BANK OF CANADA
BANQUE DU CANADA

Staff Analytical Note/Note analytique du personnel—2023-6

Last updated: May 11, 2023

Potential output and the neutral rate in Canada: 2023 assessment

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DOI: https://doi.org/10.34989/san-2023-6 | **ISSN** 2369-9639

Acknowledgements

We acknowledge the important contributions of Guyllaume Faucher, Ron Rautu, Kurt See and Rodrigo Sekkel to the analysis presented in this note. We thank Brigitte Desroches, Stefano Gnocchi, Marc-André Gosselin, Sharon Kozicki and Alexander Ueberfeldt for their useful comments and suggestions. We also thank Colette Stoeber and Jordan Press for their editorial assistance and Denis Clairand for his help translating parts of this note into French.

Overview

In this note, we present the Bank of Canada's 2023 assessment of potential output and neutral rate estimates for Canada. Relative to the April 2022 assessment (Faucher et al. 2022), we revise potential output growth down by 0.5 percentage points (pps), on average, from 2022 to 2025 (**Table 1**). The negative revisions mainly reflect a larger drag from global supply chain disruptions. Higher projected population growth—due to stronger immigration—provides a partial offset.

Compared with our April 2022 assessment, we estimate supply chain disruptions to have had a larger impact on the level of potential output. However, we continue to expect growth to pick up sharply beginning in 2023 as the impact from these disruptions levels off. The pickup is also supported by stronger population growth due to continued strength in immigration, which we expect to remain robust given the official 2023–25 immigration targets.[1] Given the inherent uncertainty around potential output growth, we consider upside and downside risk scenarios and construct a range around our benchmark estimates.

Our estimate for the nominal neutral rate—ranging between 2% and 3%—suggests no change with respect to the 2022 assessment (Table 3). However, some of our models imply small changes that offset each other:

- On the one hand, the small open-economy overlapping-generations model implies a downward revision of 25 basis points (bps) in the nominal neutral rate range. This is due to the combination of:
    - a small decline in assumptions on growth in long-run labour input and productivity
    - the assessment of a smaller net ratio of government debt to gross domestic product (GDP) in the long term
- On the other hand, the risk-augmented neoclassical growth model implies an upward revision of 25 bps of the nominal neutral rate range. This is due to a small reduction of the estimated incentives for precautionary savings resulting from the milder-than-expected negative economic impact of the COVID-19 pandemic.

[1] See the Government of Canada's 2023–2025 Immigration Levels Plan for further details.

Table 1: Comparison of potential output estimates relative to April 2022

Annual rates (%)

	Annual growth	Trend labour input growth	Trend labour productivity growth	Range for growth	Revisions to the level
2022	1.4 (1.7)	1.2	0.2	0.5–2.0	-0.9
2023	2.3 (3.3)	1.5	0.8	1.4–3.2	-1.9
2024	2.1 (2.5)	1.3	0.8	1.0–3.2	-2.2
2025	2.1 (2.3)	1.2	0.9	1.2–2.8	-2.5
2026	2.2	1.2	1.0	1.4–3.0	--

Note: Estimates of annual growth rates of potential output from the April 2022 assessment appear in parentheses. The range for potential output growth represents the methodological range implied by the risk scenarios presented in Table 2.

Canadian potential output

Potential output growth is expected to:

- rebound strongly in 2023 as the impact from supply disruptions on potential output levels off
- remain stable at just over 2% throughout the projection horizon

Compared with the April 2022 assessment, we have revised down our estimate of potential output growth in Canada, particularly in 2022 and 2023. These revisions also reflect lower capital stock data and weaker total factor productivity (TFP), while stronger population and labour data provide a positive offset on growth.

The revisions also reflect important changes to how we calculate potential output. The level and the growth rate of potential output are unobserved and therefore highly uncertain. We are thus continually expanding and improving upon existing models, indicators and judgment to arrive at our estimate for potential output. This assessment includes improvements to the Bank's trend labour input (TLI) framework with the result that labour gap estimates are more balanced and in line with the broader evidence on recent labour market tightness (Ens, See and Luu forthcoming). Other methodological changes imply revisions that align with our view that the effects of global supply chain disruptions on trend labour productivity (TLP) are more severe than assessed in April 2022.

Methodological changes to potential output estimation

Bank staff regularly review existing approaches to find ways to improve them, adding tools as needed. We make changes to the potential outlook framework based on our ability to explain historical domestic price pressures, GDP growth and labour market dynamics. This section outlines the impact of the current methodological changes on our estimates.

Since 2015, our approach to assessing potential output over history has been to use the average estimate of two different models to construct a benchmark:

- the integrated framework (IF)—a production function approach that incorporates the estimated contributions of TLI,[2] capital deepening and trend TFP
- the modified extended multivariate filter (EMVF)—an approach that combines mechanical filtering with additional information on various economic relationships (Butler 1996)

We then use the IF model to forecast potential output growth over the projection horizon.

Given that no agreed-upon approach to estimating potential output exists, this model-averaging approach aims to strike a balance between having a clear economic interpretation (a feature of the production function approach) and a mechanical approach that ties the estimate closer to the data.[3] However, no approach can capture all relevant structural changes in the economy. Therefore, we consider other sources of information (e.g., various labour market indicators and satellite models) to arrive at final estimates and projections for potential output.

We make two main methodological changes in this assessment: a modification to better control for cyclical factors in the IF, and an expansion of the suite of mechanical filters to estimate potential output over history.

Controlling for cyclical labour market factors

TLI is based on separate regression models for employment rates and average hours worked. These regression models attempt to separate the cyclical and trend factors affecting the respective movements of employment rates and hours worked over time (Barnett 2007).

A key labour-demand variable used to control for cyclical movements is the job offer rate (JOR). Though theoretically appealing, this variable is not well-suited in practice to capturing labour demand factors because of data and measurement issues.[4] A major drawback of using this variable is that it produces negative average labour gap estimates—the gap between

[2] TLI equals trend aggregate hours and is made up of three components: working-age population, trend employment rate and trend average hours worked.

[3] See Pichette et al. (2015) for details on these two models and the potential output estimation approach in general.

[4] While the JOR is a conceptually useful proxy for labour market demand, the overall data underlying this measure have changed substantially over the years. This makes creating a consistent time series for JOR challenging in practice.

actual hours worked and the trend of actual hours worked. But our regression models imply that labour gaps should be zero, on average, over the estimation sample.

Replacing the JOR with an alternative labour demand variable—the job-finding-rate (JFR) gap—yields balanced labour gap estimates. Another advantage of the JFR measure is that it captures not only changes in market tightness (as does the JOR) but also other factors that reflect equally important information about labour demand dynamics (Birinci, Wee and See 2021). For example, the JFR can identify potentially cyclical factors that are not reflected in the JOR, such as the intensity of recruiting or the likelihood that firms will make an offer to fill a vacancy.

Expanding the suite of mechanical filters

Our second methodological change in this assessment is to expand the suite of mechanical filters, using frontier statistical models that embed different assumptions about trend and cycle than those of the EMVF. In particular, we include a new unobserved components model that captures links between economic slack and domestic price pressures, as well as filters based on Hamilton (2018), Beveridge-Nelson (1981) and Clark (1989). In addition, we introduce a simplified approach that we refer to as the "direct method" based on growth accounting. Overall, our suite of models now includes six different filters that we use to estimate potential output over history (see the **Appendix**).

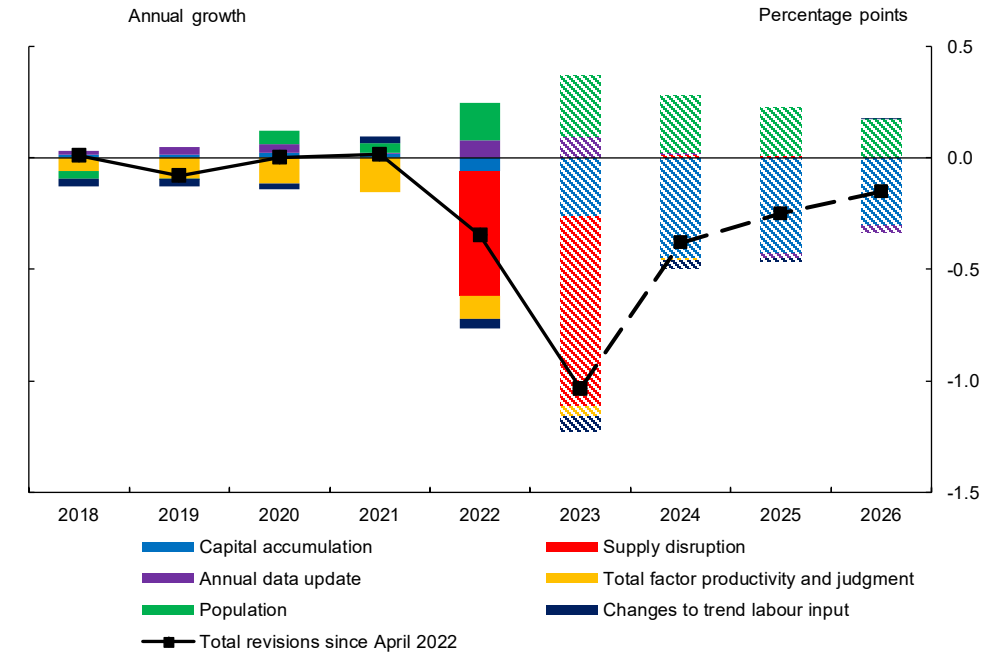
These methodological changes have implications for our historical estimates of potential output. We discuss their impact along with the regular updates in the next section.

Revisions to potential output

Compared with the April 2022 assessment, our estimate of the level of potential output is 0.9% lower in 2022 and 1.9% lower in 2023 (**Table 1**, last column). The negative revisions mainly reflect the impacts of supply chain disruptions and lower trend employment, which are captured in large part by methodological changes outlined in the previous section. Partial offsets to TLI stem from stronger labour force and population data relative to April of last year.

Among the methodological changes, the revisions resulting from the changes to the TLI model suggest that labour supply has been weaker than previously estimated. This is in line with the broader evidence of tight labour markets in Canada since mid-2021 and reports of labour shortages in many industries (see also Ens, See and Luu forthcoming). These revisions mainly affect the estimated level of TLI and translate into a small negative impact on the growth rate over history and 2023–25 (**Chart 1**, dark blue bars).

Chart 1: Potential output growth is revised down because of persistent impacts from supply disruptions



Sources: Statistics Canada and Bank of Canada estimates and projections

Last data plotted: 2026

Moreover, extending the suite of statistical filters appears to capture most of the impact from supply chain disruptions. The associated revisions to potential output, combined with revisions to trend TFP implied by new data, closely track independently constructed estimates of the impacts of global supply disruptions on Canadian output.[5]

Overall, we assess that the impact of global supply chain disruptions on Canadian trend TLP is larger and more persistent than predicted in the April 2022 assessment. These disruptions have been significantly limiting production in durable goods sectors since early 2021. Transportation bottlenecks, labour shortages and difficulties sourcing essential inputs (such as semiconductors and construction materials) have all been constraining supply and slowing down production of businesses. Relative to the April 2022 assessment, we now estimate that potential output was more severely affected in 2022 and that the economy will take longer to recover. This change in view reflects the continued difficulty of sourcing certain products, such as microprocessors, and the ongoing costs associated with supply chain reconfigurations and excess inventories being held against the risk of future disruptions.[6]

[5] These independent estimates measure differences between actual output in key sectors and counterfactual estimates of output in the absence of supply disruptions. They use a combination of empirical models and Bank staff's evaluation of underlying trends in the data.

[6] For details on measures taken by Canadian businesses to improve their resilience to supply chain disruptions, see the Bank of Canada's Business Outlook Survey—Second Quarter of 2022.

The effects of global supply chain disruptions reached their peak in 2022, removing as much as 2% from TLP—a larger peak impact than assumed in the April 2022 assessment. We still estimate these effects to have eased. However, unlike our previous assumption that these effects would fully dissipate, we expect they will stabilize at a persistent 1.4% loss to the level of potential output over 2023–26. These differences in our outlook revise down potential output growth by -0.6 and -0.9 pps in 2022 and 2023, respectively (**Chart 1**, red bars).

We have also revised down the contribution of capital accumulation to potential output growth over the projection (**Chart 1**, light blue bars). This decrease is explained by lower business investment and historical data revisions. However, this negative impact is somewhat offset by stronger engineering investment in energy-related sectors over the projection.

Positive revisions to TLI growth compared with the April 2022 assessment provide a partial offset to the larger drag from supply chain disruptions. Growth in TLI is higher over the projection horizon than previously anticipated. This is due mainly to upgraded population growth projections coming from stronger immigration, which contributes 0.3 pps on average to the potential output growth revision in 2023 and 2024 (**Chart 1**, green bars). The higher TLI growth also stems from the recent data showing a faster recovery of the labour market, part of which translates into an upward revision to the trend employment rate over 2022–24 (**Chart 1**, purple bars).

Altogether, relative to the April 2022 assessment, we have lowered potential output growth by 0.3 pps in 2022 and by 1 pp in 2023 (**Table 1**). We expect potential output to grow at pace that is 0.3 pps slower, on average, in 2024 and 2025.

Dynamics of potential output growth

The evolution of potential output growth over 2020–22 reflects the combined effects of:

- highly variable TLI growth, which captures the sharp responses of labour supply to the introduction and subsequent unwinding of the containment measures for COVID-19
- persistently weak TLP growth coming from supply chain issues

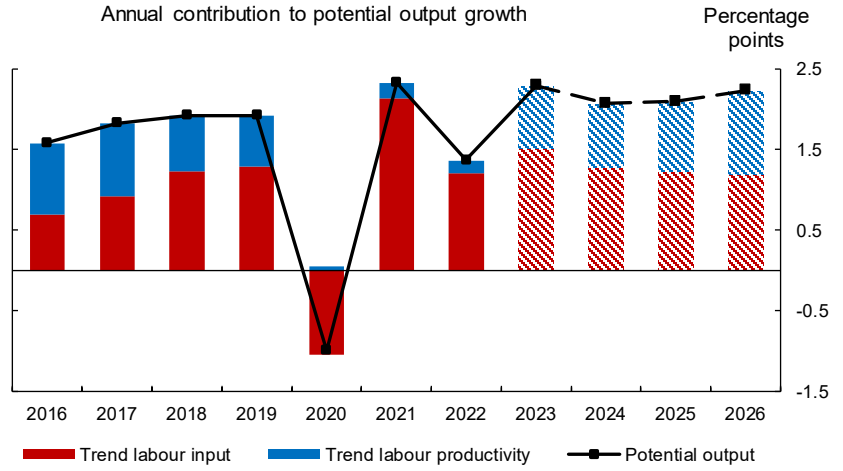
With the gradual lifting of COVID-19 restrictions in 2021 and the significant recovery in employment, TLI grew at 2.1%. It then moderated to 1.2% in 2022 as the boost from lifting containment measures dissipated (**Chart 2**, red bars). This fully accounts for the decline in potential output growth in 2022, as TLP growth remained flat at around 0.1% over 2020–22. The stall in TLP growth, in turn, largely reflects the drag from supply chain disruptions that were gradually intensifying over this period.

Growth of potential output is expected to pick up from 1.4% in 2022 to 2.3% in 2023 before stabilizing around 2.1% over 2024–26. These dynamics reflect a rebound in TLP growth in 2023, which is expected to rise to 0.8% in 2023 and to 1.0% by 2026 (**Chart 2**, blue bars). TLP

growth is attributed largely to trend TFP, which grows at an average annual rate of between 0.7% and 0.8% over 2023–26, with the remainder explained by capital deepening.[7]

Supply chain disruptions, which attained a peak negative impact in 2022, are expected to have lasting effects on the level of potential output over 2023–26. Many firms are reconfiguring their supply chains and adapting inventory management practices for greater resilience. As supply chains normalize within their new configuration from 2023 onward, the impact on both trend TFP growth and capital accumulation levels off.

Chart 2: Potential output growth picks up in 2023 as impacts from supply chain distruptions dissipate



Sources: Statistics Canada and Bank of Canada estimates and projections

Last data plotted: 2026

TLI is expected to grow at a robust annual rate of 1.2% on average between 2023 and 2026. We attribute this mainly to the impact of immigration on population growth, which is partially offset by population aging and declining trend employment rates. Population growth accelerated to 1.4% in 2022, explained by the rebound in immigration rates from their 2020–21 lows. Population growth is expected to pick up to 1.8% in 2023 before stabilizing around 1.5% on average over 2024–26 (**Chart 3**).[8]

At 1.5%, growth in the working-age population will outpace pre-pandemic averages, in line with the November 2022 increase in the federal government's immigration targets. This provides an important offset to the negative impact of population aging on the working-age

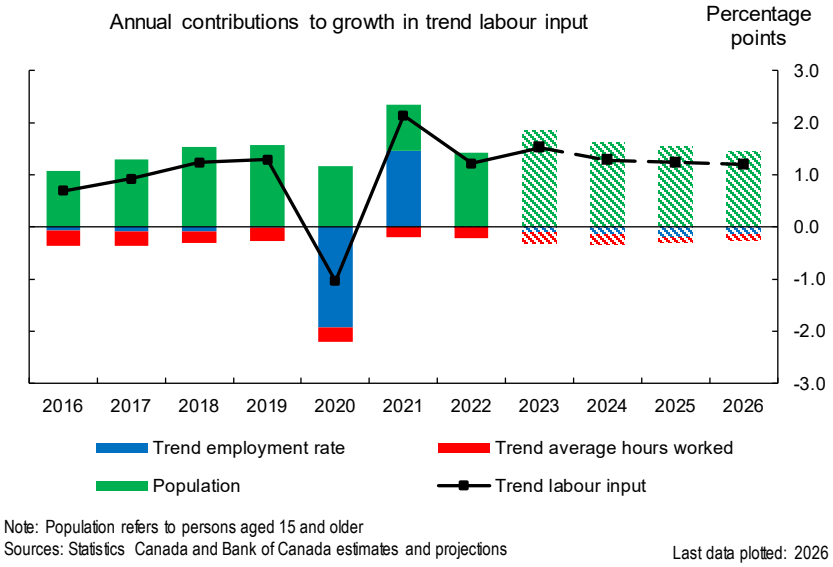
[7] We assume that trend TFP growth over the projection will gradually converge from the most recent annual data point (currently 2021, corresponding to the latest available annual capital stock estimates from Statistics Canada) to its long-run historical average of 0.7%. This long-run assumption is slightly below the average trend TFP over 2010–19, the period between the 2008–09 global financial crisis and the COVID-19 pandemic. Capital deepening is growth in the ratio of aggregate capital stock to hours worked and is therefore positively related to capital accumulation (i.e., fixed asset investment) and negatively related to TLI.

[8] "Population" in the TLI estimate refers to people aged 15 and over.

population. Potential output growth would be 0.2–0.3 pps higher on average if the demographic structure of the population remained unchanged over the projection horizon.

After rebounding in 2021, the trend employment rate is expected to weigh slightly on potential growth, contracting by 0.2% on average over 2023–26. This reflects a broader trend that precedes the pandemic and is explained in part by an aging population and the associated decline in labour force participation.

Chart 3: Population growth supports growth in trend labour input over the projection



Note: Population refers to persons aged 15 and older
Sources: Statistics Canada and Bank of Canada estimates and projections
Last data plotted: 2026

Despite anticipated improvements in both TLP and TLI growth, this outlook has several key risks. We discuss the implications of these risks for potential output in the next section.

Uncertainty around the base-case scenario

Significant uncertainty persists around our estimates of potential output growth. Many of the components of potential output are not directly observed and are challenging to forecast. To reflect this uncertainty, we construct a range around our estimates—taking into account the following key risks.

Global supply disruptions

Revisions to potential output growth that are associated with the persistent effects of global supply disruptions are subject to considerable uncertainty. Permanent changes to configurations of the supply chain from before the pandemic are likely to be widespread. However, if Canadian businesses are more resilient to supply chain disruptions than currently anticipated, they may recover the productivity losses that were from supply chain disruptions. In particular, firms may find ways to quickly adapt their business operations to minimize the

costs associated with reconfiguring their supply chains. As a result, the loss to TLP and potential output could be less persistent and instead dissipate over the forecast horizon.

We consider two possible outcomes. In the first, the recovery is swift and the associated 1.4% aggregate productivity loss as of the start of 2023 is fully recouped by the end of 2024. In the second, losses are recovered more gradually by the end of 2026. Taking the maximum impacts between these alternative outcomes in each year as our risk scenario, potential output growth is 0.7 pps higher in 2023 and 2024 and 0.4 pps higher in 2025 and 2026 (**Table 2**) relative to the baseline estimates.

Table 2: Ranges for potential output growth based on alternative risk scenarios
Annual rates (%)

Risk	Scenario	2023	2024	2025	2026
Global supply disruptions	Less persistent	0.7	0.7	0.4	0.4
Geo-economic fragmentation	More prevalent	-0.3	-0.3	-0.3	-0.3
Population growth	Lower	0.0	-0.3	-0.3	-0.3
	Higher	0.2	0.4	0.3	0.4
A global financial crisis		-0.6	-0.5	-0.3	-0.2
Growth impact range		-0.9–0.9	-1.1–1.1	-0.9–0.7	-0.8–0.8

Geo-economic fragmentation

An important downside risk to our baseline estimates is rising geopolitical tensions. These could contribute to an international trade and investment system that is permanently more fragmented. Global trade and cross-border capital flows have decelerated markedly since the global financial crisis (2008–09), alongside a sharp increase in the number of trade restrictions imposed worldwide (e.g., James 2018; Irwin 2020).[9]

In addition to rising trade protectionism, the slowdown in global economic integration also reflects the slowing pace of supply chain expansion. This can take the form of a slowing in the pace at which country production becomes highly specialized in competitive advantageous industries (Constantinescu, Mattoo and Ruta 2020). The structural trends underlying this global geo-economic fragmentation risk being worsened by the global supply chain disruptions associated with the COVID-19 pandemic, the war in Ukraine and rising geopolitical tensions between China and the United States (Arriola et al. 2023). In particular, rising trade protectionism could result in many economies relying less on international trade and investment over time. Firms could also attempt to safeguard sources of critical inputs by

[9] For a useful summary, see Georgieva (2023).

sourcing more from political allies (friendshoring) or locations with shorter trade routes (nearshoring), compressing supply chains (Wei and Wang 2022).[10]

To assess the likely impacts of geo-economic fragmentation on potential output, we draw on a recent International Monetary Fund survey of the literature on the impacts on output of increased global trade restrictions (Aiyar et al. 2023). Depending on modelling assumptions (such as the severity of the fragmentation scenario), long-run output losses range from 0.2% to 12% of GDP. We consider a risk scenario where geo-economic fragmentation escalates and lowers potential output by around 1%, corresponding to the median estimated loss among advanced economies. Assuming that the full impact is realized gradually over the projection horizon, this reduces annual growth by 0.3 pps relative to the baseline (**Table 2**).

Population growth

Population growth is sensitive to future immigration flows, which will depend on both government policy and geopolitical events. Statistics Canada's high and low population growth scenarios present upside and downside risks to our TLI outlook.

Over the projection, these scenarios mainly reflect differences in assumptions about the number of new immigrants, including temporary workers. While the extent of volatility in the number of new immigrants seen at the height of containment measures and travel restrictions in 2020 and 2021 is unlikely to recur, risks around the baseline forecast remain.

On the upside, Canada continues to welcome greater numbers of refugees fleeing Ukraine, and these numbers could grow further. Moreover, the baseline projection assumes that the federal government meets its current immigration targets for 2023–25. However, these targets could be exceeded. For example, the government's announced targets could themselves be increased, in line with government actions both before and since the beginning of the pandemic.[11] On the downside, global interruptions to cross-border migration could arise as a result of increasing geo-economic fragmentation. Compared with the baseline, the high-growth population scenario increases potential output growth by 0.2 to 0.4 pps over 2023–26, while the low-growth scenario would subtract around 0.3 pps from potential output growth over 2024–26.

Global financial crisis

The recent failure of some regional banks in the United States has caused a wide, though brief, turmoil in global financial markets amid concerns about a possible spread to the broader American banking industry and the rest of the world. Even though the risk of major

[10] In addition to friendshoring and nearshoring trends, Agarwal (2023) discusses the recent rise in government policies supporting domestic production in strategically important industries.

[11] The increases in immigration targets have accelerated even more since the beginning of the pandemic. Moreover, except for 2020, these targets have been met or exceeded.

stress to the Canadian financial sector is very unlikely, we consider a risk scenario in which a global financial crisis affects Canadian potential output.

Financial crises are frequently followed by sluggish recoveries in affected countries, with growth in real economic activity typically taking many years to return to pre-crisis trends (Cerra and Saxena 2008; Bianchi, Kung and Morales 2019; Queralto 2020). This can imply a significant decline in potential output through persistent losses in TFP, investment and labour force participation (Hall 2015; Ikeda and Kurozumi 2019; Aikman et al. 2022). According to Ball (2014), for instance, the median loss in potential output level due to the 2008–09 global financial crisis was 8.8% among the countries of the Organisation for Economic Co-operation and Development, corresponding to a 0.8 pp decline in potential output growth over 2009–14.[12]

In our risk scenario, we consider more moderate declines in potential output growth for Canada. In particular, we consider the unlikely event that the recent stress concentrated in a few banks in the United States and Europe evolves into a full-fledged global crisis. In such a case, we assume that—similar to the global financial crisis—contagion to the Canadian financial system would transmit mostly through the confidence and trade channels.

Canadian neutral rate

As in previous assessments of the neutral rate, we define the neutral rate as the policy rate consistent with output at its potential level and inflation equal to the target after the effects of all cyclical shocks have dissipated (Mendes 2014).

We find that the Canadian nominal neutral rate remains unchanged from the 2022 assessment, lying in the range of 2% to 3%. The estimate for the Canadian neutral rate is determined using the same four assessment methods as in previous years, together considering both global and domestic factors (**Table 3**):[13]

- an interest rate parity approach
- a reduced-form model
- a risk-augmented neoclassical growth model
- a new overlapping-generations model

[12] The country-level estimates of the level impact vary between -0.9% and 35.4%, with generally greater impact on European countries that were affected by a sovereign debt stress and the global financial crisis. Ollivaud and Turner (2015) also report potential output losses of similar magnitude for OECD countries.

[13] These methods were first introduced by Mendes (2014) and later updated by Carter, Chen and Dorich (2019) and Kuncl and Matveev (2023). See these papers for a detailed description of the methods.

Table 3: Summary of estimates of the nominal neutral policy rate

Annual rates (%)

	2022 estimates	2023 estimates
Pure interest rate parity approach	2.00–3.00	2.00–3.00
Reduced-form model	2.25–2.75	2.25–2.75
Risk-augmented neoclassical growth model	2.25–3.00	2.50–3.00
Overlapping-generations model	2.50–3.25	2.25–3.00
Overall assessment	2.00–3.00	2.00–3.00

Note: Rates are in nominal terms. All estimates have been rounded to the nearest 25 basis points. Reported ranges are constructed methodologically based on different counterfactuals with respect to key inputs.

Interest rate parity approach

Under the interest rate parity model (Mundell 1963), the Canadian neutral rate is determined solely by global factors and equals the global neutral rate. We continue to use the US neutral rate as a proxy for the global neutral rate. Given that the estimate of the US neutral rate has not changed from the April 2022 assessment (Ahmed et al. 2023), the estimate of the range for the Canadian neutral rate remains unchanged.

Reduced-form model

The reduced-form model uses a regression framework to consider the effect of both global and domestic factors on the Canadian neutral rate. These factors are captured by the US neutral rate and the long-run Canadian potential output growth, respectively. While the long-run growth of Canadian potential output is revised down, this change is small and not enough to alter the reduced-form model estimates of the range for the Canadian neutral rate.

Risk-augmented neoclassical growth model

The risk-augmented neoclassical growth model is a closed-economy model in which the neutral rate is driven only by domestic factors affecting households' consumption and saving decisions. A slightly lower long-run potential output growth in this assessment, as in the reduced-form model, has a small negative effect on the Canadian neutral rate. However, this effect is more than offset by an upward push on the neutral rate due to our updated assessment of incentives for precautionary savings. In particular, the milder-than-expected negative economic impact of the pandemic weakens demand for safe assets for precautionary reasons going forward compared with its peak earlier in the pandemic

(Matveev, McDonald-Guimond and Sekkel 2020).[14] Overall, we revise the lower bound of the range of estimates up by 25 bps.[15]

Overlapping-generations model

The last model used is the overlapping-generations model, an open-economy general equilibrium model that was significantly extended in the 2022 assessment and is described in detail by Kuncl and Matveev (2023). Among the four models used to evaluate the range of the neutral rate, the overlapping-generations model has the richest structure and encompasses most of the factors captured by the other models.

In this model, the Canadian domestic neutral rate of interest is driven by both international and domestic factors. International factors are summarized by the global neutral rate. Domestic factors include changes in growth rates of labour input and productivity, longevity, government debt and inequality. Lower growth in long-run labour input and productivity in this assessment has a small negative impact on the estimates of the neutral rate. Furthermore, following a decline in net public debt as a share of GDP from its elevated level during the pandemic, our assumption for the long-run level of the net public-debt-to-GDP ratio is revised down. This change reinforces a reduction of the estimate of the neutral rate. Taken together, the overlapping-generations model suggests a decline of 25 bps in the estimated range of the Canadian neutral rate.

To summarize, the interest rate parity and reduced form models suggest no change of the Canadian neutral rate. The overlapping-generations model and the risk-augmented neoclassical growth model are revised, but by offsetting amounts. Combined, the results of the four models support our overall assessment that the Canadian neutral rate remains between 2% and 3%, which is consistent with the usual practice of maintaining a range of 100 bps.

[14] Like Matveev et al. (2020), we assess the effect of precautionary savings by drawing on the non-parametric approach of Kozlowski, Veldkamp and Venkateswaran (2020) to estimate the underlying distribution of shocks that shift the trend path of economic activity. A negative economic impact of the COVID-19 pandemic that was smaller than expected leads to a thinner tail of the estimated distribution. This reduces the beliefs about the likelihood of a large negative economic shock in the future.

[15] We do not consider the recent disruptions in financial markets that started with the failure of the Silicon Valley Bank. Their impact, or lack thereof, on our future estimates of the neutral rate depends on whether these events lead to a significant economic downturn.

Appendix: An updated suite of statistical models of potential output

The integrated framework (IF) is based on growth accounting and is the main method Bank of Canada staff use to estimate potential output. However, many alternative approaches exist to estimate potential output, each with their own limitations (Mishkin 2007). One approach is to take an average of the IF model estimates and those of the extended multivariate filter (EMVF) to estimate potential output over history. This aims to strike a balance between:

- aiming for clear economic interpretation (a feature of the growth accounting approach)
- mitigating the risk of large errors from a single model (Pichette et al. 2015)

For this year's assessment, we have extended our method of estimating potential output by expanding the suite of statistical models that factor into the historical estimates.[16] These new models are the following:

- **Hamilton filter** (Hamilton 2018): This model is based on local projections of future gross domestic product (GDP) of a given horizon on current and lagged GDP. Following the modification proposed by Quast and Wolters (2022), we average estimates across 4 to 12 quarters of horizons.
- **Beveridge-Nelson filter** (Beveridge and Nelson 1981): This filter estimates potential output as a long-horizon conditional forecast of GDP. Because this method often produces very volatile potential output, we impose the low signal-to-noise ratio restriction proposed by Kamber, Morley and Wong (2018).
- **Clark's (1989) model**: This model defines potential output as the permanent component of GDP, and it links the output gap to the transitory component of unemployment rate through Okun's law.
- **Direct method**: This is a simplified approach based on growth accounting. It measures the output gap—the difference between potential output and real GDP—as the weighted average of the labour gap and industrial capacity utilization rates. We use averages estimated by Statistics Canada where the weights are the time-varying labour and capital income shares, respectively.
- **Bivariate unobserved components model:** This model relates the output gap to inflation through a hybrid New Keynesian Phillips curve (Galí and Gertler 1999). This makes it well-suited for estimating potential output as the level of output that can be maintained without inflationary pressures. This approach builds upon work spanning the broader literature (e.g., Clark 1987; Kozicki and Tinsley 2012) and jointly estimates

[16] As Pichette et al. (2015) explain, the models upon which the average estimate is based should be sufficiently different to protect against the risk of having the wrong model.

potential output and inflation expectations: the two unobserved variables of the model.

Together with the EMVF, these statistical models received 60% weight in the historical potential output estimate (10% each), with the remaining 40% assigned to the IF. This compares with the previous weighting of 50% for each of the IF and EMVF.

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