

Staff Analytical Note/Note analytique du personnel 2017-20

# Digitalization and Inflation: A Review of the Literature



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## **Acknowledgements**

We would like to thank André Binette, Harriet Jackson, Russell Barnett, Patrick Sabourin, Laurence Savoie-Chabot, Lori Rennison, Eric Santor and Césaire Meh for their helpful comments and suggestions.

## Abstract

In the past few years, many have postulated that the possible disinflationary effects of digitalization could explain the subdued inflation in advanced economies. In this note, we review the evidence found in the literature. We look at three main channels. First, we find that changes in the prices of information and communication technology-related goods and services included in the CPI have had a negligible effect on inflation in Canada. Second, we find that, due to the small share of e-commerce in Canada and the remarkably similar behaviour of online and offline prices, the “Amazon effect” has only had a small disinflationary impact to date. As e-commerce grows, however, downward pressure on inflation may amplify in the future through increased competition, but digitalization may also increase market concentration. Finally, although cost-efficient technologies should lead to increased productivity, which would put downward pressure on inflation, this effect has yet to appear in the statistics. Overall, we find it unlikely that digitalization has so far had a significant effect on inflation in Canada.

*Bank topics: Inflation and prices, Market structure and pricing, Productivity*  
*JEL codes: D22; E31; L81; O33*

## Résumé

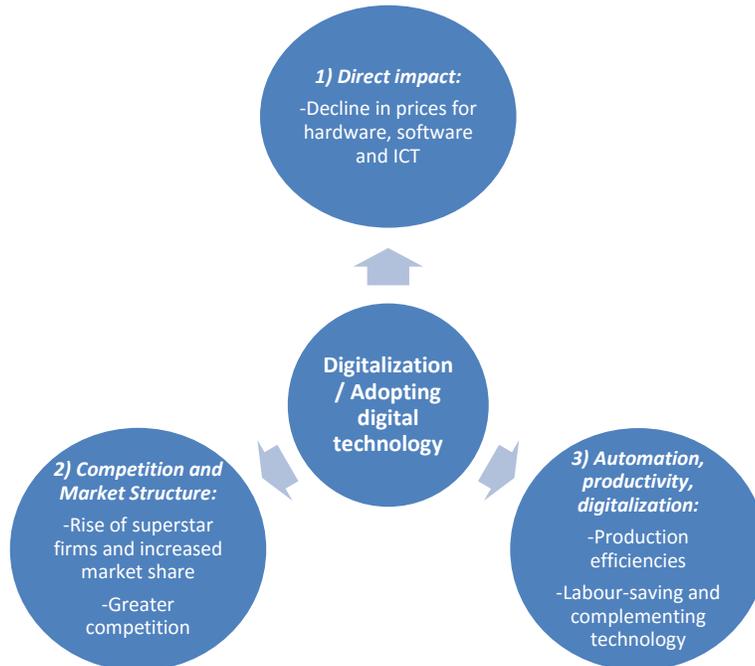
Ces dernières années, de nombreux commentateurs ont avancé que les éventuels effets désinflationnistes de la numérisation pourraient expliquer l’inflation modérée dans les économies avancées. Nous analysons les conclusions d’études sur le sujet; nous examinons trois canaux principaux par lesquels la numérisation pourrait influencer sur l’inflation. Première constatation : la variation des prix sur le marché des biens et services en technologies de l’information et de la communication qui entrent dans le calcul de l’indice des prix à la consommation a eu une incidence négligeable sur l’inflation au Canada. Deuxième constatation : compte tenu de la petite part qu’occupe le commerce électronique au Canada et du comportement très semblable des prix en ligne et aux points de vente, le « syndrome Amazon » n’a eu pour l’instant qu’un faible effet désinflationniste. Au fil de l’expansion du commerce électronique, la pression à la baisse sur l’inflation pourrait s’accroître en raison de l’intensification de la concurrence, mais il est aussi possible que la numérisation favorise la concentration du marché. Dernière constatation : même si les technologies favorisant l’efficacité opérationnelle devraient augmenter la productivité, et donc exercer une pression à la baisse sur l’inflation, les données à ce jour ne vont pas encore dans ce sens. Dans l’ensemble, nous estimons peu probable que la numérisation ait eu, jusqu’à présent, une forte incidence sur l’inflation au Canada.

*Sujets : Inflation et prix, Structure de marché et fixation des prix, Productivité*  
*Codes JEL : D22; E31; L81; O33*

## Key Messages

The literature identifies several channels through which digital technologies may affect inflation (**Figure 1**). The overall effect is disinflationary, although it appears small so far, especially in Canada.

- The direct impact of digitalization on inflation (i.e., the falling prices of information and communications technology (ICT)-related goods and services in the CPI), is small in advanced economies and almost nil in Canada. This reflects, in part, the impact of limited competition in Canada's telecommunications sector, which has offset some of the downward pressure relative to other countries.
- Digital technologies can change market structure by allowing superstar firms to become dominant, reshaping the traditional retail landscape and leading to increased competition, especially through e-commerce (the "Amazon effect"). Empirical evidence for Canada suggests not only that this country has a very small share of online retail sales, but also that online prices behave similarly to offline prices. Thus, to date, the Amazon effect in Canada is likely small.
- Although cost-efficient technologies should lead to increased productivity, this effect has yet to appear in the statistics. If the benefits of digital technologies are still to be reaped, future productivity gains should be expected to put further downward pressure on prices.
- The effect on inflation, however, will depend on the persistence of effects coming from digitalization. While monetary policy will likely look through transitory shocks affecting inflation, lasting effects on the price level may require a reassessment of the supply potential of the economy and accommodation by the monetary authority to maintain the inflation target.



## Context

The years following the global financial crisis have seen puzzlingly low inflation in many advanced economies, even in those where the output gap is close to zero. In Canada, inflation has remained subdued even as the economy has recovered from the oil price shock and economic slack has diminished. After falling during the first half of the year, CPI inflation bottomed out at 1.0 per cent in June, before starting to increase, reaching 1.6 per cent in September. While temporary, country-specific factors often explain part of the recent weakness, the pervasiveness of weak inflation across advanced economies suggests a need to look at factors beyond those integrated into our traditional Phillips curve framework.<sup>1</sup> Recent work suggests that global factors such as import prices, the global output gap and integration in global value chains cannot fully resolve the inflation puzzle.<sup>2</sup>

**Digitalization is one of the possible channels that warrants further exploration in explaining persistently low inflation.** In the past few years, many have postulated that the possible disinflationary effects of digitalization could explain the subdued inflation in advanced economies. In this note, we review the evidence found so far in the literature.

<sup>1</sup> The Bank uses a regression model based on the Phillips curve framework, where inflation dynamics are explained by a measure of economic slack, as well as movements in commodity prices and in the exchange rate.

<sup>2</sup> See [Brouillette and Savoie-Chabot \(2017\)](#)

**We explore three main channels through which digitalization can affect inflation:** (i) directly, through its effect on the prices of ICT-related goods and services; (ii) by changing the market structure and level of competition in certain sectors; and (iii) by affecting productivity and labour requirements. We look at each of these channels in turn, highlighting Canada’s level of digital development and the likely impact of each channel on inflation, based on a survey of the literature.

## Channel 1: The Direct Impact of Digitalization on Price Indexes

**The first channel through which digitalization affects inflation is its direct impact on price indexes.** The price of some ICT products has rapidly decreased from the 1990s onward due to technological change. This has been documented in other countries, particularly Europe, as having put downward pressure on inflation.<sup>3</sup> The trend in Canada, however, appears to be somewhat different. Note that the focus here is on consumer prices as defined by the CPI.

**Chart 1** and **Chart 2** illustrate the price trends for the five components of Canadian CPI that we include in our definition of ICT.<sup>4</sup> The prices of digital computing equipment and devices and of home entertainment equipment, parts and services, have been declining for the most part of the past 20 years. However, the most recent period does not exhibit particularly marked declines, especially for digital equipment; therefore, these components have not been putting additional downward pressure on inflation that could explain the recent dynamic.<sup>5</sup> Indeed, the trend was more pronounced in the late 1990s and early 2000s. This dynamic is similar to what the Sveriges Riksbank has documented for Sweden.

Where the divergence between Canada and other countries occurs is in the other components included in consumer ICT prices (communications, video and audio subscription services, and reading materials), whose prices in Canada have generally remained flat or increased over the past 20 years. Much of this price dynamic is attributable to the oligopoly of the “Big Three” telephone companies (Bell, Telus and Rogers).<sup>6</sup> Indeed, they have kept the level of competition in the sector much lower than in other countries and, consequently, communications prices have not fallen as much in Canada ([Masse and Beaudry 2015](#)). Since this component has a much larger weight in the CPI, changes in its price dominate those of the other ICT components. **Therefore, overall, the contribution of ICT products (communications and IT) to CPI growth has occasionally been negative in Canada, but not in the recent period, and it has always remained close to zero (Chart 3).**

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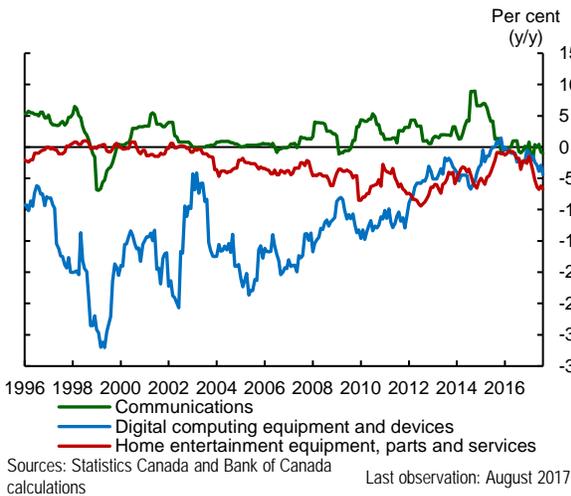
<sup>3</sup> See, for example, Sveriges [Riksbank](#) (2015).

<sup>4</sup> These components were chosen to match as closely as possible those selected by the Riksbank in its study of inflation and digitalization (see Sveriges [Riksbank](#) 2015). ICT-related includes communications; digital computing equipment and devices; home entertainment equipment, parts and services; video and audio subscription services and reading materials (excluding textbooks).

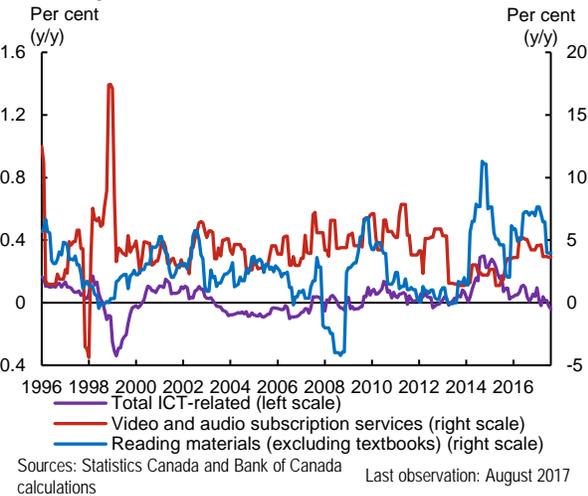
<sup>5</sup> Exchange rate pass-through is likely masking some of the dynamic in 2015 and 2016.

<sup>6</sup> This is less true for reading materials, where the depreciation of the Canadian dollar has played an offsetting role.

**Chart 1: The prices of some ICT goods have been growing slowly or declining...**

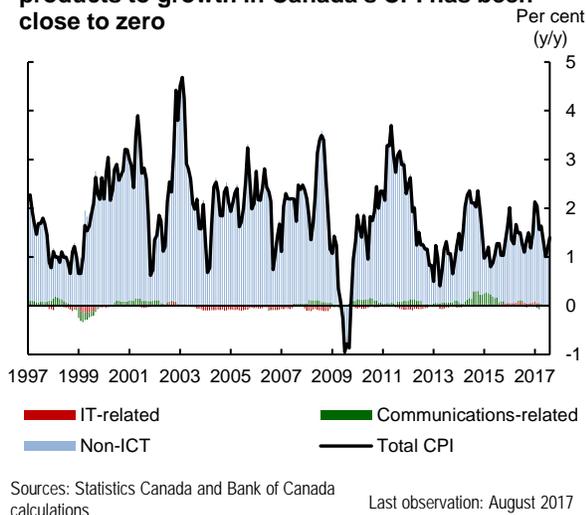


**Chart 2: ...while the prices of other ICT goods have kept total ICT price growth in positive territory**



Price measurement in the new digital economy remains a challenge for national statistical offices, due to the development/introduction of new goods and services, increased customization and quality changes (Durand 2016; Schreyer 2017). During periods of rapid technological change, past quality-adjustment methods may undervalue product improvements, resulting in overestimated prices (Ahmad and Schreyer 2016). We will come back to this issue in the third section of this note.

**Chart 3: The contribution of ICT-related products to growth in Canada's CPI has been close to zero**



Moreover, as products become more specialized, measuring price changes becomes more difficult. As well, an increasing number of free digital products (such as apps, online travel booking, etc.) are not well captured in nominal GDP or accounted for in the CPI. As consumers switch to these types of products, it causes a substitution bias in the CPI. For now, many do not consider this issue to be more significant than in the past (Ahmad and Schreyer 2016), but this could change as the pace of digitalization increases. Finally, as consumers switch to cheaper online sources, an outlet bias is created. We will revisit this issue in the next section.

## Channel 2: Market Structure, Competition and the Rise of E-commerce

**The second channel through which digitalization can affect inflation is its effect on market structure and competition.** Indeed, as digital technologies permeate almost all sectors, markets may be reshaped, with implications for pricing power and, ultimately, inflation. We look at this issue from two angles: market concentration and e-commerce.

### Channel 2.1: Market concentration

There are two competing theories concerning the impact of digitalization on market structure:

- **Some observers note that the internet and technology have reduced barriers to entry and increased competition:** Almost any firm (including small, niche firms, and start-ups) can now go global and reach potential customers faster and at a lower cost ([OECD 2017](#); [Trainer, 2016](#)).<sup>7</sup> In turn, competition for incumbent firms increases: both from digital firms invading non-tech sectors and from foreign competition more easily reaching domestic markets. Local retailers can no longer sustain a regional monopoly or oligopoly based on geography, which may create a “race to the bottom for prices” ([Trainer 2016](#)).
- **At the same time, digital technologies increasingly allow for dominant “superstar” firms<sup>8</sup> with considerable market power.** These firms grow to a size that allows them to force traditional and smaller players out of the market. Digital technologies play a major role in the success of such firms: social networks, search engines and software platforms allow them to leverage market reach and rapidly increase the number of users, with network effects and scale advantages bringing about market dominance. Moreover, digital and efficient operations allow competitive pricing which, amid easier online price and quality comparisons, lures a larger share of consumers. The result is heightened industry concentration and divergence of profit margins and productivity between “frontier” firms and others ([Andrews, Criscuolo and Gal 2015](#)).

**The extent to which the rise of superstar firms and increased competition have reshaped market structure varies by country and industry.** Indeed, concentration has increased in most industries in the United States (Hatzius et al. 2017a). Yet, in Canada, despite important changes in the retail landscape,

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<sup>7</sup> For example, digital technologies can facilitate cross-border e-commerce or selling via platform firms such as Amazon and eBay; allow firms to more easily find workers with specific skills or tap pools of labour in other countries; engage in new forms of financing (e.g., crowdfunding); and access technologies they may not have been able to buy directly (e.g., via cloud computing).

<sup>8</sup> The term denotes both firms in *digital industries* such as Google and Apple, as well as firms in *non-tech industries* but using an innovative business model enabled by digital technologies (e.g., Airbnb, Netflix, Spotify, etc.). The speed with which ideas are turned into products appears to increase, with the number of “Unicorns” (denoting start-up firms valued at \$1billion) increasing rapidly in recent years ([Blix 2015](#); [CB insights 2017](#)).

industry concentration has changed little over the past decade.<sup>9</sup> Market concentration could increase in the future, since e-commerce in Canada is growing rapidly and is dominated by large foreign retailers.<sup>10</sup>

**The effect of changes in market structure on prices is, a priori, ambiguous, although evidence points to some disinflationary pressures.** Theory would predict that greater market concentration and market power would result in higher prices. In practice, however, overall price pressures appear to be primarily downward, since superstar firms may pass on significant cost savings to consumers. The “contestable market theory” suggests that even dominant firms may not be able to translate market dominance into increased pricing power, since new entrants may rapidly copy business models and products to divert the customer base.

### Channel 2.2: The rise of e-commerce

**The rapid growth of e-commerce is another way that digitalization can enhance competition and affect inflation.** New technologies have changed the way consumers search for and compare the prices of products, and those customers benefit from increased price transparency and comparability.<sup>11</sup> Nowhere have the effects of this greater price transparency and comparability been more evident than in online markets. This has two effects:

- **First, if many consumers switch their purchases to cheaper online sources, this would have an impact on inflation that may not be captured by official statistics.**<sup>12</sup> This effect is often referred to as outlet bias. In a recent report, Hatzius et al. (2017b) argue that, for the United States, this bias is likely small, even smaller than during the rise of the big box retailer (i.e., the Amazon effect is smaller than the “Walmart effect” of the late 1990s and early 2000s). Indeed, they show that e-commerce has only recently started to grow at a comparable pace to that of the big box retailers and is still behind the gains in market share made by the big box retailers at their peak. Given that e-commerce is a much smaller share of retail in Canada than in the United States (**Chart 4**), we believe the same conclusions hold here and that the outlet bias is also minimal in Canada.

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<sup>9</sup> The Herfindahl-Hirschman index for the retail industry (a measure of market concentration calculated as the sum of the square of the firms’ market share in each industry) has been roughly flat since 2000 (Statistics Canada custom tabulation 2017).

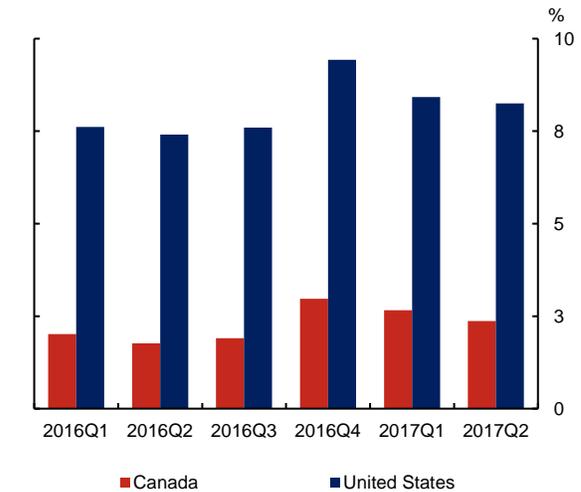
<sup>10</sup> Sklar (2015) and Sklar (2017) estimate that nearly half of online purchases in Canada are from foreign retailers.

<sup>11</sup> Like globalization, e-commerce also expands consumer options to foreign firms (Sveriges [Riksbank](#) 2015; [Blix](#) 2015).

<sup>12</sup> Price indexes are calculated on the basis of *price* changes only and do not necessarily capture shifts in *quantities* from (more expensive) brick-and-mortar stores to (cheaper) online sellers on a timely basis.

- **Second, the emergence of lower-priced online sellers such as Amazon and the greater ease of price comparison online may force (traditional) retailers to lower their prices (i.e., the Amazon Effect).** Even if e-commerce is only a modest share of retail sales, it may have important spillover effects on retailers' prices and inflation. As the share of online retail increases, the differential between online and offline prices will have a growing impact on inflation.

**Chart 4: E-commerce as a share of retail sales in Canada and the United States**



Note: Not seasonally adjusted data  
Sources: Haver Analytics and Cansim  
Last observation: August 2017

**In this context, it is important to understand how prices differ in online markets.**

The divergence between online and offline prices provides an estimate of the potential size of both the outlet bias (i.e., if online prices are the same, the prices included in the CPI are accurate) and the Amazon effect (through evidence of offline retailers trying to match Amazon prices). There are many reasons why a firm's price-setting behaviour might be different in online markets. For example, firms know that consumer search costs are much lower, and that their own costs of changing prices are also lower in online markets. Therefore, the extent to which online and offline prices align or diverge provides more information on market operations, price adjustment, discrimination and dispersion. A growing body of literature has been dedicated to this issue; three recent papers provide an overview of the main results:

- One of the largest projects in this area is the Billion Prices Project (BPP). Initiated in 2008 by Alberto Cavallo and Alberto Rigobon and owned by MIT, this project collects online prices daily in the United States and nine other countries, including Canada. One prominent paper that came out of BPP is [Cavallo \(2017\)](#). Overall, he finds that online prices are remarkably similar to offline prices. This is especially true in Canada, where prices are identical 91 per cent of the time,<sup>13</sup> much more than the 72 per cent 10-country average. When prices differ, the difference tends to be small, with about a 4 per cent online markdown, on average, and 5 per cent for Canada. A considerable pitfall of these data is that they use only multi-channel retailers for the price comparison. Naturally, this excludes retailers such as Amazon. Therefore, although the included retailers represent large shares of aggregate retail sales in their respective countries, they represent a much smaller share of e-commerce. The conclusions need to be interpreted accordingly.

<sup>13</sup> Three per cent of prices are higher online, and five per cent are lower online.

- Another study of this topic was conducted by [Gorodnichenko, Sheremirov and Talavera](#) (2016). They use prices provided by a shopping platform (price-comparison website) that covers a wider range of goods and retailers than Cavallo (2017).<sup>14</sup> Their results are largely similar to those of Cavallo. They find that online prices mirror offline prices in many regards; however, the incidence of price changes is larger online than offline.
- Similar to Gorodnichenko, Sheremirov and Talavera (2016), [Gorodnichenko and Talavera](#) (2017) use data from a price-comparison website to look at online prices in the United States and Canada, paying special attention to exchange rate pass-through. They also find that, overall, online prices behave in a broadly similar way to offline prices, although they are subject to smaller but more frequent changes. Regarding exchange rate pass-through, they find that it is incomplete in online markets, but much larger than for offline markets (60 to 75 per cent, compared with the 20 to 40 per cent found in the literature). The speed of adjustment is also much faster, with prices having a half-life of 2 to 2.5 months, relative to 9 to 12 months offline.

Contrary to what many might expect, based on anecdotal evidence, these papers find little to no evidence of dynamic pricing,<sup>15</sup> either based on consumer behaviour or in reaction to macroeconomic news. Cavallo (2017) also finds that, at least in the United States, differences from offline prices are not driven by an attempt to match Amazon prices. In addition, all three papers document that e-commerce does not appear to have affected the dispersion of prices across retailers, which remains surprisingly large. It does appear, however, to have reduced within-retailer price dispersion (across markets).

**Overall, the literature documenting the features of online prices finds that, despite more competition, lower consumer search costs, lower costs to firms of changing prices and easier cross-border purchases, online prices exhibit non-trivial stickiness and behave remarkably similarly to their offline counterparts.** This seems particularly true in Canada, where online and offline prices tend to be more similar than in other countries. Combined with the fact that e-commerce still represents a very small share of total retail sales in Canada, this finding suggests that online prices are unlikely to have a large impact on inflation.

Finally, there have been many attempts to directly quantify the effect of e-commerce on inflation. For example, the European Central Bank followed the methodology of [Yi and Choi](#) (2005) on a panel of EU countries and found that their internet variable (defined as the percentage-point change in individuals looking for offers of goods or services online) had a small but statistically significant negative effect on inflation (0.1 percentage points per year, on average).<sup>16</sup> Given that European countries have a much larger share of e-commerce than Canada, we view this as likely to be an upper bound.<sup>17</sup>

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<sup>14</sup> These data cover the United States and the United Kingdom.

<sup>15</sup> Dynamic pricing occurs when firms change their prices based on current market conditions.

<sup>16</sup> More recently, Goldman Sachs used data on goods and services categories to run a simple fixed-effects regression of inflation on e-commerce share. Although their methodology and data are questionable, they find a similar impact on core personal consumption expenditure inflation. Berezin et al. (2017) estimate a small effect of

## Channel 3: Digitalization, Productivity and Inflation

**Digitalization can affect inflation by lowering firms' operational costs, owing to efficiency gains, automation and new business models.**<sup>18</sup> Digital technologies can be labour-augmenting or labour-saving productivity improvements (Sveriges [Riksbank 2015](#)). The mechanism through which inflation is affected depends crucially on which effect predominates.

**In the first case, where digital innovation acts as a complement to labour, the disinflationary impact is straightforward.** Higher productivity translates directly into a lower cost of production. If the productivity growth is sustained, the disinflationary impact will also persist until policy-makers take the higher productivity growth into account in their assessment of the potential capacity of the economy and adjust monetary policy accordingly. In contrast, if adopting a particular digital technology leads to a one-time boost in productivity, policy-makers may not react and may instead tolerate the temporary “good” disinflation (see [Macklem 2014](#)). In this case, the price level will be permanently lower, with no long-term impact on inflation.

**In the second case, where digitalization creates productivity improvements through the substitution of labour, such as automation, the effect on inflation can come from several dimensions.** Apart from the direct impact on the cost of production (as in the first case), disinflationary effects may be associated with aggregate demand being suppressed owing to the displacement of workers (due to a skills mismatch). In addition, the adoption of digital technologies may be associated with market concentration by a handful of superstar firms such as Amazon or Google controlling a large chunk of the market share. Recent literature (e.g., [Autor et al. 2017](#)) has found a strong link between the rise of such mammoth firms and the declining labour share of income in the United States. These studies have also attributed the increase in income inequality to this phenomenon, with a greater share of income going to the wealthy. The resulting worsening of the income distribution can be a persistent drag on aggregate demand, due to the lower marginal propensity to consume of the wealthy, and can suppress inflationary pressure.

**Another possibility is that new digital technologies may suppress demand for physical investment and increase disinflationary risk by suppressing the neutral rate of interest.**<sup>19</sup> For example, WhatsApp, a typical platform firm, had the same market capitalization as Sony Inc. in 2014 but, unlike Sony, has very little need for physical infrastructure ([Summers 2014](#)). The associated reduction in investment demand

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0.1 to 0.2pp. [Duch-Brown, Gryzbowski and Verboven](#) (2015) find evidence for considerable substitution from traditional retail sales to online sales without, however, affecting price levels in offline retail and price dispersion.

<sup>17</sup> The average e-commerce share for the European Union is around 15 per cent. Many small open economies, such as Ireland, Sweden and Norway, have a share well above 20 per cent.

<sup>18</sup> For examples of efficiency-enhancing digital technologies and their impact on firms' costs, see [Dong, Fudurich and Suchanek](#) (2017).

<sup>19</sup> Indeed, Canadian firms report shifting from digital investment (e.g., hardware) to digital expenses (e.g., cloud services) (see [Dong, Fudurich and Suchanek 2017](#)), a shift that is also evident globally in the data ([OECD 2017](#)).

is one structural factor responsible for suppressing the neutral rate of interest and can potentially be a disinflationary force if the share of such firms continues to rise in a digital economy.

**Based on these channels, the pertinent question is, how much of the potential productivity gains due to digitalization are actually being realized? The productivity trend has been depressed in advanced economies since the early 2000s.** The adoption of digital technologies has not been reflected much in measured productivity growth. Some analysts, such as [Gordon](#) (2014) and [Fernald](#) (2015), interpret the post-crisis slowdown in total factor productivity growth as a permanent shift back to its historical norm. In this view, high levels of productivity growth in the United States during the five decades preceding the 1970s, as well as from the mid-1990s to the early 2000s, were exceptional. From the early 19th century until the 1970s, historically high productivity growth was spurred by a series of significant inventions (e.g., the combustion engine, electricity, telegraph, indoor plumbing and electricity, transistors etc.). It is often argued that productivity boosts from the latest cycle of advances—in information and communications technology, robotics, etc.—are unlikely to be as transformative as those from the earlier cycle. According to this view, the benefits from the information technology revolution have already been reaped, and potential future innovations, such as driverless cars, are unlikely to change business practices much. [Gordon](#) (2014) argues that latest innovations are more “evolutionary” than “revolutionary.”

**Others, however, claim that such pessimism is misplaced.** They argue that the new digital technology is still in the “installation phase,” and productivity effects will materialize during the “deployment phase” ([van Ark](#) 2016). [Brynjolfsson and McAfee](#) (2012) similarly argue that even if the current slow growth in productivity is attributable to a lower scale and scope of technology adoption, this is not a sufficient reason to predict that slower adoption is going to persist in the future. [Mokyr](#) (2014) claims that considerable technological improvement may be imminent (citing biotech, new materials, etc.) that could have a significant positive impact on productivity.

**Another view is that productivity improvements are already happening, but statisticians are unable to capture the full impact of digitalization in the productivity statistics** ([Brynjolfsson and McAfee](#) 2012). This view is widespread among policy-makers and tech industry leaders, and is commonly referred to as the “mismeasurement hypothesis.” The general conclusion in the academic literature is that mismeasurement does not explain much of the recent slowdown in productivity ([Syverson 2016](#); [Byrne, Fernald and Reinsdorf 2016](#); [Ahmad and Schreyer](#) 2016). Recently, the Organisation for Economic Co-operation and Development (OECD) and the International Monetary Fund (IMF) embarked on a joint initiative to study the challenges associated with measuring the impact of digitalization in national accounts. The conclusion of the OECD-IMF interim report ([Ahmad, Ribarsky and Reinsdorf](#) 2017) is also very much in line with the view expressed in the recent academic literature cited above.

**The effect on inflation from productivity improvement will ultimately depend on the persistence of shocks coming from digitalization.** If the benefits of digital technologies are yet to be reaped, future productivity gains should be expected to put further downward pressure on prices. While monetary policy will likely look through transitory shocks affecting inflation and perceive such shocks as

temporary, “good” disinflation, persistent shocks to the price level may make it necessary to reassess the supply potential of the economy and the degree of accommodation required by the monetary authority to maintain the inflation target.

## Conclusion

Overall, there is some evidence, mostly stemming from Europe, that digitalization can have a small dampening effect on inflation. Given the still-low share of e-commerce and the lagging adoption of ICT technologies in Canada relative to most advanced economies,<sup>20</sup> it is unlikely that digitalization is having a significant effect on inflation in Canada. As digital transformation evolves, this may change. However, countries such as Sweden, which are ahead of us in their use of digital technologies due to their more rapid adoption, have found that digitalization has a statistically significant but small impact on inflation. Its impact is therefore likely to stay small in Canada for some time, even as we catch up to Europe. Nevertheless, the impact of digitalization on inflation remains an issue that policy-makers must continue to monitor. As noted above, the appropriate response for monetary policy depends on whether we believe the effects are permanent or temporary.

Many questions are left unanswered and will be the focus of future research. While theoretical links between digitalization and inflation have been discussed, the current empirical evidence is lacking, and further work will be required; notably, on the importance of changes in market structure (superstar firms or increased competition). Moreover, detailed analysis of some related topics (e.g., the sharing economy, the gig economy, digital transformation in certain sectors such as manufacturing 4.0)<sup>21</sup> are beyond the scope of this note, but may importantly reshape the Canadian economy and thus warrant further attention.

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<sup>20</sup> Compared with other countries, Canada generally ranks behind the United States, in for example, the use of the (industrial) internet of things (IoT or IIoT), e-commerce, big data, and ICT investment and exports, although it ranks more favourably against its peers in cloud computing, ICT trademarks and patents ([OECD 2017](#)). The (I)IoT refers to the use (in manufacturing) of smart devices or objects (e.g., biochips, sensors) that are connected, for example, through the internet or cloud, allowing the collection and exchange of data, remote control and autonomous decision making.

<sup>21</sup> The sharing economy refers to a wide range of economic activities where users share or collaboratively consume goods, services, assets or resources, often through an online platform and in peer-to-peer fashion (e.g., Airbnb, Uber, carpooling, Car2Go, Craigslist, etc.). The gig economy refers to employment relations that are primarily temporary, such as contracted independent workers, short-term and flexible engagements, and working remotely.

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