The Rise (And Fall?) of Inflation in Canada: A Detailed Analysis of Its Post-Pandemic Experience

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January 2023

Abstract

Canada's inflation rate rose to generational highs in 2022. We explore this rapid surge. Using new methods and detailed household consumption data, we separately identify demand- and supply-driven price increases. We find the latter accounts for most of inflation's rise—especially among energy-intensive and highly traded items. In addition, we find items with normally transitory price changes or those highly sensitive to interest rates account for nearly all the increase. Our work sheds important new light on recent inflation trends and illustrates how new empirical methods can add value to inflation monitoring efforts in Canada.

JEL Classification: E31, E58, E65
Keywords: inflation, supply shocks, monetary policy

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1 Introduction

Canada's inflation rate rose to 8.1 percent in June 2022—the highest rate since the early 1980s, and the five point increase over June 2021 was the fastest acceleration since the early 1950s. These price increases have also been fairly broad-based, with 80 percent of items in November 2022 seeing year-over-year price increases above three percent and two-thirds of items over five percent. This paper sheds new light on the underlying drivers of inflation's recent rise. In particular, using detailed data on the prices and quantities of household consumption items, we identify and isolate the demand-side versus supply-side drivers of inflation. This kind of disaggregated analysis may be valuable for the future conduct of monetary policy. Indeed, in a recent December 2022 speech, Bank of Canada Governor Tiff Macklem noted that one of three lessons from Canada's inflation experience in 2022 was that "averages can obscure inflationary pressures. We need a more granular understanding of the balance between demand and supply..." (Macklem, 2022). Our transparent and data-driven analysis contributes to this important policy agenda.

Briefly, we find both demand- and supply-side factors are important contributors, though the latter increasingly so. We find nearly 90 percent of Canada's accelerating inflation since Q2 2021—when quarterly inflation, by our measure, first exceeded three percent—is from supply-driven price increases. We also demonstrate much of the increase is accounted for by energy intensive goods and services, and by those that are disproportionately imported. This is a challenge for monetary policy, which largely affects domestic aggregate demand rather than supply. Separating items according to whether price changes are normally transitory and whether expenditures on those items are sensitive to interest rates paints a more nuanced picture. We find that most recent price increases are among items that normally do not see persistent inflation. And of those items that do, almost all of the recent increases are among those where demand is highly sensitive to interest rates. Though it is only a first look, and much uncertainty remains, this paper sheds new and important light on the factors driving Canada's inflation to its recent generational highs.

We begin with 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)'s approach 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 home prices (excluding land), which increased dramatically through the COVID-19 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.

Beyond the direct effect of energy prices, we further estimate the extent to which spillover effects may be important. Energy, after all, is an important input in the production of many goods and services throughout the economy. Products that are transportation intensive or that

require heating or cooling—food, for example, satisfies both these conditions—may be particularly sensitive to energy price increases. To estimate this, we statistically identify items whose prices normally increase during periods of rising oil prices. We estimate that approximately one-quarter of the non-energy items within the consumer price index are sensitive to oil prices. These include air transport, restaurant meals, most food categories, hotels, various durable goods, and so on. We estimate that items sensitive to oil prices accounted for nearly 60 percent of Canada's July non-energy inflation as well as well over 85 percent of the increase since February 2020. This also suggests supply-side factors are particularly important.

To more robustly quantify the relative contribution of supply- versus demand-side factors, and the sensitivity of non-energy items to energy prices, 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. Unlike the CPI, which only periodically updates quantities, the consumption expenditure data does so continuously. This allows us to adapt Shapiro (2022b) to identify whether changes in individual components of the overall personal consumption expenditure (PCE) price index are demand- or supply-driven. Intuitively, if an item's price increases but the quantity consumers purchase decreases, then we label this change as a supply-driven price increase. After all, a negative supply shock in a simple model of competitive markets predicts that outcome. Conversely, if both price and quantity increase, then it is demand-driven. We describe the technical conditions behind this method, as well as its potential limitations, in Section 3.2. In short, identifying the existence and direction of demand and supply shocks follows from a set of reasonable sign restrictions in a VAR model (Calvert Jump, 2018). But the simple intuition suffices for now.

With this data and method, we find supply-side factors dominate the acceleration of Canada's inflation. Demand- and supply-driven factors each account for approximately half of the four percentage point increase in the PCE inflation rate from Q1 2021 to Q1 2022. Much of this is due to a sharp spike in demand-driven price increases in the third quarter of 2021; demand's contribution remains relatively stable thereafter. After Q2 2021, supply-side factors dominate. Through to Q3 2022, we find nearly 80 percent of the increase from one year earlier was supply-driven. In terms of their overall level contribution, supply-driven price increases account for 2.3 percentage points more of overall PCE inflation than do their 2010–2019 historical norms, while demand-driven price increases account for 1.3 percentage points more. The magnitudes and trends of both factors are consistent with estimates for the U.S. by Shapiro (2022c). The same is true for the specific items that we find contributing to supply-driven inflation—especially fuel, food, vehicle parts, and more. The detailed household consumption expenditure data can also readily be merged with other information from the national accounts. Doing so, we find most of the rise in inflation is driven by items with high energy cost shares and with high import shares.

That supply-side pressures drive most of the recent acceleration is a challenge for the Bank of Canada. After all, whether and how monetary policy should respond to rising inflation depends on the cause. Central banks, for example, should respond differently to short-lived changes than

to long-lived ones, since monetary policy operates with a lag. While raising 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 job losses and lower output—when inflation is supply-driven. This has long been known (Gordon, 1975; Phelps, 1978; Blinder, 1981; Aizenman and Frenkel, 1986) and recent rising inflation has brought wide attention to and concerns about its consequences and the risks of weakening growth (OECD, 2022; World Bank, 2022; United Nations, 2022). Our work sheds light on these issues in the Canadian context. To be clear, our results do not suggest the Bank of Canada should not be responding, just that the costs of doing so may be higher than if rising inflation was largely demand-driven.

To better understand the prospects for monetary policy to lean against rising prices, we explore whether price increases occur among items sensitive to interest rates or those that normally do not experience persistent inflation. Contractionary monetary policy affects consumer and business expenditure on some items more than others. Adopting the empirical estimates of sensitivity from Chernis and Luu (2018), we find that most of the demand-driven inflation is in items that are responsive to interest rates. To measure persistence, we estimate the extent to which price increases are strongly predictive of further price increases one year later. We find that roughly one-third of overall PCE inflation is driven by items that typically have persistent price changes. But among those, nearly all are highly sensitive to interest rates. The rest of the items, meanwhile, do not usually have persistent price increases. These results together paint a more nuanced picture of inflation and the potential effectiveness of monetary policy that current policy debates in Canada tend to see.

Our PCE inflation measure also provides complementary information to existing analyses of inflation using the CPI. Employers, governments, and financial institutions widely use CPI as a measure of inflation. The Bank of Canada's inflation-control target is also based on it. Less known to the Canadian public, PCE is another common measure of inflation. In the U.S., the PCE price index is published monthly by the Bureau of Economic Analysis and has been the Federal Reserve's preferred measure since 2000 (BEA, 2021). Both measures have their advantages and disadvantages, and they serve different purposes. Our analysis takes advantage of the PCE index because it provides both prices and quantitative measures for each detailed item, which allows us to classify items into supply- or demand-driven categories. The PCE measure also matches naturally with other national account information, such as input use and trade flows, which facilitates additional analysis.

Our paper is not the first to investigate Canadian inflation's supply- and demand-side drivers. For example, the Bank of Canada's recent Monetary Policy Reports (*MRP*), including Bank of Canada (2022c) and Bank of Canada (2022d), provide several informative classifications that decompose some drivers of recent inflation. Specific supply factors, such as global commodity

prices, supply-chain bottlenecks, and transportation costs are also measured. Others, most recently Perrault and Lalonde (2022), also explore these questions. And IMF (2022) provides some early international evidence of the effect of pandemic-related fiscal measures on inflation through 2021. Our paper complements this work by using new, transparent, and data-driven identification techniques to quantify demand- and supply-side contributions to recent inflation and to separate effects across various types of goods and services. This is novel for Canada.

Our work also contributes to recent research examining specific shocks and their impacts on inflation. Leibovici and Dunn (2021) and LaBelle and Santacreu (2022) investigate the effect of supply chain disruptions on prices in the U.S. and found they contributed significantly to rising inflation. Di Giovanni et al. (2022) study 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 negatively impacted manufacturing output, which contributed to higher 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, 2022) and on Canada's recent experience in particular (Azad, Serletis, and Xu, 2021; Ambler and Kronick, 2021).

2 The Composition of CPI Inflation

In this section, we begin by examining the drivers of inflation in two ways. First, we estimate the contribution of individual products to Canada's overall inflation by applying well-established methods to the latest data. Second, we measure the extent to which price increases of non-energy items may be related to energy prices.

2.1 A Simple Product-Level Decomposition

A decomposition of changes in Canada's CPI is not itself particularly novel, and can be found, for example, in Bank of Canada (2022d). But it is informative nonetheless and a useful place to start. The intuition is also simple. In a simple Laspeyres price index, overall inflation is the average change in prices across items, weighted by base-period expenditure shares. Each item j's contribution is then that item's price change times its weight. Canada's CPI, however, is more complex: a chain-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 s. The contribution of item j to

inflation over this period is

$$c^j_{t-12,t} = \left(\frac{p^j_s}{p^j_{t-12}} - 1\right) w^j_{t-12} + \left(\frac{p^j_t}{p^j_s} - 1\right) w^j_s \left(\frac{P_s}{P_{t-12}}\right), \tag{1}$$

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

$$w^j_t = \frac{b^j_t(p^j_t/p^j_s)}{\sum_k b^k_t(p^k_t/p^k_s)}, \tag{2}$$

using whatever basket weight b^j_t 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

$$c^j_{t-12,t} = \left(\frac{p^j_t}{p^j_{t-12}} - 1\right) w^j_{t-12}. \tag{3}$$

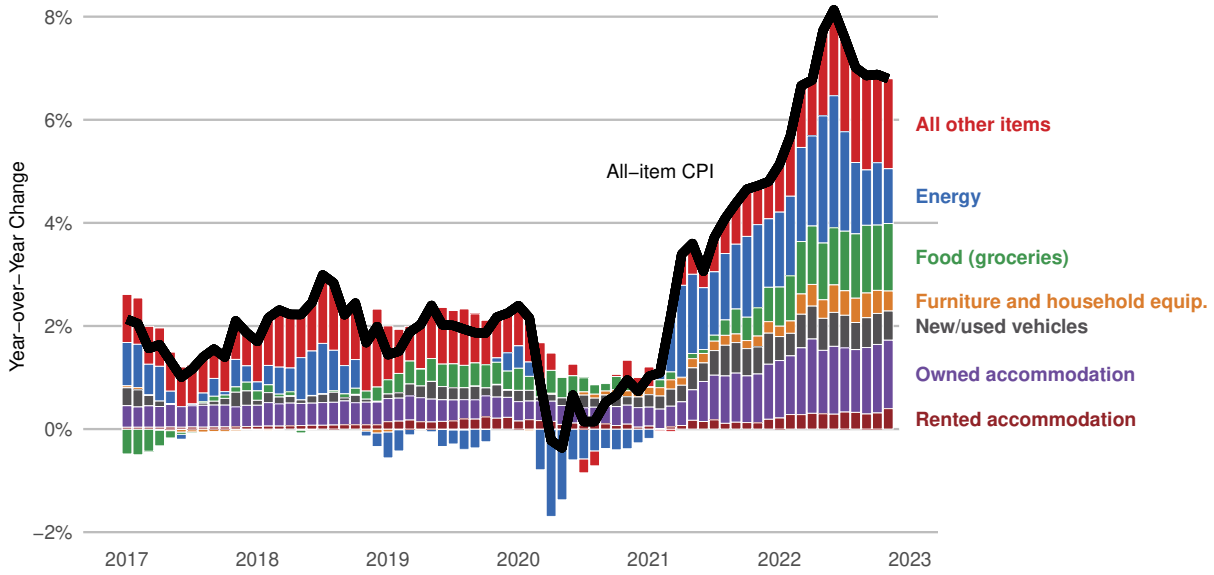
In either case, overall CPI inflation is $\pi_{t-12,t} = \sum_j c^j_{t-12,t}$. Changing basket weights matters for estimating an item's contribution to recent inflation because the latest link month was April 2022.

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 peak inflation in June 2022, higher energy prices caused 2.6 percentage points (with 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. Moreover, the rise in these half-dozen categories since February 2020 accounts for nearly 5.2 percent of the 6 percentage point increase through to June 2022. Had energy and shelter prices alone remained constant, we estimate headline inflation in June would have been 4 percent instead of the actual 8.1 percent. And the modest 1.3 percentage points decrease through to November, as is also clear in Figure 1, was entirely due to lower energy prices.

That energy is an important determinant of changes in Canada's inflation is not new. To see this, we quantify the contributions of individual components to variation in Canada's inflation using a Shapley-Owen decomposition (Huettner and Sunder, 2012). Simply put, this method attributes the contribution of individual regressors to the overall goodness-of-fit measure R^2. Applied to a regression of Canada's inflation between February 1995 and February 2020 on the half-dozen items listed in Figure 1, we find energy accounts for nearly 70 percent of the variation.[1] But the large and abrupt increase in 2021 and 2022 was unusual. If oil prices do not rapidly rise once again, this critical factor driving high inflation will soon dissipate. To be clear, inflation pressures are broad, with three-quarters of items experiencing annual price increases above three percent. But the top contributors are quantitatively the most important drivers. We find the top ten of 150 individual items accounted for nearly five percentage points of Canada's CPI inflation in June 2022.

[1]Starting in Feb 1995 avoids the 1994 tobacco tax cut; ending in Feb 2020 avoids the pandemic.

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



Note: Displays the contributions 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.

Another unusual feature of the recent inflation acceleration is the large contribution of a non-cash component of owned accommodation: homeowners' replacement cost. As with any physical asset, homes depreciate, and this is a cost to the owner. Statistics Canada estimates the cost of depreciation using its index of new home prices (excluding land). It specifically presumes annual depreciation costs equal 1.5 percent of new home prices. So as home values increase, there is a mechanical effect on rising consumer price inflation, despite this not representing a cash expense of homeowners and despite their wealth increasing. There is no single ideal approach to measuring the cost of home ownership, and various statistical agencies opt for different methods, while some exclude it entirely. In Canada, it has rarely mattered for movements in the overall headline rate of CPI inflation. But between July 2021 and April 2022, this single factor contributed on average over 0.7 percentage points to CPI inflation—nearly triple the previous record contribution set by this item in 2006 and well over two-thirds of the total contribution from owned accommodation costs. This post-pandemic experience may motivate a reform to the CPI or the use of other, complementary measures of inflation, which we will describe next. Regardless, as real estate prices decline—and they have since early 2022—this important driver of inflation will ease.

For other items, there is no shortage of potential explanations for the rapid rise in prices. 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 them higher still. As an important input into the production of so much else, energy prices 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 pushed up producer prices (LaBelle and Santacreu, 2022). Some point to rising corporate profits as a driver, although we estimate average markups were lower in Q3 2022 than one year earlier.[2] On a macroeconomic level, others point to expansionary fiscal and monetary policy as key drivers. Income support programs through the pandemic may have increased consumer demand, which leads to some concern about rising inflation (Summers, 2021; Cochrane and Hartley, 2022). And low interest rates and rising asset prices, perhaps driven by loose monetary policy, may have added to this pressure.[3] To further investigate the nature and significance of different contributors to inflation, we first explore the potential for high energy prices to account for non-energy price increases. We then turn to a new approach and different data to separately identify demand- versus supply-driven inflation.

2.2 Items Sensitive to Oil Prices

To classify items according to whether they are sensitive to oil prices, we statistically estimate the historic relationship between year-over-year changes in oil prices and in a given item's price using monthly data from 1995 onward. Specifically, for each item, we estimate

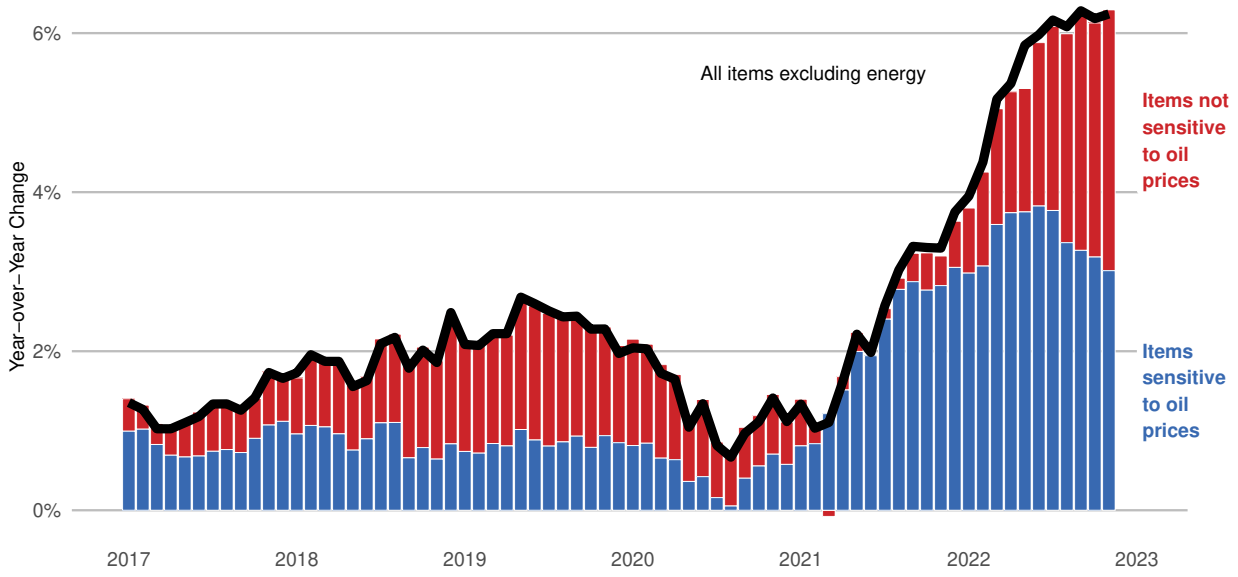
$$\pi^j_{t-12,t} = \beta^j_0 + \beta^j_1 \Delta p^{WTI}_{t-12,t} + \epsilon^j_t, \tag{4}$$

where $\pi^j_{t-12,t}$ is the year-over-year increase in item j's price and $\Delta p^{WTI}_{t-12,t}$ is the change in the Canadian-dollar per barrel price of West Texas Intermediate crude oil over that same period. We classify items where $\beta^j_1 > 0$ and statistically significant ($\mathbf{t}(\beta^j_1)$>1.96) as sensitive to oil prices. Estimating this relationship on a subset of 145 individual non-energy CPI components, we find 48 items tend to move positively with oil prices and 97 do not. The oil price–sensitive items include homeowners' replacement costs, other owned accommodation expenses, traveller accommodation, air transportation, vehicle rentals, almost all food categories, restaurant meals, rent, and various durable goods categories such as new vehicles, furniture, and most clothing. Of course, an historical positive relationship between an item's price and oil prices does not imply a causal relationship exists between the two. This exercise is a simple statistical decomposition. To build on this later in the paper, we present an alternative measure of inflation where data on item-specific energy cost shares are available. Many (though certainly not all) of the items captured by this statistical method have high energy shares, including food, certain clothing, vehicle rentals,

[2]Source: Authors' calculations from Statistics Canada data table 33-10-0226-01.

[3]A comparison to the United States' experience may also be informative. Compared to the U.S., the price acceleration in Canada was smoother and slightly milder due to Canada's higher pre-pandemic rate and lower peak level. The U.S. inflation started to rise a few months earlier than in Canada, and both countries' inflation peaked around June/July 2022. Food and energy were essential drivers, like in Canada (Hobijn et al., 2022). Although due to a strong U.S. dollar, the impacts of high commodity prices are less pronounced in the U.S. compared with many other OECD countries. Unlike Canada, though, an unusually strong demand for durable goods, such as cars and home appliances, contributes notably to U.S. inflation. Shelter inflation also increased in the U.S. in early 2022 (Wessel and Campbell, 2022).

Figure 2: Contribution of Items Sensitive to Oil Prices to Non-Energy CPI Inflation



Note: Displays the contribution of items sensitive to oil prices to Canada's rate of non-energy CPI inflation. Estimates are based on 145 individual components of the non-energy CPI (that is, excluding natural gas, fuel oil and other fuels, gasoline, electricity, fuel, and parts and accessories for recreational vehicles). May not aggregate to the official all-items excluding energy series due to rounding.

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

accommodation services, and more.[4]

With that caveat in mind, we aggregate the contribution of each individual item to Canada's non-energy CPI inflation and find most of the recent acceleration is due to items that historically move with oil prices. We display these results in Figure 2. In July 2022, we estimate that of the over six percent increase in non-energy consumer prices, as compared to one year earlier, items sensitive to oil prices contributed 3.8 percentage points. That is, over 60 percent of Canada's non-energy inflation rate in July arises from items that historically tend to move closely with oil prices. And of the four percentage point rise in non-energy inflation since February 2020, increases among those items sensitive to oil prices account for fully 3 percentage points. This has eased somewhat in recent months, but items that tend to move with oil prices account for nearly half of Canada's non-energy inflation rate in November. Including all items with an historically significant relationship to oil prices, whether positive or negative, shows an even larger 4 percent contribution in November. These results suggest high energy prices, and the resulting production cost increases for many other goods and services throughout the economy, may largely explain Canada's accelerating inflation.

[4]Homeowners' replacement cost in the CPI is highly positively correlated with oil prices but is a non-cash item. In our later analysis, we find materials for the maintenance and repair of dwellings to have a high energy cost share. To the extent that this may increase new homes building costs as well, then replacement costs will mechanically rise since it is inferred from the house-only index of new home prices. We do not explore this issue further in the paper.

3 Identifying Supply and Demand Driven Price Changes

To quantify the contributions of demand- versus supply-side drivers of recent price increases, we require continuously updated data on prices *and* quantities. The CPI does not include this. In this section, we describe a simple new method to identify demand- and supply-driven price changes that exploits key features of an alternative data source.

3.1 Empirical Approach: Simple Intuition

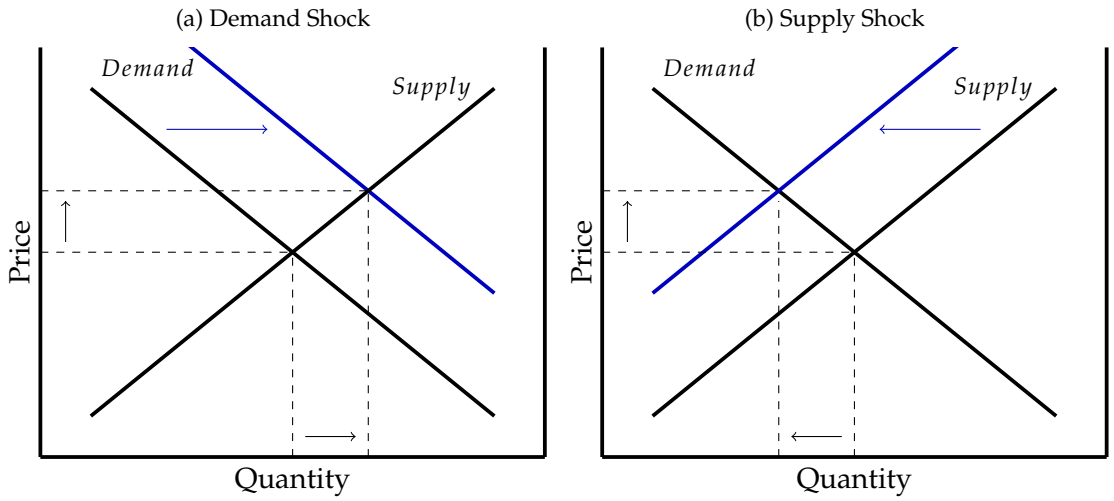
Before describing technical details, consider the simple intuition we illustrate in Figure 3. If prices are determined in competitive markets, demand curves slope downward, and supply curves slope upward, then one can identify the existence of demand or supply shocks by comparing the direction of price and quantity changes. If prices increase while quantities also increase, then a positive demand shock occurred, as illustrated in panel (a). But if prices increase while quantities decrease, then a negative supply shock occurred, as illustrated in panel (b). One could similarly identify shocks that lower prices. In effect, the structural relationship between prices and quantities is governed by demand and supply curves. And with certain reasonable restrictions on those curves, empirically identifying underlying structural shocks to demand or supply is possible using readily available data on prices and quantities.

This insight was recently put forward by Calvert Jump (2018) and Calvert Jump and Kohler (2022), who demonstrate that a set of technical restrictions that we describe in the next section can identify the sign of aggregate demand and supply shocks. They apply this to historical unemployment and inflation data for the United Kingdom. More relevant for our purposes, Shapiro (2022b) adopts this approach to decompose recent changes in the U.S. inflation rate. In this context, a shock is a shift in the demand curve, the supply curve, or both. And the sign restrictions required to identify shocks in the VAR model are, first, that the price elasticity of supply is positive and, second, that the price elasticity of demand is negative. Given these restrictions, one can identify the sign of the underlying structural demand or supply shock. This approach, to be clear, cannot identify the sign of both shocks that may be occurring simultaneously. That is, if prices and quantities both increase then a positive demand shock occurred, though an unknown supply shock could have as well. Similarly, if prices increase but quantities decrease then a negative supply shock occurred, though an unknown demand shock could have also as well. For example, a negative supply shock could have occurred without changing the sign of the price and quantity changes, so long as the supply shock was not too large. We therefore label a price change as *supply-driven* when we know a supply shock occurred and *demand-driven* when we know a demand shock occurred. With this intuition in hand, we can turn to the technical details.

3.2 Empirical Approach: Technical Details

Consider a structural VAR of the form $Az_t = \sum_{i=1}^{\rho} A_i z_{t-i} + \epsilon_t$, where z_t is a vector of data, A_i and A are matrices of parameters, and ϵ_t are shocks. Under certain conditions, this implies

Figure 3: Intuitive Illustration of Supply and Demand Shocks



Note: Illustrates an intuitive approach to classify an individual good or service's price changes as supply- or demand-driven. In the data, we cannot observe either demand or supply curves but instead classify changes based on whether the observed price and quantity move together (as in panel a) or in opposite directions (as in panel b) from one quarter to the next. See text for details.

$z_t - E[z_t|z_{t-1}, ..., z_{t-\rho}] = A^{-1}\epsilon_t = \nu_t$, where ν_t are the residuals in a reduced form VAR (Fernández-Villaverde et al., 2007). That is, unexpected changes in z_t provide information about the unobservable structural shocks ϵ_t, conditional on certain properties of A, since $\epsilon_t = A\nu_t$. In a competitive market, A governs the contemporaneous relationship between price and quantity and therefore reflects features of the underlying supply and demand curves. If demand slopes down and supply slopes up, then reasonable sign restrictions on A are such that

$$\begin{bmatrix} \epsilon_{Dt} \\ \epsilon_{St} \end{bmatrix} = \begin{bmatrix} + & + \\ - & + \end{bmatrix} \begin{bmatrix} \nu_{Pt} \\ \nu_{Qt} \end{bmatrix} \tag{5}$$

That is, a positive demand shock increases price and quantity while a positive supply shock decreases price and increases quantity.

We implement this empirically by estimating the reduced form bivariate VAR

$$\boldsymbol{Z}_t^j = \beta_0^j + \sum_{i=1}^{\rho} \boldsymbol{\beta}_i^{j\prime} \boldsymbol{Z}_{t-i}^j + \boldsymbol{\nu}_t^j, \tag{6}$$

where $\boldsymbol{Z}_t^j = [P_t^j \ Q_t^j]'$ are (log) prices P_t^j and quantities Q_t^j for item j, $\boldsymbol{\nu}_t^j = [\nu_{Pt}^j \ \nu_{Qt}^j]'$ are the residuals of interest, and $\rho = 4$. We estimate this equation separately for each item on a rolling ten-year window of seasonally adjusted quarterly data, which allows the reduce-form coefficients $\boldsymbol{\beta}_i^j$ to change over time. The residuals capture unexpected changes that, when combined with the above sign restrictions, can identify underlying demand and supply shocks. For instance, if the unexpected changes in price and quantity are both positive ($\nu_{Pt}^j > 0$ and $\nu_{Qt}^j > 0$), then we label this

a demand-driven price increase since equation 5 implies $\epsilon^j_{Dt} > 0$ while the sign of ϵ^j_{St} is unknown. We similarly infer the sign of all other shocks.

There are challenges to this method. One is measurement error that could affect our classification. To mitigate this concern, we classify unexpected changes in price or quantity that are close to zero (within 0.1 standard deviations) as ambiguous. This captures approximately one-fifth of all observations. We explore other cutoff ranges and find this approach is conservative. There is also the possibility of model misspecification. We confirm our results are robust to using between one and eight quarterly lags. The AIC estimate of the optimal model order varies across products and date windows. The mode estimate is one lag and the mean is four, which motivates our choice for $\rho = 4$. We also confirm our results are robust to a rolling window of between five and 20 years or no rolling window at all. A more serious misspecification, however, involves the underlying structural process determining prices and quantities. If markets are competitive, then only supply and demand relationships are necessary and our sign restrictions are sufficient. But if prices and quantities are determined in other ways, then equation 6 may not be sufficient to identify demand and supply shocks. We do not pursue that here.

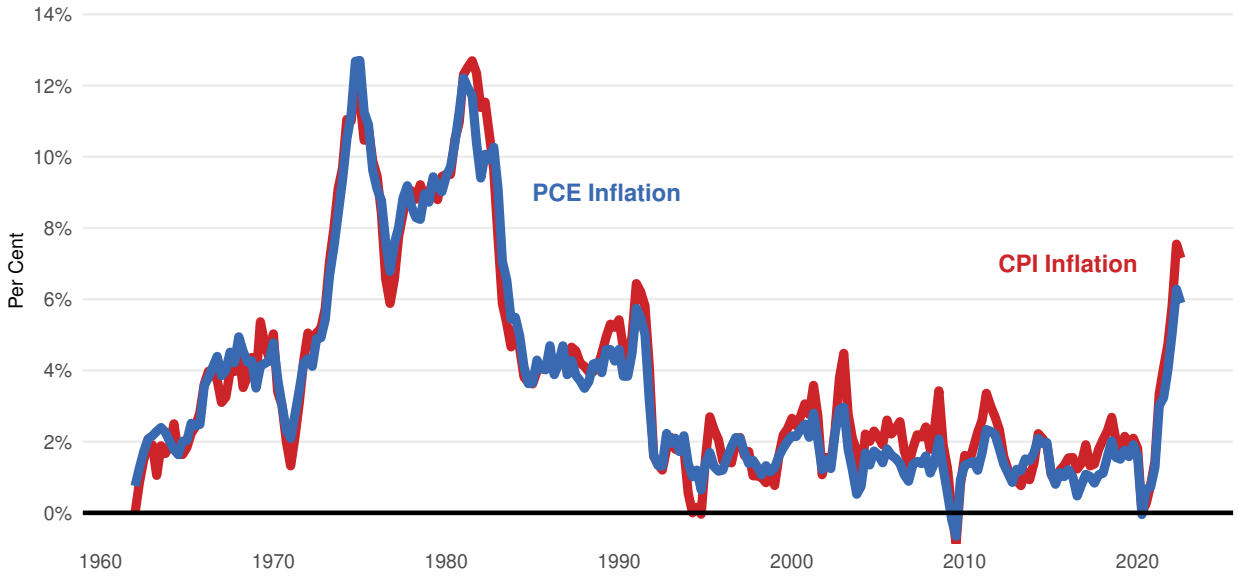
One must also interpret the results with caution, as we identify only proximate shocks rather than ultimate ones. A negative supply shock in the market for new cars, for example, may cause a positive demand shock in the market for used cars as buyers substitute away from the now higher priced new cars. The ultimate cause of both new and used car price increases is a negative supply shock for new cars. But the proximate cause of used car price increases is a positive demand shock for used cars. We can only identify the latter. Our method also cannot identify the specific cause of the shock. If we measure a negative supply shock, for example, this could be due to rising oil prices, rising wages, falling productivity, and so on. Similarly, a positive demand shock could be due to expansionary fiscal or monetary policy, changing consumer behaviour, or any number of other factors. Later in the paper we try to shed at least some light on the underlying drivers, but the statistical method we deploy here is more limited. As demonstrated by Shapiro (2022b), however, the results of this method are not only fairly robust but produce results consistent with some theoretically predicted responses to externally identified supply and demand shocks. We aim to apply this work and insight to the Canadian context.

3.3 Disaggregated Price and Quantity Data and an Alternative Inflation Measure

As discussed, we require disaggregated data on both prices and quantities. This does not exist within the CPI data but does within Statistics Canada's *Detailed Household Final Consumption Expenditure* data (DHFCE, table 36-10-0124-01). This provides detailed quarterly information on final expenditures for nearly 100 specific items.[5] These data report nominal expenditures by item and, importantly for our purposes, real expenditures at constant prices. The price index for an item is

[5]We 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 the *Household Final Consumption Expenditure* dataset (table 36-10-0107-01), which begins in 1961 but has a more aggregated classification.

Figure 4: Two Measures of Inflation in Canada, Q1 1962 to Q3 2022



Note: Displays our measure of quarterly PCE inflation, as 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. For the quarterly CPI, we take the average of monthly index values within each quarter.

the ratio of nominal to real expenditures and the quantity index is simply real expenditures.

These data allow us to construct a measure of inflation known as the Personal Consumption Expenditures (PCE) inflation rate. While our PCE inflation measure differs from the CPI, it is nevertheless highly informative. Both are widely used by central banks, and they broadly follow similar trends.[6] We display quarterly PCE and CPI inflation in Figure 4, using our own estimate of the quarterly rate of CPI inflation constructed from the official monthly data. The two series are highly correlated, though there are differences. In Q3 2022, we estimate Canada's PCE inflation rate to be 5.8 percent, while the all-items CPI increased 7.1 percent over that same period.[7] The lower rate of PCE inflation as compared to CPI is visible in the United States as well, where the former was 6.3 percent in the third quarter, while the latter was 8.3 percent.[8]

Several factors account for these differences, including data sources, product coverage, calculation formulas, and the frequency of basket updates. Our PCE inflation is based on the seasonally adjusted DHFCE data, which are 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 the same data we use, plus supplementary data from the *Survey of Household Spending*. There is

[6]Since 1962, quarterly PCE inflation has 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. The correlation coefficient between the two is 0.98.

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

[8]Source: Authors' calculations from St. Louise FRED data series PCECTPI and CPIAUCSL.

also a difference in the scope, as our PCE index covers all resident households and CPI contains only private ones.[9] The formula and calculations also differ. The CPI, as we noted, infers homeowner depreciation costs from an index of new home prices, while the DHFCE aligns with national accounts and estimates the rental equivalent cost of home ownership.

As an alternative measure of inflation, the PCE complements both the headline CPI and the Bank of Canada's various core inflation measures for monetary policy targets. Which index should be used for inflation targeting has long been discussed (Smith, 2009), and each comes with advantages and disadvantages. Both CPI and PCE measures provide useful information to understand underlying inflation pressures and are selected for different purposes in different contexts. For example, the expenditure weights in the PCE measure change with quarterly expenditure data. During the pandemic, these changing weights were large. In Q2 2020, the share of spending on restaurants declined from 4.8 percent of total consumer expenditures to 3.3 percent. Spending on fuel declined by 1.2 percentage points, air transport by 1 percentage point, and clothing by 0.6 percentage points. Meanwhile, the share of expenditures allocated to grocery purchases increased by 1.5 percentage points, telecommunications services by 0.3 percentage points, alcohol by 0.3 percentage points, and so on. These changing consumption patterns are reflected in the CPI only when basket weights are updated—which Statistics Canada will now do annually. While this is a useful feature of the PCE index, there are drawbacks. It is only available quarterly, for example. And the PCE index is subject to revision while the CPI is not. This may make the CPI a better measure for the purposes of indexation arrangements within government benefit programs, pension benefits, wage contracts, and the like. For our purposes, the major advantage of PCE inflation is it contains both price and quantity information.

3.4 Main Quantitative Results

With this data and method in hand, we measure contributions of each item to inflation using a Laspeyres approach. This is distinct from the U.S. PCE inflation, which uses a Fisher approach, but it better approximates the method used for CPI inflation and provides for a more intuitive decomposition.[10] Specifically, quarterly changes in item j's price are $\pi^j_{t-1,t} = (p^j_t / p^j_{t-1}) - 1$. Given expenditure weights ω^j_t, item j's contribution to inflation is $\omega^j_{t-1}\pi^j_{t-1,t}$ and therefore

$$\pi_{t-1,t} = \underbrace{\sum_{j\in\Omega^s_t} \omega^j_{t-1}\pi^j_{t-1,t}}_{\text{Supply-Driven}} + \underbrace{\sum_{j\in\Omega^d_t} \omega^j_{t-1}\pi^j_{t-1,t}}_{\text{Demand-Driven}} + \underbrace{\sum_{j\in\Omega^a_t} \omega^j_{t-1}\pi^j_{t-1,t}}_{\text{Ambiguous}} \tag{7}$$

[9] The CPI target population does not include people who live in collective households, such as members of communal colonies, prison inmates, and chronic care patients in hospitals and nursing homes.

[10] Our results are robust to using a Fisher approach to calculating PCE. In Q3 2022, for example, quarterly inflation was 0.713 percent using a Laspeyres approach and 0.708 using a Fisher approach. The Fisher index is theoretically ideal, as it is a superlative index that is a second-order approximation to any utility function. But it adds complexity to our decomposition for little quantitatively meaningful differences in results.

where Ω_t^s, Ω_t^d, and Ω_t^a are the set of items classified as experiencing a supply-driven, demand-driven, or ambiguous price change, respectively. Annual PCE inflation is then the rolling four-quarter sum of these quarterly changes, rather than a year-over-year comparison. We do this since an item may experience a supply shock in one quarter and a demand shock in another.

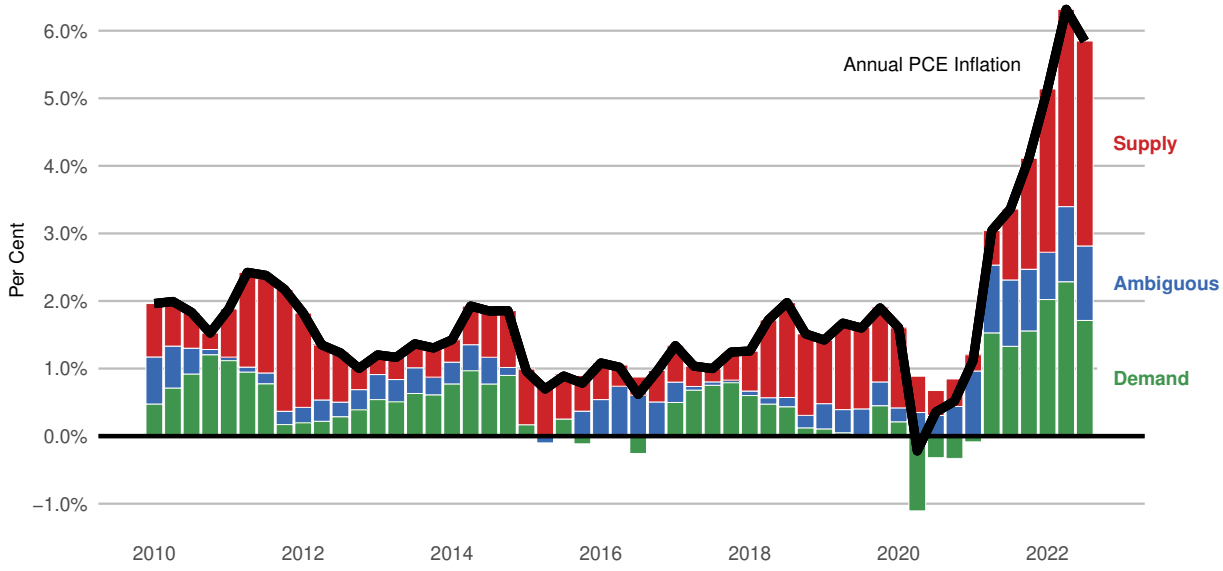
We report the results of this exercise in Figures 5a and 5b. They reveal several important patterns. Annual PCE inflation fell at the onset of the pandemic, stayed low during it, and rose at the beginning of 2021. Quarterly changes reveal a sharp decline in Q2 2020, followed by an equally sharp rebound in the third quarter. The annual inflation rate continued to grow through 2021 and quarterly changes accelerated. By 2022 Q2, PCE inflation peaked at over six percent—the highest rate since 1983. In Q3 2022, however, a sharp drop in quarterly changes slightly decreased the annual rate. The relative contributions of demand- and supply-driven price changes are also clear. Early in the pandemic, between Q1 2020 and Q2 2020, demand accounted for over 70 percent of the drop in annual inflation. And early in the initial recovery, through to Q2 and Q3 2021, demand-driven price increases were the main drivers. But the picture later changed, with supply driving more recent inflation increases, accounting for three percentage points of PCE inflation in Q3 2022. The contribution of supply-driven price increases has also increased strongly in recent quarters, accounting for nearly 80 percent of the total increase in PCE in Q3 2022 compared to one year earlier. To be clear, both supply and demand factors have increased relative to their historic norms. Between 2010 and 2019, the average supply-driven price increases with PCE inflation was 0.7 percentage points and demand-driven increases averaged 0.5 percentage points. In Q3 2022, meanwhile, supply-driven increases were 2.3 percentage points higher than these historical levels and demand-driven increases were 1.3 percentage points higher. The sharp drop in quarterly inflation in Q3 2022 was entirely driven by lower demand side factors.

As for individual drivers of PCE inflation, we report the top contributors in Table 1. We estimate the contribution of each item to overall demand- or supply-driven inflation by summing that item's supply or demand contribution over the past four quarters. Consider the simple example of natural gas for home heating. We estimate that from Q4 2021 to Q3 2022 (inclusive), this item's price increase was demand-driven in three quarters and supply-driven in one. Its contribution to demand-driven inflation over the year would then be the sum of the three demand-driven quarters' contributions while its contribution to supply-driven inflation would be the other quarter. The table reports the contributions in percentage points towards the overall annual PCE inflation in Q3 2022. We find the top demand-driven inflation contributors come from imputed rent (for owned accommodation), natural gas for home heating, household furnishings, accommodation services, air transport, restaurants, and other items. The supply-side items driving inflation are vehicle fuel, groceries, rent, vehicles parts, new trucks/vans/SUVs, and more. As noted, items can experience both demand- and supply-driven price changes in different quarters over the year so may appear in both columns. Altogether, the top ten supply-driven contributors accounted for 2.4 percentage points of overall PCE inflation. The top demand contributors accounted for 1.5 percentage points.

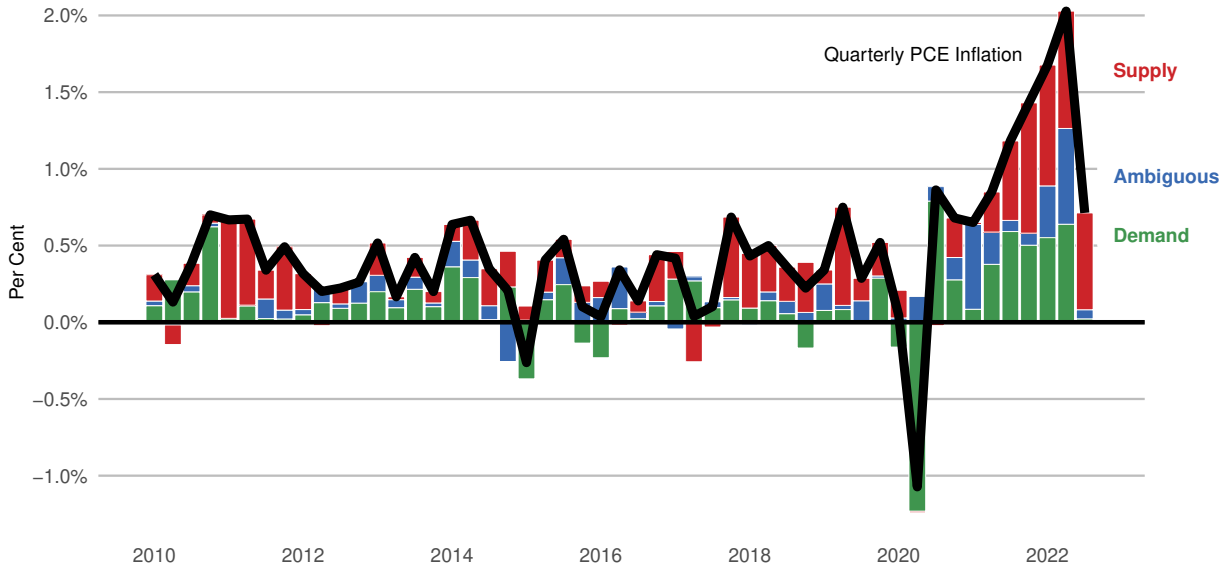
The Bank of Canada's mandated target is headline inflation between one and three percent,

Figure 5: Contribution of Supply and Demand Shocks to PCE Inflation, 2010 to Q3 2022

(a) Annual PCE Inflation



(b) Quarterly PCE Inflation



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 those within 0.1 standard deviations of zero.

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

Table 1: Top Contributors to Annual PCE Inflation (Q3 2022)

Demand Shocks		Supply Shocks	
Item	Contribution	Item	Contribution
Imputed rent (homeowners)	0.74	Vehicle fuel/lubricants	0.66
Natural gas for homes	0.12	Food (groceries)	0.65
Furniture and furnishings	0.12	Paid rental fees for housing	0.22
Accommodation services	0.11	Food (restaurants)	0.20
Air transport	0.09	Vehicle parts/accessories	0.14
Food (restaurants)	0.09	Accommodation services	0.13
Out-patient services	0.08	Non-alcoholic beverages	0.10
Games of chance	0.07	New trucks/vans/SUVs	0.10
Personal elec. appliances	0.07	Natural gas for homes	0.09
Other actual financial charges	0.05	Alcoholic beverages	0.07

Note: Displays the top ten demand and supply contributors to year-over-year PCE inflation in Q3 2022. Calculated as the cumulative quarterly percentage point contributions of each item accounted for by demand and supply shocks, respectively. Products with both demand-driven and supply-driven changes during the year may appear in both columns.

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

regardless of whether it is supply- or demand-driven. However, the source of inflation matters for how fast the central bank can bring it down and how likely they are to achieve a "soft landing" of the economy. Simple macroeconomic theory suggests contractionary monetary policy can mitigate demand-driven inflation by lowering aggregate demand and therefore prices. To the extent that such inflation occurs due to the economy operating above its potential output level, monetary policy can both lower inflation and move the economy towards a sustainable level. Supply shocks, on the other hand, are a trickier beast. In this case, a central bank would have to bring aggregate demand down while the supply shock was also lowering output.

The persistence of shocks also matters. Those that are large and persistent can be particularly harmful, as wages and salaries across the economy will be under pressure to increase over time to keep pace. This may create a wage-price spiral that is more difficult for the central bank to control. In such a situation, the 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 avoid a rapid increase in interest rates (Caballero and Simsek, 2022). Before turning to our analysis of inflation persistence and potential monetary policy effectiveness, we turn to several additional decompositions of the data that may be instructive.

3.5 Additional Results and Analysis

In addition to classifying price changes as supply- or demand-driven, we separate the contributions from goods versus services, tradeable versus non-tradable items, and energy intensive versus non-intensive goods. We also use a longer time-series of data to explore the inflation and disinflationary

periods of previous decades.

3.5.1 Goods vs Services

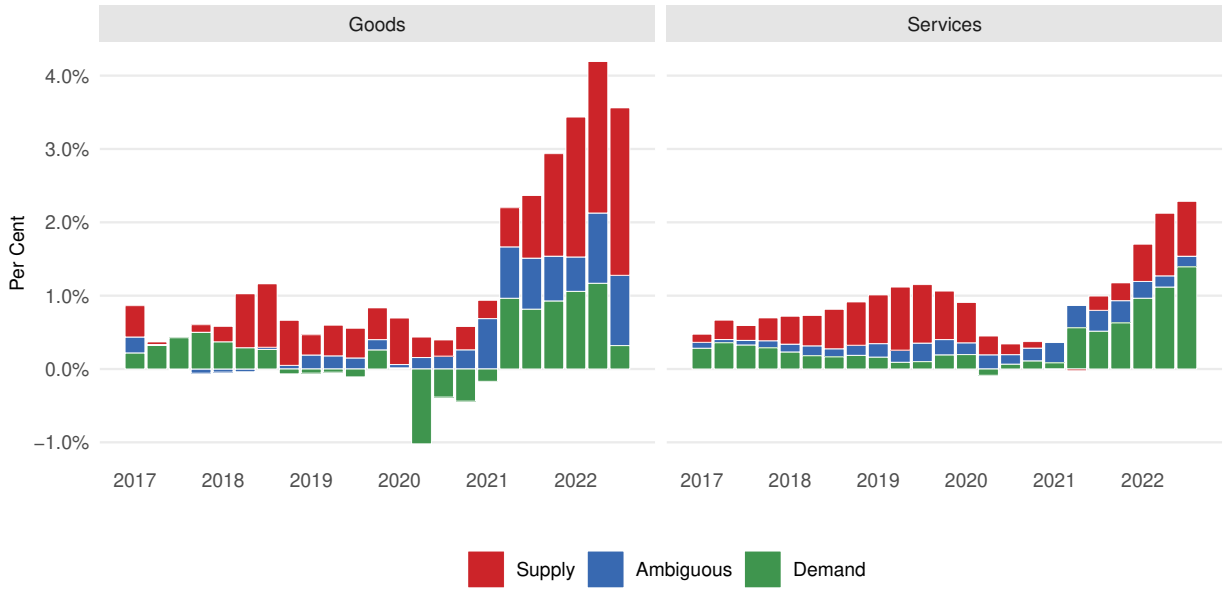
For several reasons, goods and service sectors tend to respond differently to different shocks. Supply chain disruptions, for example, can tighten capacity constraints on businesses and add to production costs. This primarily affects physical goods rather than services and can harm firms' ability to accommodate increased demand without sharply raising prices. The Bank of Canada's Business Outlook Survey, which collects information from many businesses, asks "What would be the most important obstacles or bottlenecks to being able to meet an unexpected increase in demand?" Over 40 percent of firms in recent quarters pointed to supply chain disruptions—up significantly from the ten percent that said this between 2010 and 2019 (Bank of Canada, 2022a). Another increasingly important supply shock is labour disruptions or shortages. Due to high labour input shares, service sectors are more vulnerable to rising labour costs and therefore more susceptible to contributing to a wage-price spiral. In the Business Outlook Survey mentioned above, over 60 percent of firms point to "labour bottlenecks" as the most important obstacle to meeting demand (firms can select more than one obstacle). Of those surveyed, the average expected wage increase from Q2 2022 to Q2 2023 is 5.8 percent—the highest expected increase in many years—and nearly 60 percent of firms report inflation-related pressures as an "important source of wage growth" (Bank of Canada, 2022a). As a result, comparing service versus goods sectors might help us better understand both inflation's drivers and its potential impacts.

We separately identify demand- and supply-driven price increases across goods and services and display the results in Figure 6. Both goods and services show sharp increases in prices since Q2 2021, with the magnitude of the former being twice that of the latter. Starting in Q2 2021, demand shocks to goods contributed roughly one percentage point to overall PCE inflation in Canada, and they have remained relatively stable until Q3 2022. Demand shocks formed a similarly large contribution to price increases for services over the same period, but supply shocks are clearly concentrated among goods. In Q3 2022, nearly 2.3 percentage points of overall PCE inflation is among goods subject to supply-driven price increases. In contrast, supply-driven price increases among services account for just 0.7 percentage points. Though the contribution of service-sector supply shocks has grown in recent quarters, the accelerated rise may also indicate the effects of mounting labour shortages and the need to increase wages, and therefore costs, to retain and recruit talent.[11]

While many consider oil price shocks and supply chain bottlenecks transitory—in the sense that their causes are not long-term structural shifts and they could dissipate quickly—labour shortages can be a temporary phenomenon too. Persistently rising labour costs, however, might cause a wage-price spiral that would increase inflation expectations and lead to yet more inflation.

[11] In supplementary analysis not included in this paper, we find the majority of supply-driven increases within services are accounted for by items in the top quartile of labour intensity, as measured by wages and salaries and social contributions as a share of total input purchases.

Figure 6: Goods and Services Inflation, 2017 to Q3 2022



Note: Displays the contributions of demand and supply shocks to headline annual final consumer expenditure inflation for goods and services in Canada.

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

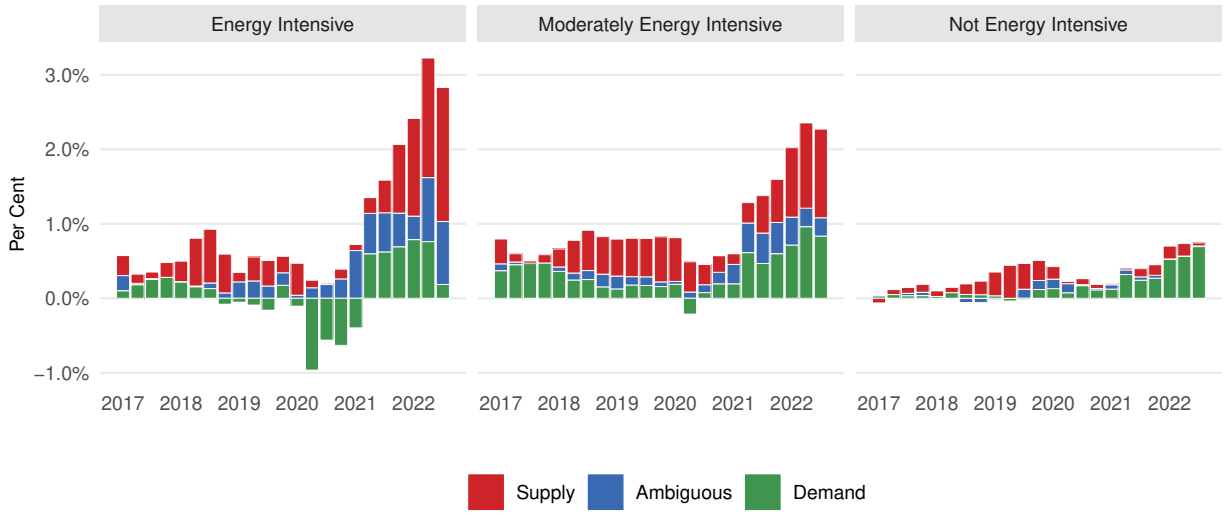
This may become problematic for the central bank. As with the other supply shocks, there is little that monetary policy can do to alleviate labour shortages, but by lowering overall aggregate demand, the pressure on these businesses to expand capacity and hiring may decline. To clarify, this does not imply supply shocks to services are more persistent or a greater source of concern than those to goods. Some of contributors to supply-driven service price increases, after all, may be in interest-sensitive areas, such as imputed rent for homeowners. We explore this shortly.

3.5.2 Energy Cost Shares

Our analysis in Section 2.2 suggested that items sensitive to oil prices accounted for a substantial share of Canada's rising inflation rate. Our measure of PCE inflation can more directly measure this potential relationship. As our data is based on final consumption expenditure categories that correspond to Canada's supply-and-use tables, calculating each item's energy intensity is straightforward. First, we estimate the share of an industry's total input purchases accounted for by energy products, such as natural gas, coal, electricity, and so on.[12] These shares range from zero (owner-occupied dwellings) to over 70 percent (petroleum refining). Second, household final consumption expenditures on a given product are supplied by different sectors. We therefore

[12]Energy products in the supply-and-use tables are defined by Statistics Canada in data table 36-10-0478-02. They include: fuel wood, conventional crude oil, synthetic crude oil, natural gas, natural gas liquids, crude and diluted bitumen, coal, electricity, steam and heated or cooled air or water, motor gasoline, diesel and biodiesel fuels, light fuel oils, aviation fuel, heavy fuel oils, coke, and petrochemicals.

Figure 7: Inflation Contributions by Energy Intensity, 2017 to Q3 2022



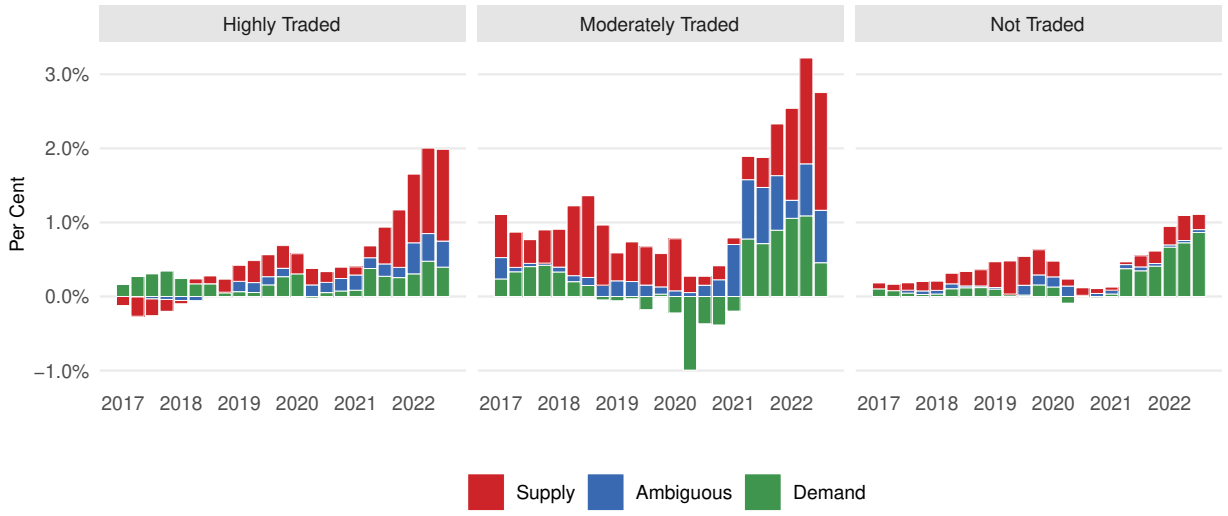
Note: Displays the contributions of demand and supply shocks to headline annual final consumer expenditure inflation in Canada. We separate items based on their measured energy cost shares: the top quartile (expenditure weighted) is defined as intensive, the interquartile range as moderately intensive, and the bottom quartile as not intensive.

Source: Authors' calculations using Statistics Canada data tables 36-10-0124-01, 36-10-0478, and 36-10-0001-01. See text for details.

estimate the energy cost share of each product as the consumption expenditure weighted average energy cost share across those sectors. We classify those products with energy cost shares in the top quartile (weighted by expenditures) as energy intensive, those in the interquartile range as moderately energy intensive, and those in the bottom quartile as not energy intensive. We find fuel and energy products, transportation services, garden supplies, laundry services, postal services, food, clothing materials, repair services, materials for the maintenance and repair of dwellings, among other products, are energy intensive. Items like financial services, insurance, imputed rent, and repair services, meanwhile, are not energy intensive.

Separating the contribution to recent inflation by each item's energy intensity further suggests that rising energy costs are an important factor. We display these results in Figure 7. Energy intensive items contributed nearly three percentage points to overall PCE inflation in Q3 2022. And supply-driven price increases are considerably larger than demand-driven ones. The contribution of energy intensive items to core-PCE (which excludes energy products) exceeds 1.5 percentage points. Items that are not energy intensive, meanwhile, contribute very little to overall inflation, and demand-driven increases overwhelmingly dominate. At a more granular level, we find the correlation between an item's year-over-year price increase in Q2 2022 (when inflation peaked) and its energy cost share is modest ($\rho = 0.22$, excluding energy products) but statistically significant ($p = 0.03$). To quantify how much of the overall increase in PCE inflation this may account for, we take the 73 percent annual increase in energy prices in Q2 2022 (as measured by the Bank of Canada Commodity Price Index) and multiply this by each item's energy cost share. This estimates the energy-only price change under full passthrough. Aggregating across all non-energy items, we

Figure 8: Inflation Contributions by Trade Intensity, 2017 to Q3 2022



Note: Displays the contributions of demand and supply shocks to headline annual final consumer expenditure inflation in Canada. We separate items based on their measured import shares: the top quartile (expenditure weighted) is defined as highly traded, the interquartile range as moderately traded, and the bottom quartile as not traded.

Source: Authors' calculations using Statistics Canada data tables 36-10-0124-01 and 36-10-0001-01 and the detail-level domestic and import use tables for 2020 (catalogue 15-207-X). See text for details.

find 0.9 percentage points of the overall 4.7 percent core-PCE inflation rate could be due to rising energy prices. And of the change since Q1 2020, energy prices may account for over 40 percent of the 2.9 percentage point increase. This suggests energy was a meaningful factor driving recent price increases of non-energy items.

3.5.3 Tradeable vs Non-Tradable

Canada is a small open economy where imports account for a significant portion of consumer expenditures—over one-third of durable goods spending is on imports, for example—and therefore price changes elsewhere may drive inflation in Canada.[13] Exchange rate changes will also passthrough to inflation in Canada as a lower Canadian dollar raises import prices. Conveniently, as with energy cost shares, the PCE items align with Statistics Canada's detail-level domestic and import use tables allowing one to estimate the share of final household consumption spending allocated to imports. These shares range from zero for nearly two-dozen services to nearly two-thirds for telecommunication equipment. As in the previous section, we define items with import shares in the top (expenditure-weighted) quintile as highly traded, those in the interquartile range as moderately traded, and those with zero imports as not traded. The latter is also the bottom quintile.

We find traded items account for most of inflation's rise. We display the results of our main decomposition in Figure 8. Highly traded items account for two percentage points of PCE inflation—

[13]Import shares are from the detail-level symmetric IO tables. We thank Paul Jacobson for providing these data.

twice the contribution of non-traded items. Modestly traded items account for more. But among traded items, supply-driven price increases dominate. In Q3 2022, supply side factors among tradeable goods account for 2.8 percentage points of overall inflation while demand-driven increases account for 0.8 percent. Among non-tradable, demand shocks are a significantly larger driver of price increases than supply. The highly traded item contributing the most to Q3 2022 inflation is food, whose price increases that quarter we classify as supply-driven. This is closely followed by spare parts and accessories for vehicles, which we also classify as supply-driven.

These are simple estimates, and future research will better explore the nature and consequences of recent international shocks on domestic economic outcomes in Canada. And, as discussed earlier, what we measure to be a demand or supply shock is only the proximate shock in the market for a particular item. A positive demand shock in the United States for electrical appliances for personal care (which has a high import share in Canada) would increase its price in Canada. All else equal, the quantity consumed by Canadian households would decline. Our method would label this as a negative supply shock. Whatever the ultimate shock, however, these results suggest international developments may be important drivers of inflation in Canada. That is a challenge for monetary policy. But before turning to the potential for monetary policy effectiveness, we take a brief detour to the experience of previous decades.

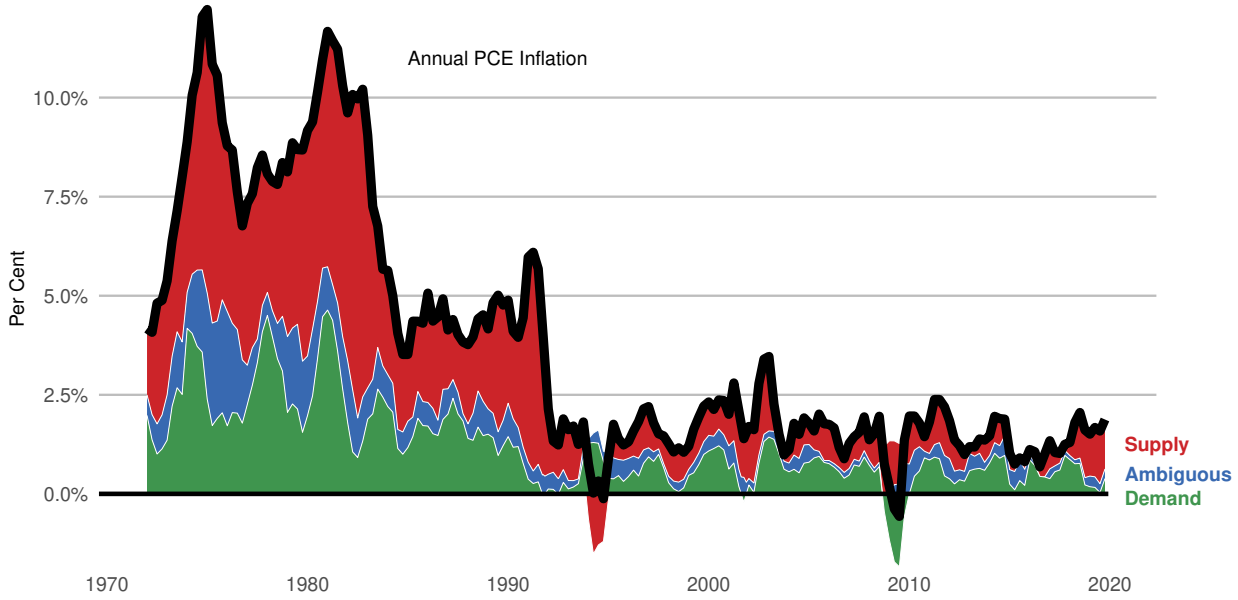
3.5.4 A Brief Comparison to Previous Decades

The last major supply shock that most economists and non-economists alike would remember was in the 1970s. A four-fold increase in oil prices—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 thereafter, it increased again through the late 1970s and early 1980s, reaching nearly 13 percent by 1981. Meanwhile, the economy struggled. By 1982, actual GNP was 18 percent lower than the steady growth path, accumulating a $91 billion loss (in 1971 dollars) between 1974 and 1982 (Helliwell, 1984). 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 9. For this, we use the Household Final Consumption Expenditure dataset (table 36-10-0107-01), which begins in 1961, but with a more aggregated classification. 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 4.5 percent two years earlier. Both rising demand- and supply-side factors each account for roughly 40 percent of this increase. While large in magnitude, these initial shocks were not persistent, and PCE inflation receded notably by 1977.

The early 1980s may also be relevant. PCE inflation gradually increased, averaging over 11 percent in 1981. Both supply- and demand-side factors largely accounted for this. But a sharp drop in Canada's inflation soon followed. From 1981 to 1985, we estimate PCE inflation declined by over seven percentage points—from nearly 11.2 percent to 4.1 percent. We find supply accounted

Figure 9: Contribution of Supply and Demand Shocks to PCE Inflation, 1972 to 2019



Note: Displays the contributions 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 those within 0.1 standard deviations of zero.

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

for 60 percent of this decline (4.2 of a total seven percentage points) while demand accounted for roughly one-third (2.3 percentage points). Falling oil prices, especially in the mid-1980s, may have contributed on the supply side, as might labour market developments. The Bank of Canada, for example, noted the most important driver of inflation's decline in 1983 was "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 in 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 58 percent of the variation and demand for 22 percent.

Also displayed in Figure 9 are more recent patterns during the inflation targeting era of the 1990s through to the end of 2019. For the most part, inflation was stable. Periods of sharp and sudden changes were in 1994, which was a tobacco tax cut that our method correctly identifies as a supply shock, and in 2009 during the Great Recession, which we identify as a demand-driven drop in inflation. The decline in inflation in the 2015–2017 period that was largely due to a sharp drop in oil prices is also correctly identified as supply-driven. Overall, we find that in the 1995–2019 period, 60 percent of the variation is due to demand and 35 percent to supply. To the extent that demand shocks are easier for monetary policy to offset, this may partially contribute to our

understanding of how inflation targeting was so successful during this period. Firmly anchored inflation expectations may have also contributed significantly to the success in this period (Ravenna and Mølbak Ingholt, 2021), and that may also contribute to the lower volatility in supply-driven price changes. We do not explore this period or these important issues further.

Today, as in the early 1980s, the decline in inflation may also be supply-driven as the strains in global energy markets and supply chain bottlenecks ease, though contractionary monetary policy will likely cause several demand-driven factors to contribute. We turn to this next.

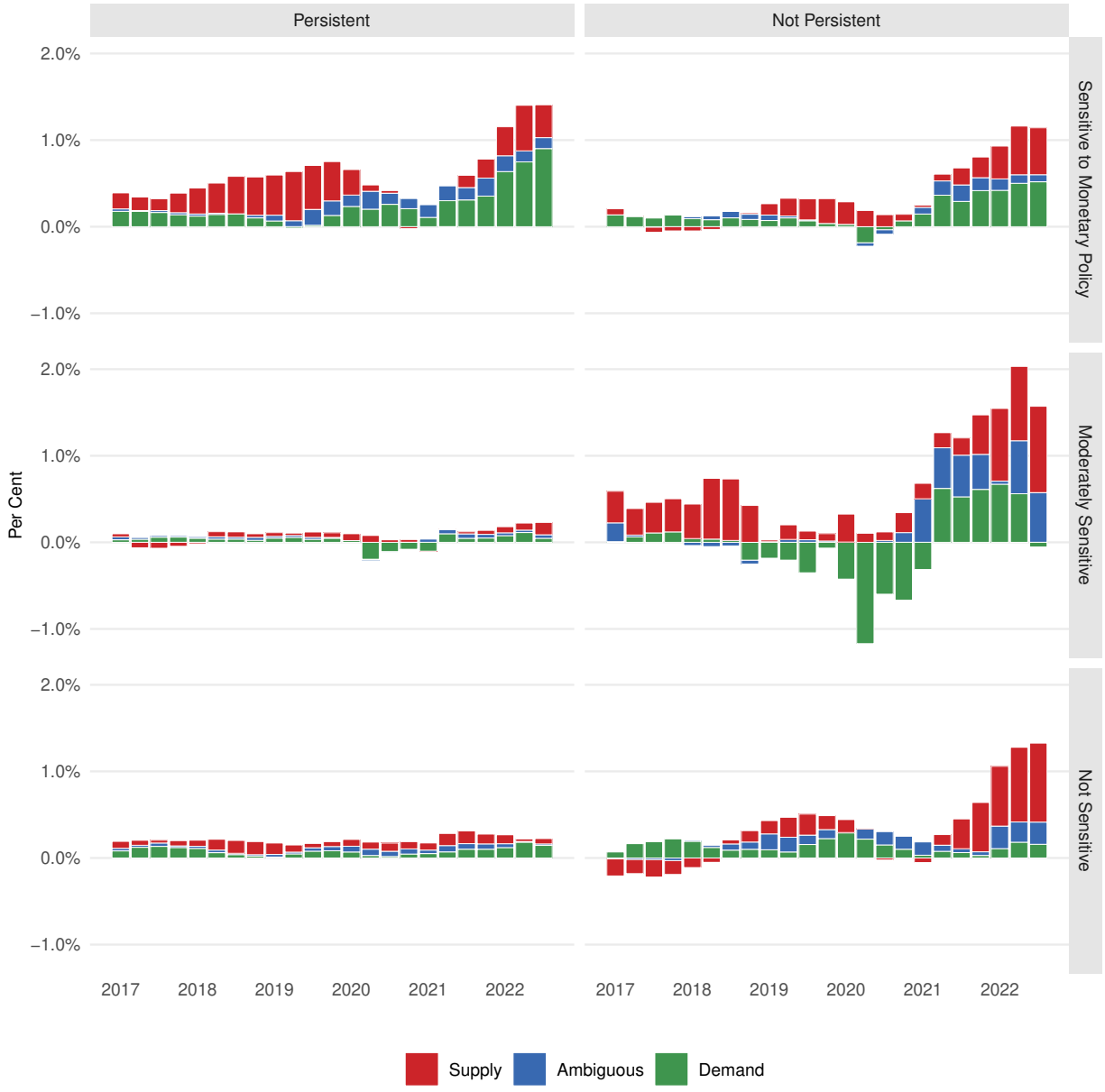
4 Potential Effectiveness of Monetary Policy

In response to the decades-high inflation, monetary policy is tightening. The Bank of Canada's key policy rate, which affects interest rates throughout the economy, increased from 0.25 percent in January 2022 to 4.25 percent by December. These rapid rate increases aim to bring inflation down to the Bank's mandated target range of between one and three percent. Such effort has long raised questions regarding the potential welfare consequences (Fortin, 1996; Freedman and Macklem, 1998), but our paper does not explore this. Instead, we ask to what extent items whose prices have increased are responsive to interest rate changes. In general, higher rates can lower household and business expenditures on goods and services that are sensitive to those rates, of which durable goods and residential investment are two notable examples. But monetary policy acts with a considerable lag, so central bank decisions reflect not only current conditions but expected future ones. The persistence of price changes therefore also matters for this reason. Moreover, persistent price changes may be more likely to affect individual inflation expectations. This is particularly relevant today since, according to the most recent Canadian Survey of Consumer Expectations (Bank of Canada, 2022b), short-term expectations for inflation are elevated, although long-term expectations are near pre-pandemic levels. To gain insight into the prospects of effective monetary policy action being able to combat inflation in Canada, we further decompose PCE inflation based on individual items' historical price persistence and sensitivity to interest rates.

Some goods and services are more sensitive to interest rate increases than others. Demand for items that are not discretionary, such as groceries or healthcare related expenditures, may change little as monetary policy tightens. Durable goods, such as new vehicles or residential investments, meanwhile, can be highly sensitive. Recent empirical work by Chernis and Luu (2018)—which was also cited in Bank of Canada (2022d)—estimates the response of Canadian household expenditures to monetary policy, and conveniently uses similar data to that with which we measure PCE inflation and identify demand- and supply-driven factors. They classify goods and services into three categories: sensitive to monetary policy shocks, moderately sensitive, and not sensitive. We map their classification onto our data to determine if items that will respond to monetary policy are among the recent drivers of accelerating inflation.

We further identify whether the price increases are among items that tend to have transitory

Figure 10: Inflation Persistence and Sensitivity to Monetary Policy, 2017 to Q3 2022



Note: Displays the contributions of demand and supply shocks to annual final consumer expenditure inflation. Items are classified according to those experiencing demand and supply shocks, as before, and according to (1) whether the underlying household expenditure categories are sensitive to interest rate changes and (2) whether historical price changes tend to persist for at least a year.

Source: Authors' calculations using Statistics Canada data table 36-10-0124-01 and the monetary policy sensitivity as determined by Chernis and Luu (2018). See text for details.

price changes. To estimate this, we regress annual price changes on their one-year lag,

$$\pi^j_{t-4,t} = \beta^j_0 + \beta^j_1 \pi^j_{t-8,t-4} + \epsilon^j_t, \tag{8}$$

where $\pi_{t-4,t}$ denotes the price change from quarter $t-4$ to t. We label items showing a strong positive and statistically significant ($\mathbf{t}(\beta^j_1)$>1.96) relationship between past and current price increases as persistent. Intuitively, this will classify items as persistent if price increases in one year are typically followed by further increases one year later. Our results are generally unaffected by using quarter-over-quarter price changes regressed on the one-year lag of quarter-over-quarter changes or using a single-quarter rather than one-year lag. They are also robust to using higher ($\mathbf{t}(\beta^j_1)$>2.58) or lower ($\mathbf{t}(\beta^j_1)$>1.65) significance levels. We estimate this for the period between Q1 1995 and Q4 2019; that is, for the low inflation period prior to the pandemic.[14]

Combining these two classifications—sensitivity to monetary policy and the historic persistence of price increases—reveals important results for policymakers. We display a decomposition of demand- and supply-driven factors separately for persistent and non-persistent items and for items very sensitive, moderately sensitive, and not sensitive to monetary policy in Figure 10. Non-persistent items account for over two-thirds of PCE annual inflation in Q3 2022. Both demand and supply shocks are important drivers of price increases in most categories, though nearly all of the contribution by persistent items is among those highly sensitive to monetary policy. And demand-driven price increases account for most of that. This suggests that price increases among items of the greatest potential concern (those without typically transitory price increases) may respond strongly to recent interest rate increases. Moreover, among items that we estimate are experiencing demand-driven price increases, nearly all of their contribution to overall inflation in Q3 2022 is by items sensitive to monetary policy. While only suggestive, these results suggest tighter monetary policy, along with time, may help ease inflation.

5 Conclusion

While future inflation and monetary policy remain uncertain, this paper explores various drivers leading to higher recent rates of inflation. First, we demonstrate that a relatively small number of items—energy and shelter costs, in particular—account for much of the rise in average consumer prices. And of the non-energy items in the CPI, we show that the overwhelming majority of the increase relative to pre-pandemic inflation rates is due to price increases among the relatively few items that are historically sensitive to oil prices. This suggests supply-side factors are a key driver

[14]Our results are robust to including data from Q1 2020 onwards or to including the available pre-1995 data. We also validate the resulting classification by comparing persistent items to those that are less frequently trimmed by the Bank of Canada's CPI-Trim measure of core inflation. This measure cuts items in the bottom and top quintile of price changes, which eliminates volatile components of the CPI. While the mapping from our DHFCE items to the 55 used in CPI-Trim is imperfect, our best effort suggests items we label as persistent align with items that have a low probability of being trimmed by the CPI-Trim. The median probability being trimmed among our persistent items is just over 20 percent, less than the bottom quartile among the 55 products included in CPI-trim since 1989.

of Canada's accelerating inflation. To identify this, we use detailed data on prices and quantities and new but intuitive VAR methods to empirically separate demand- from supply-driven changes. We find supply-driven price increases are the dominant contributor to the recent acceleration in inflation. Using additional data from Canada's supply-and-use tables, we also show price increases among energy intensive items and items with high import shares also dominate.

These results matter for policy in several ways. First, we confirm—with different data and empirical methods—what others have pointed out: that the rise of Canada's inflation rate in 2022 was largely a supply-side story. While supply-driven inflation makes monetary policy more difficult and costly, we present further suggestive evidence that recent price increases are driven either by items that normally have transitory price increases or by items that are highly sensitive to interest rates. Time and recently rising interest rates may therefore help to continue bringing inflation down from its 2022 highs. And beyond providing a more granular data-driven look at the drivers of inflation, we demonstrate that new empirical methods can add value to inflation monitoring efforts in Canada. Producing the household consumption data at monthly frequency may therefore be warranted. Not only does the data provide quantity information, but also readily aligns with national account information on input use, trade flows, and more. The PCE inflation measures should not substitute for CPI measures, however. It is instead an important complement that could be an important input into how policymakers, researchers, and the general public understand macroeconomic developments. At the very least, and though there is *much* more to learn, this paper sheds new and important light on Canada's recent inflation experience.

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