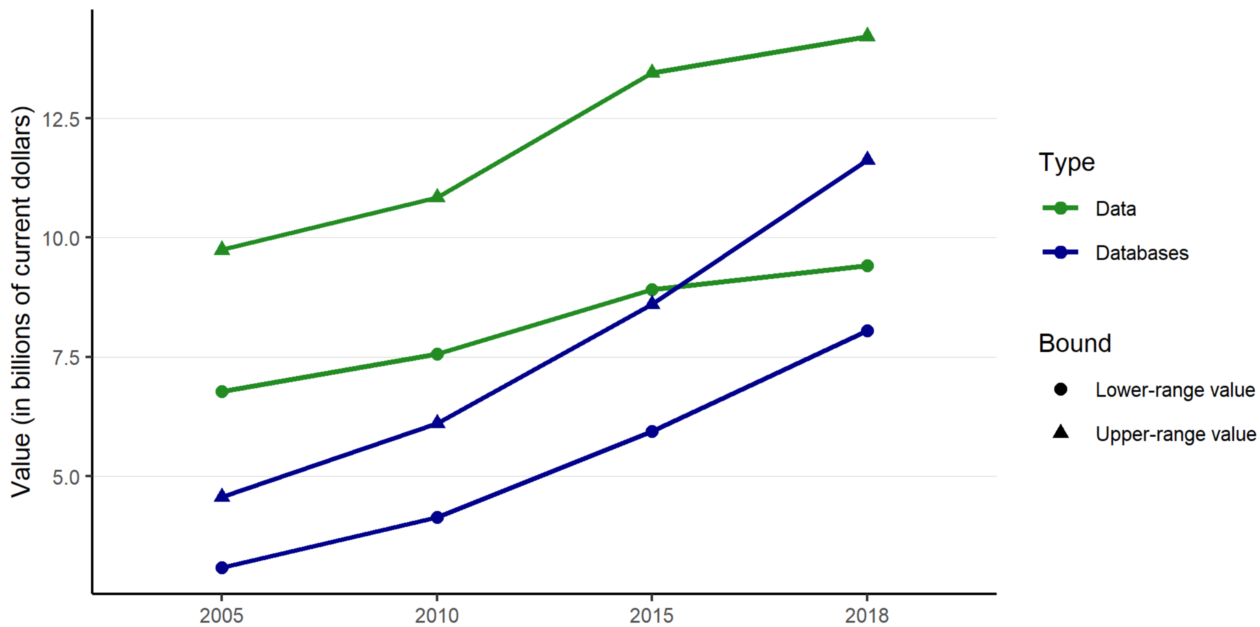
[29] A database is estimated by a sum-of-costs approach that is embedded in the calculation of software accumulation.

[30] In the Statistics Canada (2019c) study, data are defined as "observations that have been converted into a digital form that can be stored, transmitted or processed and from which knowledge can be drawn."

[31] In the study, Statistics Canada separates the cost of producing databases from the cost of producing software when calculating its estimates. The study adds labour costs that contribute to database development and removes labour costs that contribute to software development to get more precise estimates of the value of databases.

[32] Although these estimates of data and databases are based on costs of production already included in national accounts, we are using them to proxy for the value of data and databases that are not included.

Chart 5: Statistics Canada experimental estimates of the value of data and databases



Note: "Current dollars" refers to current in the year of observation.

Source: Data and computations from Statistics Canada (2019c)

We take the mid-point of the upper and lower estimates for the value of data and databases from Statistics Canada (2019c) from 2005 to 2019 and see whether it can explain the missing output.[33], [34]

We find that from 2005 to 2019, the value of data increased by $1.4 billion and databases by $5.5 billion in chained 2012 dollars. The combined value of both is $6.9 billion, which explains only 3.0 percent of the missing output.

These figures are perceived as a lower bound since they were made with estimates for data from their input cost only. The contribution could be much higher, with valuations of data that include its future stream of revenue.

What's not missing

Statistics Canada has made efforts to incorporate an increasing proportion of the digital economy in the SNA.

[33] The last Statistics Canada estimate of the value of data was for 2018. To get estimates for 2019, we assume the growth rate from 2018 to 2019 was the same as the average annual rate from 2015 to 2018.

[34] We apply the GDP deflator to the value of data and databases to convert these values to chained 2012 dollars.

In a 1997 revision, the SNA began to include software under Intellectual Property Products in Gross Capital Formation.[35] To avoid double-counting of own-account software, Statistics Canada uses the Annual Capital and Repair Expenditure Survey, where firms report own-account spending. While additional intangibles have been included in the SNA over the years, estimates have found their addition to the SNA did not significantly increase labour productivity after 2000.[36] Moreover, data science, which is estimated to be valued at between $11 billion and $18 billion in 2018 (Statistics Canada 2019b), has been included under R&D expenditures since the introduction of the 2008 SNA.[37]

Likewise, Statistics Canada includes revenue from peer-to-peer activity in the SNA. For instance, ridesharing expenditures for Uber and Lyft are included under personal expenditures through the category for taxi and limousines. However, figures from ridesharing cannot be separated from expenditures on other taxi services because they are under the same code (C17323). A 2016 survey that estimated consumers' spending on ridesharing (Statistics Canada 2017) found that consumers spent $241 million in peer-to-peer ride services in 2016, approximately one-fifth of the taxi and limousines category.

Finally, peer-to-peer private accommodation revenues (enabled by platforms such as Airbnb and VRBO) are contained within the traveller accommodation expenditure series. The traditional way to capture these revenues is through reports by private accommodation hosts in their goods and services tax accounts. In 2019, Statistics Canada (2019b) estimated its mismeasurement of private short-term accommodation revenue by comparing its numbers with data from AirDNA, a third-party company that scrapes data from Airbnb. It estimated that unreported revenues accounted for 2 to 5 percent of private short-term accommodations between 2015 and 2019. Starting in 2015, Statistics Canada added these uncaptured revenues to the traveller accommodation expenditure series.

Conclusion

In this note, we evaluated whether the mismeasurement of the digital economy could explain the productivity slowdown in Canada since 2005. We used four different approaches to assess the mismeasurement hypothesis: estimating counterfactual growth rates for the ICT sector, calculating the internet's consumer surplus with time-use data, comparing the sizes of GDPi and GDPe, and adding the value of data and databases to GDP.

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[35] Gu (2018) states that software is included only partially in the SNA. He makes alternative calculations of software (as well as of R&D and mineral exploration) and finds no significant difference in labour productivity.

[36] Gu and Macdonald (2020) expand on the list developed by Gu (2018) of intangible assets by including advertising and brand equity, financial innovation, architectural design, purchased non-R&D science, own-account non-R&D science, firm-specific human capital, and own-account and purchased organizational capital to GDP as capital assets using gross fixed capital formation accounting from 1976 to 2016. They find that they do not significantly change measures of productivity growth after 2000.

[37] Information on R&D expenditures is collected through surveys and firms' tax filings.

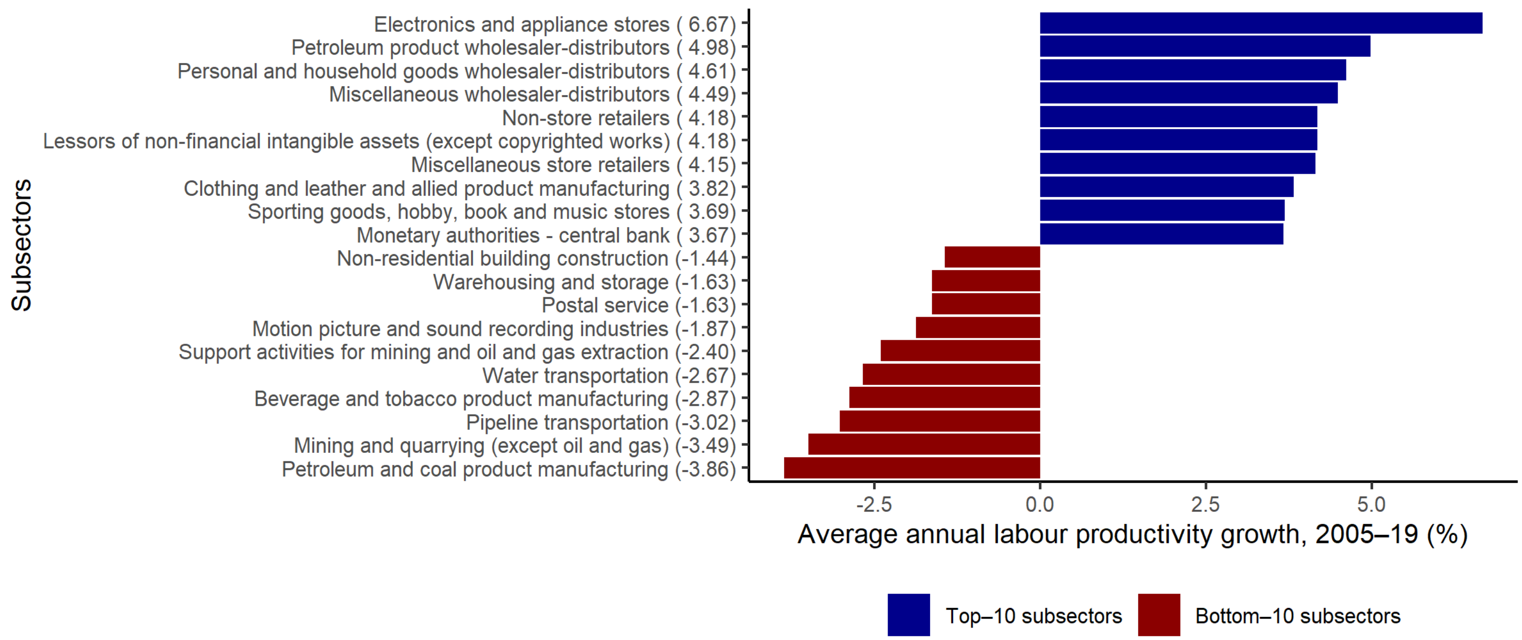
For each exercise, we conclude that the mismeasurement of free DGS fails to fully explain the missing output calculated from the decline in productivity growth. We find the following:

- These experiments can explain only 11.6 percent of the missing output when estimating consumer surplus from free DGS and 3.0 percent of the missing output when accounting for the value of data and databases.
- Applying the missing output to the ICT sector would imply an implausible growth rate for that sector since 2005.
- The GDPi–GDPe gap does not support the argument of workers being paid to produce free DGS.

Our results for Canada are in line with findings for the United States (Syverson 2017). Nevertheless, as economies further digitalize—a trend accelerated during the pandemic—mismeasurement has the potential to increase.

Appendix

Chart A-1: Average annual labour productivity growth by subsector during the productivity slowdown



Note: In Chart A-1, we use 3-digit North American Industry Classification System (NAICS) codes and 4-digit for NAICS codes for subsector 541 (Professional, scientific and technical services).

Sources: Statistics Canada Table: 36-10-0480-01 and authors' calculations

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