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Digitalization: Prices of Goods and Services

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Overview

What are the implications of digitalization for prices? This paper explores this question by looking at the various channels through which digitalization can affect prices. First, we assess the importance of the direct channel—the prices of digital goods and services in the consumer price index (CPI) basket. Then we discuss indirect channels related to automation and cost reduction as well as competition and markup. We also review the rise of e-commerce and how it can affect price-setting behaviour. Finally, we highlight important questions yet to be answered that will enhance our understanding of digitalization's impact on prices.

Key messages

- **The relatively small price increases for information and communications technology (ICT) and digital products—partly explained by technological progress—contribute negatively to overall CPI inflation in Canada, but the size of this effect remains small.**
    - Since the recovery phase of the COVID-19 pandemic began, inflation in sectors related to ICT and digital goods and services remains close to zero and well below core and headline inflation.
- **The net effects of the indirect channels (i.e., automation, competition and the increased use of the internet) on consumer prices are theoretically ambiguous and depend on which driving forces dominate.**
    - Evidence in the literature suggests that digitalization is associated with lower consumer prices, despite leading to less-competitive markets (i.e., contributing to the rise of superstar firms[1]) and higher markups.
    - However, these distinct channels are difficult to observe separately.
- **E-commerce in Canada can lower consumer prices as households shift to purchase cheaper goods online and as traditional brick-and-mortar stores lower their prices to remain competitive.**

[1] *Superstar firms* are companies that achieve monopoly scale through large investments in (typically intangible) assets, such as research and development and branding.

1. Digitalization and prices

1.1 Prices of digital goods and services depend on the pace of technological advancement and adoption

The first personal computer was developed less than 50 years ago in 1974, and the first portable personal computer was introduced 7 years later in 1981. Merely 2 years after that, the internet was born, and then, in 1989, how people work, share ideas and entertain changed dramatically with the creation of the World Wide Web. As of 2021, about 4.9 billion people around the world are active internet users—more than double the number from 2012. The ICT era was characterized by the predominant use of digital technologies by both firms and consumers, which further changed how they interact, produce, distribute and consume goods and services. Technology has again advanced and entered another era partly characterized by the use of mobile and cloud platforms by organizations and individuals.

With this acceleration of innovation in information technology, the prices of ICT goods and services have declined significantly since their introduction. As of 2020, ICT prices continued to decline globally but at a slowing pace (International Telecommunications Union 2020).[2] In 2011, Marc Andreessen, the co-founder of the first cloud computing company Loudcloud, wrote in *The Wall Street Journal* that in 2000, "…the cost of a customer running a basic Internet application was approximately $150,000 a month. Running the same application today in Amazon's cloud costs about $1,500 a month" (Andreessen 2011). These figures imply an average decline in prices of more than 50% every two years between 2000 and 2010.

This reflects Moore's Law. In 1965, Gordon Moore hypothesized that the number of transistors in an integrated circuit (i.e., single chip) doubles every two years, while the cost remains unchanged. The idea is that digital technologies double in performance and functionality approximately every two years while their price remains the same. Alternatively, the price would be halved every two years for the same unchanged product (i.e., chip with the same speed). Empirical evidence for mainframe computers has been remarkably consistent with Moore's Law, but it also suggests that the rate of improvement for this technology may be slowing.[3]

A similar price pattern is observed in the case of other ICT-related products, as shown by Byrne and Corrado (2017a, 2017b), although significant heterogeneity does exist across products and

[2] The International Telecommunications Union's ICT price basket is composed of different information and communication service packages (e.g., fixed broadband, data-only mobile broadband, data and voice for high consumption).

[3] Using information on IBM mainframes for System/390 between 1994 to 1999, Byrne and Corrado (2017a) also show this phenomenon. They find that the price per performance declines on average 31% per year, which translates to roughly 47% every two years. When the same calculations are done for the zSeries mainframes, released between 2005 and 2012, the annual growth rate of the price per performance declined to 12% per year.

services. For example, the quality-adjusted US price indexes for personal computers, computer servers and storage declined between 30% and 50% per year on average from 1994 to 2004, implying that prices fall by more than half every two years.[4] Over the following decade, however, these rates decelerated somewhat to 24%–26% per year.[5] Prices of other categories of ICT investment have declined at slower rates, with communications equipment and software price indexes declining by an average of 8% and 7% per year, respectively, over 2004–15. Similarly, their analysis suggests that quality-adjusted prices of data and cellular networking services also decline more gradually than implied with Moore's Law, at around 12%–18% per year.

Moore's Law, and the decline in ICT-related products and services more broadly, is closely connected to the productivity impacts of digitalization discussed in Mollins and Taskin (2023). However, the impacts of digitalization on prices and inflation extend beyond the price dynamics of ICT products themselves. Digitalization has not only affected how efficiently we work and carry out daily tasks—as discussed in Chernoff and Galassi (2023)—but has also impacted the way consumers purchase and pay for goods. For example, consumers increasingly have the option to search for and purchase staple goods online while making payments digitally. These developments have implications for competition, wages and consumer search costs, potentially influencing consumer prices and inflation, whether directly or indirectly.

1.2 Digitalization can play a role in consumer prices in several distinct but connected ways

Digitalization can affect consumer prices and, in turn, inflation through four main transmission channels (**Figure 1**).[6] We introduce the channels below and discuss each one in detail in the sections that follow.

1) **Direct effects through CPI components**. This channel includes the impact of digitalization on the prices of digital and ICT goods and services in the CPI basket. The prices of these items tend to fall more rapidly compared with other CPI components, translating into lower consumer price inflation.

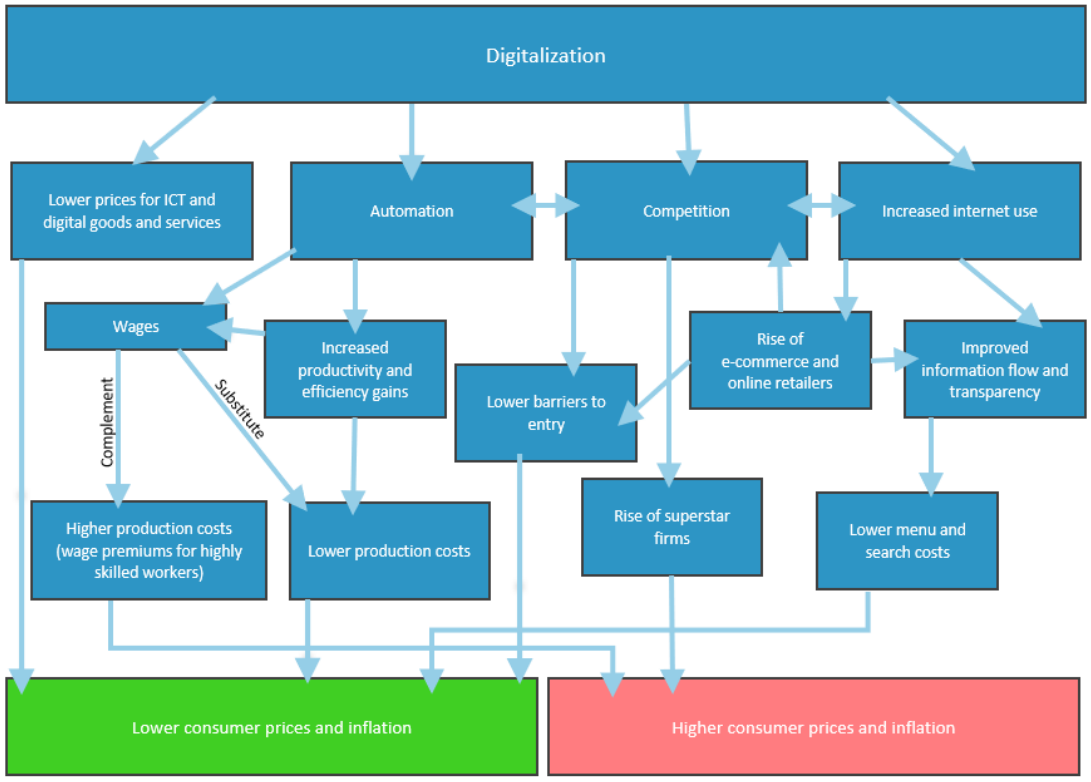
[4] Byrne and Corrado (2017a) provide a detailed discussion on how each price index is constructed. The personal computer price index builds on the work of Berndt and Rappaport (2003), who relate prices to characteristics of personal computers using a flexible form for the hedonic function for prices before 2003. To account for post-2003 improvements in quality, Byrne and Corrado (2017a) use an adjusted producer price index as a personal computer investment price deflator. This is because recent research has shown that the clockspeed and other features in hedonic regressions after 2003 are not an accurate proxy for the performance of microprocessing units.

[5] They also estimate that the current official rate of real ICT price change is understated by approximately 6 percentage points.

[6] For other discussions on transmission channels, see, e.g., Charbonneau et al. (2017), Sveriges Riksbank (2015) and, more recently, Csonto, Huang and Tovar (2019) and European Central Bank (2021).

2) **Indirect effects from automation and productivity-enhancing digital technologies that lead to cost reduction**. Digital technologies can act as either complements to or substitutes for labour (automation of production), which tends to increase firms' productivity. Automation and adoption of digital technologies also affect wage formation and hence production costs.
3) **Indirect effects via different degrees of market competition.** The second indirect channel is through competition and markups. On the one hand, digitalization can increase competition and decrease markups by reducing barriers to entry (for example, by lowering fixed costs or making it easier for firms to reach broader consumer markets). On the other hand, the scalability of certain digital technologies and the creation of superstar firms can lead to higher markups and prices, at least in the long run.
4) **Indirect effects through the increased use of the internet and the rise of e-commerce.** The growth of e-commerce and expanding presence of online retailers can either decrease or increase consumer prices. Online retail improves the flow of information and can reduce both search and menu costs, resulting in lower overhead costs, greater variety of goods and increased competition, which can all help decrease consumer prices. These effects also tend to lead to more frequent price adjustments, which has implications for monetary policy. However, e-commerce has also enabled some online retailers to scale up and dominate markets, which could lead to both higher markups and prices over time.

Figure 1: The transmission channels of digitalization to consumer prices



Note: ICT is information and communications technology.

These four main transmission channels may seem distinct, but they are highly interconnected. In many cases, the boundaries between them become blurred. **Figure 1** shows how these channels complement or reinforce each other. For example, one of the important ways in which the growth of e-commerce brought about by digitalization is likely to impact prices is by increasing competition in retail markets. However, e-commerce has other important implications for prices beyond its effects on competition, and how digitalization affects competition is not limited to e-commerce only. This makes it very difficult (if not impossible) to fully disentangle the channels in the data. Still, the growing literature reviewed in this paper provides useful insights on the importance of each of these separate channels.

2. ICT and digital goods and services in the CPI basket can directly reduce inflation

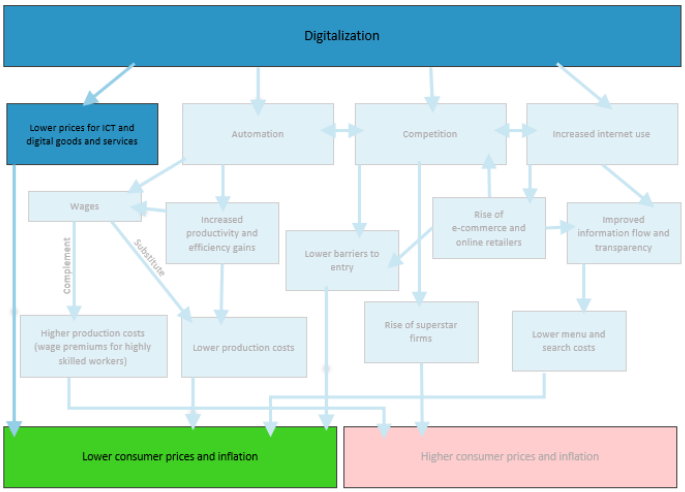
Digitalization directly affects consumer prices for ICT and digital goods (**Figure 2**). As technology has continued to develop, the prices of ICT and digital goods and services have

decreased significantly since the early 1990s. **Because these items are included in the CPI price basket,**[7] **their prices also have a direct effect on inflation**.

2.1 Prices of ICT and digital goods and services have declined on average since 2014

The prices of digital computing equipment and devices as well as home entertainment equipment, parts and services have declined, on average, over the past 30 years (**Chart 1**). However, the latter has seen a slight increase in prices coinciding with the onset of the COVID-19 pandemic. In contrast, the price of communications equipment had remained relatively stable until 2014 and has since followed a downward trend. The prices of other ITC-related goods, such as reading material (excluding textbooks) and video and audio subscription services, have experienced relatively stronger price growth (**Chart 2**). However, overall prices of ICT-related products have tended to decline.

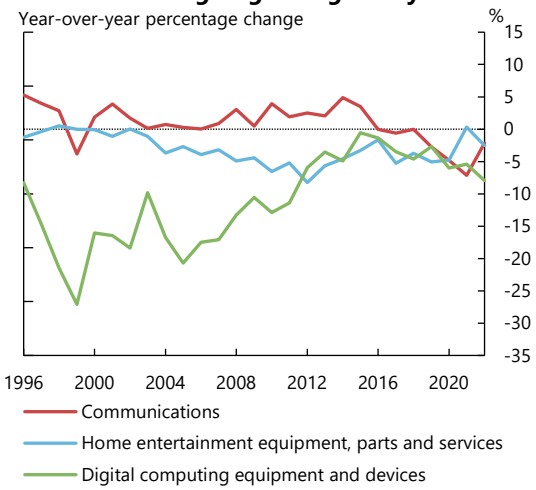
Figure 2: Direct transmission channel on consumer prices



Note: ICT is information and communications technology.

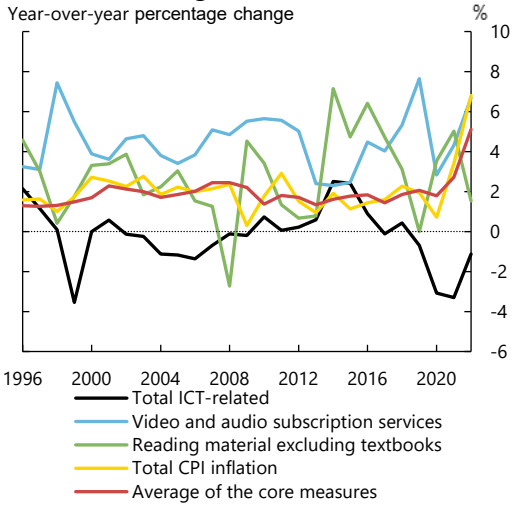
[7] We define ICT and digital goods and services in the CPI basket as communications; reading material (excluding textbooks); home entertainment equipment, parts and services; digital computing equipment; and video and subscription services. This definition does not capture cloud computing. For details on representative products of the CPI, see the Statistics Canada documentation. Also see Charbonneau et al. (2017).

Chart 1: Prices of some ICT and digital goods and services have been declining or growing slowly



Sources: Statistics Canada and Bank of Canada calculations
Last observation: December 2022

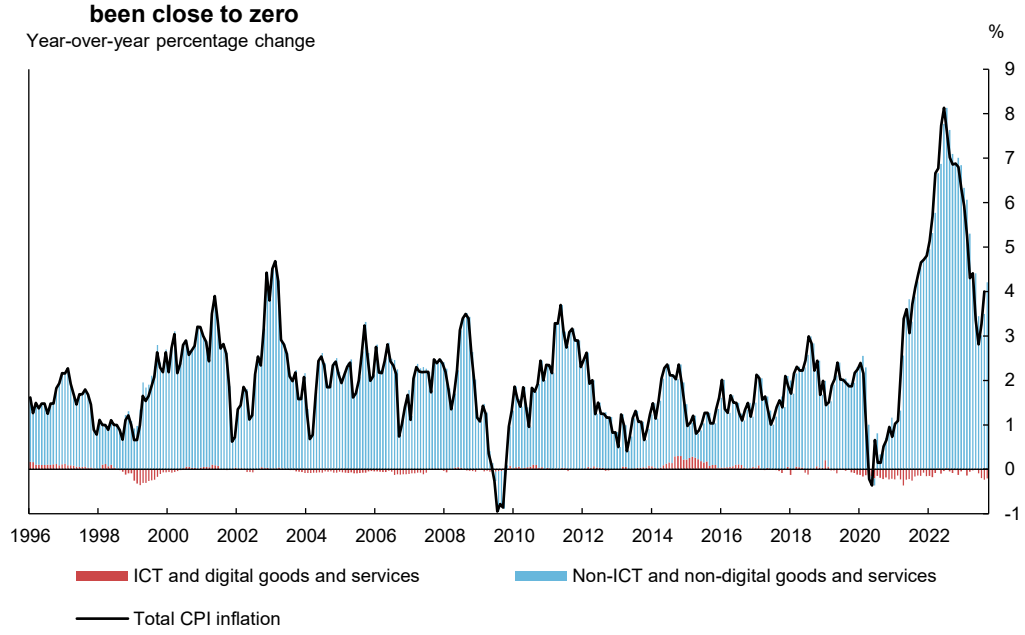
Chart 2: Total price growth for ICT-related goods and services has been close to zero or negative



Sources: Statistics Canada and Bank of Canada calculations
Last observation: December 2022

Since 2018, the inflation rate of prices for ICT and digital goods and services has contributed negatively, on average, to headline CPI by about -0.1 percentage point. This negative contribution has become larger since the onset of the COVID-19 pandemic and reached -0.4 percentage points in March 2021 (Chart 3, red bars). To calculate the contribution to headline CPI inflation, we update the analysis of Charbonneau et al. (2017) to include data up to September 2022. In line with their original findings, we find the contribution of ICT and digital goods and services to CPI growth has been occasionally negative but remains close to zero in Canada. These impacts are rather small, reflecting the small share of the total CPI basket that these products make up, which is around 5%.

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



Sources: Statistics Canada and Bank of Canada calculations

Last observation: August 2023

Our analysis suggests that the direct channel is quantitatively small. However, as digitalization expands, it is important to understand how the broader notion of this phenomenon can affect different segments of the economy and, in turn, prices. As discussed in Faucher and Houle (2023), while the scope of digitalization is most conveniently measured by assessing the industries that offer ICT and digital goods and services, digitalization is not confined solely to those industries. For example, Statistics Canada uses a broader concept when evaluating the value of the Canadian digital economy. That evaluation is based on the importance of the intermediate use of digital and ICT technologies, as measured in the supply and use tables.[8] Therefore, another way digitalization could affect final product prices is through the cost of intermediate inputs, taking markups and labour costs as given. (Digitalization is also likely to have implications for markups and labour costs, which are discussed in the sections that follow.)

Classifying goods and services according to digital intensity yields similar insights: sectors that are digitally intensive moderate inflation because of lower average price growth, but the total contribution to CPI is relatively small. We base our classification on the digital intensity of production index of Liu and McDonald-Guimond (2021).[9] Specifically, we construct industry-level price indexes by mapping CPI components to each two-digit North

[8] According to Statistics Canada's definition, growth of the digital economy has outpaced the ICT sector in recent years, and in 2019, it made up 5.5% of the total economy (Statistics Canada 2019).

[9] Digital intensity is calculated from multi-dimensional indicators using various data sources and built from data on ICT capital stock and investment, the use of intermediate ICT goods and services, digital-related occupations, and robot use. Results show that the use of digital inputs has increased in most Canadian industries over time, but with considerable unevenness across industries.

American Industry Classification System (NAICS) category,[10] and we classify digitally intensive industries as those for which Liu and McDonald-Guimond's 2013–15 intensity index exceeds 0.5 (on a scale of 0 to 1).[11] In doing so, we find that about 45.9% of CPI components fall under retail trade, which is not classified as digitally intensive. We therefore break out digital computing equipment and devices, audio and video equipment as a separate category, since that industry is digitally intensive. Grouping it together with retail trade would mask its contribution to average consumer prices. Using this adjusted classification, we find that digitally intensive goods and services account for 5.2% of the total CPI basket. We also find that inflation for digitally intensive industries has declined since 2014, and this trend is mostly driven by the broadcasting industry—in particular telecommunications—and computing equipment. Further, compared with recent post-pandemic increases in core and headline inflation, inflation in digitally intensive sectors is still close to zero. These findings are in line with the impact of prices for ICT and digital goods and services on the CPI documented above. Details are provided in Table A-1 of the Appendix.

2.2 Free digital goods and services may increase consumer welfare but are not captured in the CPI

With digitalization, many firms have been offering many free goods and services. These free items are not captured in official price indexes. Like other free products, free digital goods may increase welfare and **affect the official CPI implicitly in two ways:**

1) The provision of new free digital products can impact the prices of other products in the CPI basket. Usually, if the products are substitutes, one would expect the price of the non-free product to decrease. For example, we might expect the introduction of free services such Google Maps or Google Translate to lead to lower prices for maps and dictionaries.
2) When free digital products entirely replace priced products of similar quality, inflation indexes reflect only a conservative estimate of the associated decline in the cost of living, since free products' prices are not captured in the CPI.

The increasing prevalence of free digital goods and services and the associated potential gains in utility and welfare highlight the question of whether and how free goods and services should be reflected in consumption price indexes. However, from a monetary policy perspective, this question is a less pressing concern. It is not clear whether CPI would be a better target variable if welfare gains from free goods and services were captured. First, monetary policy works to preserve the value of money, which depends on the prices of goods

[10] See the Appendix for details.

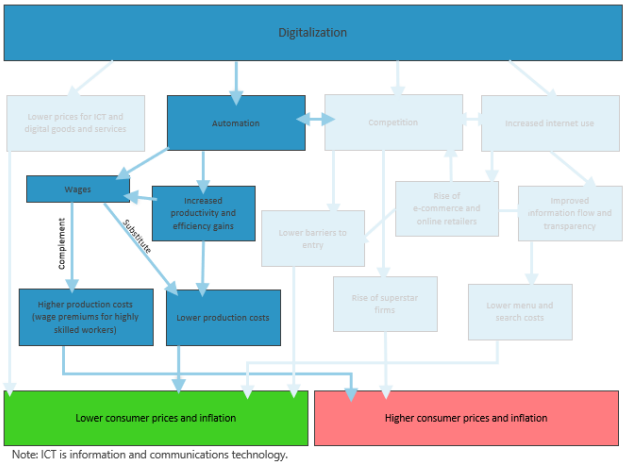
[11] These sectors include information services, broadcasting services, architectural, legal, accounting, engineering and related services, advertising services and design, computer systems, and management services.

and services that money is used to buy. However, adjusting for free goods and services in the CPI would lead to a broader inflation rate measure that is not as closely tied to the value of money and stability of prices. Second, from a conceptual perspective, it is impossible to include in a price index every welfare-enhancing good or service that does not have a market price. Once we consider capturing welfare gains in price indexes, we must consider not only free digital goods and services but also other welfare-improving aspects that are not priced in markets, such as clean air or home production (childcare, caring for the elderly, etc.). It is unclear which free goods and services one should include in such adjustments, and accounting for only a select set of free items could result in a price index that has a less general or a confusing interpretation.

3. Cost reductions from automation and digital technology are passed on to consumers

We now explore one of the main indirect channels through which digitalization affects prices—automation. Specifically, we look at the cost savings from lower operational costs and how digital technologies have transformed the way firms operate and produce goods. These sub-channels are challenging to disentangle, and several are tightly linked to discussions in two other papers in this Digitalization Overview series (see Chernoff and Galassi 2023; Mollins and Taskin 2023).

Figure 3: Indirect effects via automation and productivity-enhancing technologies on consumer prices



Note: ICT is information and communications technology.

How does digitalization, and in particular automation, reduce firms' operational costs and lead to lower consumer prices and inflation (Figure 3)? One of the main ways in which digitalization and advancements in artificial intelligence (AI) have enabled cost reductions is through automation and other labour-saving technology. Firms can displace routine tasked labour (typically found among lower-skilled occupations) using robots and AI-assisted machines and software, such as replacing a cashier with a self-checkout register, or customer service representatives with chatbots. The net effect of automation and the consequent reduction in payroll expenses is increased efficiency and lower unit production costs for firms that adopt digital technology. All else being equal, the forces of competition should lead to lower prices of final goods as adoption becomes more widespread. As with the direct channel discussed earlier, the impact of digital technology on consumer prices lies mainly in lower costs. However, this channel can potentially affect any product or service with automatable processes

(not just ICT products and digital technologies themselves). The threat of firms automating their tasks can also decrease workers' bargaining power, resulting in lower wages and, in turn, lower prices (Arnoud 2018).

A small but growing literature documenting the aggregate impacts of automation and robot adoption on consumer prices provides some empirical support for this sub-channel. Examining automation in the French manufacturing sector at both the firm and industry levels,[12] Aghion et al. (2020) find that a 10% increase in adoption of automating technology is associated with a 1%–2% decline in either producer or export prices. This suggests that firms that automate pass through at least some of their productivity gains to consumers. Similarly, Graetz and Michaels (2018) examine the impacts of industrial robots on productivity growth at the industry level in 17 countries. They find that the decline in output prices resulting from increased robot use is proportionate to the increase in total factor productivity, suggesting that many of the gains are passed on to consumers.

Interpreting these findings as evidence that supports the labour-saving channel might seem at odds with the mixed evidence on the impacts of robot adoption on wages and employment presented in Chernoff and Galassi (2023). However, as those authors discuss, several theoretical reasons exist for the general equilibrium wage and employment effects to diverge from decisions at the firm level. For example, Graetz and Michaels (2018) find that robot adoption tends to increase average wages somewhat with no significant impact on overall employment. This suggests a negligible (or even positive) change in overall wage costs, despite the negative impact of robot adoption on output prices. However, as discussed in Chernoff and Galassi (2023), there is a counteracting effect for firms or industries where the adoption of labour-saving technology is the greatest, raising labour demand. At the same time, the general equilibrium effects can result in a decline in labour demand for less productive, non-automating firms as their market share declines. Moreover, the response of wages in automating industries depends on the relative substitutability and complementarity of digital technologies to different skills, as well as the relative skill composition of the economy. (See, for example, Gubler and Sax 2014.)

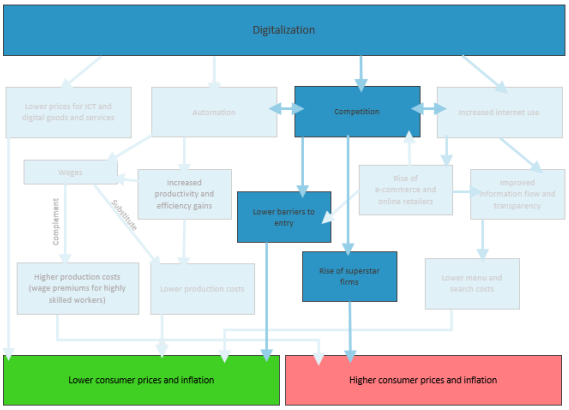
Unfortunately, direct evidence appears to be scarce on the importance of this channel for Canada. This is an important area for future research. Further cross-country evidence on the impacts of automation and robot adoption on inflation is discussed in Chu et al. (2023).

[12] They consider three proxy measures for automation using firm-level data: values of industrial equipment, usage of electro-motive force, and imports of automating industrial machines.

4. Prices and markups also depend on how digitalization influences competition

Digitalization can affect the degree of competition, which also has implications for consumer prices (**Figure 4**). Whether digitalization promotes or stifles competition is likely to depend on initial market characteristics, the type of technology concerned, and the time horizon.

Figure 4: Indirect effects via competition on consumer prices



Note: ICT is information and communications technology.

Digitalization can reduce barriers to entry by allowing firms to scale up quickly and compete more easily. With new businesses challenging the market power of incumbent firms, markups and consumer prices could be reduced. For example, the increased use of data, software, and research and development has transformed firms' ability to scale up business processes. Firms can now scale up their process innovations faster without needing a physical presence in a consumer location—in other words, achieving "scale without mass" (Brynjolfsson et al. 2006). An unsurprising example is Amazon, the world's largest online retailer. Using digital technologies, Amazon has been able to make innovations instantly available to all users and virtual storefronts worldwide. For instance, digital copies of improved processes created by marketing specialists to reduce abandoned shopping carts can be deployed immediately to the web to increase consumer engagement and spending. This has enabled firms to scale up at a lower cost and thus increase competition among incumbent firms. Local brick-and-mortar stores face increased competition against larger and more productive online firms. To survive, these local stores may need to lower their markups, which translates to lower consumer prices. This is often called the "Amazon effect" (Cavallo 2018). Also, online firms are not immune to increased competition. For example, Canadian online firms have reduced their average product scope dramatically from 1999–2012 in response to the increased competition from Amazon.com (Chernoff 2019).[13]

The growing use of the internet alongside digital technologies that lower marginal costs give rise to winner-takes-all market structures and the emergence of "superstar" firms, eroding competition and increasing markups. For example, Korinek and Ng (2017) propose a theoretical framework to evaluate the implications of a firm in one sector of the economy that adopts a digital technology that is labour- or capital-saving and competes with non-

[13] Amazon.com's expansion accounts for 37% of the observed reduction in product scope.

adopting firms.[14] In their model, the adopting firm captures the entire market and becomes a monopolist. Demand for both labour and capital in this sector declines and is diverted to other sectors, wages fall, and the cost savings from lower traditional input use translate into a higher markup. Indeed, the empirical evidence points to digitally intensive firms having higher average growth in markups compared with less digitally intensive firms (Calligaris, Criscuolo and Marcolin 2018). Rising markups, declining labour costs and higher ratios of fixed or overheard costs over the past several decades have also been attributed to the impact of technological innovations on industry concentration and market structure. Specifically, Autor et al. (2020) and De Loecker, Eeckhout and Mongey (2021) find that technological advancement has contributed to the emergence of superstar firms, higher markups and declining labour shares in some sectors of the United States. Further, De Loecker, Eeckhout and Unger (2020) conclude that the increases in average markup and in the ratio of profits to sales in the United States between 1981 and 2014 (markups rose approximately 40 percentage points while profits increased from 1% to 8% of sales) are partly a response to, but still exceed, increases in overhead costs. De Loecker, Eeckhout and Unger (2020) also find that these trends can quantitatively account for the observed decline in wages of lower-skilled workers (see also Chernoff and Galassi 2023).

Despite the positive effects on markups, a higher concentration of market power held by superstar firms is not necessarily expected to coincide with higher consumer prices. The empirical evidence suggests a negative overall impact on prices, though theoretically, prices could respond positively or negatively, at least in the long run. The negative empirical relationship between automation and prices discussed in section 3 is also consistent with Korinek and Ng's (2017) model-predicted response of prices to digitalization. In their framework, the incumbent firms that are displaced can always re-enter the market using the old technology and paying no fixed costs should the superstar monopoly attempt to raise prices. This limits prices from rising, and their theory predicts that prices even fall when productivity gains from the new technology are large enough. However, under a more general set of assumptions, it is possible for a superstar firm to deter competitors from entry by threatening to price them out of the market.[15] This could increase the sale price above previous competitor prices.

Overall, the implications of digitalization for competition, markups and prices are inconclusive. Recent evidence supports concerns that digitalization leads to the emergence of superstar firms and higher markups, which does not appear to lead to

[14] In modelling the technology, the authors make critical assumptions, including that adoption entails a significant fixed cost but negligible marginal costs (i.e., it is non-rival), and that the firm can exclude competing firms from also using the technology. The authors argue that the cost assumptions are typical of many digital technologies, consistent with the scale-without-mass effect discussed above.

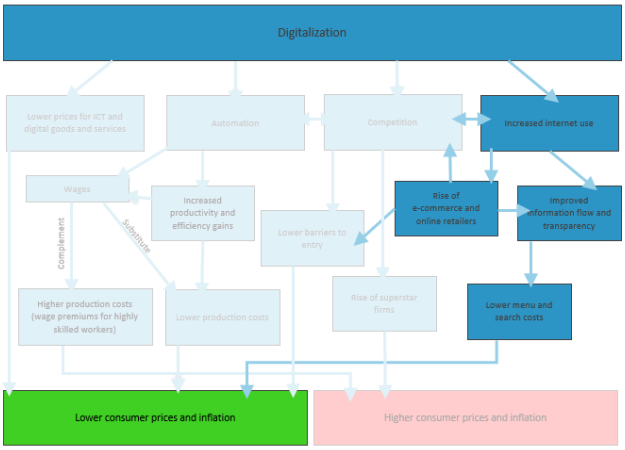
[15] Specifically, if potential competitors also face significant overhead production costs, the mere threat that the superstar monopoly would undercut their average cost price could be a sufficient disincentive to compete.

positive price pressures. Theory suggests that, even when digitalization promotes the rise of superstar firms and leads to higher markups, the long-run impact on prices could be positive or negative. Empirically, the negative relationship between some forms of digital technology adoption (such as automation) and prices suggests that the increase in markups could be more than offset by the effect of lower input costs in firms' pricing decisions (as in Korinek and Ng's [2017] framework). The longer-term response of prices once market competitiveness is sufficiently eroded is an important area for future research, though this relationship is likely to be difficult to tease out from the data.

5. Increased internet use and e-commerce are associated with lower and more flexible prices

Digitalization has been associated with an increased use of the internet (**Figure 5**). This has at least two important implications for prices. First, the expansion of e-commerce affects competition in the retail sector, including traditional brick-and-mortar sellers. Section 4 touched on the topic in the broader context of digital technologies that enable firms to scale up faster. In this section, we delve into more detail about the rise of e-commerce—a uniquely digitalization-driven phenomenon affecting the competitive landscape of the retail sector.

Figure 5: **Indirect effects via increased internet use on consumer prices**



Note: ICT is information and communications technology.

Second, and related to the rise of e-commerce, is the impact on price-setting behaviour. Specifically, lower price-adjustment costs (i.e., the cost incurred by firms when changing prices)[16] and improved price transparency (as consumers can more easily search for and compare prices across both online and traditional retailers) could have implications for the dispersion and volatility of prices among both online and offline retailers. We provide a brief overview of these hypothesized channels and then review the literature that leverages detailed product-level price data to understand the differences between online and offline pricing patterns and the relationships between them.

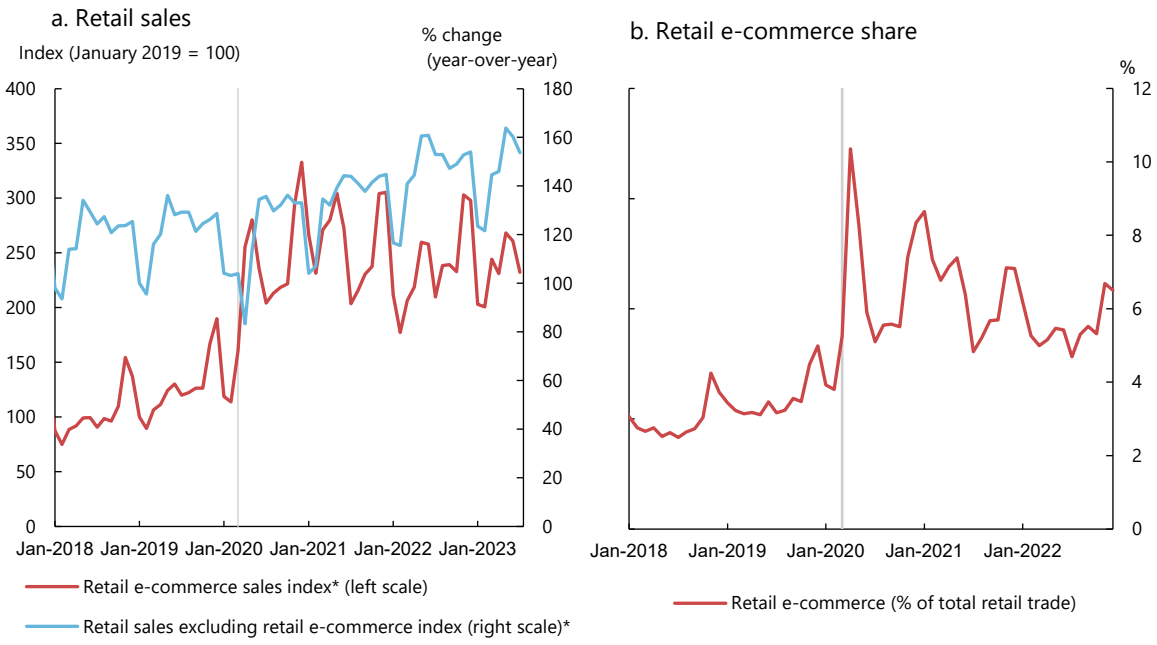
[16] Even brick-and-mortar stores that display prices digitally potentially benefit from the use of technology that allows them to adjust prices at a lower cost.

5.1 The rise of e-commerce and how it affects price-setting behaviour

Digitalization has contributed to a rapid expansion of e-commerce over the past decade. Since 2012, the number of internet users has more than doubled. This has enabled both consumers and firms to change the ways in which they purchase goods and services and how firms operate. With the onset of the COVID-19 pandemic, lockdown and physical distancing measures prevented businesses from opening or operating at normal capacity. Many Canadians turned to purchasing goods and services online, and some firms adjusted their business operations, such as creating an online shop or providing delivery services. **Chart 4** shows the spike in retail e-commerce sales following the first lockdown. Between February and May 2020, online retail sales expanded by 150% and has remained at more than double the pre-pandemic average. At the same time, retail sales that were not conducted online declined at the onset of the pandemic but have since recovered. While retail e-commerce increased during the pandemic, it continues to account for a small proportion of retail trade: 4.9% as of March 2022 (**Chart 5**). However, it is important to note that Statistics Canada's e-commerce estimates do not include sales by Amazon.ca, which likely leads to an underestimation of the importance of e-commerce for Canada (see Chernoff 2019).[17] More details on retail trade data are discussed in Faucher and Houle (2023).

[17] This measurement issue has also been described by Statistics Canada (2016) as the following: "If an on-line retailer has a Canadian location that operates as a retail business, it is included as a Canadian retail operation. If it does not, it is excluded, even if the retailer has significant sales to Canadian consumers, a website ending in .ca, or even logistics, fulfillment centres/warehousing, or shipping services that are based in Canada. These businesses are classified as foreign-based retailers, not Canadian retailers."

Chart 4: At the start of the pandemic, retail e-commerce sales grew while retail sales fell



Note: Grey vertical line represents the first lockdown in March 2020. Retail trade includes electronic shopping and mail-order houses.

Sources: Statistics Canada and Bank of Canada calculations

Last observations: panel a, July 2023; panel b, December 2022

E-commerce can affect consumer prices in at least two important ways:

- **Traditional brick-and-mortar stores may be forced to lower their prices to compete with the growing presence of online businesses, including superstar firms.** This relates to the Amazon effect discussed in section 4. In addition to the potential cost advantages discussed earlier in this section, online retailers could also have a competitive advantage in being able to gauge demand in real time by monitoring activity on their websites and in being in a better position to monitor the pricing behaviour of competitors (Mitchell 2019). Some evidence does exist linking internet use and the penetration of e-commerce to lower average prices and inflation. For example, examining a panel of 207 countries, Yi and Choi (2005) find that a 1% increase in the ratio of internet users to the total population is associated with an average reduction in the inflation rate by 0.04–0.13 percentage points over 1991–2000.[18] Similarly, the European Central Bank (2021) finds that a 1 percentage

[18] The negative relationship between the ratio increase and prices could reflect factors other than e-commerce. Indeed, the authors hypothesize that internet use increases labour productivity.

point increase in the proportion of people searching for goods and services online reduces non-energy industrial goods inflation by 0.025 percentage points. While these findings are suggestive of the pro-competitive effects associated with the rise of e-commerce and price transparency, internet use also affects labour productivity, and hence prices, in other ways. A comparison of detailed online and offline price data is needed to isolate the role of e-commerce from broader digitalization trends. We review this literature in the next section.

- **Lower menu and search costs can influence prices both directly—resulting in more frequent online price changes—and through their effects on competition.** Some digital technologies can make it easier for firms to optimize and adjust prices, while e-commerce enables consumers to acquire information about seller prices and products more quickly and at a lower cost. For example, Smith, Bailey and Brynjolfsson (2001) find that online markets are characterized by lower menu costs. While this could contribute to the lower average prices in online markets by lowering the costs of doing business, it also has the important effect of allowing firms to change prices more frequently. Indeed, empirical research has found that online retailers tend to make smaller and more frequent changes to their prices compared with brick-and-mortar retailers (Brynjolfsson and Smith 2000; Gorodnichenko and Talavera 2017). Furthermore, by allowing consumers to compare prices of dozens or even hundreds of similar products from different retailers in just as many clicks of a button, online markets are reducing consumer search costs. Both outcomes potentially imply more competitive pressure on conventional stores. In particular, greater availability of price information has the potential to increase competition between firms and to lower prices. (See Bakos [1997] for evidence in the context of multi-product online markets.) However, online markets don't involve informational advantages just for consumers. Online sellers are often able to observe detailed information about consumers, such as their purchase and browsing histories (Borenstein and Saloner 2001; Hannak et al. 2014; Ichihashi 2020). This can lead sellers to adopt price discrimination strategies in an attempt to offset competitive pressures. Such strategies can result in higher price dispersion and increase information costs through information obfuscation (Sandulli and López-Sánchez 2014).[19]

It is also worth noting that, as consumers shift toward purchasing more competitively priced goods online, the competition effect on the official price index could be underestimated. This is a concern if weights are adjusted to reflect declining expenditure shares (so-called outlet bias). For example, to account for the some of the shift to online

[19] In addition, online firms may account for both learning costs and waiting times in their pricing strategies, which allows them to charge more (less) for high- (low-) demand goods to less (more) patient consumers.

spending during the pandemic, Statistics Canada updated the 2021 CPI basket weights.[20] The weight of clothing and footwear declined from 5.4% in 2017 to 4.1% in 2020 due to lower prices from online discounts and significant declines in sales from the suspension of in-person shopping. To maintain the accuracy of measuring inflation dynamics, the consumer price index (CPI) should be adapted. Currently, 17% of the CPI basket is priced online and measured using goods and services regularly purchased online by Canadians. Some examples of CPI aggregates priced entirely online include air transportation, telephone services and internet access services, while some priced partially online includes audio equipment and the purchase of digital media.

5.2 Offline versus online prices

Given the potential spillover effects e-commerce can have on prices of traditional retailers, it is important to understand the difference between online and offline prices. A firm's online pricing behaviour could differ from that of a traditional firm because of consumers' lower search costs or lower menu costs. The difference between online and offline prices can also shed light on the extent of the Amazon effect discussed earlier (i.e., traditional retailers lower their prices to match online retailers) as well as whether outlet bias is a major concern (that is, to the extent that online and offline prices are similar, the official CPI would accurately capture consumer prices).

The shift in spending patterns toward online purchases, along with the acceleration of digitalization, has led to the emergence of research comparing pricing behaviour between traditional brick-and-mortar firms and online retailers. The literature has two main takeaways:

- **Online prices tend to be lower, on average, than those in brick-and-mortar stores, but the difference appears to be small when comparing identical products from the same multi-channel retailers.**
    - Using Adobe Analytics online transactions data covering millions of product prices, Goolsbee and Klenow (2018) find that between 2014 and 2017 in the United States, online price inflation is, on average, about 1.3 percentage points lower per year than offline price inflation.[21] In particular, when comparing price indexes constructed from online prices within detailed product categories (e.g., categories such as "Men's sport coats and tailored jackets") with the CPI using equivalent CPI weights, the imputed inflation rate of the former is substantially lower.

[20] See Statistics Canada (2021).

[21] A subset of the transaction data that come from 20 of the 30 largest employers in the United States and 80% of the Fortune 500 retailers is used in their analysis. Their dataset accounts for 19% of the CPI relative importance weights in the U.S. Bureau of Labor Statistics.

- Conversely, Cavallo (2017) finds little difference between online and offline prices when comparing scanner data from the Billion Prices Project.[22] He compares prices of over 24,000 products from a collection of 56 large multi-channel retailers in 10 countries, including Canada. Prices are identical about 72% of the time, based on a 10-country average. In Canada, the prices scanned in physical stores match those with the same barcode on the same retailer's website 91% of the time.[23] When prices did differ, 3% of online prices were found to be higher, while 5% were lower and the difference was a markdown of, on average, 5%. These findings are in stark contrast to Goolsbee and Klenow (2018). This suggests that observed differences in pricing strategies relate to goods that are priced "online only" and not necessarily identical to those sold in stores, or, at a minimum, relate to goods that are not sold both online and in-store by the same seller. It is also important to note that because Cavallo's study excludes firms without a physical retail store—like Amazon—it examines only a small share of e-commerce.
- Evidence from Canadian CPI microdata used to explore the difference in online and offline prices suggests similar patterns as in Cavallo (2017). That is, prices for identical products online and in-store tend to be similar. In cases where they did differ, online prices were more frequently below those in-store. (See **Box 1** for details.)

- **Online price changes tend to be smaller and more frequent than those of traditional retailers—which implies more flexible prices—except for prices of products from multi-channel retailers.**
  - Gorodnichenko and Talavera (2017) compare durable goods prices by detailed product code (similar to barcode scanner data) in Canada and the United States. They find that the average size of online store price changes (around 4%) is less than half of that for traditional brick-and-mortar stores (around 10%, found in Nakamura and Steinsson 2008). In addition, online price changes are more frequent—occurring every three weeks compared with every four to five months or more for traditional stores—and exhibit a greater degree of exchange rate pass-through. Mitchell (2019) reports similar findings for prices underlying the Canadian CPI. Comparing prices underlying the CPI that were collected online with those collected at physical outlets, that author finds that prices collected from online-only retailers changed more frequently. This evidence is consistent with the notion that online retailers face fewer barriers to price adjustment, such as lower menu

[22] The Billion Prices Project founded in 2008 by Albert Cavallo and Alberto Rigobon at MIT and Harvard is one of the largest studies comparing online and offline prices. In 2010, the creators launched PriceStats, as discussed in Faucher and Houle (2023), to produce high-frequency indexes for central banks and financial institutions, including a daily inflation series.

[23] The retailers included in the study for Canada are Canadian Tire, Home Depot, The Source, Toys "R" Us and Walmart.

costs, or lower costs of collecting and processing information when optimizing prices.

- Hillen and Fedoseeva (2021) focus on prices of grocery items sold on Amazon Fresh in the United States. Like Gorodnichenko and Talavera (2017), they find that online prices change much more frequently compared with the traditional grocery store price changes reported in Nakamura and Steinsson (2008). (The average price spell of groceries sold online is only 18 days compared with approximately 3.5 months for traditional stores.) However, when the authors focus only on products that are also sold at physical locations of Whole Foods Market (which was acquired by Amazon in 2017), they find that this subset of online prices exhibits the same degree of stickiness commonly reported for traditional stores. These findings are in line with Cavallo (2017), who finds that online and offline price changes by the same multi-channel retailer have similar frequencies and sizes.

These empirical regularities are also apparent in the behaviour of the PriceStats series for Canada (Box 2).[24] **Chart 2-A** in **Box 2** compares the PriceStats measure with official CPI inflation and service and goods inflation in Canada. The PriceStats measure tracks inflation relatively well and correlates best with goods inflation (using monthly averages of the daily PriceStats measure, the correlation with the monthly CPI goods inflation is 0.71). Moreover, the PriceStats inflation measure is, on average, lower and more volatile than total CPI inflation.

The rise of e-commerce in Canada appears to be contributing to lower average prices, although the overall impact on inflation is likely small. So far, evidence for Canada seems to suggest that online and offline prices do not differ significantly, but when they do diverge, online prices are usually lower. This, coupled with the relatively low share of e-commerce in total retail sales in Canada, suggests that the impact of e-commerce is probably not large. However, the fact that the sales of large foreign-owned retailers such as Amazon are not captured by most measures makes it difficult to assess the size of e-commerce in Canada. Also, further studies are needed to quantify the impacts of e-commerce and the use of the internet on inflation.

[24] The PriceStats daily inflation series is an average of individual price changes across multiple categories and thousands of online retailers. The index is composed of a basket of goods that change over time and is updated daily and published with a three-day lag. Prices are obtained through web-scraping technology and the product categories account for about 80% of goods weights in the CPI basket (or 27% of total CPI weights). In particular, the PriceStats measure is composed of (approximately): clothing and footwear; furnishing and household products; other goods (including personal care products); recreation and culture (mainly electronics); food and non-alcoholic beverages; and health.

Box 1

Online and offline prices: Evidence from Canadian CPI microdata before the COVID-19 pandemic

Prepared by Peter Campion,[1] Helen Lao,[2] Corinne Luu[2] and Patrick Sabourin[2]

At the time of writing, global inflation remains elevated largely due to higher prices for energy and food. In May 2023, consumer price index (CPI) inflation in Canada was 4.4%, somewhat above the target range of 1% to 3%. These high levels of inflation have not been seen since before the Bank of Canada introduced inflation targeting in 1991.

Before the onset of the COVID-19 pandemic, during more normal times, inflation remained weak in many advanced economies, and some have suggested that this is due the rising share of e-commerce, among other factors. This increase in e-commerce may reflect the availability of less-expensive goods and services online. While CPI measurements may not include these products immediately, through time their availability may place downward pressure on prices in stores. Before the pandemic, inflation in Canada was well explained by fundamentals despite goods inflation being somewhat weaker than expected based on this relationship. To assess the likelihood that the availability of products online may have had implications for inflation and its dynamics, we examine microdata of in-store prices included in the CPI and a web-scraped sample of identical online products from June 2018 to July 2019.[3]

In particular, we explore to what extent online prices are cheaper than those in store and whether monthly dynamics in these prices differ, thereby contributing to weaker goods inflation. Overall, the key findings are as follows:

- On average, prices online tended to be similar to those in store. The aggregate ratio of online to offline prices averaged 1 over our sample. However, for furniture, personal care, and clothing and footwear, online prices were slightly lower, on average, than those in store.[4]
- Half of the products included had identical prices (**Chart 1-A**) online and in store (60% were within 1%; **Chart 1-B**). When prices were not identical, online prices were more frequently below those in store.[5]
- Our constructed price indexes using the monthly evolution of prices for matched products suggest that from June 2018 to July 2019, online prices tended to weaken to a greater degree than those in stores. This could suggest that had online prices been more prominent in the CPI sample (before the pandemic began), year-over-year inflation could have been weaker on the margin (-0.1 percentage point). However, this should be interpreted with caution because this result is based on a limited sample and could reflect methodological differences.
- Consistent with the previous literature, online prices tend to be more volatile than those in store, which could reflect lower menu costs online and the use of algorithmic pricing strategies.

[1] Statistics Canada

[2] Canadian Economic Analysis Department, Bank of Canada

[3] Over this period, a total of 35,784 products were matched.

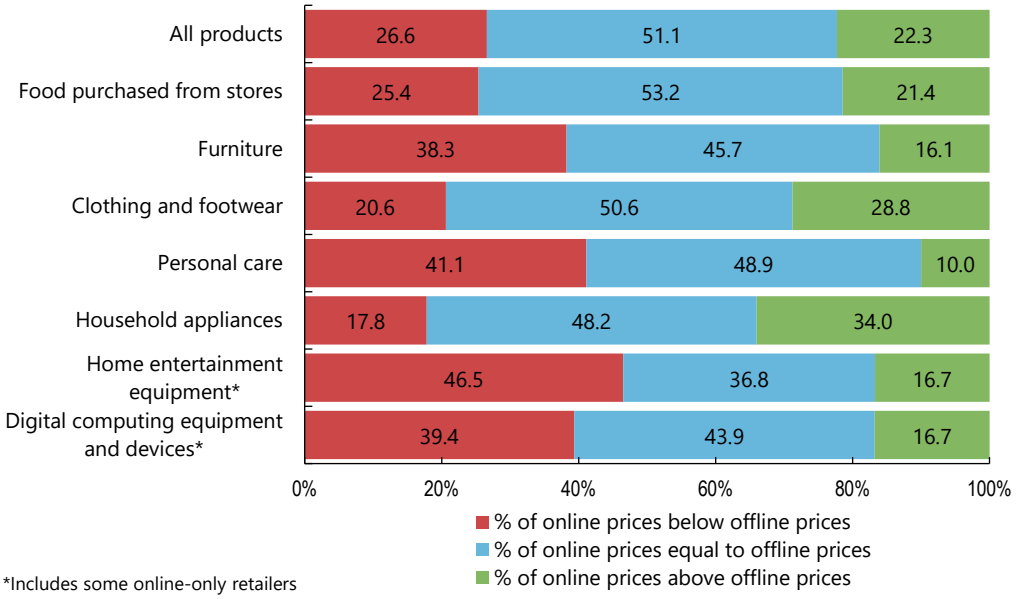
[4] We find the opposite for household appliances, which tended to have higher prices online.

[5] These two findings are consistent with the past literature. See Cavallo (2017) for more details.

Box 1 (continued)

Chart 1-A: Roughly half of online and offline prices are identical

Average monthly distribution of online-to-offline price ratios, June 2018 to June 2019, monthly data

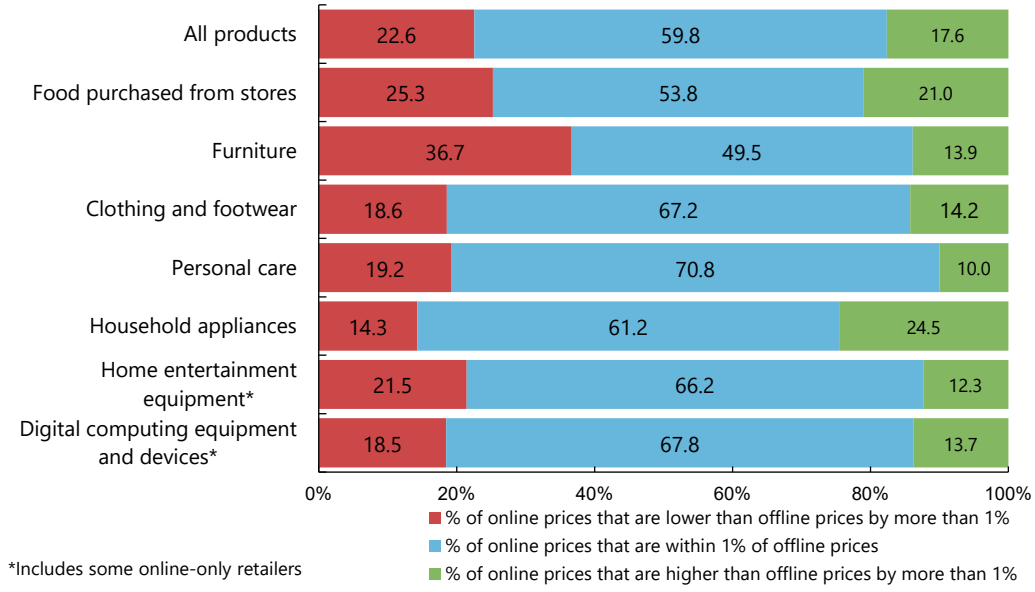


*Includes some online-only retailers

Sources: Statistics Canada and Bank of Canada calculations

Chart 1-B: Roughly 60% of online prices are within 1% of offline prices

Average monthly distribution of online-to-offline price ratios, June 2018 to June 2019, monthly data



*Includes some online-only retailers

Sources: Statistics Canada and Bank of Canada calculations

Box 2

How does a measure of inflation of online retailer prices compare with the CPI inflation measure?

PriceStats is a high-frequency (daily) measure of inflation that collects the prices of millions of items sold by online retailers.[1] It is a real-time consumer price index available daily on State Street's *Insights* dashboard.

The PriceStats series for Canada is available from July 2011 and captures general movements in annual and monthly inflation reasonably well. Since the data are available in real time, the measure provides an approximation of today's inflation rates (based on observable data), at least one month before the release of official consumer price index (CPI) data.

PriceStats carefully monitors the categories of goods within each retailer, concentrating on those categories that are part of traditional CPI baskets and avoiding categories that are over-represented online, such as CDs, DVDs, cosmetics and books. On average, almost 195,000 retail prices are observed every day and are placed into major goods categories.[2] Using these detailed price data, PriceStats constructs daily, monthly (month-over-month)[3] and annual (year-over-year)[4] inflation measures.

Chart 2-A shows the annual inflation series for Canada. The path of the PriceStats index has mirrored that of CPI inflation well, particularly the increase since the start of the COVID-19 pandemic. But the difference between the two measures has widened over the course of 2022.

When we analyze the summary statistics and compare this high-frequency measure of inflation to CPI inflation in year-over-year terms, we find the following:[5]

- In terms of annual averages, the **PriceStats inflation measure (year-over-year) is, on average, lower and more volatile than CPI inflation (year-over-year)**.[6] Specifically, **Table 2-A** shows that the PriceStats series exhibits both a lower mean inflation rate and lower standard deviation compared with the CPI in most years. The exception is in 2020–21, during the onset of the pandemic.

[1] The PriceStats daily inflation series is an average of individual price changes across multiple categories and thousands of online retailers. The index is composed of a basket of goods that change over time; it is updated daily and published with a three-day lag. Prices are obtained through web-scraping technology, and the product categories account for about 80% of goods weights in the CPI basket (or 27% of the total CPI weights).

[2] In particular, the PriceStats measure is comprised of (approximately): clothing and footwear; furnishing and household products; other goods (including personal care products); recreation and culture (mainly electronics); food and non-alcoholic beverages; and health.

[3] A month-over-month series computed as the percentage change between the average of the daily inflation series of the last 30 days and the average of the previous month.

[4] A year-over-year series computed as the percentage change between the average of the daily inflation series of the last 30 days and the average for the same period a year ago.

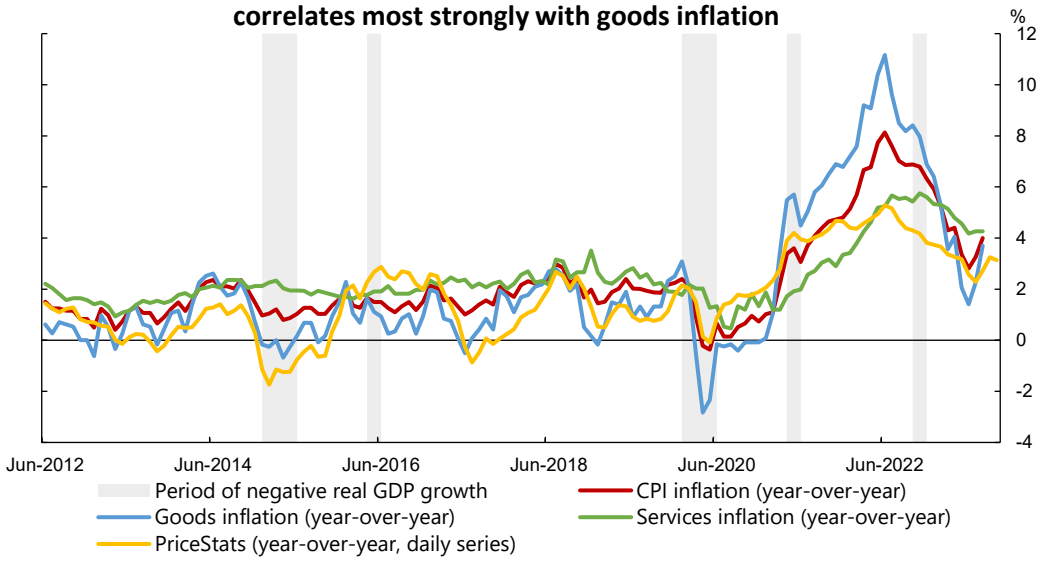
[5] CPI inflation (year-over-year) is the year-over-year increase in the total consumer price index (CPI) with a base year of 2002. It is composed of a basket with about 700 goods and services that Canadians typically buy. The basket includes food, housing, transportation, furniture, apparel, recreation, and other items.

[6] Monthly aggregates are calculated by taking the average of the daily series for a given month; annual aggregates are calculated by taking the average of the monthly aggregates for a given year.

Box 2 (continued)

- For monthly averages, PriceStats inflation evolves similarly to CPI. The contemporaneous correlation between PriceStats and CPI is relatively high at 0.80 and the highest relative to the correlation between lags or leads (**Table 2-B)**.
- PriceStats data as early as one week into a month show a high correlation with CPI data, suggesting the first few weeks of data can be informative of the monthly PriceStats measure. This allows for more timely analysis without a month of publication lag as with the CPI measure.
- When we compare the PriceStats index with inflation of CPI subcomponents, the correlation is strongest with goods inflation and is mostly driven by durable goods.

Chart 2 - A: PriceStats inflation measure has mirrored CPI inflation closely and correlates most strongly with goods inflation



Sources: Statistics Canada, State Street Global Market Research and Bank of Canada calculations

Last observations: inflation measures, August 2023; PriceStats, October 8, 2023

Table 2-A: Summary of key statistics

Year	Range (%)		Mean (%)		Standard deviation	
	CPI	PriceStats	CPI	PriceStats	CPI	PriceStats
2012*	0.83–1.5	0.72–1.44	1.14	1.12	0.24	0.26
2013	0.41–1.32	-0.43–0.7	0.94	0.14	0.30	0.34
2014	1.14–2.36	0.28–1.41	1.91	0.92	0.40	0.39
2015	0.8–1.61	-1.74–0.95	1.13	-0.66	0.23	0.75
2016	1.1–2.01	1.63–2.88	1.43	2.33	0.24	0.37
2017	1.01–2.13	-0.88–2.58	1.60	0.64	0.37	1.17
2018	1.68–2.99	0.43–2.68	2.27	1.69	0.39	0.72
2019	1.44–2.4	0.5–1.79	1.95	0.98	0.27	0.37
2020	-0.37–2.4	-0.08–2.14	0.72	1.39	0.84	0.71
2021	1.02–4.8	2.06–4.68	3.39	3.74	1.33	0.87
2022	5.14–8.13	3.81–5.28	6.80	4.57	0.83	0.42
2023*	2.81-5.92	2.29–3.74	4.16	3.11	1.04	0.46
Aggregate	-0.37–8.13	-1.74–5.28	2.27	1.66	1.80	1.61

* First observation: June 30, 2012

** Last observations: August 2023 (CPI) and October 8, 2023 (PriceStats)

Note: PriceStats monthly aggregates are calculated by taking the average of the daily series for a given month. PriceStats annual aggregates are calculated by taking the averages of the monthly aggregates for a given year.

Table 2-B: Contemporaneous correlation of PriceStats with CPI is strongest

Correlation	CPI_{t-3}	CPI_{t-2}	CPI_{t-1}	CPI_t	CPI_{t+1}	CPI_{t+2}	CPI_{t+3}
$PriceStats_t$	0.68	0.73	0.79	0.81	0.80	0.78	0.77

6. Important future trends and open questions

Prices of digital and ICT-related products are rising at a more moderate pace compared with other products in the CPI basket. This is consistent with the relatively high rate of technological progress in those specific sectors. To date, this direct negative impact on inflation in Canada has been rather trivial, reflecting the products' relatively small weight in the overall basket, but this weight will likely rise as digitalization continues. Similar conclusions can be drawn for e-commerce, which accounts for a small share of total retail sales in Canada. On average, the shift to online shopping has had a negligible impact on prices, but a potentially large proportion of e-commerce remains unmeasured in official statistics. Given that e-commerce and digitalization are accelerating, national statistical offices are working to maintain and update the list of goods included in the official CPI basket so that it can remain representative of Canadian consumption.

Research on digitalization and prices remains relatively new and many gaps still need to be addressed. Up until the last few years, much of the existing literature focused exclusively on the implications of digitalization on productivity, labour reallocation and economic growth rather than prices and inflation. An important area where more empirical research is needed is the impact of digitalization on competition and markups. Digitalization can both increase and decrease competition among firms, and markups can be impacted in either direction. While the existing evidence suggests digitalization leads to a concentration of market power among superstar firms and to higher markups, it is less clear whether these forces are large enough to offset the pass-through of lower costs to consumer prices.

Another key related area is understanding the channels through which e-commerce is changing firms' pricing behaviour, and what this implies for the future path of inflation and price flexibility. Much of the existing research on prices generally compares those online with those of identical products in traditional brick-and-mortar stores and typically finds little difference. Whether the growth in e-commerce will continue to result in even lower and more flexible prices will depend on the ability of the sellers of online-only products to compete with traditional stores, and how the availability of these goods changes consumer search methods. Moreover, this research has mostly stemmed from Europe, thus further analysis with Canadian data is required to fully understand how digitalization is transmitted to prices.

6.1 Key open questions

Continued research on the implications of digitalization for production costs, competition and prices will improve our understanding of the key drivers of inflation. This, in turn, allows central banks to fulfill their price-stability mandates. We conclude with a list of key topics for future research to address the important open questions on the impacts of digitalization on prices in Canada:

- How is e-commerce evolving in Canada and how much does it contribute to the Canadian economy? To understand its implications for prices in Canada, we need to know how much of domestic retail sales is represented by large online retailers such as Amazon.
- How much does digitalization—especially automation—impact firms' prices in Canada? In particular:
    - To what extent are decreased production costs passed on to consumers through lower prices?
    - Or conversely, how is digitalization contributing to higher markups?
    - How do the impacts of both of these scenarios vary by sector and evolve over time?

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Appendix

Table A-1: Mapping of CPI components to GDP industries

Industry code	Industry name	CPI basket component	Digital intensity index (2013–15)
44, 45	Retail trade	Food purchased from store; Alcoholic beverages purchased from stores; Tobacco products and smokers' supplies; Household cleaning products; Paper, plastic and aluminum foil supplies; Pet food and supplies; Seeds, plants and cut flowers; Other horticultural goods; Other household supplies; Furniture and household textiles; Household equipment; Clothing and footwear; Purchase of passenger vehicles; Gasoline; Passenger vehicle parts, accessories and supplies; Health care goods; Personal care supplies and equipment; Sporting and exercise equipment; Toys, games (excluding video games) and hobby; Other recreational equipment; Purchase and operation of recreational vehicles; Books and other reading material (excluding textbooks)	0.18
334	Computer and electronic products	Digital computing equipment and devices	0.92
481	Air transportation	Air transportation	0.08
482	Rail transportation	Rail, highway bus and other inter-city	0.10
485, 487, 488	Other transportation: transit and ground passenger transportation	Local and commuter transportation	0.10
491, 492, 493	Warehousing: postal service	Postal and other communications services	0.13
511, 518, 519	Information services: publishing industries (except Internet)	Newspapers, magazines and periodicals	0.73
515, 517	Broadcasting	Spectator entertainment (excluding video and audio subscription services); Video and audio subscription services; Communications	0.66
52	Finance and insurance	Tenants' insurance premiums; Mortgage interest rate cost; Homeowners' replacement cost; Homeowners' home and mortgage insurance; Other owned accommodation expenses; Financial services; Passenger vehicle insurance premiums; All other passenger vehicle operating expenses	0.31

53	Real estate and rental and leasing	Rent; Leasing of passenger vehicles; Rental of passenger vehicles; Rental of digital media	0.08
561	Administrative and support services	Services related to household furnishings and equipment; Travel tours	0.28
61	Educational services	Education	0.22
62	Health care and social assistance	Childcare services; Health care services	0.20
71	Arts, entertainment and recreation	Recreational services; Use of recreational facilities and services	0.15
72	Accommodation and food services	Food purchased from restaurants; Traveller accommodation; Alcoholic beverages served in licensed establishments	0.07
81	Other services (except public administration)	Tenants' maintenance, repairs and other expenses; Homeowners' maintenance and repairs; Housekeeping services; Other household services; Passenger vehicle maintenance and repair services; Parking fees; Personal care services	0.18
91	Public administration	Property taxes and other special charges; Passenger vehicle registration fees; Drivers' license	0.24

Note: Industries are those with a composite index characterizing digital intensity, as defined in H. Liu and J. MacDonald-Guimond, "Measuring Digital Intensity in the Canadian Economy," Statistics Canada Economic and Social Reports, Catalogue No. 36-280001 (February 2021).

Sources: Statistics Canada and Bank of Canada calculations

Chart A-1: Prices in digitally intensive sectors have not been growing at the same rate as total CPI

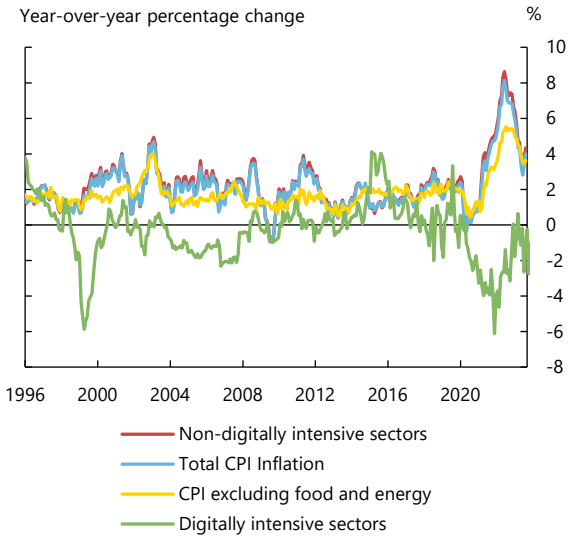
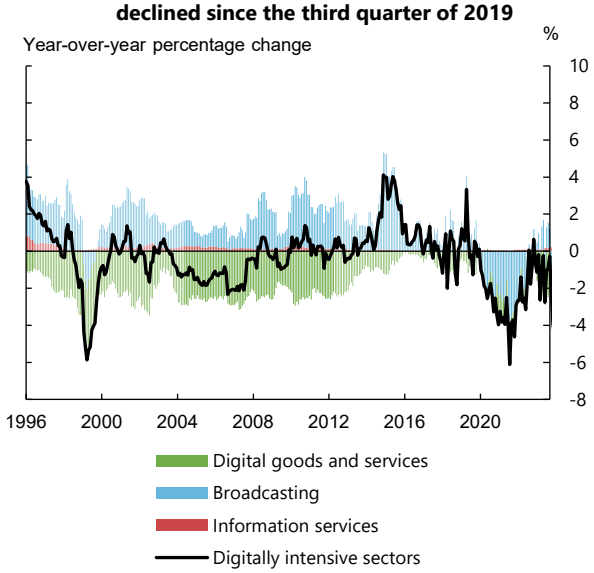


Chart A-2: CPI in digitally intensive sectors has declined since the third quarter of 2019



Notes: Sectors included in both charts are those with a composite index characterizing digital intensity above 0.5, as defined in H. Liu and J. MacDonald-Guimond, "Measuring Digital Intensity in the Canadian Economy," Statistics Canada Economic and Social Reports, Catalogue No. 36-280001 (February 2021).

Sources: Statistics Canada and Bank of Canada calculations

Last observation: August 2023