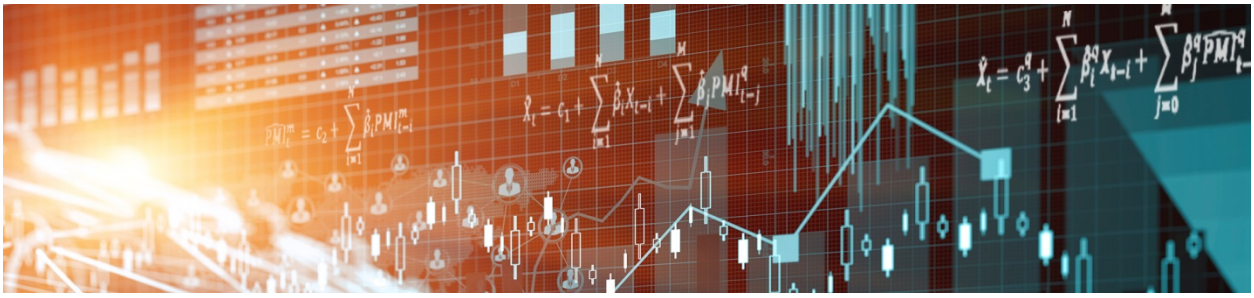
BANK OF CANADA
BANQUE DU CANADA

Staff Analytical Note/Note analytique du personnel 2018-10

Potential Output in Canada: 2018 Reassessment



by Andrew Agopsowicz, Dany Brouillette, Bassirou Gueye, Julien McDonald-Guimond, Jeffrey Mollins and Youngmin Park

Canadian Economic Analysis Department
Bank of Canada
Ottawa, Ontario, Canada K1A 0G9
aagopsowicz@bank-banque-canada.ca
dbrouillette@bank-banque-canada.ca
bgueye@bank-banque-canada.ca
jmollins@bank-banque-canada.ca
jmcdonald-guimond@bank-banque-canada.ca
ypark@bank-banque-canada.ca

Acknowledgements

We would like to thank Eric Santor, Jing Yang, Russell Barnett, Claudia Godbout, Jean-Phillipe Cayen, Ben Tomlin, Daniel de Munnik, Lise Pichette, Marie-Noëlle Robitaille and Olena Senyuta for their helpful comments and suggestions. We would also like to thank Nicole van de Wolfshaar for her editorial assistance.

ISSN 2369-9639

Abstract

This note summarizes the reassessment of potential output, conducted by the Bank of Canada for the April 2018 *Monetary Policy Report*. Overall, the profile for potential output growth is expected to remain flat at 1.8 per cent between 2018 and 2020 and 1.9 per cent in 2021. While population aging will continue to be a drag on potential output growth, this drag is expected to be offset by a pickup in trend labour productivity. This year's profile represents a substantial revision relative to the April 2017 reassessment. This is mostly a result of the historical revisions to the levels of business investment and capital stock released in November 2017 by Statistics Canada, strong employment gains in 2017 and a slightly more optimistic outlook for investment over the projection horizon. An analysis of alternative scenarios suggests a range for potential output growth from ±0.3 percentage points in 2018 to ±0.6 percentage points in 2021.

Bank topics: Potential output; Productivity; Labour markets
JEL codes: E, E00, E2, E22, E23, E24, E37, E6

Résumé

La présente note résume la réévaluation de la production potentielle à laquelle procède la Banque du Canada et dont les résultats ont été publiés dans le *Rapport sur la politique monétaire* d'avril 2018. Globalement, la trajectoire de la croissance de la production potentielle devrait demeurer stable, à 1,8 % entre 2018 et 2020 et à 1,9 % en 2021. Même si le vieillissement de la population continuera de freiner la croissance de la production potentielle, on s'attend à ce que ce phénomène soit contrebalancé par un redressement de la productivité tendancielle du travail. La trajectoire de cette année constitue en soi une révision importante de la trajectoire issue de la réévaluation d'avril 2017. C'est principalement le cas en raison des révisions apportées aux données historiques sur les niveaux des investissements des entreprises et sur le stock de capital qui ont été publiées en novembre 2017 par Statistique Canada, mais aussi de la solide progression de l'emploi en 2017 et du léger regain d'optimisme touchant les perspectives d'investissement pour la période de projection. L'analyse d'autres scénarios laisse entrevoir que la croissance de la production potentielle s'établira dans une fourchette comprise entre ±0,3 point de pourcentage en 2018 et ±0,6 point de pourcentage en 2021.

Sujets : Production potentielle; Productivité; Marchés du travail
Codes JEL : E, E00, E2, E22, E23, E24, E37, E6

1. Introduction

Each year, Bank of Canada staff conduct a reassessment of potential output ahead of the publication of the April *Monetary Policy Report*.[1] This note presents the staff's view on potential output growth rates between 2018 and 2021. The drivers and sources of revisions for projected potential output growth rates—that is, factors that can affect trend labour input (TLI) and trend labour productivity (TLP)—are also discussed in Section 2.

To assess the uncertainty around the projection of potential output growth, the staff have developed several alternative scenarios (Section 3). This year, in addition to the usual risk around the population projection and the outlook for investment, the following scenarios are considered: effect of digitalization on TLP above what is currently embedded in the projection, untapped potential coming from individuals who (re)integrate into the labour force, and the inclusion of uncapitalized intangible investment.

2. Potential output growth estimates

2.1 Overview

As shown in **Table 1**, the current profile for potential output growth is flat with growth rates of 1.8 per cent up to 2020 and 1.9 per cent in 2021.[2] **Chart 1** shows that potential output growth can be decomposed into TLI (the trend of total hours worked) and TLP (the trend of output per hour worked). The contribution of TLI to potential output growth should continue to decline, largely reflecting the ongoing drag from population aging.[3] This will, however, be offset by a pickup in TLP.

[1] See Agopsowicz et al. (2017).

[2] Throughout this note, numbers in tables and charts may not always add to the total because of rounding.

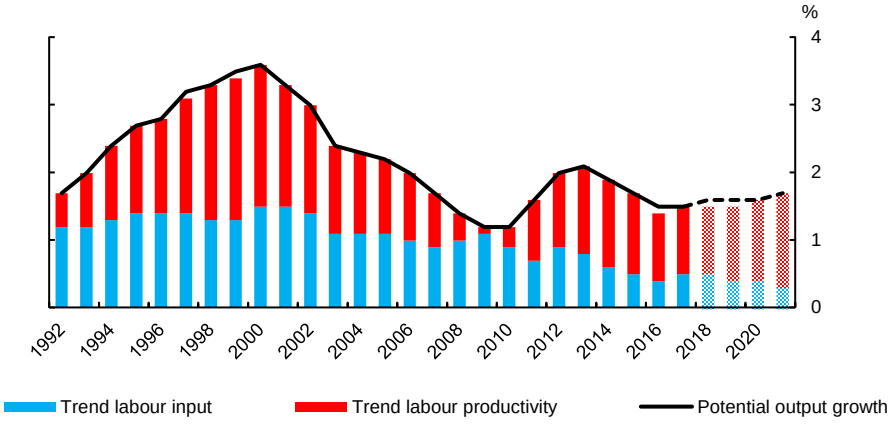
[3] If the age distribution of the population remained at its 2008 level, TLI growth would be 0.5 percentage points higher over the projection horizon.

Table 1: Potential output growth rates projection (%)						
	April 2017 MPR	**January 2018 MPR**	**April 2018 *Monetary Policy Report***			
	Potential output	Potential output	Potential output	Trend labour productivity	Trend labour input	Range for potential output growth
2010–16	1.9	2.0	1.9	1.0	0.9	
2017	1.3	1.5	1.7	1.0 (0.6)	0.7 (0.7)	1.4–2.0
2018	1.4	1.6	1.8	1.0 (0.8)	0.7 (0.7)	1.5–2.1
2019	1.5	1.6	1.8	1.1 (0.9)	0.6 (0.6)	1.4–2.2
2020	1.6	1.6	1.8	1.2 (1.1)	0.6 (0.5)	1.3–2.3
2021			1.9	1.4	0.5	1.3–2.5

Note: Numbers in brackets refer to the estimates from the April 2017 MPR. Numbers may not add to the total because of rounding.

Chart 1: The potential output growth profile will be mostly flat over the projection

Annual data



Sources: Statistics Canada and Bank of Canada calculations

Last data plotted: 2021

The staff profile is revised upward compared with the April 2017 reassessment. However, part of this revision was already accounted for in the January 2018 MPR (**Table 1**, second column). Relative to January, however, the expected potential output growth rate is about 0.2 percentage points higher in each year from 2018 to 2020, about half of this increase can be attributed to revisions to TLI growth.

While the revision to potential output growth is partly explained by model changes, most of it is explained by revisions to the data. For TLP, the substantial historical revisions to business investment and capital stock affect TLP growth up to 2020. The bulk of the effect from the data revisions occurs before 2019. A slightly stronger outlook for investment, however, explains the revisions between 2019 and 2021. For TLI, strong employment numbers in 2017 had a positive effect, mainly through a higher trend of the employment rate.

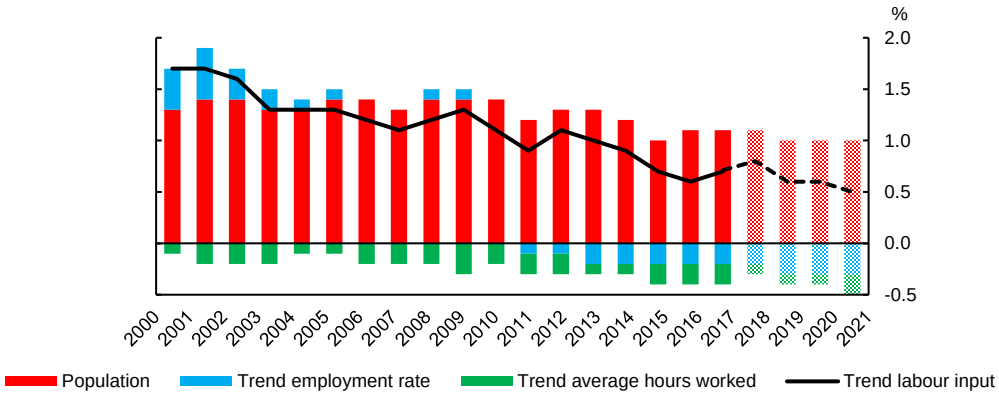
2.2 Trend labour input

An aging population is expected to continue to drag on trend labour input in the coming years

The narrative for TLI growth has not changed much since the April 2017 reassessment. **Chart 2** shows the decomposition of TLI growth rates. From 2018 to 2021, TLI growth is expected to decrease from 0.7 per cent to 0.5 per cent.

Chart 2: **Trend labour input growth is projected to decline, largerly due to population aging**

Annual data



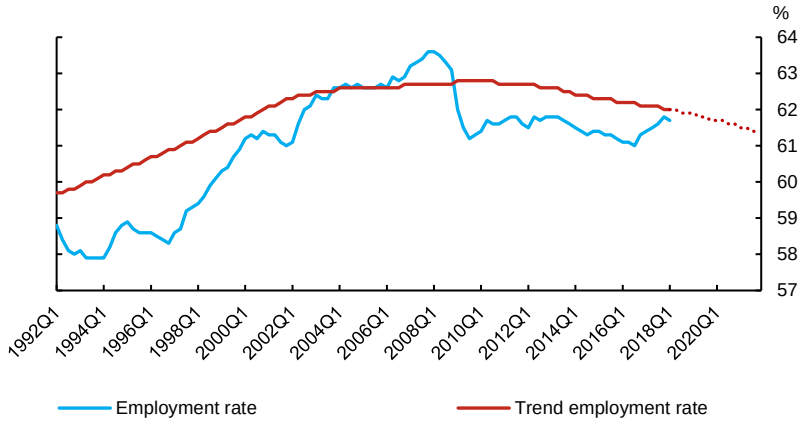
Souce: Bank of Canada calculations

Last data plotted: 2021

TLI growth can be decomposed into growth in population, trend average hours worked (TAHW) and trend employment rate (TER). Population growth remains the main driver of TLI growth and is expected to slightly decline over the projection horizon. This decline would be even faster without immigration, which continues to be the primary contributor to population growth and is expected to account for about two-thirds of population growth on average from 2018 to 2021. TER and TAHW continue to be a drag on TLI growth, with TER lowering growth by 0.3 percentage points and TAHW lowering growth by 0.1 percentage points over the same period. This is also visible on the levels of TER and TAHW as shown in **Chart 3** and **Chart 4**.

Chart 3: **Employment rate and trend employment rate**

Quarterly data

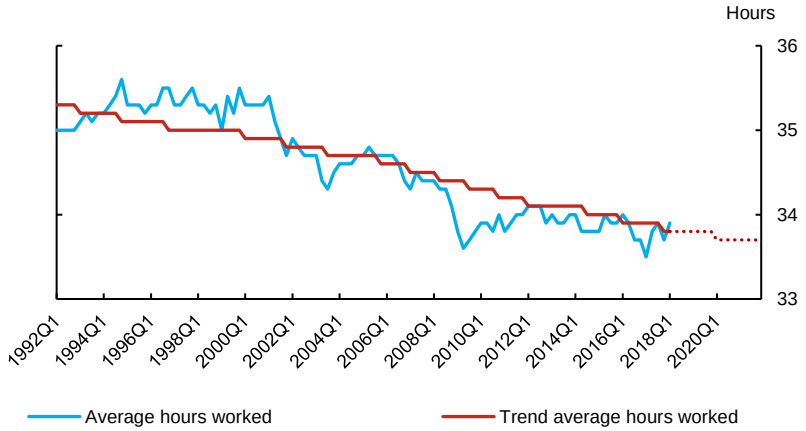


Source: Statistics Canada and Bank of Canada calculations

Last data plotted: 2021Q4

Chart 4: **Average hours worked and trend average hours worked**

Quarterly data

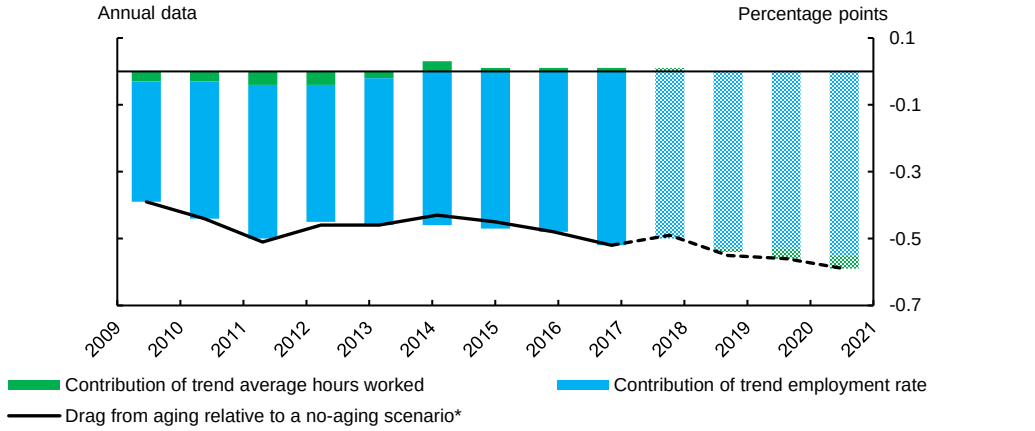


Source: Statistics Canada and Bank of Canada calculations

Last data plotted: 2021Q4

Chart 5 shows that population aging is reducing the TLI growth rate by about 0.5 percentage points over the projection horizon. The main effect of aging is seen on TER because older workers have a much lower TER than youth and prime-age workers, although the employment rate of older workers increased over the past two decades.[4] In contrast, the decline in the contribution of TAHW mainly reflects the secular decline in hours we have observed over the past 40 years (**Chart 4**). Two factors likely contributed to this decline: the increase in the share of workers in the service sector, and the increase in the share of working women.[5] Because workers in these two groups, on average, work fewer hours per week than their respective counterparts (the goods-producing sector and men), an increase in their share of employment will tend to lower TAHW.

Chart 5: Aging is dragging on trend labour input growth mainly through trend employment rate



*Note: The black line shows the difference in trend labour input growth between the base-case and the no-aging scenarios. The no-aging scenario assumes that the population structure is fixed to 2008.

Souces: Statistics Canada and Bank of Canada calculations

Last data plotted: 2021

The effects of labour market developments in 2017

Relative to April 2017, TLI growth is stronger by about 0.1 percentage points over the projection horizon (**Chart 6**). Strong employment data in 2017 led to upward revisions of TER levels and growth rates (0.1 percentage points). In contrast, TAHW growth rates were barely revised. TAHW levels were nevertheless revised down, mainly due to the removal

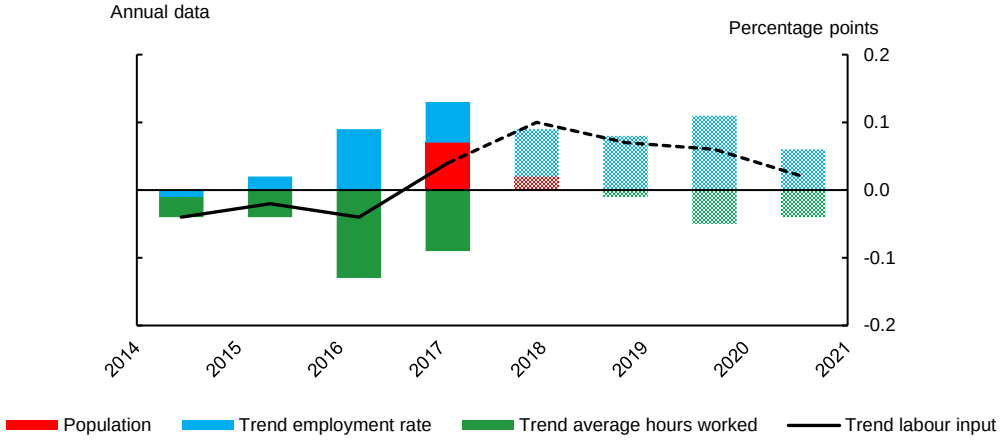
[4] Employment rates of older workers (55+) increased from 22 per cent in 1996 to 36 per cent in 2017. In comparison, that of prime-age workers (25–54) was 76 per cent and 82 per cent in 1996 and 2017, respectively.

[5] These two factors are difficult to disentangle because women are more likely to work in the services sector. Between 1976 and 2017, employment in the services sector increased by about 130 per cent. Female employment contributed more than three-fifths of this increase.

of ad hoc judgment on individual age groups and gender and to the inclusion of group cohort effects in the TAHW model. Population projections are the same as last year and include the current immigration targets set by Immigration, Refugees and Citizenship Canada.

Chart 6: Higher trend employment rate growth relative to April 2017 explains the revisions to trend labour input growth

Annual data



Souce: Bank of Canada calculations

Last data plotted: 2021

2.3 Trend labour productivity

Projection: Investment pickup in the aftermath of the commodity prices decline

In the integrated framework (IF), TLP can be decomposed into capital deepening (capital per hour worked) and trend total factor productivity (trend TFP).[6, 7] **Chart 7** shows the TLP decomposition and suggests that the adjustments from the commodity price decline are completed, as investment in the oil and gas sector bottomed out in 2016 and the trough in TLP growth occurred in 2017 (**Chart 8**).[8]

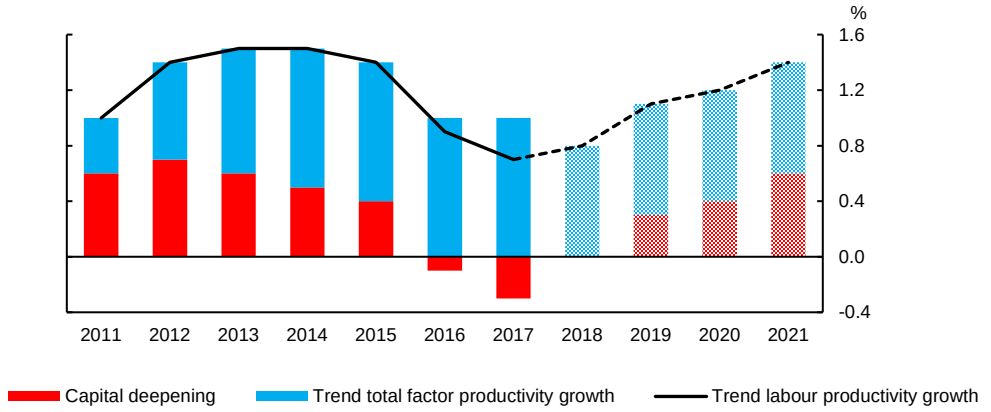
[6] See Pichette et al. (2015) for a description of the IF. TFP is an unobserved variable, and it is derived as a residual from a growth accounting framework.

[7] TLP growth in **Chart 7** is slightly different than the TLP growth in **Chart 1** because the potential output growth in the staff projection (**Chart 1**) is based on several information sources, one of them being the IF. Moreover, this decomposition is currently unique to the IF. This discrepancy does not materially affect the narrative over the projection horizon, and the IF remains useful to understand the influence of investment dynamics and capital formation on potential output growth, particularly since the commodity price decline of 2014.

[8] The trough for recommended TLP growth also occurred in 2017 (**Chart 2**).

Chart 7: Capital deepening is expected to be the main driver of trend labour productivity growth over the projection

Annual data

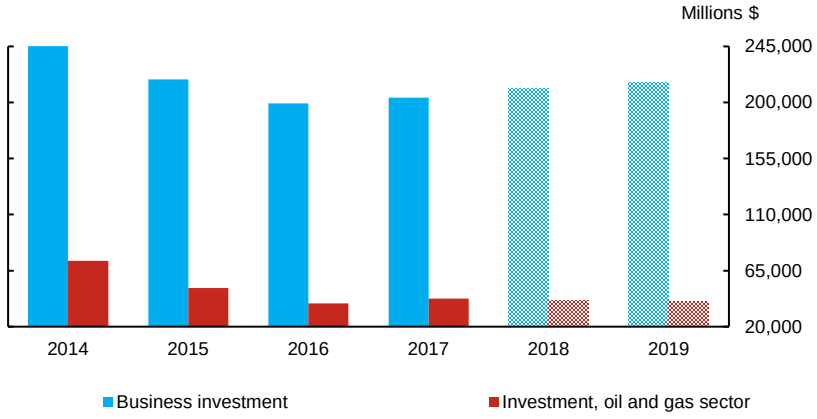


Source: Bank of Canada calculations

Last data plotted: 2021

Chart 8: Although increasing over the projection horizon, business sector investment has not yet returned to its 2014 level

Annual data



Sources: Statistics Canada and Bank of Canada calculations

Last data plotted:2019

Between 2014 and 2016, the sudden and sharp decline in investment in the oil and gas sector, as well as the general weakness of broader business investment, were the main factors weighing on TLP growth. This effect from the commodity price decline was also amplified by the large share of oil and gas investment in total business investment (about 30 per cent in 2014).

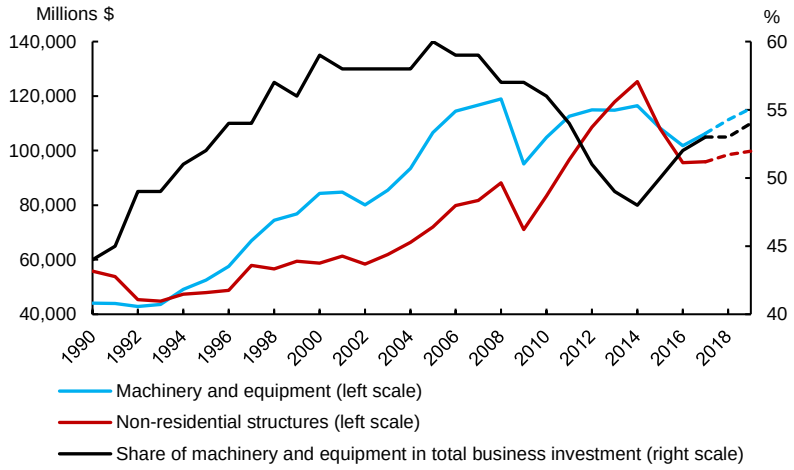
Moreover, the reallocation of resources may have also contributed to the observed decline in labour productivity growth in 2015, despite the low share of employment of this sector. This results from workers transitioning from a sector with high levels of productivity (oil and gas) to other sectors with lower levels or growth rates. This has been partly offset, however, by an increase in labour productivity growth in the oil and gas

sector because output dropped proportionally less than hours as production processes were streamlined. Yet, some of the latter effect may have been partly reversed in recent quarters as hours began to increase in the oil and gas sector.

TLP growth will be supported by capital deepening as the contribution of trend TFP remains flat (**Chart 7**). TLP growth is expected to reach 1.4 per cent in 2021, above its long-term average (1.1 per cent). Investments in the oil and gas sector are expected to remain flat going forward, consistent with oil prices stabilizing over the projection horizon.[9] Higher capital deepening and TLP growth will therefore be fuelled by business investment in the rest of the economy: while business investment has started recovering from the trough in 2016, it still falls short relative to the levels of 2014 (**Chart 8**). Furthermore, **Chart 9** shows that most of the increase will come from investment in machinery and equipment (M&E), which is considered to be more productivity-enhancing than investment in non-residential structures (NRS).[10]

Chart 9: The share of machinery and equipment investment increased since 2014

Annual data



Sources: Statistics Canada and Bank of Canada calculations

Last data plotted: 2019

[9] It is interesting to note that despite these lost investments, capacity in the oil and gas sector is still expanding. This likely reflects investments in the oil and gas sector taking several years, more than in the rest of the economy, before becoming productive. Given the importance of investment in the oil and gas sector, this would imply that the effect of the decline in commodity prices could have been overestimated by the IF. This is because the capital deepening profile would have been flatter since some pre-2014 investments would have become productive after and not before 2014.

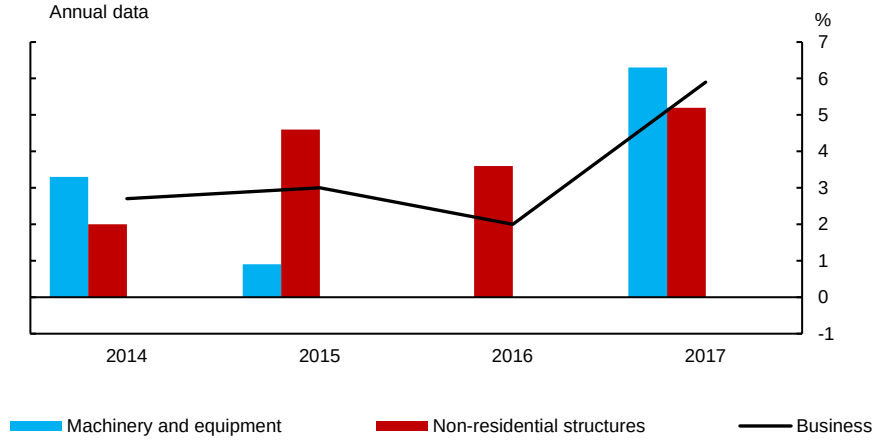
[10] M&E investment includes the following intellectual property products: research and development, software, and mineral exploration. The other category of investment, non-residential structure, includes engineering and non-residential buildings.

Data revisions and changes in the composition of investment

TLP growth revisions explain most of the revisions to potential output growth for 2017–20 shown in **Table 1**. These revisions are mainly due to two factors: the large and positive historical revisions to business investment and capital stock for 2014 released by Statistics Canada in November 2017 (**Chart 10**), and the more optimistic outlook for investment relative to January 2018. Most of the effects from the historical revisions to business investment and capital stock are felt before 2019: TLP growth increased by about 0.3 percentage points per year on average from 2014 to 2018 (**Chart 11**, blue bars).[11] Meanwhile over the projection horizon, the slightly stronger outlook for investment is the main driver of TLP growth revisions, adding about 0.1 percentage points from 2019 to 2021 (**Chart 11,** red bars).

Chart 10: Revisions (relative to April 2017) to the level of business investment and its components

Annual data



Sources: Statistics Canada and Bank of Canada calculations

Last data plotted: 2017

Not all units of capital are created equal. M&E investments (including software and research and development [R&D]) are generally viewed as increasing productivity beyond the physical capital stock because they are often accompanied by changes in the production process, co-innovation and reorganization of the workplace. Distinguishing between M&E and non-residential structures—by recognizing that their output elasticities may differ—acknowledges that changes in composition are relevant for TLP. Interestingly, **Chart 9** shows that the composition of business investment has changed over time. The share of M&E declined after the 2007–09 recession until 2014, at which

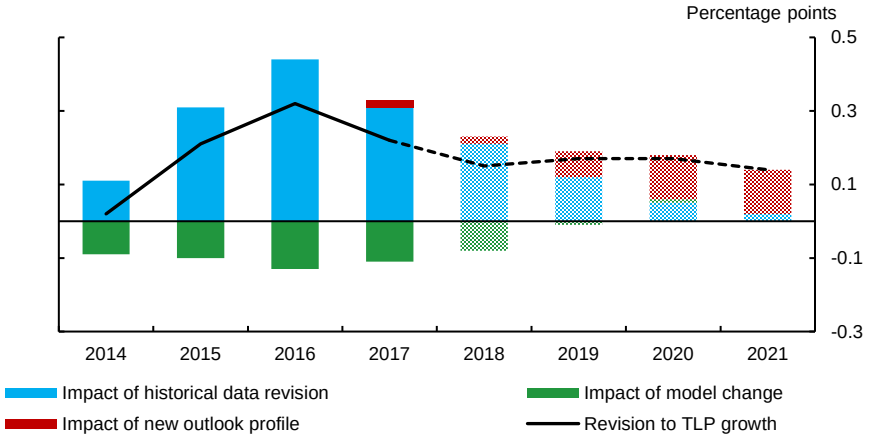
[11] Numbers in **Chart 11** also include revisions to gross domestic product (GDP) published in November 2017 by Statistics Canada. A decomposition of the revisions using the TLP growth from the staff projection (**Chart 2**) yield similar results.

time the decline in investment in engineering from the oil and gas sector, as a result of the commodity prices shock, led to the collapse of NRS investment.

To better account for this change, the IF was improved by introducing these two types of capital. Allowing for two types of capital implies a lower capital contribution after 2009, roughly matching the time at which the share of investment in M&E started declining (**Chart 9**). Yet, these model changes have a limited impact over the projection horizon (**Chart 11**, green bars).

Chart 11: **Revison to trend labour productivity (TLP) growth rates**

Annual data



Source: Bank of Canada calculations

Last data plotted: 2021

Other considerations

Apart from the pickup in investment, there are other developments that could affect potential output in the long run. Increased digitalization of the economy could be a source of labour productivity gains, not necessarily from the accumulation of capital related to information and communications technology (ICT), but from new ways of doing business. The decline in firm dynamism observed in Canada (see Cao et al. 2015) and other advanced economies over the past decade could, however, offset some of these potential gains. That is because this decline could prevent the reallocation of resources from less productive firms to more productive ones. Moreover, fewer entrants could lower the number of new ideas and business models being introduced by entrants.

2.4 Comparison with other projections

Table 2 compares our potential output projection with the ones from some other institutions. Our projections are close to those from the Parliamentary Budget Officer (PBO 2017) and the International Monetary Fund (IMF 2017), especially after 2019. The short-term discrepancies could be attributable to the fact that their projections did not include the revisions to business investments released in November 2017.

Table 2: A comparison of potential output growth projections (%)

	April 2018 MPR	PBO (October 2017)	OECD (November 2017)	IMF (Article IV, July 2017)
2017	1.7	1.2	1.5	1.5
2018	1.8	1.5	1.5	1.6
2019	1.8	1.8	1.6	1.7
2020	1.8	1.9		1.8
2021	1.9	2.0		1.8

PBO: Parliamentary Budget Office, OECD: Organisation for Economic Co-operation and Development, IMF: International Monetary Fund.

3. Potential output growth estimates

The baseline estimates for potential output growth rely on many assumptions about future conditions. To put our projection in perspective, and to establish reasonable bounds around the baseline estimates, a few alternative scenarios that may materialize with some reasonable probability are considered. The effects of the various scenarios are presented in **Table 3**.

Table 3: Impact of alternative scenarios on potential output growth (percentage points)				
	2018	2019	2020	2021
3.1 Digitalization: upside risk	0.1	0.2	0.3	0.3
3.1 Digitalization: downside risk (timing)	-0.1	-0.2	-0.2	-0.1
3.2 Untapped potential output from labour market	0.1	0.1	0.1	0.1
3.3 Intangible capital	0.2	0.2	0.2	0.2
3.4 Population and immigration: low scenario	-0.1	-0.1	-0.2	-0.2
3.4 Population and immigration: high scenario	0.1	0.1	0.2	0.2
3.5 Impact of global and domestic uncertainty on investment growth	-0.1	-0.2	-0.2	-0.2

3.1 Digitalization

There is evidence that the Canadian economy is being digitalized.[12] It has been observed that despite a perceived rapid increase in technological advancement in the digital era (post-2004), many countries (including Canada) have experienced a slowdown in labour productivity growth. The link between digitalization and potential output is unclear, however; while some argue that the labour productivity gains could be substantial (Van Ark 2016; Brynjolfsson and McAfee 2014), others are skeptical that digitalization will produce any significant future gains (Gordon 2016).

The timing is also highly uncertain. Some claim that if compared with previous periods of technological change, it seems likely that an acceleration of labour productivity will begin within the next few years (Syverson 2013), while others acknowledge that implementation lags can delay the benefits from new technology by decades (Brynjolfsson, Rock and Syverson 2017). The view of the staff strikes a compromise between these two views. As firms install the new digital technology, for example,

[12] Digitalization is often characterized as the use of and access to mobile technology and the Internet, storage of information in the cloud, use of artificial intelligence/machine learning and big data, and the matching of providers with end-users using intermediating digital platforms.

artificial intelligence, they also need to develop and implement complementary human and organizational capital. This may cause a disruption in efficiency gains in the first few years (labelled the "installment phase" by Van Ark [2016]), but positive labour productivity gains will follow as firms adapt to using the new technology (labelled the "deployment phase"), offsetting the initial losses.

Given that past technological revolutions may present some insight into the possible effect of innovations currently taking place, the positive risk of this scenario is that the long-run growth of TFP is comparable to the high-growth period of the ICT revolution in the late 1990s, which we consider a reasonable upper bound. It is assumed here that the deployment phase of the digital technology is underway.[13] Therefore, the long-run growth rate of TFP will gradually rise to 1.2 per cent annually by 2025, substantially higher than its historical average of 0.7 per cent.[14] The downside risk to this scenario is that the installment phase is still occurring. In such a case, trend TFP could remove about 0.2 percentage points per year from TLP growth between 2018 and 2020 before gradually returning to 1.2 per cent slightly after 2025.[15]

3.2 Untapped potential from the labour market

Many demographic groups, such as women, youth, immigrants, and people living with a disability, have lower attachment to the labour market than, for example, prime-age males, as a result of various structural factors. The 2007–09 recession could have accentuated these factors and further depressed TLI—above and beyond the downward trend caused by an aging workforce. However, improving economic and labour market conditions may result in some of these individuals (re)integrating in the labour force.[16] Therefore, this scenario evaluates the amount of untapped potential that exists within these groups.

[13] Although not apparent in investment data, employment in computer systems design and related services increased on average by nearly 7 per cent over the past 5 years. This is much higher than the 2001–13 average of 0.6 per cent for that industry and the long-term average of 1.4 per cent in the total economy.

[14] In this scenario, we assume that only TLP could be affected. TLI may also be affected if digitalization reduces barriers to entry of certain groups of individuals, such as women or people living with a disability.

[15] Another take at the downside risk is that the benefits from digitalization may not be realized if a few superstar firms extract large economic rents. For a more comprehensive overview of the overall effect of digitalization on the economy, see D'Souza and Williams (2017).

[16] (Re)integration includes both individuals who previously left the labour force, such as individuals who lost their job after the recession and could not find another one, and individuals who integrate the labour force for the first time, for example, students who postponed entry into the labour market.

While the past 40 years have seen remarkable growth in female participation in the labour market, a gap between participation of men and women remains. To assess the implication of this gap on TLI, we run a scenario in which the TER of women is set to equal the TER of men. This scenario also assumes that the employment rate of prime-age immigrants will rise to the level of native workers and that youth employment rates return to their pre-recession level.

Under this scenario, about 600,000 more women would be employed in the workforce. This corresponds to a level of TLI up to 3.3 per cent higher than otherwise. As for immigration, TLI could be boosted by about 0.5 per cent (160,000 individuals). Closing the employment rate gap of youths would lead to approximately an additional 110,000 employed youths. However, this would not contribute to an increase of the TER for youths because this trend is already close to its 2008 level. Finally, some further pickup could come from increased participation of people living with a disability and members of First Nations.

Together, this suggests that there remains a large source of untapped potential growth in the Canadian economy. If this scenario gradually unfolds over the next decade, annual potential output growth could be about 0.1 per cent higher than otherwise.

3.3 Uncapitalized intangible assets

Currently, the system of national accounts includes some measures of intangible capital.[17] However, it has been argued that other forms of intangible capital, such as organizational and human capital, need to be accounted for because they can affect output and productivity statistics (Baldwin, Gu and Macdonald 2012). Baldwin, Gu and Macdonald (2012) show that from 1976 to 2008, total investment in intangibles grew quickly and represented 66 per cent of tangible investment by 2008. However, their findings suggest that adding the uncapitalized intangible investment increases labour productivity growth by only 0.2 percentage points because of a decline in the relative importance of TFP growth.

To assess the effect of uncapitalized intangible capital on potential output growth, the staff re-estimate the integrated framework using uncapitalized business sector intangible investment and GDP-adjusted series provided by Statistics Canada up to 2016. The improved two-type of capital model was used because the cost share of intangible

[17] Namely, software, research and development, and mineral, oil and gas exploration.

investment was also available, which ultimately changes the income shares of the other factor inputs.[18]

Overall, the results confirm what was found by Baldwin, Gu and Macdonald (2012). TLP growth would be about 0.2 percentage points higher on average, coming equally from increases in the contribution of TFP and capital deepening.

3.4 Population projections

The staff use the high- and low-growth population scenarios published by Statistics Canada to assess the upside and downside risk associated with population growth. As for the population projection embedded in the base case, the high- and low-growth scenarios are the same as those in the April 2017 reassessment.

Under the high-growth population scenario, TLI growth rates would be higher by 0.2 to 0.3 percentage points over the projection horizon. In contrast, under the low-growth population scenario, TLI growth rates would be lower by 0.2 to 0.4 percentage points. Potential output growth could thus lie between -0.2 to +0.2 percentage points around the base-case scenario by 2021.

3.5 Global and domestic uncertainty about investment

There are several challenges currently faced by Canadian firms that suggest a downward risk on the investment outlook above what is already embedded in the staff outlook. Global uncertainty associated with US fiscal policy, possible disruption to our trade arrangements—further tariffs on Canadian exports, for example—could take their toll on expected growth of potential output through less investment in Canada than otherwise.

On the domestic front, the increasing discrepancies between regulatory policy in Canada relative to the United States, such as environmental regulation in the oil and gas sector, could also weigh on the outlook. Moreover, investment intentions surveys suggest that historical investment data may be revised down later this year. Finally, there is a risk that the weakness in Canadian business investment could be attributable to more structural factors than previously thought (Barnett and Mendes 2017).

To illustrate these downside risks, the staff developed a scenario where the levels of business investment are 5 per cent lower by the end of 2020. In assessing the effect on

[18] Intangibles were included in the growth accounting equation by adding an additional term for the intangible income share multiplied by the change in its capital stock, while also incorporating the additional investment into GDP.

potential output, it is assumed that TLI growth is not affected, at least in the short term. In the long run, however, TLI could also adjust downward to re-establish a capital-to-labour ratio consistent with the lower levels of investment and aggregate demand, further pushing down potential output growth. Results from the simulation suggest that the growth rate of potential output would be lower by as much as 0.3 percentage points in 2019 and up to 0.7 percentage points by 2021 (cumulative effect).

3.6 Range of potential output growth

All the alternative scenarios described above are considered to establish uncertainty bounds around the baseline estimates of potential output growth, which are presented in **Table 4**.

Table 4: Uncertainty around potential output projections (%)				
	2018	**2019**	**2020**	**2021**
Range for potential output	1.5–2.1	1.4–2.2	1.3–2.3	1.3–2.5
Mid-point of the range	1.8	1.8	1.8	1.9

References

Agopsowicz, A., B. Gueye, N. Kyui, Y. Park, M. Salameh and B. Tomlin. 2017. "April 2017 Annual Reassessment of Potential Output Growth in Canada." Bank of Canada Staff Analytical Note 2017-5.

Baldwin, J., W. Gu and R. Macdonald. 2012. "Intangible Capital and Productivity Growth in Canada." Statistics Canada Catalogue no. 15-206-X, No. 029.

Barnett, R. and R. Mendes. 2017. "A Structural Interpretation of the Recent Weakness in Business Investment." Bank of Canada Staff Analytical Note 2017-7.

Brynjolfsson, E., D. Rock and C. Syverson. 2017. "Artificial Intelligence and the Modern Productivity Paradox: A Clash of Expectations and Statistics." NBER working paper 24001.

Brynjolfsson, E. and A. McAfee. 2014. *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies*. London: W. W. Norton & Company.

Cao, S., M. Salameh, M. Seki and P. St-Amant. 2015. "Trends in Firm Entry and New Entrepreneurship in Canada." Bank of Canada Staff Discussion Paper No. 2015-11.

D'Souza, C. and D. Williams. 2017. "The Digital Economy." *Bank of Canada Review* (Spring): 5–18.

Gordon, R. J. 2016. *The Rise and Fall of American Growth: The U.S. Standard of Living Since the Civil War*. Princeton: Princeton University Press.

International Monetary Fund (IMF). 2017. "Canada: 2017 Article IV Consultation—Press Release and Staff Report." July.

Organisation for Economic Co-operation and Development (OECD). "Economic Outlook No. 102." November.

Parliamentary Budget Officer (PBO). 2017. *Economic and Fiscal Outlook—October 2017*.

Pichette. L., P. St-Amant B. Tomlin and K. Anoma. 2015. "Measuring potential output at the Bank of Canada: The Extended Multivariate Filter and the Integrated Framework." Bank of Canada Staff Discussion Paper 2015-1.