

The Twin Supply Shocks to Canada's Post-Pandemic Inflation and Monetary Policy

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Abstract

Canada's inflation rate rose from 3.1 percent in June 2021 to 8.1 percent one year later. Monetary policy is consequently tightening. We explore some causes and consequences of these developments. Using detailed price and quantity data, we separately identify demand- from supply-driven inflation. We find two-thirds of Canada's accelerating inflation since Q1 2020 is supply-driven, which complicates monetary policy. Another supply shock — large increases in bank reserves — may complicate it further. We estimate that ample reserves and rising interest rates may cause large financial losses for the Bank of Canada. This creates novel reputational and communications challenges for the Bank and highlights underappreciated connections between monetary and fiscal policy. These twin supply shocks — to consumer products and overnight balances — are important aspects of Canada's recent inflation and monetary policy experiences.

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1 Introduction

Canada’s inflation rate rose from 3.1 percent in June 2021 to 8.1 percent one year later — the highest since the early 1980s and the fastest acceleration since the early 1950s. Monetary policy is consequently tightening. To understand Canada’s inflation and monetary policy experience following COVID-19, one must understand two important supply shocks: one that drives inflation and another that may cause financial losses for the Bank of Canada. First, using detailed data on prices and quantities of household consumption items, we identify and isolate demand-side versus supply-side drivers of inflation. We find two-thirds of Canada’s accelerating inflation since Q1 2020 is from supply shocks, roughly ten percent from demand, and the residual is ambiguous. With supply-side factors accounting for most of Canada’s rising inflation, monetary policy will have a difficult time. Another supply shock — a large increase in reserves held at the Bank of Canada (i.e., settlement balances) — may complicate monetary policy further. Ample reserves and rising interest rates imply growing interest expenses for the Bank, since most deposits there earn interest. Expenses may grow so large that potentially large financial losses will result. This creates novel reputational and communications challenges — especially at a time of heightened political attention towards monetary policy issues. This development also reveals underappreciated connections between monetary and fiscal policy, with remittance from the Bank to the Government of Canada likely to cease for several years and interest on government deposits already suspended. These twin supply shocks — to consumer products and overnight balances — are important aspects of Canada’s recent inflation and monetary policy experiences.

This paper first presents a simple decomposition of consumer price changes. Measuring the contribution of individual goods and services to year-over-year changes in the all-items consumer price index (CPI) is relatively straightforward. Intuitively, the basket-weighted price change of an item is (almost) its contribution to overall inflation. We follow Statistics Canada (2019) and describe the full method in more detail in the next section. We find that a clear majority of Canada’s high inflation is due to a small handful of items: energy, food, and home-ownership costs. The latter is particularly interesting since Statistics Canada infers home depreciation from changes in new homes prices (excluding land), which increased dramatically through the pandemic until early 2022. These three items account for over 60 percent of Canada’s overall inflation in June, and an even larger share of the acceleration over the prior year. They also suggest supply shocks, to global energy and food markets in particular, were central to Canada’s rising inflation rate.

To more robustly quantify the relative contribution of supply- versus demand-side factors, we turn to other data. Specifically, we use detailed household final consumption expenditures, with quarterly information on prices and quantities for nearly 100 specific items. With this data, we adapt the method developed by Shapiro (2022a) to identify whether changes in individual components of the overall personal consumption expenditure (PCE) price index are demand-driven or supply-driven. Intuitively, if an item’s price increases but quantity decreases, we label this change as supply-driven. Conversely, if both price and quantity increase, then it’s demand-driven. Using a rolling ten-year window of quarterly price and quantity data, we identify unexpected changes in

each by focusing on prediction errors using the past year’s data. That is, if prices or quantities rise or fall by more than what one would expect based on historical patterns, then we classify price changes as supply-driven (if unexpected quantity and price changes move in the opposite direction) or demand-driven (if quantity and price changes move in the same direction) and as ambiguous otherwise.

We find supply-side factors dominate the acceleration of Canada’s inflation. Of the four percentage point increase in the PCE inflation rate from Q1 2021 to Q1 2022, just over roughly 14 percent is due to demand-driven changes and nearly over half are due to supply-driven changes. From Q2 2021 to Q2 2022, nearly 85 percent is due to supply. And from Q1 2020 to Q2 2022, two-thirds is supply-driven. The share of supply contribution is notably higher than the supply contribution found in the U.S. data by Shapiro (2022b). But the specific items that we find contributing to supply-driven inflation — especially fuel, food, appliances, vehicle parts, and more — are common. This is a challenge for the Bank of Canada. After all, whether and how monetary policy should respond to rising inflation depends on the cause. While higher interest rates is a powerful tool against demand-driven inflation, it does not “solve” inflation arising from supply shocks such as oil production disruption, supply chain bottlenecks, or disappointing crop harvests. Unlike positive demand shocks that increase both output and inflation, negative supply shocks reduce output while increasing inflation. As a result, contractionary monetary policy tends to be costlier — in terms of lower output and job losses — when inflation is supply-driven. This has long been known (Gordon, 1975; Phelps, 1978; Blinder, 1980; Aizenman and Frenkel, 1986). And recent rising inflation has brought wide attention and concerns about its consequences and risks of weakening growth (OECD, 2022; World Bank, 2022; United Nations, 2022). Our work sheds light on these issues in the Canadian context.

Our PCE inflation measure provides complementary information to existing analyses of inflation using the CPI. Employers, governments and financial institutions widely use CPI as the measure of inflation. The Bank of Canada’s inflation-control target is also based on it.¹ Less known to the Canadian public, since there is no official series, PCE inflation is another common measure of inflation. In the U.S., PCE price index is published monthly by the Bureau of Economic Analysis and is the Federal Reserve’s preferred measure (BEA, 2021). Compared to CPI, the expenditure weights in the PCE can change as households substitute away from some goods and services toward others, avoiding some of the upward bias associated with the fixed-weight nature of the CPI (Bullard, 2013; Greenspan, 2000). PCE inflation also allows for a more consistent comparison over time. Our analysis of PCE inflation also suggests it may be a measure that the Bank of Canada may benefit from using to evaluate, estimate, and predict inflation.

In addition to supply shocks affecting goods and services, the Bank of Canada’s response to rising inflation is further challenged by another large supply shock. But a subtle one involving the market for overnight funds. Prior to the pandemic, the Bank of Canada influenced the overnight

¹While the Bank’s mandate targets all-items CPI changes, other “core” inflation measures, including CPI-trim, CPI-median and CPI-common, guide policy.

rate within an operating band and the supply of settlement balances was negligible. Today, in sharp contrast, the supply of settlement balances is very large and overnight rates are determined by the rate paid on deposits held at the Bank. Under this approach — known as a “floor system” — the overnight target rate and the deposit rate are the same.² The challenge for the Bank comes from rapidly rising interest rates, which increases deposit rates and therefore interest expenses. For the first time in its history, expenses will exceed revenues. Using a simple model of Bank finances, we estimate losses would have happened in the second-quarter of 2022, but government deposits stopped earning interest on May 16, 2022. This allowed for a modest net income of \$144 million that quarter instead. But we estimate that even with this change, net income will be negative in the third-quarter and potentially remain negative for two to three years thereafter. We project cumulative losses between 2022-23 and 2024-25 of between \$2 and \$8.5 billion, depending on the trajectory of future deposit rates and interest-earning balances. While we describe several caveats, this projection provides a useful sense of scale. Our analysis is the first to explore this.

These losses illustrate what Berentsen, Marchesiani, and Waller (2014) label the “unpleasant fiscal arithmetic of a floor system” and will have important policy implications. Bank profits are normally remitted to the government, so the fiscal implications direct. To be clear, this is modest. Between fiscal years 1935-36 and 2021-22, we estimate total remittances approached \$155 billion (in real 2020 dollars), averaging about 0.2 percent of GDP. We project losses comparable to cumulative remittances between 2019-20 and 2021-22. In addition, Bank of Canada operations and its ability to achieve policy goals are not undermined by negative net income. But there are potentially important concerns around whether this creates novel reputational risks for the Bank. Much will depend on the public and political reaction, which itself may depend on how losses are accounted for and communicated. But as of late August 2022, the Bank’s remittance agreement with the government does not include provisions for such losses.³ It is a novel challenge, though not unique to Canada. Recent analysis suggests financial losses for the Federal Reserve are likely by late 2022 (Anderson et al., 2022), and this possibility was raised in the July 2022 FOMC meeting. The Fed’s accounting approach to losses is fully developed, and we propose a simple adaptation of this that is consistent with the Bank of Canada Act.

Our paper informs ongoing debates about the nature and consequences of recently high inflation. We are the first to disentangle the effects of demand- and supply-shocks on Canada’s overall inflation. Our findings align with recent research examining specific shocks and their impacts on inflation. Leibovici and Dunn (2021) and LaBelle and Santacreu (2022b) investigate the role of supply chain disruptions on prices in the U.S. and found this contributed significantly to rising inflation. Di Giovanni et al. (2022) study the Euro Area inflation during the pandemic and found that foreign shocks and global supply chain bottlenecks played an outsized role relative to domestic aggregate demand shocks. Celasun et al. (2022b) use data from 30 countries in 2021 to show that supply shocks had a negative impact on manufacturing output, which contributed to higher

²For a detailed discussion of the payments system and settlement balances see Chu et al. (2022).

³We acknowledge and thank staff at the Bank of Canada communications department for providing us a copy of this agreement and clarifying some details.

goods prices. These studies confirm that supply-side factors have been a major driver behind the recent elevated inflation in many countries. We also help shed light on the connection between pandemic related disruptions and inflation (Shapiro, 2022a; Ball et al., 2021; Leibovici and Dunn, 2021; de Soyres, Santacreu, and Young, 2022; Di Giovanni et al., 2022; Celasun et al., 2022a; LaBelle and Santacreu, 2022b) and Canada’s recent experience in particular (Azad, Serletis, and Xu, 2021; Ambler and Kronick, 2021). Finally, we are the first to quantify the potential financial losses of the Bank of Canada. This work therefore fits within a growing literature examining the fiscal implications of monetary policy and of paying interest on reserves in particular (Ernhagen, Vesterlund, and Viotti, 2002; Cúrdia and Woodford, 2011; Kashyap and Stein, 2012; Berentsen, Marchesiani, and Waller, 2014; Cavallo et al., 2018; Reis, 2019; Goncharov, Ioannidou, and Schmalz, 2021).

2 The Composition of Inflation

Knowing whether high inflation is demand- or supply-driven is essential not just for its own sake but also for the appropriate conduct of monetary policy. Of course, this is not easy. The price increase of some goods might be caused by rising demand, while for others the same price increases might be caused by falling supply. In this section, we provide two decompositions to examine the drivers of inflation. First, we estimate the contribution of individual products to Canada’s overall inflation using well established methods applied to the latest data. Second, we adapt the novel approach of Shapiro (2022a) to identify the relative importance of demand and supply shocks.

2.1 A Simple Product-Level Decomposition

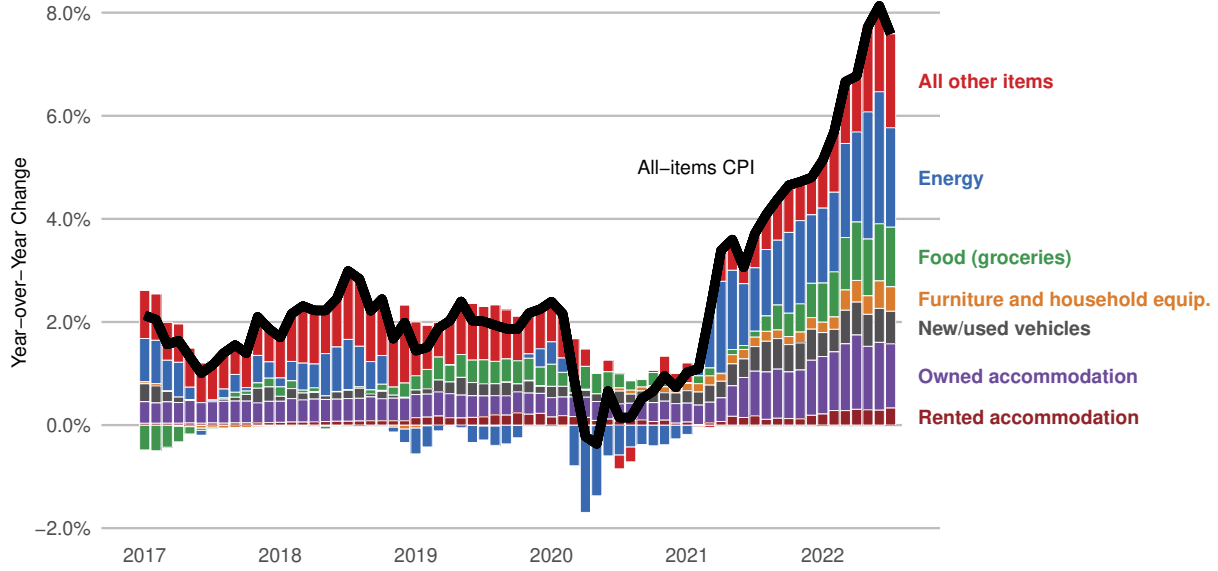
We begin with a decomposition of Canada’s CPI. In a simple Laspeyres price index, overall inflation is the average change in prices across items, weighted by base-period expenditure shares. Quantifying each item j ’s contribution is then that item’s price change times its weight. Canada’s CPI, however, is more complex. It is a chained-linked index with periodic basket re-weighting. Determining an item’s contribution to inflation is complicated when periods span two baskets. Following Statistics Canada (2019, Ch. 8), consider a situation where between months $t - 12$ and t there is a change in basket weights from b_{t-12} to b_t at link month $(t - 12) < s < t$. The contribution of item j to inflation over this period is

$$c_{t-12,t}^j = \left(\frac{p_s^j}{p_{t-12}^j} - 1 \right) w_{t-12}^j + \left(\frac{p_t^j}{p_s^j} - 1 \right) w_s^j \left(\frac{P_s}{P_{t-12}} \right), \quad (1)$$

where P_t is the all-items CPI at time t and w_t^j is the relative importance of item j ,

$$w_t^j = \frac{b_t^j (p_t^j / p_s^j)}{\sum_k b_t^k (p_t^k / p_s^k)}, \quad (2)$$

Figure 1: Key Drivers of Consumer Price Inflation in Canada, Jan 2017 to Jul 2022



Note: Displays the contribution of specific categories of items to Canada's headline rate of consumer price inflation over time.

Source: Authors' calculations using Statistics Canada data tables 18-10-0004-01 and 18-10-0007-01. See text for details.

using whatever basket weight b_t^j is relevant for that month. Notice that if months $t - 12$ and t share the same basket — such as would occur if $s < (t - 12)$ — then the above collapses to

$$c_{t-12,t}^j = \left(\frac{p_t^j}{p_{t-12}^j} - 1 \right) w_{t-12}^j. \quad (3)$$

In either case, overall CPI inflation is $\pi_t = \sum_j c_{t-12,t}^j$.

With this method, we find only a few items account for rising inflation. We display the results in Figure 1. Of the 8.1 percent inflation in June 2022, 2.6 percentage points were accounted for by higher energy prices (1.9 percentage points from gasoline alone). This was followed by 1.6 percentage points from owned and rented accommodation, 1.1 percentage points from groceries, 0.7 percentage points from new and used vehicles, and 0.5 percentage points from furniture and household equipment. The rise in these half-dozen categories also fully accounts for the recent increase. And the modest decrease in the July inflation rate, as is also clear in Figure 1, was due to energy prices falling relative to June. That energy is an important determinant of changes in Canada's inflation is not new. A Shapley-Owen Decomposition of inflation between February 1995 and February 2020 regressed on the contributions from these six items gives energy a value of nearly 0.7, suggesting the overwhelming majority of the variation was due to energy.⁴ But the large and abrupt increase in 2021 and 2022 was unusual.

⁴Starting in Feb 1995 avoids the 1994 tobacco tax cut; ending in Feb 2020 avoids the pandemic.

There are no shortages of potential explanations. Energy prices increased through 2021 and early 2022 due to a robust economic recovery from the pandemic and lagging oil production in key OPEC countries. Russia’s invasion of Ukraine sent energy prices higher still. As this is an important input into the production of so much else, this may be a broad source of price increases. Durable goods like vehicles and household appliances also faced supply chain disruptions and transportation bottlenecks, both of which may have prices (LaBelle and Santacreu, 2022a). On a macroeconomic level, some point to expansionary fiscal and monetary policy as key drivers. Income support programs through the pandemic may have increased consumer demand, which in turn may have increased prices (Summers, 2021). And low interest rates and rising asset prices, which may be driven by loose monetary policy, may have added to this pressure. Our decomposition cannot answer these questions — as it is merely an accounting exercise — so we instead turn to a new approach and different data required for the analysis.

2.2 Household Consumption Expenditure Inflation

We construct a measure of inflation using a personal consumption expenditure (PCE) deflator. Our main data source is the publicly available Statistics Canada data *Detailed Household Final Consumption Expenditure* (DHFCE, table 36-10-0124-01), which provides a detailed disaggregation of final expenditures into nearly 100 specific items.⁵ These data report nominal quarterly expenditures by item and, importantly for our purposes, real expenditures at constant prices. The implied price index for an item is the ratio of nominal to real expenditures and changes in real expenditures provides a measure of quantity changes.

To cleanly decompose the contribution of specific items to inflation, we use a Laspeyres approach. This is distinct from the U.S. PCE inflation, which uses a Fisher approach, but better approximates the approach used in determining the headline rate of CPI and provides for a more intuitive decomposition.⁶ Specifically, year-over-year changes in item j ’s price at quarter q is

$$\pi_q^j = \frac{p_q^j}{p_{q-4}^j} - 1, \quad (4)$$

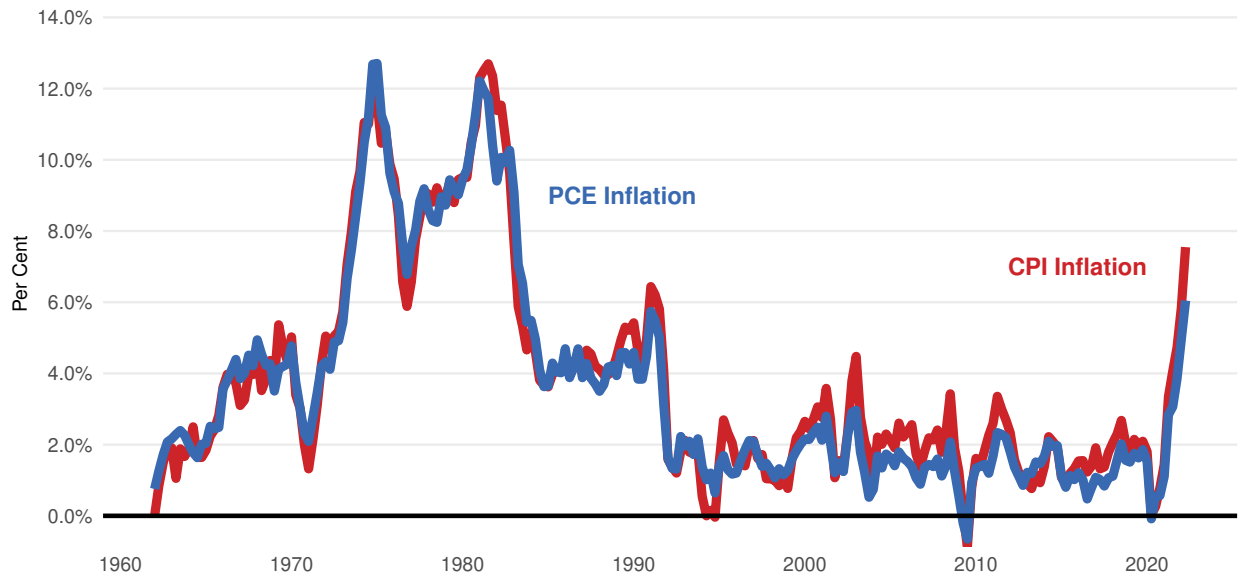
where p_q^j is the item’s price index. Given expenditure weights ω_q^j , the contribution of item j to overall final consumption expenditure price changes is $\omega_{q-4}^j \pi_q^j$ and therefore

$$\pi_q = \sum_j \omega_{q-4}^j \pi_q^j. \quad (5)$$

⁵We exclude adjusting entries, net expenditure abroad and its subcategories, and cannabis related items. These detailed data begin in 1981. For a longer time series, we use data *Household final consumption expenditure* (table 36-10-0107-01), which begins in 1961 but with a more aggregated classification.

⁶Our results are robust to using Fisher weights for each item. In Q1 2022, for example, inflation using a Laspeyres approach is 5.1 percent and using a Fisher approach is 5.0. The largest difference between the two formula since 1982 is 0.1 percentage points. A chained-type index is also similar.

Figure 2: Two Measures of Inflation in Canada, Q1 1962 to Q2 2022



Note: Displays our aggregate measure of quarterly PCE inflation compared to an estimate of quarterly CPI inflation.

Source: Authors' calculations using Statistics Canada data tables 18-10-0004-01 and 36-10-0107-01.

While our PCE inflation measure differs from the CPI, it is nevertheless highly informative. Both measures are widely used by central banks and they broadly follow similar trends.⁷ We display quarterly PCE and CPI inflation in Figure 2. The two series are highly correlated, though there are differences. In Q1 2022, we estimate Canada's PCE inflation rate to be five percent while the all-items CPI increased 5.8 percent over that same period.⁸ In Q2, we estimate the PCE inflation rate rose to 6.1 percent compared to the CPI increase of 7.5 percent. The lower rate of PCE inflation compared to CPI is observed in the United States as well, where the former was 6.5 percent in Q2 compared to the latter of 8.6 percent.⁹

Several factors account for these differences, including data sources, product coverage, calculation formulas, and frequency of basket updates. Our PCE inflation is based on the DHFCE data, which is a component of Canada's system of national accounts. CPI prices are collected from a sample survey to reflect retail prices, and the CPI basket is constructed with same data we use plus a supplement data from the *Survey of Household Spending*. There is also a difference in the scope as our PCE index covers all resident households, and CPI contains only private households.¹⁰ The formula and calculations also differ. The CPI, for example, infers homeowner depreciation costs

⁷Since 1962, quarterly PCE inflation averaged 3.6 percent compared to 3.8 for quarterly CPI. Since 2000, PCE inflation averaged 1.6 percent compared to 2.1 percent for CPI. That PCE is generally lower than CPI inflation is consistent with McCully, Moyer, and Stewart (2007). CPI also tends to report larger deflation if changes are negative.

⁸Source: Authors' calculations from Statistics Canada data table 18-10-0006-01.

⁹Source: Authors' calculations from St. Louis FRED data series PCECTPI and CPIAUCSL.

¹⁰People who live in collective households — such as members of communal colonies, prison inmates, and chronic care patients in hospitals and nursing homes — are not included in the CPI target population.

from an index of new home prices (excluding land) while the DHFCE data, which aims to align with national accounts, estimates the rental equivalent value of owned accommodation.

PCE inflation has two advantages over CPI inflation that are particularly relevant to understanding recent inflation trends.¹¹ First, the expenditure weights are more frequently updated, as they are constructed from expenditure data, compared with CPI’s fixed-basket design. Second, unlike CPI, the PCE data is revised and modified to account for newly available information and improvements in measurement techniques within the national accounts. The result is a more consistent series over time and a potentially better comparison to historical data, which we undertake in section 2.4. Understanding movements in PCE inflation is therefore highly informative and complements the CPI measure.

2.3 Estimating Supply- and Demand-Driven Price Changes

We adapt Shapiro (2022a) to distinguish demand and supply shocks in the data. The intuition is simple. We categorise changes for each item in the household expenditures data as *supply-driven*, *demand-driven* or *ambiguous* based on whether unexpected changes in quantity and price are in the same direction (demand) or not (supply). And by unexpected changes, we mean deviations from historically normal changes in quantities and prices. Specifically, using a ten-year rolling window, we regress log price levels or log quantity levels for each item on the information available over the past year. That is, for $x \in \{price, quantity\}$ we estimate

$$\log(x_q^j) = \beta_0^j + \sum_{s=1}^4 \beta_s^j \log(Z_{q-s}^j) + \epsilon_q^j, \quad (6)$$

where Z^j contains both past price and quantity data. Intuitively, this method uses information within a window from quarter $q - 40$ to $q - 1$ to construct a prediction for the price or quantity for item j at quarter q . The residuals $\hat{\epsilon}_q^j$ capture unexpected changes. Using these residuals for both price and quantity, we classify shocks based on their signs. If the unexpected changes in price and quantity are in the same direction then we conclude this item was subject to a supply shock. Similarly, if the unexpected changes in price and quantity are in opposite directions, we conclude the item was subject to a demand shock. We label items with price or quantity changes that are sufficiently close to zero as *ambiguous*.¹²

The results in Figure 3a reveal several important patterns. PCE inflation fell at the onset of the pandemic, stayed low during the pandemic, and rose at the beginning of 2021. The year-over-year inflation rate continued to grow. By 2022 Q2, PCE inflation exceeded six percent, which

¹¹The Federal Open Market Committee (FOMC) switched from CPI to PCE in 2000 as its primary inflation measure to conduct monetary policy.

¹²We follow Shapiro (2022a) in classifying any unexpected change in price or quantity between the 40th and 60th percentiles of residuals in each rolling 10-year window as ambiguous. Our results are robust to using one lag or as many as eight. With many lags, though, the ambiguous portion becomes larger. If we classify as ambiguous only those changes within the middle ten percent of the distribution of residuals within each window, then with eight lags supply factors account for over 70 percent of the acceleration in inflation from Q1 2020 to Q2 2022.

is the largest rate since 1983. Early in the pandemic, between Q1 2020 and Q2 2020, demand accounted for nearly 90 percent of the decline. And early in the initial recovery through Q2 and Q3 2021, demand-side factors were the main source of increases. But the picture later changed, with supply driving recent inflation increases, accounting for 3.4 percentage points of PCE inflation in Q2 2022. And supply contributions were nearly 85 percent of the total increase in PCE in Q2 2022 compared to one year earlier.¹³ This is notably higher than an average of around 50 percent contribution in the U.S. (Shapiro, 2022a). The contribution of supply-side drivers is also increasing strongly through 2021, which will pose a challenge for monetary policy going forward. We provide a starker visualisation of the relative contributions of supply and demand factors in Figure 3b. While demand driven inflation is 0.8 percentage points higher relative to its average level during the post-2010 period, supply driven inflation has increased 2.8 percentage points from its average. This *change* in the supply-driven inflation alone is higher than the overall average PCE inflation from 1982 to 2019 of 2.3 percent. Also evident is the sharp drop in demand early in the pandemic.

As for individual drivers of PCE inflation, we report the top contributors in Table 1. The top demand-driven inflation contributors come from accommodation services, car rentals, home heating, and household furnishings. The items pushing inflation up from the supply-side reveal different sources of disruptions, including high global commodity prices after Russia's invasion of Ukraine (fuel, food) and supply chain disruption (personal appliances, new vehicles, vehicle parts). Altogether, the top ten supply-driven contributors account for 2.8 percentage points of the overall PCE inflation in Canada. And compared to the pre-COVID Q1 2020 level, they together account for 54 percent of the increase. The top demand-driven contributors, meanwhile, account for only 0.8 percentage points of the overall inflation and none of the acceleration.

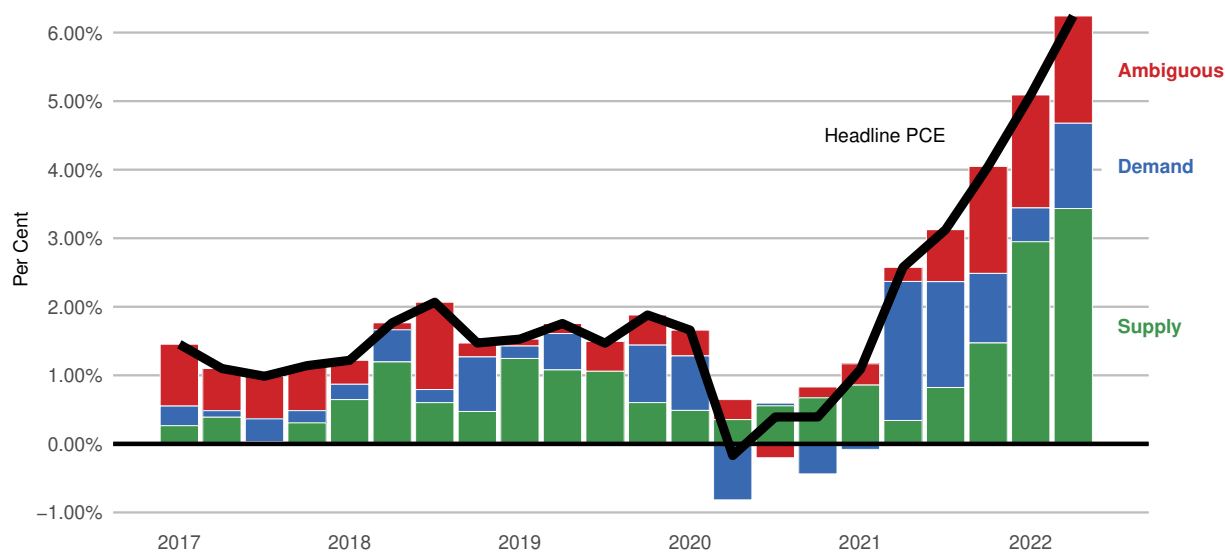
The Bank of Canada's mandated target is headline inflation to between one and three percent, regardless of whether inflation is supply- or demand-driven. However, the source of inflation matters for how fast the central bank can bring down inflation and how likely they are to achieve a "soft-landing" of the economy. Simple macroeconomic theory tells us the demand-driven inflation can be mitigated by contractionary monetary policy, which will lower aggregate demand and therefore prices. To the extent that such inflation was due to the economy operating above its sustainable potential output level, monetary policy can both lower inflation and move the economy towards a sustainable level. Supply shocks are a trickier beast. In this case, a central bank would have to bring aggregate demand down while the supply shock lowered output levels below potential. In addition, supply shocks might cause negative demand effects if forward-looking consumers and investors have concerns regarding future output and generate pessimistic expectations of future income and wealth.

The persistence of shocks also matters. Ones that are large and persistent can be particularly harmful, as wages and salaries across the economy will be pressured to increase over time to keep

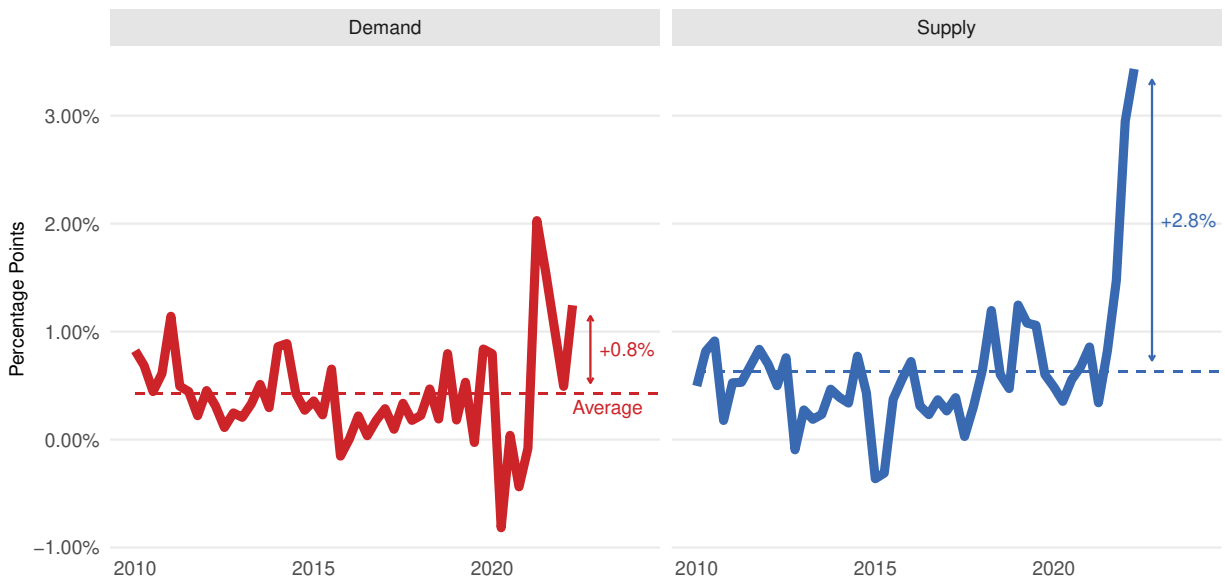
¹³If all changes are apportioned to supply or demand, regardless of the size of the unexpected change, then supply-driven changes account for 76 percent of the Q2 2022 inflation and 86 percent of the increase from Q1 2020.

Figure 3: Contribution of Supply and Demand Shocks to Inflation in Canada

(a) Contributions to PCE Inflation, Q1 2017 to Q2 2022



(b) Relative to the Post-2010 Average



Note: Displays the contribution of demand and supply shocks to individual goods and services to headline final consumer expenditure inflation in Canada. Items are classified based on whether unexpected price and quantity changes move together (demand) or not (supply). Ambiguous changes are too small to classify, defined by the middle 20 percent of residuals for each window.

Source: Authors' calculations using Statistics Canada data table 36-10-0124-01. See text for details.

Table 1: Top Contributors to PCE Inflation in Q2 2022

Demand Shocks		Supply Shocks	
Item	Price Change	Item	Price Change
Accommodation services	33.8%	Fuel/lubr. for vehicles	43.2%
Passenger vehicle renting	21.0%	Air transport	13.3%
Natural gas for homes	20.5%	Food (groceries)	10.1%
Furniture and furnishings	15.7%	Vet. services for pets	8.7%
Other transport equip. services	11.7%	Personal elec. appliances	8.4%
Household textiles	9.3%	Other vehicles	8.3%
Carpets/floor coverings	8.3%	Home maintenance materials	7.0%
Non-alcoholic beverages	8.0%	Vehicle parts/accessories	7.0%
Misc. stationery	7.3%	Garden products/plants	6.2%
Cable/satellite service	6.7%	New trucks/vans/SUVs	6.1%

Note: Display the top ten demand and supply contributors to year-over-year PCE inflation in Q2 2022.

Source: Authors' calculations using Statistics Canada data table 36-10-0124-01. See text for details.

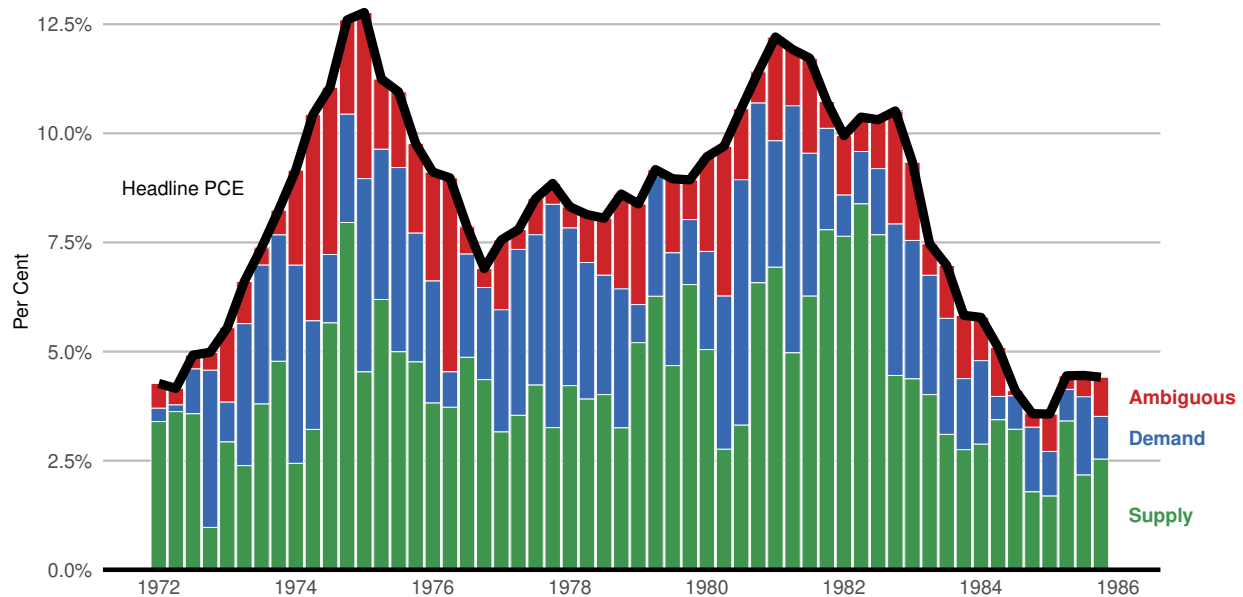
pace. This may create a wage-price spiral that is more difficult for the central bank to control. In such a situation, the central bank may need to be more aggressive and raise interest rates rapidly. A recession may likely follow. But temporary shocks may not affect inflation expectations of wage and price setters in the same way. A central bank should therefore respond differently (Caballero and Simsek, 2022). Our estimates do not allow us to distinguish between transitory and persistent shocks, but the individual products involved suggests that as strain in global energy markets and supply chain bottlenecks ease then so too will much of the recent inflation pressure. A comparison to the 1970s may be instructive.

2.4 A Brief Comparison to the 1970s and Early 1980s

The last major supply shock that most economists and non-economists alike would remember was in the 1970s. A four-fold increase in the oil price — due to lower supply from oil-exporting countries in the Middle East — accelerated inflation and slowed economic growth. In Canada, inflation rose from less than six percent early in 1973 to over 12 percent by the end of 1974. Though it declined somewhat following this spike, it increased again through the late 1970s and early 1980s, reaching nearly 13 percent by 1981. Meanwhile, the economy struggled. Actual GNP was 18 percent lower than the steady growth path by 1982, accumulating a \$91 billion loss (in 1971 dollars) between 1974 and 1982 (Helliwell, 1983). Unemployment also increased. Today's rising inflation rate is leading many to draw parallels with the 1970s.

As before, we isolate supply- and demand-side factors and display the results in Figure 4. For this, we use the Household Final Consumption Expenditure data (table 36-10-0107-01), which begins in 1961 but with a more aggregated classification. We treat as ambiguous any unexpected change in price or quantity that is within the middle ten percent of the sample distribution of

Figure 4: Contribution of Supply and Demand Shocks to PCE Inflation, 1972 to 1985



Note: Displays the contribution of demand and supply shocks to headline final consumer expenditure inflation in Canada. Items are classified based on whether unexpected price and quantity changes move together (demand) or not (supply). Ambiguous changes are too small to classify in either category, defined by the middle ten percent of residuals for each window.

Source: Authors' calculations using Statistics Canada data table 36-10-0107-01. See text for details.

residuals instead of the middle 20 percent. Though these data are not as detailed, and our estimates are slightly more volatile, the overall pattern is clear. On average, PCE inflation in 1974 was nearly 11 percent — up from an average of 4.6 percent two years earlier. Rising demand-side factors account for over one-quarter of this increase while supply-side factors account for 30 percent. While being large in magnitude, these initial supply shocks were not persistent and PCE inflation receded notably by 1977.

The experience in the early 1980s may also be relevant. Inflation gradually increased and exceeded ten percent by 1980. Both supply- and demand-side factors largely accounted for this, as is evident in Figure 4. But a sharp decline in Canada's inflation soon followed. From Q1 1982 to Q1 1985, we estimate PCE inflation declined by nearly 6.4 percentage points — from nearly ten percent to 3.6 percent. Comparing the 1985 annual average to the 1981 average, we find supply accounted for 54 percent of the decline (4.0 percentage points of the overall 7.4 percentage point decline) while demand accounted for nearly one-third percent (2.4 percentage points). Falling oil prices, especially into the mid-1980s, may have been a contributor on the supply side. Labour market developments may have been as well. The Bank of Canada in its 1983 Annual Report, for example, noted "[t]he most important factor underlying the improvement in Canadian inflation has been a slowing in the rate of increase of domestic production costs. Of particular significance was the deceleration of nominal wage increases in 1983..." (Bank of Canada, 1983, p. 17). On the demand side, contractionary monetary policy, especially in the United States, sharply slowed economic

activity in the early 1980s. Whatever the cause, we conclude much of the rise and subsequent fall of Canada's inflation rate in the 1970s and 1980s was a story of both demand- and supply-side factors. A Shapley-Owen decomposition of demand- and supply-side contributions to overall PCE inflation between 1972 and 1985 suggests supply accounts for 49 percent of the variation and demand accounts for 33 percent. Today, the decline in inflation may also be supply-driven, though contractionary monetary policy will likely cause several demand-driven to contribute as well.

3 A Supply Shock to Monetary Policy

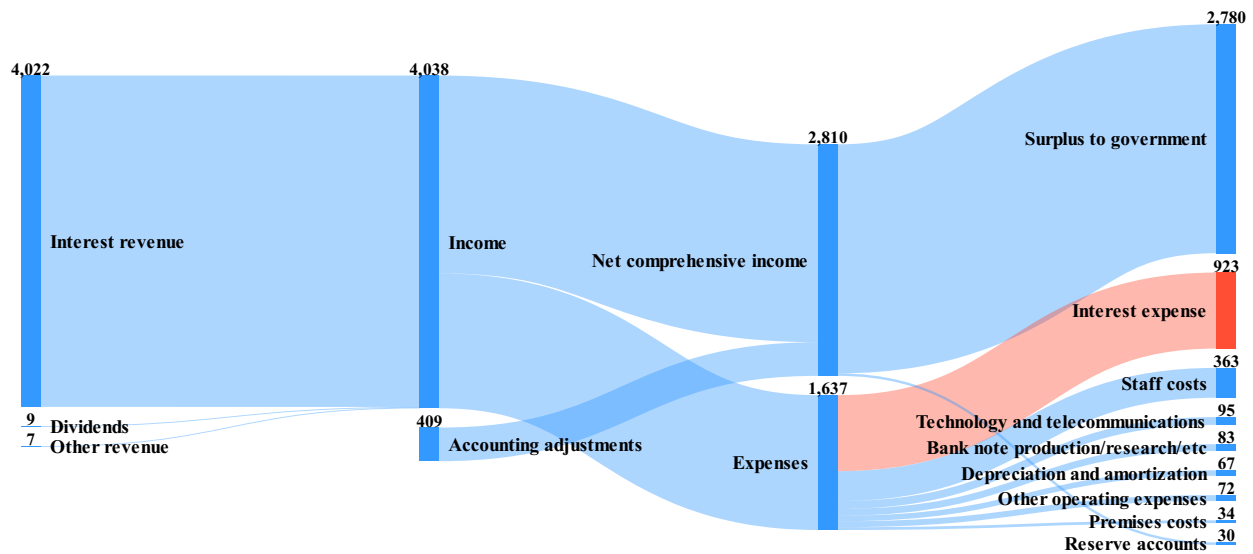
As discussed, supply-driven inflation is a challenge for the Bank of Canada. Less well known is that interest rate increases also interact with a second supply shock to create an entirely new challenge for the Bank, though one of a more subtle nature related to its own finances. Before exploring this challenge in detail, some background is necessary.

3.1 Bank of Canada Finances

The Bank of Canada is a large and complex institution, but the broad strokes of its finances are simple. Bank revenues are largely from its assets holdings. Prior to the pandemic, this was mainly Government of Canada bonds (\$80 billion) and treasury bills (\$25 billion). These holdings generated roughly \$2 billion in revenues that more than offset the less than \$1 billion in expenses. Those expenses include labour compensation for staff employees, technology and telecommunications costs, the cost of producing, researching, and processing bank notes, maintenance on buildings, and so. For revenue from asset holdings to exceed — often by a very wide margin — operating expenses is normal for most central banks, and is an important way in which they maintain their independence from fiscal authorities. Its objective, we must be clear, is not to maximise profits. This is sometimes made explicit. To quote the Bank itself, “assets and liabilities on the Bank's balance sheet are there to support the Bank's core functions and ensure its independence, not to maximise profits” (Bank of Canada, [2022b](#)). Finally, any excess of revenue over expenses is remitted to the federal government, less any amounts required to maintain certain reserve funds at the Bank.

In recent years, the picture has changed with the growth of a new item: interest expenses. To help visualise this, we display the Bank of Canada's annual financial inflows and outflows for 2021 in Figure 5. Beyond its normal operating expenses, the largest expense in recent years has been interest paid on deposits held at the Bank, which we highlight in the figure. Paying interest on deposits is a modern development. Indeed, the original 1934 Bank of Canada Act stated in Section 21 that “The Bank shall not ... pay interest on any moneys deposited with the Bank” (Bank of Canada Act, [1934](#)). It even restricted the Bank from paying interest on government deposits. But as the role of the Bank evolved, so too did its powers. A major reform enacted through the Payment Clearing and Settlement Act in 1996 gave the Bank authority over the payments system

Figure 5: Bank of Canada Financial Flows, 2021



Note: Displays the financial inflows (from the left) and outflows (to the right) to and from the Bank of Canada

Source: Authors' calculations from the Bank of Canada Annual Report 2021, Statement of Net Income.

in Canada; it also allowed for interest payments on deposits.¹⁴ And in early 1999, when the Large Value Transfer System started, the Bank began to do just that (Bank of Canada, 1999, p. 54). These payments, however, were relatively modest as bank balances held at the Bank were negligible by design; only government deposits were material. We estimate that between 1999 and 2019, the average annual interest paid by the Bank to all depositors was approximately \$100 million per year — roughly 90 percent of which was to the Government of Canada. The pandemic, however, changed the picture dramatically.

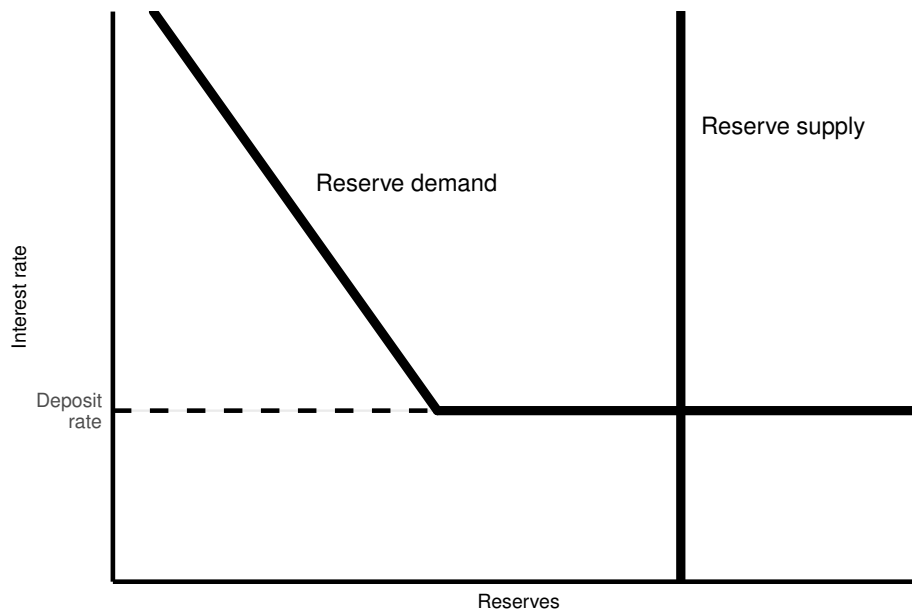
3.2 A New Approach to Monetary Policy

Prior to the pandemic, monetary policy involved the Bank of Canada influencing overnight interest rates within an operating band bounded below by the deposit rate and above by the bank rate. That is, the Bank would set a target range for the rate at which financial institutions would borrow or lend to each other overnight. The Bank would pay interest on deposits at the deposit rate slightly (0.25 percentage points) below the mid-point of the range, and stood ready to lend at the bank rate slightly (0.25 percentage points) above. And settlement balances — or bank reserves held at the Bank of Canada — were actively managed and kept very low (near zero) to minimise borrowing from or depositing with the Bank. This was known as the “corridor system”.

The COVID-19 pandemic changed how the Bank conducts monetary policy. With the target for

¹⁴Enacted through Schedule 162 of *An Act to Amend, Enact and Repeal Certain Laws Relating to Financial Institutions*, 1996, Canada 44-45 Elizabeth II, c.6. The ability to pay interest on government deposits was added separately through *An Act to Amend Certain Laws Relating to Financial Institutions*, 1997, Canada 45-46 Elizabeth II, c.15. Interest expenses did exist prior to these reforms — interest was paid on unclaimed deposits, for example — but these were negligible.

Figure 6: Illustrating a Floor System in the Market for Overnight Funds



Note: Displays a stylised representation of the overnight market when the supply of settlement balances is very large and demand is perfectly elastic at the deposit rate (also the target rate).

Source: Adapted from Goodfriend (2002, p. 3).

the overnight rate cut to near zero by late March 2020, additional monetary policy action to ease financial conditions and lower longer-term interest rates required the Bank to engage in large-scale asset purchases. There were many specific programs, but the largest — the Government of Canada Bond Purchase Program (GBPP) — was announced in late-March 2020. This program, along with several others targeted at other assets, continued through to late 2021. At its peak, the Bank’s balance sheet expanded by well over \$400 billion. Not since World War II has the Bank of Canada expanded its holdings so much so quickly.¹⁵ While its impact will be the subject of much future research, early evidence suggests this program lowered Government of Canada bond yields as intended (Arora et al., 2021), but also exposed the Bank to certain financial risks.

The Bank largely purchased bonds with reserves held at the Bank; that is, with settlement balances. This mattered. The increased supply of settlement balances was so large that the previous corridor system was no longer appropriate. The Bank therefore moved to a system where actively managing the overnight supply of settlement balances to influence the overnight rate was no longer necessary. It adopted what is called a “floor system”, where the target overnight rate is pinned down by the deposit rate. We illustrate a stylised representation of this system in Figure 6. In this system, settlement balances are so large that they no longer matter for the overnight rate, since the demand for balances is nearly perfectly elastic at the deposit rate. This provides a new tool for the Bank of Canada to conduct monetary policy. It can now independently move

¹⁵Between 1939 and 1947, Bank of Canada asset holdings as a share of GDP increased by approximately 12 percentage points. Between 2019 and 2022, asset holdings increased by approximately the same 12 percentage points.

the policy rates and the overall level of liquidity in the system, a key point raised by Goodfriend (2002), which recent research suggests is potentially valuable (Kashyap and Stein, 2012). And in April 2022, the Bank of Canada announced the floor system would remain.

3.3 The Effect of Rising Interest Rates

The massive increase in settlement balances — a supply-shock to monetary policy, if you will — exposes the Bank of Canada’s own finances to significant interest rate risk. To illustrate this, we display the total value of Canadian dollar deposits at the Bank of Canada in Figure 7a. These deposits (with the new exception of government deposits) earn interest at the deposit rate, as mentioned. And rapidly rising policy rates required rapidly rising in the deposit rates. As of August 2022, this rate was 2.5 percent — up sharply from the 0.25 percent that prevailed at the beginning of the year. With roughly \$200 billion in interest-earning deposits at the Bank, as of August 2022, rate changes have large effects on interest expenses. Though not explicitly reported, we estimate the total value of interest payments made by the Bank on those deposits in Figure 7b. Payments on deposits held at the Bank are now orders of magnitude larger than in the past, and have increased more rapidly than at any point in the Bank’s history.

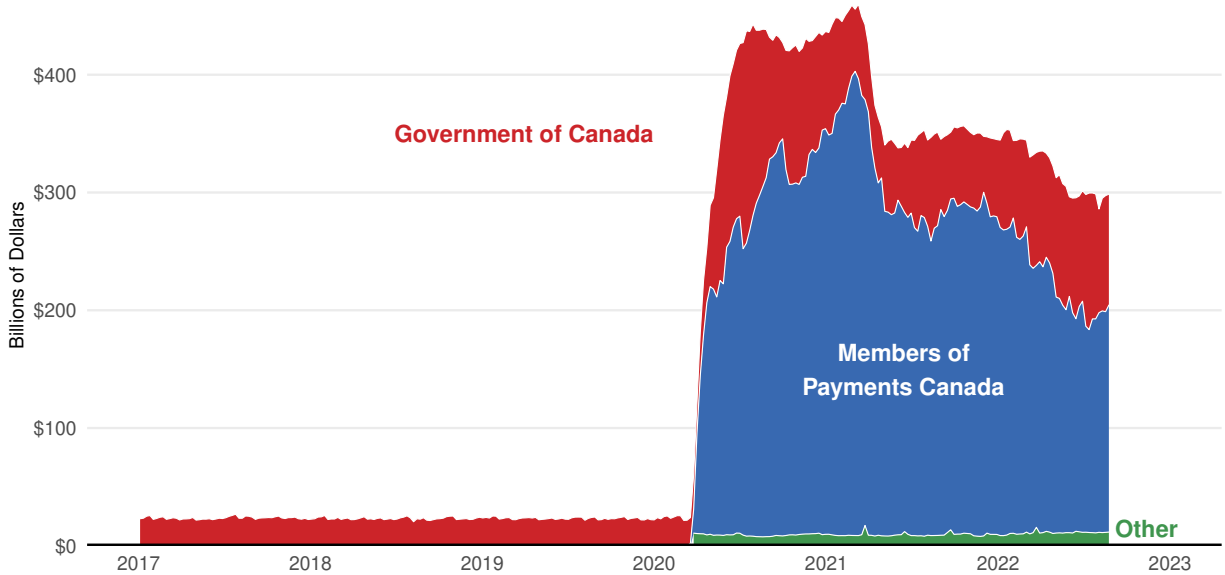
This will have important financial implications for the Bank. On the one hand, rising interest rates tend to lower bond prices. Writing down the value of Bank bond holdings may create large unrealised losses. This is not a particular challenge in Canada, however. Outright losses on Bank bond holdings acquired through the pandemic are explicitly indemnified by the federal government. And if bonds are held to maturity, then any unrealised loss will fall to zero. On the other hand, though, the bulk of the Bank’s bond purchases were during a low interest environment, and it is not acquiring more as interest rates rise. Interest revenues will therefore lag rising interest expenses and potentially cause large financial losses.

3.4 A Projection of Bank of Canada Income

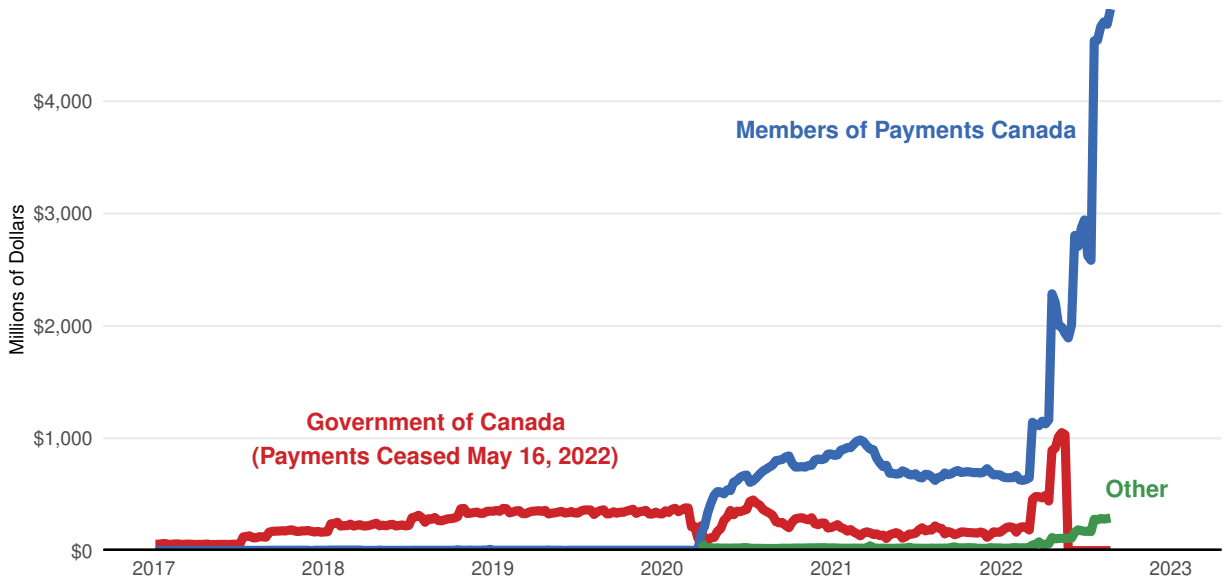
To illustrate the potential path of Bank income and expenses, we construct a simple projection. Starting with Q2 2022 financial statements, we project forward bond holdings and deposits, which imply a path of revenue and expenses. Given current policy, the Bank’s bond holdings will gradually mature and roll off their balance sheet at a known schedule (Bank of Canada, 2022a). We assume interest revenues evolve proportionally to bond holdings and the remaining weighted average coupon rate. We further assume declines in bond holdings are reflected dollar-for-dollar in changes in deposits held at the bank, with interest-earning deposits accounting for between 50 to 75 percent of the decline, depending on the scenario. Interest expenses evolve proportionally to interest-earning deposits and the prevailing deposit rate, which we assume rises to three percent in September 2022 and to between 3.5 and 4.5 percent by December 2022, depending on the scenario, remaining constant thereafter. We illustrate the results in Figure 8. This projection is highly uncertain and contingent on several assumptions. It is only illustrative of some potential paths of

Figure 7: Deposits at and Interest Payments from the Bank of Canada

(a) Deposits at the Bank



(b) Estimate of Interest Payments (Annualised)



Note: Displays the total value of deposits at the Bank of Canada and our estimate of interest earned on those deposits. Interest payment estimates are weekly and presented on an annualised basis. Effective May 16, 2022 the deposit rate on government deposits is zero.

Source: Authors' calculations from Statistics Canada data tables 10-10-0108-01, 10-10-0136-01, and 10-10-0139-01.

Bank interest revenue and expenses. Our aim is to provide a sense of scale and trajectory. The actual path will change with market conditions and monetary policy decisions, such as the size and composition of asset purchases or target rate changes.

With these caveats in mind, the projection suggests Bank losses may continue until late 2024 or 2025, with peak losses in Q1 2023. We estimate cumulative loss may be between \$2.5 billion to \$8.5 billion with our preferred estimate of just over \$5 billion. To be clear, the long-run financial position of the Bank remains sound despite this. Our projections show a return to positive net income within two to three years, and various policy choices or economic developments may affect that timeline. And since the yield on government bonds will normally exceed the deposit rate and a large portion of Bank asset holdings are funded with currency in circulation, which pays no interest, steady-state financial losses by the Bank even within a floor system are unlikely.

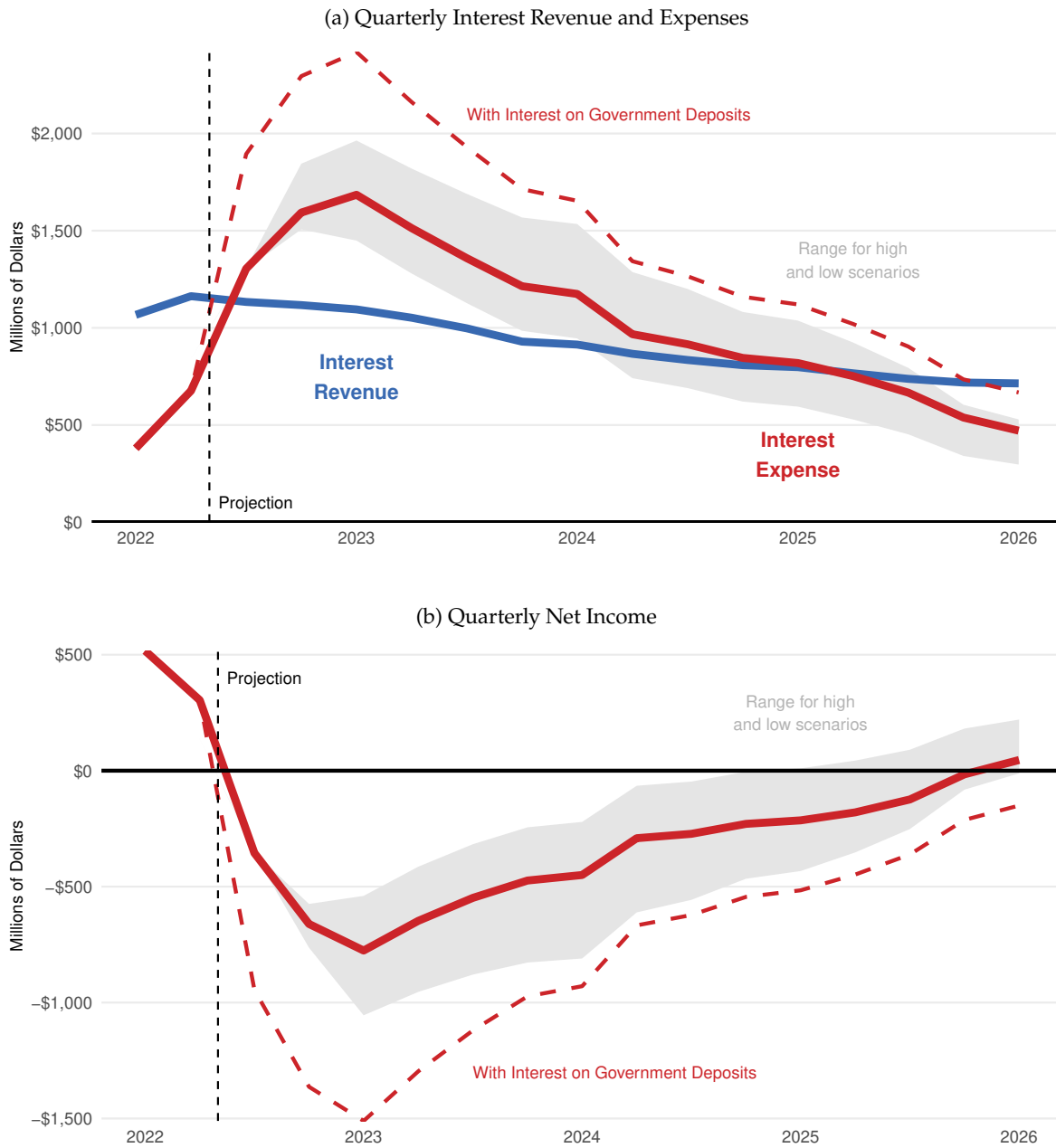
3.5 Reputational and Communications Challenges

Accounting losses or even negative central bank equity do not mechanically undermine monetary policy objectives. The Bank of Canada, after all, can create liquidity as needed to achieve its objectives regardless of the accounting value of its equity. Unlike a commercial bank, the Bank of Canada has a monopoly on the issue of currency. To quote the 2021 Annual Report, the Bank “is the ultimate source of liquid funds to the Canadian financial system and has the power and operational ability to create Canadian-dollar liquidity in unlimited amounts at any time” (Bank of Canada, 2021, p. 26). And their goal is maximising welfare, not profits.

The Bank of Canada, however, has always earned profit since its founding in 1935. Indeed, the Bank normally remits significant amounts to the federal government. To show this, we construct a full series of Bank of Canada remittances using several data sources — in particular the historical Public Accounts of Canada and various Bank of Canada Annual Reports and Financial Statements. We display the results in Figure 9. Since financial losses at the Bank will negatively affect government finances, negative political and public attention may result, especially in light of recent high-profile critiques of the Bank. To be clear, these losses are modest relative to GDP — approximately 0.03 percent at peak — and relative to recent remittances. Profits between 2019-20 and 2021-22, for example, were larger than the losses projected here. Finally, and perhaps most importantly, large scale asset purchases through the pandemic likely helped support the economy and accelerate recovery. This benefited both the government’s budget and Canadians generally. But the optics of a central bank with negative net income may spark a reaction nonetheless.

Canada will also be in good company. The United States Federal Reserve, for example, faces a similar challenge, though accounting approaches may differ. This issue has received increasing attention in recent months as analysis suggests Fed net income will soon turn negative (Anderson et al., 2022). When this happens, remittances to the U.S. Treasury will cease and a deferral asset will accumulate the net losses. Future net income depletes the deferral asset before remittances resume. This practice ensures Fed capital remains positive despite potentially large net losses, which Anderson et al. (2022) estimate may peak at over \$75 billion (CAD), though the margin of

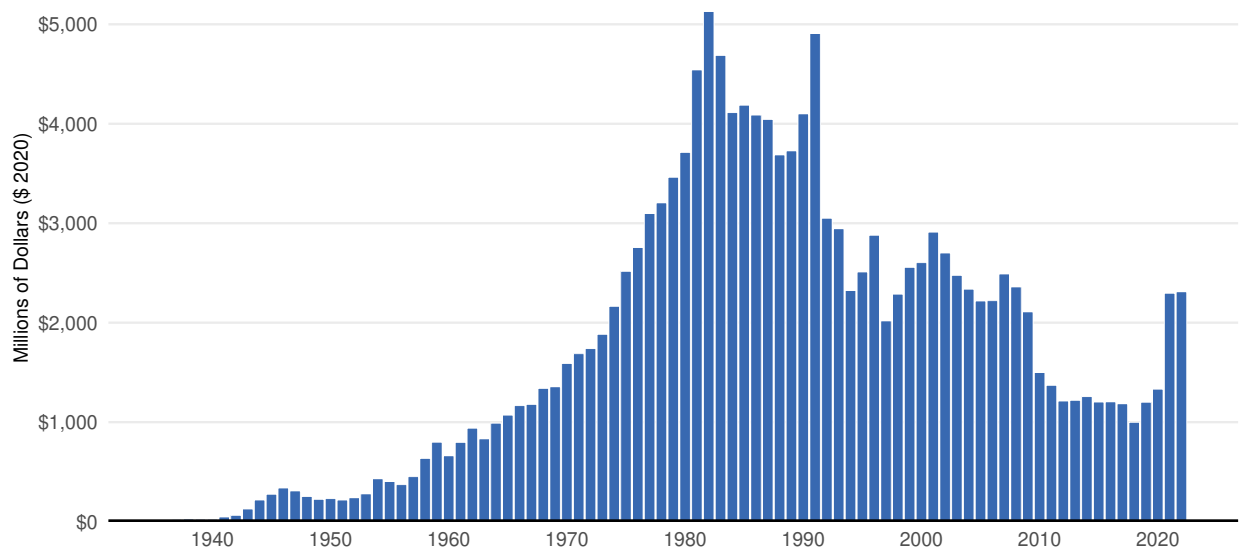
Figure 8: Projection of Bank of Canada Interest Revenue and Expenses



Note: Displays a projection of Bank of Canada interest revenue and expenses. Assumes deposit rate of 3 percent by September 2022, rising to four percent by December, and assumes two-thirds of maturities subtract from interest earning deposits. The high and low scenarios uses deposit rates of between 3.5 and 4.5 percent and presumes between half and three-quarters of maturities subtracts from interest earning deposits. Panel (b) displays the projected quarterly net income, including an estimate of core non-interest expenses.

Source: Authors' calculations. Bank holdings of Government of Canada bonds mature as reported in Bank of Canada (2022a). All projected changes are relative to the Q2 2022 interim financial statements.

Figure 9: Bank of Canada Profits Remitted to the Federal Government, 1935-36 to 2021-22



Note: Displays Bank of Canada profits remitted to the government. We exclude early remittances to private shareholders, which ceased in August 1938, and include dividend payments on government-owned shares, which ceased in July 1954.

Source: Authors' calculations from several sources, included Government of Canada Public Accounts and Bank of Canada Annual Reports and Financial Statements. We convert to real dollars using the Finances of the Nation Macroeconomic Database.

error around this estimate is large.¹⁶ Though a new development for the Federal Reserve as well, it has been a potential outcome since the financial crisis (Carpenter et al., 2015).

Canada's approach to cash losses at the Bank are not yet known, but will matter. As of late August 2022, the remittance agreement between the Bank of Canada and the government contains no provisions for cash losses. But there are simple options available. The Bank of Canada Act, for example, has always *implicitly* contained provisions that could govern losses. In the absence of a surplus from operations, the Bank could simply not remit anything to the government. And if losses subtract from a reserve fund, potentially turning it negative, then Section 27 of the Act (Section 30 under the original Act) may be relevant. With reserve funds below paid-up capital (the \$5 million in shares owned by the Government of Canada) one-third of any future Bank profit would be retained and allocated to the reserve. This would continue until reserves return to a certain threshold and then only one-fifth is retained.¹⁷ Eventually, once reserve funds return to the desired level of \$25 million, all profits would once again be remitted. Importantly, as in the U.S., financial losses by the Bank would implicitly be borne by the federal government.

¹⁶Negative liabilities on the Fed balance sheet will be under "Earnings remittances due to U.S. Treasury". The Federal Reserve system has reported losses and the use of deferral accounts at certain individual Reserve Banks, such as the Federal Reserve Bank of New York in November 2011, so this practice is not entirely unprecedented.

¹⁷Today this threshold is defined in Section 27(b). If reserves are at least paid-up capital, then one-fifth of profits are retained; and if reserves are at least five times paid-up capital, then no profits are. This was added in 1954. Originally, if reserves were at least paid-up capital but less than twice paid-up capital then one-tenth of profits are retained. For clarity, prior to 2007 the reserve fund was called a rest fund. Today, the Bank has multiple reserve funds.

While unique in Canadian history, financial losses among central banks are not rare (Stella, 1997; Dalton and Dziobek, 2005). And while generally only seen in weak central banks (Ize, 2007) there are several example where even strong ones have experienced losses. The European Central Bank, for example, booked a €247.3 million net loss in 1999 (European Central Bank, 1999). This was largely covered by direct charges on the national central banks. More recently, the Swiss National Bank posted a nearly \$130 billion (CAD) loss for the first half of 2022, due to losses on its foreign currency holdings. And the Reserve Bank of Australia recorded a \$3.9 billion (CAD) net loss in 2020-21. These reflected changes in the unrealised value of certain assets, and were handled within reserve accounts established for that purpose out of previously unrealised profits. The Bank of England too recorded a recent loss in 2017-18 within the Banking Department, though this is not comparable to the Bank of Canada's structure since seigniorage is accounted for separately within the Issue Department and financial statements are not consolidated. And in the United States, there was concern of potential losses when the Federal Reserve began its process of balance sheet normalisation after the financial crisis (Cavallo et al., 2018). In short, central bank losses occur and have received some attention in the research literature (Archer and Moser-Boehm, 2013). It's worth noting some of the insight here.

First, financial losses risk a political response that may erode confidence in the central bank. Although there is some evidence that central bank financial strength may matter for policy outcomes (Stella, 2005; Stella, 2010), losses primarily create a reputational risk rather than an economic one. Indeed, there is some evidence that central banks do indeed care about their profits, at least at the margin, for potentially this very reason (Goncharov, Ioannidou, and Schmalz, 2021). And the prospect for losses undermining the Federal Reserves' reputation has been publicly recognised by its own leaders following the financial crisis (Dudley, 2013) and reiterated more recently (Miller, 2022). For these reasons, various measures of central bank independence overall incorporate measures of financial independence (Amttenbrink, 2010; Ivanovic, 2014; Jasmine, Mona, and Talla, 2019) and careful consideration of how profits and losses are treated, ideally separately from fiscal authorities, is an important aspect of central bank design (Reis, 2013).

Second, policy makers may reform Bank policy as a result of financial losses. This would not be unprecedented. There were increases in Bank reserve accounts following the financial crisis, which grew its capital from \$30 million (which has prevailed since the 1950s) by creating a special reserve of at most \$400 million. The floor system's large supply of settlement balances, and the increased interest rate risk this creates, may motivate further increases in reserves to ensure the Bank has sufficient capital to absorb financial losses as they strive to achieve monetary policy objectives. Some argue there is little risk of over-capitalisation (Ernhagen, Vesterlund, and Viotti, 2002). Absent such capital reserves, allowing for future reductions in remittances to the fiscal authority to make-up for past losses is an important component of central bank solvency (Hall and Reis, 2015). Ensuring Canada's approach to financial losses at its central bank is formula-driven and transparent will be critical.

Finally, increasingly active and accessible communications, to ensure a broad public under-

standing of its actions and objectives exists, may help (Bernanke, 2022). Recent op-eds by Governor Tiff Macklem are examples of efforts in that regard (Macklem, 2022). Ultimately, future seigniorage will offset modest short-term losses by the Bank. The challenge is to smooth these losses in a way that minimises adverse political responses. Given that paying interest on deposits with the Bank at a rate equal to the target policy rate may be an efficient approach to conducting monetary policy (Cúrdia and Woodford, 2011), these challenges are important to overcome. While the interconnections between monetary policy, central bank balance sheets, and resource available to fiscal authorities has been explored in depth in the research literature (Reis, 2019), it is a novel and previously underappreciated issue in Canadian public policy discussions. The pandemic changed that dramatically.

4 Conclusion

While future inflation and monetary policy remains uncertain, this paper explores two critical challenges underlying both. First, we find supply-side drivers of price increases are the dominant contributor to Canada’s high inflation through Q2 2022. This makes it difficult and costly for monetary policy to respond. Second, we explore a novel challenge for monetary policy from an unprecedented increase in the supply of settlement balances at the Bank of Canada. Large interest-earning reserves deposited at the Bank means higher interest rates, which aim to combat inflation, may soon result in large financial losses for the Bank — a first in Canadian history. This is neither new globally nor does it undermine Bank operations or its ability to conduct monetary policy, but it may pose a non-trivial reputational and communications challenge. This is especially so during a period of heightened political interest in monetary policy in general and the Bank in particular. Though there is much else to learn, these twin supply shocks are central to understanding Canada’s post-pandemic inflation and monetary policy experiences.

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