# The Digital Economy

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- Digital technologies are transforming how businesses operate by facilitating tasks that rely intensively on connectivity, information usage, prediction and collaboration.
- Firms with high levels of organizational capital (e.g., people-management and decision-making processes that are high quality) and human capital (skilled labour) are likely to see the largest productivity benefits from investments in digital technologies.[1] These firms tend to be agile and able to maximize the benefits of their investments by identifying and exploiting opportunities for sales growth, process redesign and production efficiencies.
- The transition to a digital-technology-intensive economy could have wide-ranging implications for the macroeconomy.

Digital technologies are transforming the way we live, work, consume and produce goods and services. Examples include cloud computing, the Internet of Things, advanced robotics, advanced analytics (including big data, artificial intelligence (AI) and machine learning), biotechnology, social media, three-dimensional (3D) printing, augmented and virtual reality, broadband Internet and wireless mobility.[2] Broadband Internet and wireless mobility are not new. However, their widespread adoption and improved

1 *Organizational capital* is an intangible business asset consisting of processes, systems, norms, values and enterprise knowledge that shapes how a firm's resources are used in combination to become productive. The firm's resources include machines, patents, brands, information and communications technologies (ICTs) and human capital. Organizational capital is an asset that cannot be easily imitated by competitors and therefore offers a competitive advantage to the firm's owners (Lev, Radhakrishnan and Evans 2016).

2 *Cloud computing* provides on-demand, shared processing resources and data to computers and other devices over the Internet. The *Internet of Things* is the networking of physical devices—such as smart devices, vehicles, buildings and other items—embedded with sensors, electronics, software, actuators and network connectivity that enable these objects to detect and transmit events or changes in a device's environment. *Big data* refers to the large volumes of data that businesses collect and analyze to uncover hidden patterns, market trends, customer preferences, etc. *Artificial intelligence* (AI) computer systems are able to perform tasks that normally require human intelligence, such as speech recognition and decision making. *Machine learning*, a field of AI, involves programming computers that learn from sample data or past experience. It is most powerful in situations where a computer program cannot be written directly to solve a given problem (Agrawal, Gans and Goldfarb 2017). *Augmented reality* involves a live view of a real-world environment with portions that are augmented by computer-generated sensory input such as sound, video, graphics or GPS data. In contrast, *virtual reality* replaces the real world with a simulated one.

bandwidth provide essential virtual connectivity for the digital economy—just as energy, transport and analog communications networks provided essential physical connectivity for the development of the industrial economy.

This article compares the current digital transformation with past industrial revolutions. It discusses whether digitalization should be seen as an evolution of the information and communications technology (ICT) revolution or as a new epoch. During the ICT revolution (discussed below), firms used electronics to automate a limited number of routine steps in production.[3] Moving forward, firms will use digital technologies to automate many more routine steps in production as well as some that are complex and non-routine.

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Varian (2016) proposes five main ways in which digital technologies will transform economic activities:

(i) *Data collection and analysis*—Firms will be able to collect large amounts of information about customer preferences that can be used to predict customer behaviours and improve service delivery.

(ii) *Personalization and customization*—Firms will be able to deliver customized products and services. Customers expect a streamlined experience and count on merchants to possess relevant information about their purchase history, billing preferences, shipping addresses and other details.

(iii) *Experimentation and continuous development*—Firms will be able to exploit large data sets and employ powerful prediction algorithms to automate systems and inform decisions on production and resource allocation.

(iv) *Innovations in contracting*—Firms and consumers will be able to track, monitor and verify the performance of others with whom they are conducting transactions. This will facilitate new types of economic transactions (e.g., ridesharing, e-money, distributed ledgers).[4]

(v) *Coordination and communication*—Communication tools (e.g., document-sharing software, video conferencing, wireless mobility devices) will allow people and resources to interact with increased flexibility, regardless of where they are located. Firms will be able to service a global market for their products and services more easily.

After reviewing the historical background, this article surveys how new digital technologies are challenging existing systems of production in select industries. Finally, it explores the effects of digitalization at the macroeconomic level, including some implications for policy-makers.

## Historical Context: A Fourth Industrial Revolution?

There have been three industrial revolutions in history, and the emergence of the digital economy is considered by some to represent a fourth.[5] The first industrial revolution, originating in Britain between roughly 1760 and 1850, centred on the shift from rural-agrarian to urban-mechanized systems of

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3 ICT capital inputs include computer hardware, telecommunications equipment, and computer software and databases (Organisation for Economic Co-operation and Development 2016).

4 Electronic payments represent a technology to purchase goods and services while electronic money or *e-money*, such as Bitcoin, represents a new form of currency. Both can facilitate economic transactions. For details, see Fung, Molico and Stuber (2014) and Fung and Halaburda (2016). A *distributed ledger* simultaneously records data across multiple locations, without there being a central repository.

5 See Schwab (2016), for example.

production.[6] Key technological advances included cotton spinning, steam power, steamships, railways and the transition from wood to metal (Gordon 2015, 2016). Britain saw a "gradual acceleration to a steady but unspectacular [rate of real gross domestic product (GDP)] growth with rapid productivity advance confined to relatively few sectors" (Crafts 2014, 1). Growth in British labour productivity (GDP per hour) averaged from approximately 0.3 to 0.6 per cent per annum during that era.[7]

The second industrial revolution spanned roughly the century after 1870. Over time it became led by the United States and centred on the shift to mass production, distribution and communication. Key innovations included electricity, urban water and waste systems, the telephone, the internal combustion engine, air transport, highways, radio, television, plastics, air conditioning, high-rise buildings, antibiotics and treatments that reduced infant mortality. In contrast to the earlier era, productivity increases were significant and sustained. Growth in US labour productivity averaged 2.8 per cent per annum from 1920 to 1970 (Gordon 2016).

The third industrial revolution, centred on ICTs, began roughly in the 1960s and was led by the United States. Significant advances in networked computing and telecommunication capabilities were accompanied by steep price declines and rapid quality improvements in ICT hardware and software. Key innovations included advances in semi-conductor manufacturing, the switch from mainframe to personal computers, email, faxes, photocopying, electronic documents, the Internet, e-commerce, bar-code scanning, electronic catalogues, automatic teller machines, automatic credit scoring and mobile telecommunications. ICT diffusion, especially in offices and in the retail and wholesale sectors, contributed to labour productivity growth in the United States of around 2.5 per cent per annum between 1996 and 2004 (Gordon 2015).

*Is a fourth industrial revolution that will fundamentally transform economies and societies now under way?*

There is no consensus in the literature as to whether digitalization should be seen as an evolution of the third (ICT) revolution or as a distinct, fourth revolution. Gordon (2015, 2016), for example, sees digital technologies as evolved ICTs that are less transformative and have far less scope to generate large, sustained increases in productivity compared with innovations in earlier eras.[8] In contrast, Schwab (2016) argues that a fourth industrial revolution is under way that will fundamentally transform economies and societies by fusing the physical, digital and biological worlds through, for example, highly interconnected production chains and semi-automated prediction and decision-making processes. Brynjolfsson and McAfee (2014) describe the digital era as a "second machine age." Whereas the first machine age (the period since the first industrial revolution) featured the automation of tasks reliant on manual labour, the second machine age will see many cognitive or knowledge-based tasks automated and cheaply produced at great scale.

6 Britain became "the workshop of the world" (Temin 1997, 80).

7 See Broadberry, Campbell and Van Leeuwen (2013) and Crafts (2014). Technological diffusion during the first industrial revolution was slow. The peak contribution from steam power to British productivity was not realized until after 1850, almost a century after James Watt's patent (see Crafts 2014).

8 For example, Gordon (2015, 2016) points out that the ICT revolution's impact on productivity growth was short-lived and "tended to be channeled into a narrow sphere of human activity involving entertainment, communication, and the collection and processing of information" (Gordon 2016, 1). He also points out that the employment share of new firms (a potent source of new technologies and creative destruction) and initial public share offerings have been in decline in the United States since 2000.

## Transformative Effects at the Firm and Industry Levels

Across industries, digital technologies have the potential to drive efficiencies, provide opportunities for firms to increase earnings and market share, and facilitate ongoing innovation. It is still unclear, however, whether and when these predictions will be borne out empirically. For example, signs of business dynamism, such as new firm entry and new entrepreneurs, remain in long-term decline in both the United States and Canada (Davis and Haltiwanger 2014; Cao et al. 2015).

Digitalization can be measured using the following attributes:[9]

(i) *Ubiquity*—the extent to which consumers and enterprises have universal access to digital services and applications;

(ii) *Affordability*—the extent to which digital services are priced in a range that makes them available to as many people as possible;

(iii) *Reliability*—the quality of available digital services;

(iv) *Speed*—the extent to which digital services can be accessed in real time;

(v) *Usability*—the ease of use of digital services and the ability of local ecosystems to boost adoption of these services; and

(vi) *Skill*—the ability of users to incorporate digital services into their lives and businesses.

According to Van Ark (2016), only a limited number of firms in the United States, the United Kingdom and Germany have made a full transition to the digital economy. As a result, few sectors and industries have seen large productivity gains to date. He suggests that advanced economies are still in an installation phase, a lengthy period during which new technologies emerge and advance, driven by new and superior ways of doing things, disrupting established practices and organizations. Efficiency gains may not arise until a deployment phase, when the new technologies are widely used and fully entwined both within firms and in their relationships with customers and suppliers. Innovations in the installation phase do not diffuse rapidly across all firms in an industry because successful first movers, in terms of early adoption, are limited as a result of an ongoing battle between new and old technologies and their applications. Schumpeter (1939, 1947) argues that the process of "creative destruction" could initially cause slower potential economic growth, in part reflecting the structural displacement of labour (Keynes 1930).[10]

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We now discuss how new digital technologies are challenging existing systems of production, for example, in retail, wholesale, logistics, construction and automotive industries.

9 Katz and Koutroumpis (2013) construct a digitalization index across 150 countries using these attributes. In their study, Canada placed tenth, after the United States, which placed sixth, in rankings associated with digitalization. In recent years, these "advanced" digitalized nations have improved ICT usability, developed skilled labour to take advantage of available technologies, and improved the speed and quality of digital services.

10 According to Schumpeter (1994, 82–83), creative destruction describes the "process of industrial mutation that incessantly revolutionizes the economic structure from within, incessantly destroying the old one, incessantly creating a new one." Keynes (1930, 358–373) introduces the concept of "technological unemployment" as the situation where the "means of economising the use of labour outrun the pace at which we can find new uses for labour."

## Retail and wholesale

In both the retail and wholesale sectors of the economy, sensors, AI and machine learning allow retailers and wholesalers to manage their inventories, e-commerce strategies (e.g., pricing) and activities across a network of physical and virtual stores and storage facilities in real time and in a semi-autonomous fashion. Arthur (2011, 2) suggests that more and more "large and fairly complicated conversations . . . occur entirely among things remotely talking to other things: servers, switches, routers, and other Internet and telecommunication devices, updating and shuttling information back and forth."

*Social media networks are transforming the retail sector*

Social media networks are transforming the retail sector. The benefits of firms' social media engagement include providing information to consumers, generating customer feedback, acquiring new customers and driving sales from existing customers. Consumers today, with the assistance of new digital technologies, benefit from greater visibility of real-time prices, improved convenience and new opportunities for cross-border purchasing, which can potentially enhance competition and the welfare of its consumers (Reynolds and Cuthbertson 2014).

## Logistics

As retail and wholesale sectors of the economy are transformed by digital technologies, closely related industries, such as logistics, face a similar transformation. The logistics industry might have been thought to suffer as email traffic and digital downloads replaced physical products over the past two decades, but, in fact, more packages than ever before are now being shipped around the globe. On any single day, about 85 million packages and documents are delivered around the world (World Economic Forum [WEF] 2016a). Still, the industry faces significant inefficiencies—for example, 50 per cent of trucks travel empty on their return journey after making a delivery.

*Data are at the heart of the logistics business*

There is a race within the logistics industry to eliminate inefficiencies.[11] Firms continue to build digitally enabled platforms that decentralize monitoring and control. Information and analytical services that rely on the simultaneous application of cloud-based computer analysis, sensors and the Internet of Things, for example, have positioned data at the heart of the logistics business. The objective is to detect and predict problems and to optimize decision making. These information services also help reduce operating costs while improving the efficiency of operations. In the future, new delivery capabilities, such as self-driving vehicles and drones, could allow logistics firms to deliver shipments more efficiently (WEF 2016a).

## Construction

Building information modelling (BIM) has gained popularity in the construction industry as broadband Internet speeds have increased and computer processing power has improved. In BIM, a digital representation of the physical and functional characteristics of a building extends traditional two-dimensional technical drawings even beyond three dimensions, supplementing a building's representation with time and cost as fourth and fifth

11 Earlier advances associated with ICT investment in the logistics industry were one of the main factors contributing to the development of global value chains and the expansion of global trade in recent decades.

dimensions. The most important aspect of BIM software is that it defines objects in such a way that if one is amended by an individual participant, related objects will automatically change.

Virtual and augmented reality devices may be connected to BIM software to demonstrate the design and provide progress reports throughout the life of the project, allowing stakeholders to be more engaged. Through mobile connectivity, firms can further engage with their workers with real-time communications. In the construction industry, 3D printing technologies are now used to fabricate buildings and construction components. Machines are integrated into production lines featuring additive, subtractive and formative manufacturing processes. Potential advantages include faster construction, lower labour costs, increased complexity and/or accuracy and less waste. Still, 3D printing is at an early stage of development. A number of issues persist, including the fact that large-scale printing jobs are slow and often produce uneven results (WEF 2016b).

*Three-dimensional printing technologies are now used to fabricate buildings and construction components*

### Automotive

Over the past decade, automotive manufacturers have strategically decentralized their production process to reduce their costs and mitigate risks. Supply chains in the industry are sometimes characterized "as a complex structure, aimed at getting the right parts into the right factories at the right time" WEF (2016c, 14). Low-cost sensors, wireless mobility and advanced analytics are enhancing the efficiency of the automobile supply chain by improving transparency across connected manufacturers and by gathering and analyzing data to reduce long lead times. Much of this integration along the supply chain is facilitated through cloud computing, which enables upstream and downstream firms in the chain to look at the same data, creating more efficiency and stability throughout the chain.

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## Effects on the Macroeconomy

### Productivity

*Productivity isn't everything, but in the long run it is almost everything. A country's ability to improve its standard of living over time depends almost entirely on its ability to raise output per worker.* (Krugman 1997, 11)[12]

Productivity is the efficiency with which an economy transforms inputs into outputs. Growth accounting provides a systematic way of thinking about the possible channels through which firms' investments in digital technologies could affect productivity.[13] Growth in labour productivity, or GDP per unit of hour worked, can be defined as the weighted[14] sum of the following:

(i) *Capital deepening*—growth in capital input per hour;

(ii) *Labour quality improvements*—increases in how productive each unit of labour is, which is a function of the age and skill levels of the workforce; and

(iii) *Multi-factor productivity (MFP) growth*—output growth that is unexplained by (i) and (ii).

12 Terms-of-trade movements (which are generally viewed as driven by external forces) can also have important impacts on living standards in small open economies like Canada.

13 Growth accounting relies on strict neoclassical assumptions (e.g., separability of inputs, constant returns to scale, no adjustment costs, competitive factor markets and efficient firms) as well as correctly measured inputs and outputs. Violations of these assumptions can show up as multi-factor productivity. See Baldwin et al. (2014) and Baldwin and Gu (2013) for details.

14 The weights correspond to each factor's revenue share of total output.

Investments in digital technologies contribute to higher productivity by providing workers with more tools to do their work. The production process becomes more capital intensive. Falling prices for digital technologies provide encouragement for firms to modernize their equipment so they can achieve cost efficiencies and enhanced capabilities.

Another channel by which investments in digital technologies could raise productivity is through higher MFP growth. MFP captures a wide range of other potential influences on labour productivity. These include technological change (to the extent this is not measured by capital intensity), dynamic reallocation (the economy's ability to shift outputs and inputs to achieve best use, including through firm entry, exit or reorganization, outsourcing and offshoring) and economies of scale (the ability to produce more output with fewer inputs, such as through increased specialization of individual aspects of the production process). For example, firms may find subcontracted cloud computing capacity or on-demand software more scalable and flexible than maintaining in-house servers and software. The diffusion of digital technologies has the potential to disrupt business models, shift resources from old to new systems of production, spur the development of new products and services, and engender greater specialization and economies of scale.

The experience of the ICT revolution may offer lessons for how this diffusion process plays out. Studies directly estimating the impact of firms' ICT investments on productivity typically find that a 10 per cent increase in ICT investment raises output by around 0.5 to 0.6 per cent (Cardona, Kretschmer and Strobel 2013).[15] Bloom, Sadun and Van Reenen (2012) and Van Reenen et al. (2010) find that firms with high-quality management and organizational practices, and employing or having access to skilled labour ("talent"), tend to reap large productivity benefits from their investments in ICT. The agility of such firms enables them to successfully utilize their ICT investments to see and pursue opportunities for sales growth, process redesign and production efficiencies. Firms that are intensive users of technology tend to grow faster than other types of firms and survive, leading to resource reallocation across the economy. The corollary is that investments in organizational, human and ICT capital should be seen as investments in complementary factors of production.[16]

*Investments in organizational, human and information and communications technology capital should be seen as investments in complementary factors of production*

Nevertheless, there are reasons to be cautious about the likelihood of Canada seeing sizable MFP gains from the diffusion of digital technologies. Canadian MFP growth has consistently lagged that of the United States since the 1960s and fell further behind during the ICT revolution (Baldwin et al. 2014; Baldwin and Gu 2013). Lagging MFP growth accounts for most of the differential in Canada–United States labour productivity levels. Bibbee (2012) finds that MFP differentials with the United States are widely spread across industries and are largest in sectors that are sheltered (utilities, information and culture, arts and entertainment) and knowledge-intensive and dynamic (professional, scientific and technical services and high-tech

15 These studies estimate the productivity effects of ICT investments. In the digital era, ICT investments might have different impacts on productivity and across industries because of the automation of cognitive and non-routine tasks.

16 Bloom and Van Reenen (2010) identify 10 factors associated with better management practices across firms and countries. "Management and organisational practices of the firms such as *people management* (better hiring, firing, promotion and pay practices) and *decentralisation* (giving more power to employees further down the managerial hierarchy) appear complementary with ICT. Additionally, skills appear to be very complementary with ICT" (Van Reenan et al. 2010, 13–14). Van Reenen et al. (2010) find that about half of the productivity performance differential between the United States and Europe during the ICT revolution can be accounted for by firm-level differences in organizational capital.

manufacturing). Impediments to firm growth, resource mobility and innovation, as discussed by Bibbee (2012), could affect Canada's ability to benefit from the use of digital technologies relative to other countries.

## Labour markets

Digitalization could have wide-ranging implications for the labour market. Some occupations will see significantly higher wages as a result of increased labour demand for scarce skills. New and more specialized occupations that complement technology will emerge. Other occupations will become redundant as a result of automation.[17] Frey and Osborne (2017) discuss a wide range of occupations that could be affected by the automation of both routine and non-routine tasks. Occupations most susceptible to automation involve transportation and logistics; office and administrative support; and factory, sales and service jobs that do not involve high-level social skills (the ability to build relationships and navigate social environments) or a variety of tasks. Occupations least susceptible to automation involve creative and social skills, persuasion, negotiation, originality or complementarities with technology. Examples include most jobs in education, (non-diagnostic) health care, management, business, finance, sports and arts, mathematics, science and engineering.

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Technology-driven changes in the distribution of employment across occupations are not new, but they could become more pressing and widespread in years to come.[18] Green and Sand (2015) show that the United States, Europe and Canada have seen rises in the share of employment in high- and low-skill jobs since the 1970s. Specifically, employment shares have risen for high-skill management, professional and technical occupations and for low-skill sales and service occupations. Meanwhile, employment shares have fallen for mid-skill occupations in production, crafts and operations and, since the 1990s, for secretaries and clerical support.[19] These trends have contributed to a polarization of the United States labour market since the 1970s. Canada's experience was similar over the three decades before 2000. After roughly 2000, however, the resource boom appears to have dominated the effects arising from technological change in Canada (Green and Sand 2015).[20] The ending of the resource boom could see technology-driven changes become more important in determining Canadian employment outcomes.

17 Industrial robots—autonomous machines programmed to perform a range of manual tasks—provide a case in point. Boston Consulting Group (2015, 3) projects that "growth in the global installed base of advanced robotics will accelerate from around 2 to 3 percent annually today to around 10 percent annually during the next decade," resulting in the share of industrial tasks performed by robots rising from 10 to 25 per cent globally by 2025. Acemoglu and Restrepo (2017) evaluate the equilibrium impact of increased industrial robot usage on United States local labour markets between 1990 and 2007. They find large and robustly negative net impacts on employment and wages. The displacement of labour (especially routine manual jobs) was not offset by increased labour demand in other industries and occupations during the period.

18 These challenges have echoes of the past. As Tugwell (1931, 227) wrote, "In any new regime in which machines and power play a greater role than they do even today, men will not have become useless; but the nature of their tasks will have changed. It is man's destiny to perform those functions which machines can never do—the thinking and contriving ones. We shall be on the way to that destiny for a very long time, with various ups and downs during the transition. Our task is the double one of speeding the process and of taking precautions meanwhile against unnecessary personal and family loss and suffering. We are not excused from these duties in any case; and ways will somehow be found to meet them; they may be better or worse ways, but human revolt against intolerable conditions will insure some sort of action."

19 The decline in the employment share for secretarial and clerical support jobs coincides with the ICT revolution's transformation of the office environment.

20 Green and Sand (2015) suggest that after 2000, because of job opportunities during the resource boom in Canada, low-skilled workers were not pushed into sales and service sector jobs to the same extent as they were in the United States.

Recent evidence also suggests that technological changes contribute to a declining share of total national income paid to labour. Autor et al. (2017) find that many product markets in the United States increasingly exhibit "winner takes most" competition. Across a wide range of industries since the early 1980s, sales have become increasingly concentrated among a small number of highly profitable firms with a low labour share. These "superstar" firms exhibit high capital- and technology-intensity, high productivity or superior product offerings. Industries that became more concentrated over 1982–2012 saw faster productivity growth (as measured by output per worker, value-added per worker, MFP or patents per worker) and a more pronounced decline in the share of income paid to labour.[21]

## Inflation and monetary policy

Structural changes in the Canadian economy resulting from digitalization will take many years to play out. Though it is too early to offer conclusions about what these transitions mean for inflation dynamics, we can start to trace some possible channels for further investigation. The Riksbank (2015) identified three potential (and interrelated) channels by which digitalization could affect inflation: (i) productivity and cost structures, (ii) competition and market structures, and (iii) direct effects on the components of the consumer price index (CPI).

First, digitalization may raise productivity and potential output growth. All else being equal, a higher rate of potential output growth requires a higher neutral policy rate to achieve the inflation target (Mendes 2014). As discussed earlier, productivity gains could arise through firms applying more capital to the production process (capital deepening) or finding cheaper and better ways to combine capital and labour (higher MFP). Canada could also benefit indirectly to the extent that digitalization leads to faster world growth. However, in the transition to the digital economy, there could be an increase in skill mismatches and long-term unemployment (e.g., among older workers in occupations that become obsolete) and slower potential output growth. Shifts in wealth and income distributions could also have implications for macroeconomic dynamics.[22]

A related issue is the "mismeasurement hypothesis," which states that technological change is accelerating but is not fully reflected in productivity statistics (e.g., Brynjolfsson and McAfee 2014). It is argued that this is because official statistics fail to fully capture quality improvements in new ICT goods and services and ignore the benefits to consumers from freely available products (e.g., digital photos, social media and online encyclopaedias).[23] However, Syverson's (2016) empirical study finds these measurement issues explain very little of the post-2004 productivity slowdown across advanced economies, suggesting they have not necessarily become more germane over time.[24]

21 The industries examined by Autor et al. (2017) are manufacturing, retail trade, wholesale trade, services, finance, and utilities and transportation.

22 For example, see Kaplan, Moll and Violante (2016).

23 See Dervis and Qureshi (2016).

24 Moreover, Gordon (2014a, 2) points out that "[R]eal GDP measures have *always* missed vast amounts of consumer surplus since the dawn of the first industrial revolution almost three centuries ago" and "No credit is given in real GDP for the safety, convenience, and brightness of the electric light, or the elevator, or air conditioning, or the replacement of the horse by the motor vehicle, or the end of the dismal task of cleaning the streets of horse manure, or of the epochal decline of infant mortality in the first half of the 20th century" (Gordon 2014b, 8).

Second, there could be shifts in the intensity of competition, in market structures and in price-setting behaviour. E-commerce, high-speed connectivity and social media, for example, enable consumers to search, compare and make their purchases from anywhere in the world. This could lead to prices adjusting more quickly to market forces (becoming less "sticky"). Stronger import competition could also exert downward pressure on inflation. Some local firms may not survive these competitive pressures, while others will gain access to new markets as well as the opportunity to operate at a much greater scale. Canadian service exporters appear well-placed to benefit from these trends (Poloz 2016). However, digital technologies encourage networks and economies of scale, so it is also possible that they could encourage the concentration of market power among a few highly successful global firms (see Autor et al. 2017).

*There could be shifts in the intensity of competition, in market structures and in price-setting behaviour*

Third, there could be direct effects on components of the CPI as a result of falling production costs. These trends have been under way for some time (Riksbank 2015). However, price pressures for an increasing range of products may be affected by the lower costs of digital-intensive production and distribution (e.g., online news, films and other services).

Finally, there are questions about how monetary policy should be conducted as the economy becomes more digital-intensive and service-oriented. The Bank targets inflation by adjusting the policy interest rate to minimize the gap between actual and potential output (the "output gap") over time. Assessing the degree of excess capacity in the economy could become more difficult as its structure changes.[25] As Poloz (2016, 6) notes, "In terms of economic models, it is worth considering whether the relationship between inflation and economic growth could change as the economy evolves. Certainly, the concept of an output gap is gradually changing, as services capacity depends mainly on people and skills rather than industrial capacity, while some parts of our old industrial capacity could become redundant in the face of major structural changes. The concept of investment is shifting away from plants and machinery toward human capital. Even the concept of inventories is changing."

## Conclusion

Digitalization could have wide-ranging effects across the economy. More and more business tasks that are currently done by humans will be executed electronically. Many of these processes will occur in digital form "'speaking to' other processes in the digital economy, in a constant conversation among multiple servers and multiple semi-intelligent nodes that are updating things, querying things, checking off things, readjusting things, and eventually connecting back with processes and humans in the physical economy" (Arthur 2011, 3).

The benefits of digitalization are likely to be greatest among firms with high levels of organizational and human capital that use knowledge intensively. However, there are few signs of accelerating productivity across advanced economies like Canada, even in economies that rank high in terms of overall measures of digitalization. It is possible that advanced economies are still in an "installation phase," focused on finding new ways of doing things and disrupting established practices and organizations. Economy-wide productivity gains might not arise until a "deployment phase" is reached, where new technologies and business processes are omnipresent.

25 See Ericsson (2016) on economic forecasting in the context of structural change.

We are only beginning to understand how the digital economy will function. To successfully manage the transition to digitalization, policy-makers will need to ensure that the economy is adaptable; that firms are encouraged by market forces to be agile; that economic gains are widely distributed; that the "various educational, apprenticeship, immigration and employment insurance programs all work well together with the on-the-job training commitments of employers" (Poloz 2016, 6); and that the tools (e.g., statistics, taxation, competition and industrial-relations policies) and associated institutions to manage the economy are up-to-date and fit-for-purpose.

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