BANK OF CANADA
BANQUE DU CANADA

Staff Analytical Note/Note analytique du personnel—2025-29

Last updated: December 12, 2025

PULSE check: Measuring underlying inflation and its drivers

Luis Uzeda
Canadian Economic Analysis Department
Bank of Canada
LUzedaGarcia@bankofcanada.ca

Bank of Canada staff analytical notes are short articles that focus on topical issues relevant to the current economic and financial context, produced independently from the Bank's Governing Council. This work may support or challenge prevailing policy orthodoxy. Therefore, the views expressed in this note are solely those of the authors and may differ from official Bank of Canada views. No responsibility for them should be attributed to the Bank.

DOI: https://doi.org/10.34989/san-2025-29 | ISSN 2369-9639

© 2025 Bank of Canada

Acknowledgements

I would like to thank Mikael Khan and several participants at internal seminars at the Bank of Canada for their comments and suggestions in preparing this note.

Abstract

This note presents PULSE, a new measure of underlying inflation in Canada based on a dynamic factor model estimated on disaggregated inflation data. PULSE captures the persistent component of inflation and decomposes it into broad-based and sector-specific inflationary pressures. We find that broad-based inflationary pressures account for most underlying inflation, while sector-specific factors—particularly shelter—have become more inflationary since 2021. Unlike CPI-common, PULSE is less prone to large historical revisions and maintains a strong correlation with economic slack.

Topics: Econometric and statistical methods; Inflation and prices; Monetary policy transmission
JEL codes: C5, C55, E31, E52

Résumé

Cette note présente PULSE, une nouvelle mesure de l'inflation sous-jacente au Canada basée sur un modèle factoriel dynamique estimé à partir de données désagrégées sur l'inflation. PULSE saisit la composante persistante de l'inflation et la décompose en pressions inflationnistes généralisées et sectorielles. Nous constatons que l'inflation sous-jacente vient en majeure partie des pressions inflationnistes généralisées, tandis que les facteurs sectoriels – en particulier ceux liés au logement – sont plus inflationnistes depuis 2021. Contrairement à l'IPC-comm, PULSE est moins sujet à d'importantes révisions des données historiques et reste fortement corrélé aux capacités excédentaires de l'économie.

Sujets : Méthodes économétriques et statistiques ; Inflation et prix ; Transmission de la politique monétaire
Codes JEL : C5, C55, E31, E52

1. Introduction

Conventional wisdom holds that monetary policy decisions take about a year or longer to affect inflation (see Friedman 1961 and Havranek and Rusnak 2013). This implies that monetary policy should focus on persistent rather than transitory movements in overall inflation. By filtering out short-lived, "noisy" price changes, measures of underlying inflation isolate the persistent component of price changes, providing a useful guide for monetary policy.[1]

Equally important, however, is understanding what drives this persistent component. Generally speaking, inflation persistence can stem from both broad and narrow forces. This distinction matters because it carries different implications for monetary policy. For example, broad-based price changes that are common across sectors are more likely linked to macroeconomic fundamentals—such as changes in employment, gross domestic product (GDP) and consumer spending—which monetary policy can influence through aggregate demand. In contrast, narrower drivers of inflation typically reflect sector-specific developments in the form of relative price shifts, which monetary policy may be less effective in addressing.[2]

Taking this common-versus-sectoral perspective on board, this note proposes a new measure of underlying inflation in Canada. We then use this measure to examine what drives underlying inflation—namely, whether it stems from common or sector-specific factors. We use a flexible dynamic factor model (DFM) on disaggregated consumer price index (CPI) data. Notably, this DFM builds on methods used to construct CPI-common, one of the Bank of Canada's measures of core inflation that recently encountered measurement challenges (Khan, Morel and Sabourin 2013; Sullivan 2022). We refer to this new measure of underlying inflation as *persistent underlying latent signal extraction*, or PULSE.

One important advantage of PULSE is that it explicitly models both persistent and transitory price movements. This approach avoids conflating the size of a price change with its duration—a limitation of the Bank's preferred core inflation measures, CPI-trim and CPI-median, which treat outliers in the price distribution as short-lived fluctuations. However, tail events such as the sharp rise in food and energy prices during the COVID-19 pandemic can sometimes reflect more persistent inflationary forces. PULSE also enables an assessment of whether these persistent signals arise from sector-specific

[1] In this note, we use the terms "core" and "underlying" inflation interchangeably. That said, a distinction can be made. Underlying inflation can be interpreted as a concept that refers to the broad and persistent drivers of price pressures, while core inflation is one of several statistical measures used to gauge underlying inflation (see, e.g., Khan, Morel and Sabourin 2015 and Mendes 2025).

[2] See, e.g., Aoki 2001 and Wolman 2011.

pressures or from more broad-based inflationary dynamics. This distinction is important because, as mentioned above, monetary policy is generally viewed as more effective in addressing economy-wide price pressures through its influence on aggregate demand.[3]

The main findings of this note are as follows:

- Underlying inflation in Canada has a strong common component, though sector-specific forces also matter.
- Sector-specific forces were largely deflationary before the pandemic but have turned inflationary since 2021, driven mainly by shelter prices.
- The PULSE measure of underlying inflation is robust to historical revisions in the post-pandemic period, unlike CPI-common.
- PULSE shows a Phillips-curve-type relationship with economic slack.

The remainder of this note is structured as follows. Section 2 briefly describes the empirical framework for estimating PULSE. Section 3 presents PULSE estimates, compares them with CPI-trim and CPI-median, and discusses the revision properties of PULSE relative to CPI-common. Section 4 proposes several decompositions of underlying inflation based on the common versus sector-specific dichotomy, assesses the recent role that mortgage interest cost (MIC) plays in underlying inflation and examines the relationship between PULSE and economic slack. Section 5 concludes.

2. Methodology

Our empirical strategy is an application of the DFM framework discussed in Stock and Watson (2016).[4] Two features of the model are key. First, each CPI component is split into persistent and transitory parts, with the persistent part feeding into overall underlying inflation. Second, to distinguish broad from sector-specific dynamics, the model includes both a persistent common component and a persistent sector-specific component. Estimation uses a 55-sector CPI disaggregation—the same breakdown used to construct the Bank's CPI-trim and CPI-median measures of core inflation.[5]

---

[3] It is worth emphasizing, however, that there is no such thing as an infallible measure of core inflation. Because of this, the Bank uses a broad range of indicators to assess underlying inflation, with core inflation measures being just one approach.

[4] The same framework is currently used by the Federal Reserve Bank of New York to produce its multivariate core trend (MCT) inflation measure. See Eo, Uzeda and Wong (2023) for an alternative sectoral approach to estimating trend inflation.

[5] While finer CPI disaggregation levels exist using micro-level data, these are not used in this analysis. A key limitation is that micro-level data do not provide a complete breakdown for all components, most notably shelter price inflation, which is an important part of overall inflation. Another drawback of micro-level data is that finer granularity is accompanied by a substantial number of missing observations.

In what follows, we present the two key equations from the DFM that are most relevant for interpreting the results we report in section 4: the specification of inflation in each sector and the derivation of an overall measure of underlying inflation. For a detailed description of the model, see Stock and Watson (2016).

Sectoral measures of underlying inflation

Let $\pi_{i,t}$ denote year-over-year inflation for each sector. At a high level, $\pi_{i,t}$ can be described as consisting of a low-frequency (or underlying) and a high-frequency (or transitory) component. In turn, each of these components contains a common and a sector-specific component. Formally, we have:

$$\pi_{i,t} = \overbrace{\underbrace{\lambda_{i,t}\tau_{t,c}}_{(a)} + \underbrace{\tau_{t,i}}_{(b)}}^{Underlying} + \overbrace{\underbrace{\gamma_{t,i}\epsilon_{t,c}}_{(c)} + \underbrace{\epsilon_{t,i}}_{(d)}}^{Transitory}, \qquad (1)$$

where:

(a) is the **common** component of **underlying** inflation for sector i

(b) is the **sector-specific** component of **underlying** inflation for sector i

(c) is the **common** component of **transitory** inflation for sector i

(d) is the **sector-specific** component of **transitory** inflation for sector i

To distinguish between low- and high-frequency dynamics, trends in equation (1) ($\tau_{t,c}$ and $\tau_{t,i}$) are modelled as random walk processes, a standard specification in the signal extraction literature. In contrast, the terms associated with the transitory component ($\epsilon_{t,c}$ and $\epsilon_{t,i}$) are specified as serially uncorrelated error terms. For increased flexibility, transitory dynamics are modelled using outlier-augmented stochastic-volatility methods.[6] Lastly, to allow for the possibility that the importance of common dynamics within and across sectors may differ over time, time-varying loadings ($\lambda_{i,t}$ and $\gamma_{t,i}$) are appended to the model.

Backing out an overall measure of underlying inflation (PULSE)

The goal is to construct a measure of overall underlying inflation based on the estimates of underlying inflation for each sector (i.e., the sum of terms (a) and (b) in (1)). We do so by computing the following weighted average:

$$\tau_t = \sum_{i=1}^{N} w_{i,t}\left(\lambda_{i,t}\tau_{t,c} + \tau_{t,i}\right), \qquad (2)$$

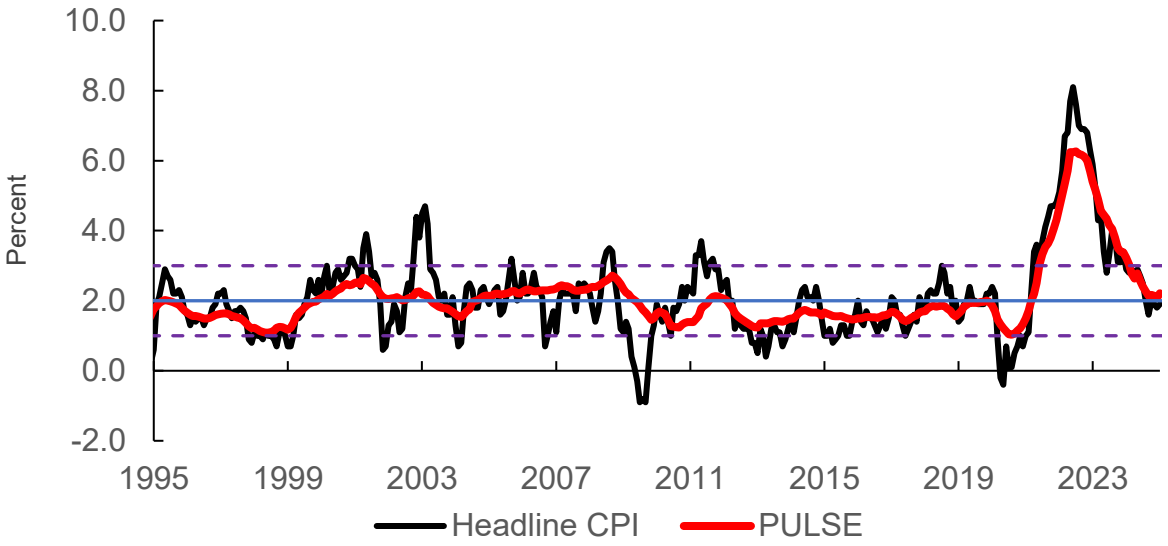
where $w_{i,t}$ is based on the CPI basket weight for each of the 55 sectors provided by Statistics Canada. We estimate the model using Bayesian Markov Chain Monte Carlo methods.

[6] The model also incorporates stochastic volatility in the errors driving both the common and sector-specific components of underlying inflation.

3. PULSE and other measures of underlying inflation

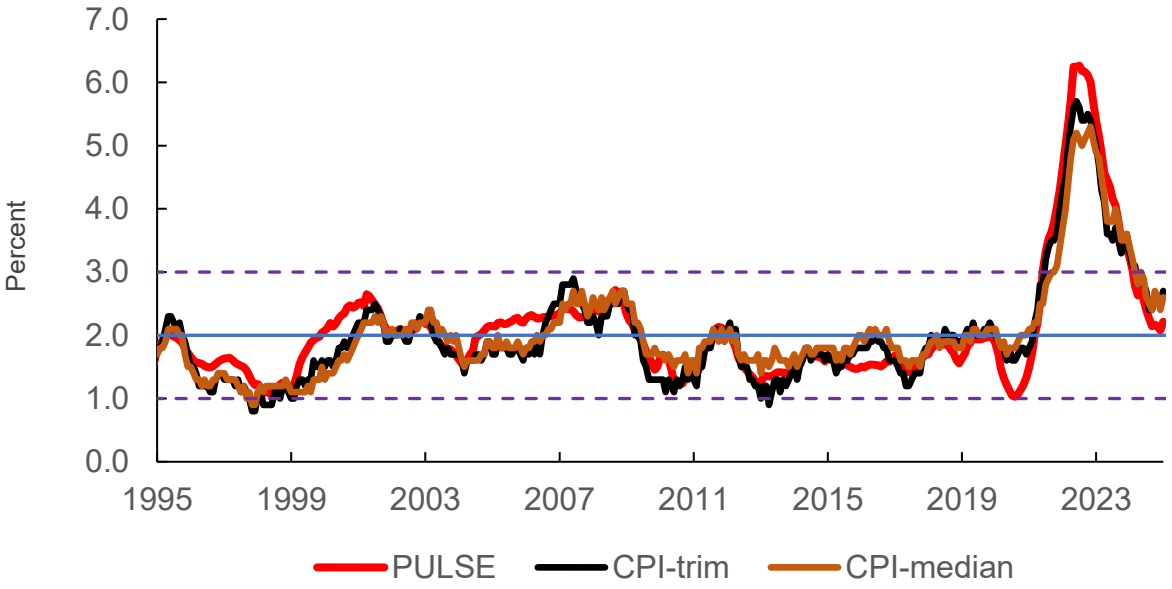
We begin by comparing headline inflation with the measure of underlying inflation derived from the framework in section 2, both shown in **Chart 1**. Two features stand out. First, PULSE effectively strips out transient noise: in the pre-pandemic period, underlying inflation remains close to the 2% target, even as headline inflation shows short-lived swings, occasionally moving outside the 1% to 3% control range. Second, PULSE interprets the recent surge in inflation as largely persistent rather than transitory while still capturing the gradual return of headline inflation toward the target.

Chart 1: PULSE estimate of underlying inflation



Note: CPI is consumer price index. Headline CPI and underlying inflation denote monthly year-over-year estimates. Headline CPI inflation is non-seasonally adjusted.
Sources: Statistics Canada and Bank of Canada calculations
Last observation: January 2025

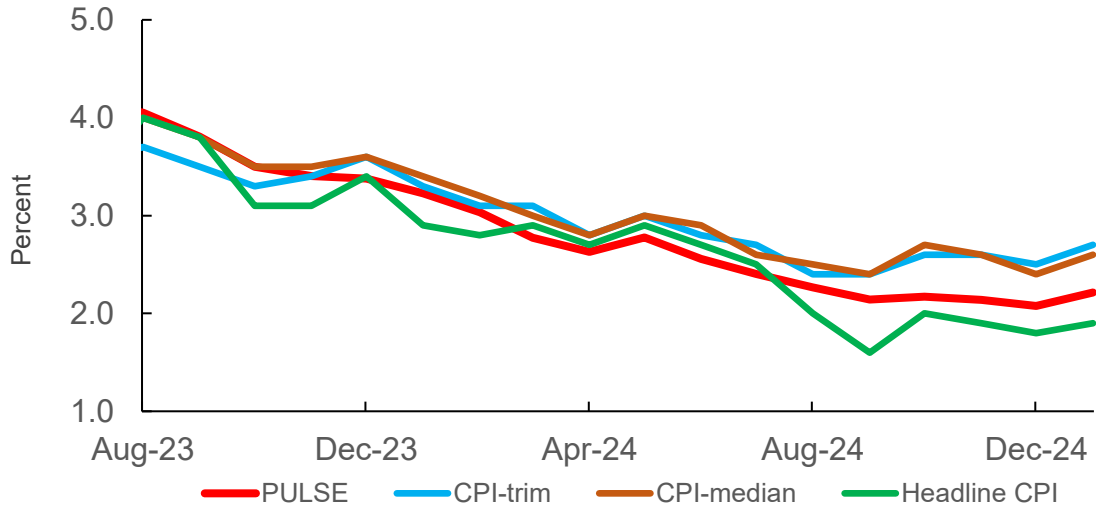
Chart 2: Underlying inflation from PULSE and the Bank of Canada's preferred measures of core inflation



Note: All series denote monthly year-over-year estimates.
Sources: Statistics Canada and Bank of Canada calculations
Last observation: January 2025

Next, we examine how PULSE compares with other core inflation measures published by the Bank, notably CPI-trim and CPI-median. **Chart 2** suggests that PULSE provides a complementary perspective on underlying inflation, moving closely with CPI-trim and CPI-median but also diverging notably in some periods. For instance, PULSE initially exhibits a sharper drop and rebound in underlying inflation during the pandemic than CPI-trim and CPI-median. Moreover, although headline CPI has hovered around the 2% target since August 2024, CPI-trim and CPI-median do not fully reflect this recent loss of inflationary momentum. In contrast, as shown in **Chart 3**—which focuses on developments since August 2023—PULSE aligns more closely with the softer inflation picture conveyed by headline CPI.

Chart 3: PULSE and the return of headline CPI inflation to target



Note: All series denote monthly year-over-year estimates. CPI is consumer price index. Headline CPI inflation is non-seasonally adjusted.

Sources: Statistics Canada and Bank of Canada calculations

Last observation: January 2025

3.1 Revisions

PULSE is estimated using a two-sided filter, which means end-of-sample values are revised as new data become available. Such revisions are useful: they allow new information to correct potential biases in real-time estimates of unobserved measures, providing a more accurate view of historical inflation dynamics. Nonetheless, monetary policy depends on real-time information, so it is important that revisions be small enough that they do not materially change the interpretation of inflation developments.

To assess this trade-off, we conduct a sensitivity-to-revision analysis and summarize the results using the root mean squared error (RMSE), calculated from the differences between the (pseudo) real-time and the full-information estimates of underlying inflation. Simply put, real-time estimates show what could be inferred about underlying inflation at each CPI release, while full-information estimates show the complete historical trajectory of underlying inflation.[7]

For the remainder of this section, we compare the revision properties of PULSE with those of CPI-common, one of the Bank's core inflation measures that, as mentioned

[7] The real-time series for CPI-common and PULSE are built from successive end-of-sample estimates, beginning with the first publicly available CPI-common vintage in December 2016 and ending in January 2025. For CPI-common, the final estimate is from the January 2025 vintage; for PULSE, it comes from fitting the DFM through January 2025.

earlier, has recently faced measurement challenges. Both are based on factor models but, as described in section 3, PULSE offers a more flexible framework. It is therefore useful to assess whether this added flexibility translates into more robust measurement.

Table 1 shows that underlying inflation from PULSE is less prone to revision than CPI-common in an RMSE sense. This holds across the three periods considered: pre-COVID-19 (December 2016 to December 2019), January 2020 to January 2025, and the full sample (December 2016 to January 2025). Although the margin is not large, PULSE outperforms CPI-common.

Table 1: Root mean squared errors for revisions based on real-time estimates of underlying inflation from PULSE and CPI-common

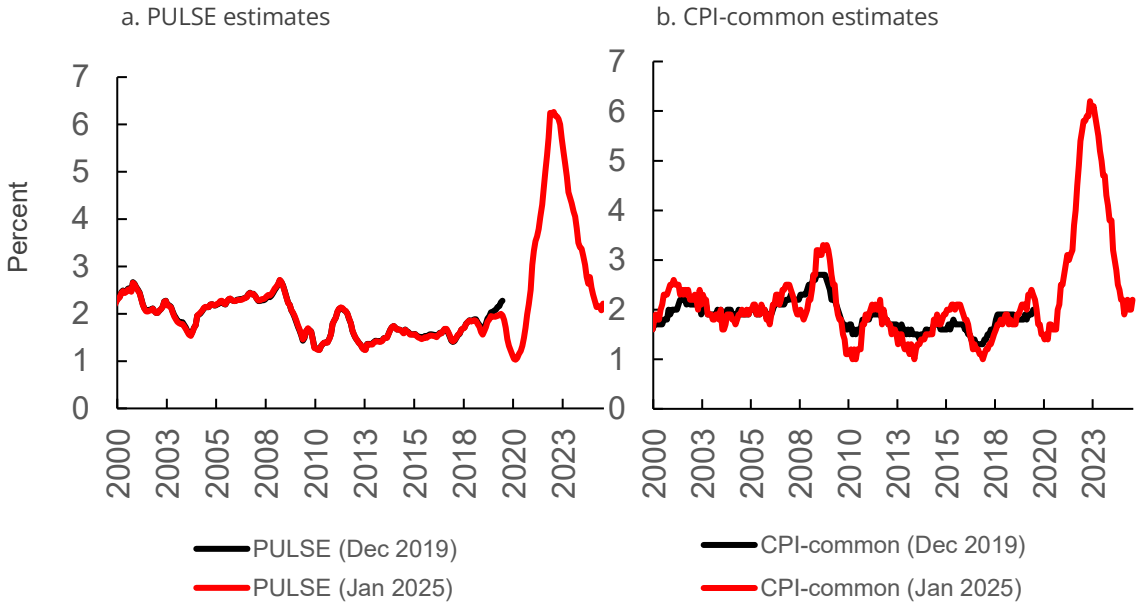
	RMSEs for each sub sample		
Measure	**Dec 2016–Dec 2019**	**Jan 2020–Jan 2025**	**Dec 2016–Jan 2025**
PULSE	**0.14**	**0.42**	**0.52**
CPI-common	0.23	0.52	0.64

Note: RMSE is root mean squared error. Revisions are gauged in terms of the RMSE calculated from the differences between the real-time and final estimates of underlying inflation. The lower the RMSE, the less prone the real-time estimates are to revisions. Numbers in bold denote the best-performing measure.

It is also useful to examine whether the parametric flexibility for PULSE reduces the size of historical revisions to pre-pandemic estimates of underlying inflation—revisions that have been sizable for CPI-common. As shown in panel a of **Chart 4**, pre-pandemic estimates are virtually unchanged for PULSE regardless of whether the model is estimated through December 2019 or over the full sample including the recent inflation surge. This stability contrasts with CPI-common (**Chart 4**, panel b), where estimates differ considerably across the two samples. Overall, this suggests that the additional flexibility built into PULSE provides robustness in measuring underlying inflation during both low and high inflation regimes.[8]

[8] That is not to say PULSE estimates of underlying inflation are immune to revision. As noted at the start of this section, these estimates are derived using a two-sided filter (consistent with a Bayesian inferential framework), which makes revisions to recent observations almost inevitable. However, internal analysis suggests that such revisions tend to be modest.

Chart 4: PULSE estimates of underlying inflation with and without post-2020 data



Note: CPI is consumer price index. This chart shows underlying inflation estimates from two samples: one ending in December 2019 and the other in January 2025.

Sources: Statistics Canada and Bank of Canada calculations

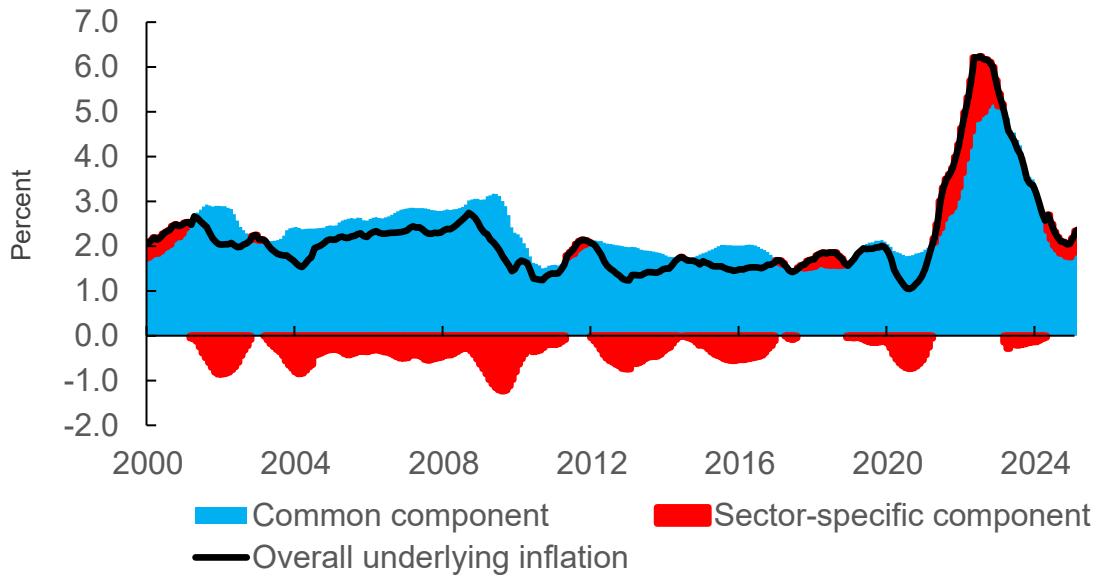
Last observation: January 2025

4. Common and sector-specific drivers

We have established that PULSE estimates for underlying inflation align with core inflation measures such as CPI-trim and CPI-median, and that PULSE is robust to the historical revision problems that plagued CPI-common after the 2021 inflation surge. We now turn to how the empirical framework presented in section 2 can inform assessments of underlying inflation.

Recall that PULSE decomposes the drivers of inflation into a common (broad) and a sector-specific component. **Chart 5** shows the contribution of each of these components to overall underlying inflation. Notably, our measure of underlying inflation exhibits a strong common component, which aligns with the notion that underlying inflation should reflect broad-based price changes across the many items in the CPI basket. Moreover, the presence of a strong common component suggests that monetary policy should be effective in reining in underlying inflation through its influence on aggregate demand.

Chart 5: Decomposition of underlying inflation into its persistent components: common and sector-specific



Note: All series denote monthly year-over-year estimates.
Sources: Statistics Canada and Bank of Canada calculations
Last observation: January 2025

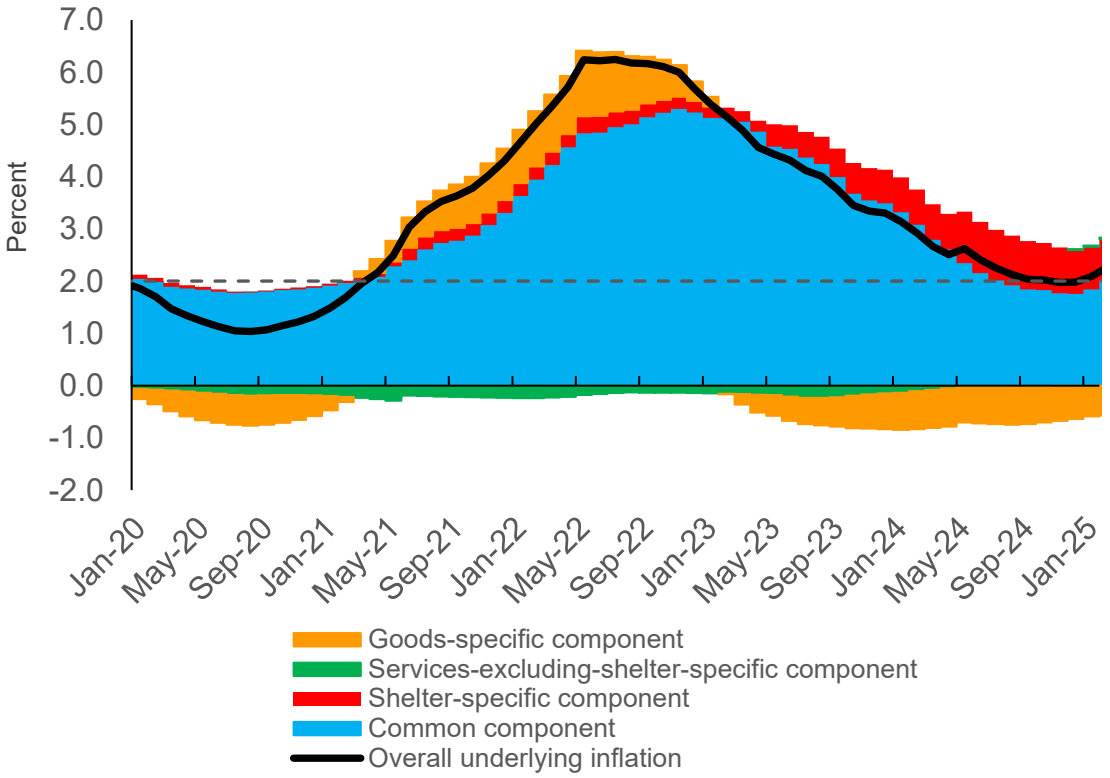
Nevertheless, sector-specific forces are non-negligible and have played opposite roles during the pre- and post-pandemic periods. Before the pandemic, these forces acted primarily as a drag on underlying inflation—a trend largely associated with China's growing role in the consumer goods market following its accession to the World Trade Organization in 2001. In contrast, since early 2021, sector-specific inflation has exerted upward pressure on underlying inflation. We explore this point further in section 4.1.

4.1 Disentangling sector-specific contributions since the pandemic

Chart 6 provides a closer look at the surge and subsequent normalization of underlying inflation observed since the first half of 2021, highlighting common and sector-specific price pressures in greater detail. While broad-based price pressures clearly played a major role in the recent inflationary episode, sector-specific inflation further fueled inflation. In particular, the persistent sector-specific component of goods inflation contributed to underlying inflation's peak of 6.3% in May 2022. This aligns with the persistent rise in food and energy prices, which stemmed from supply chain disruptions during the pandemic and the impact of the war in Ukraine on energy markets,

respectively. This result cautions against the systematic exclusion of food and energy prices from measures of underlying inflation.

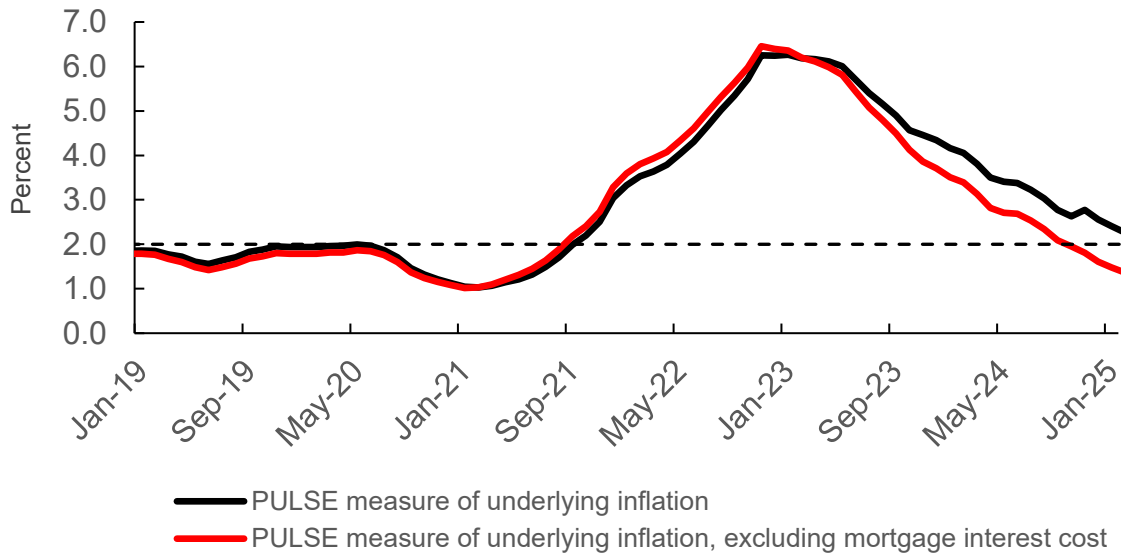
Chart 6: Decomposition of underlying inflation into its persistent components: common and selected sector-specific



Note: All series denote monthly year-over-year estimates.
Sources: Statistics Canada and Bank of Canada calculations
Last observation: January 2025

As underlying inflation begins to subside toward the end of the sample, two aspects are worth noting. First, from July 2024 onward, the common component of underlying inflation is broadly in line with the 2% target for headline inflation, suggesting that the recent cycle of monetary policy tightening has helped reduce broad-based persistent price pressures. Second, over the same period, the model identifies upward inflationary momentum arising from the persistent sector-specific component of shelter inflation. Because MIC is a key part of shelter inflation and largely reflects the Bank's policy rate, it is useful to assess the extent to which the latest readings of underlying inflation might be influenced by the recent tightening of the policy rate.

Chart 7: Recent behaviour of underlying inflation, with and without mortgage interest cost



Note: All series denote monthly year-over-year estimates.
Sources: Statistics Canada and Bank of Canada calculations
Last observation: January 2025

Chart 7 illustrates the issue by showing that since late 2023, underlying inflation excluding MIC has been consistently lower than the measure of underlying inflation that accounts for all 55 CPI components. This raises the issue of whether MIC should be included in readings of underlying inflation, as discussed by, for example, Macklem (2001) and Khan, Morel and Sabourin (2015).

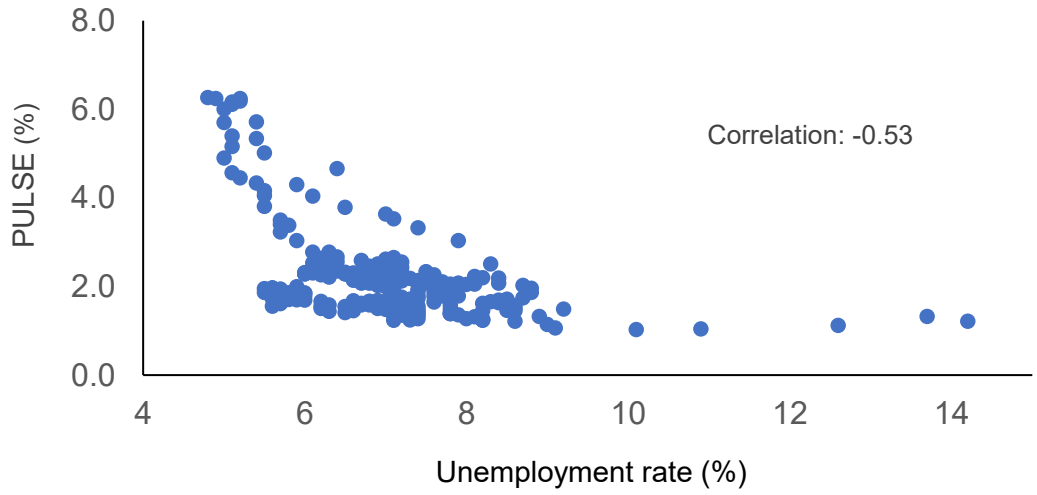
While this note does not aim to provide a definitive guideline on this matter, the results in **Chart 7** suggest that the recent momentum from the sector-specific component of shelter inflation shown in **Chart 6** reflects a persistent relative price shock driven by MIC inflation. This further underscores the importance of considering how to treat such a component—whether by inclusion or exclusion—when evaluating the behaviour of underlying inflation in Canada.

4.2 Underlying inflation and economic activity

For monetary policy, measures of underlying inflation are useful in that they bear some connection with economic fundamentals, as suggested by textbook-like Phillips curves. In this section, we take a simple approach to examine this issue by showing by how PULSE results for underlying inflation relate to the unemployment rate.

In line with economic theory, **Chart 8** shows that our proposed measure of underlying inflation is negatively correlated with the unemployment rate. The magnitude of this correlation is comparable to what previous studies have documented for other measures of core inflation for Canada (see Khan, Morel and Sabourin 2015). Moreover, given the explicit signal and noise decomposition that the DFM uses to estimate the PULSE result, **Chart 8** suggests that when viewed through the lens of inflation's lower-frequency movements, the Phillips curve relationship between prices and economic slack—often argued to have flattened over time—appears to persist.[9]

Chart 8: A Phillips-curve type of correlation between the PULSE measure of underlying inflation and unemployment



Note: All series represent monthly estimates. Inflation is non-seasonally adjusted and measured in year-over-year terms. The unemployment rate is seasonally adjusted and reflects the population aged 15 and older in the Labour Force Survey. The sample ranges from January 2000 to January 2025.

Sources: Statistics Canada and Bank of Canada calculations

Last observation: January 2025

5. Taking stock

This note provides new estimates of underlying inflation based on a flexible dynamic factor model fitted to disaggregated CPI inflation data. A key feature of the model is that it allows for both a persistent common component and a persistent sector-specific component. The latter is particularly relevant in contexts where relative price changes,

[9] See Bianchi, Nicolò and Song (2023) for a related claim on separating high and low inflation frequencies and Philips-curve-type relationships for the US economy.

such as those in sectors like shelter or energy, become more entrenched and consequently affect estimates of the underlying rate of inflation.

Overall, our proposed measure is robust to the historical revisions that affect CPI-common when accounting for post-pandemic inflation dynamics. Our findings also indicate that underlying inflation in Canada has a strong common component. This, in theory, should make monetary policy effective in reining in inflation through the usual aggregate demand channels.

However, we do find a non-negligible sector-specific component as well. More recently, this component has largely manifested through shelter-specific inflation, contributing upside momentum to an otherwise softer estimate of underlying inflation. In addition, we provide suggestive evidence of a Phillips-curve-type relationship between underlying inflation and economic slack. Going forward, the PULSE measure could be a useful addition to the broad suite of indicators the Bank of Canada monitors to assess underlying inflation pressures.

6. References

Aoki, K. 2001. "Optimal Monetary Policy Responses to Relative-Price Changes." *Journal of Monetary Economics* 48 (1): 55–80.

Bianchi, F., G. Nicolò and D. Song. 2023. "Inflation and Real Activity Over the Business Cycle." National Bureau of Economic Research Working Paper No. 31075.

Eo, Y., L. Uzeda and B. Wong. 2023. "Understanding Trend Inflation Through the Lens of the Goods and Services Sectors." *Journal of Applied Econometrics* 38 (5): 751–766.

Friedman, M. 1961. "The Lag in Effect of Monetary Policy." *Journal of Political Economy* 69 (5): 447–466.

Havranek, T. and M. Rusnak. 2013. "Transmission Lags of Monetary Policy: A Meta-Analysis." *International Journal of Central Banking* 9 (4): 39–76.

Khan, M., L. Morel and P. Sabourin. 2013. "The Common Component of CPI: An Alternative Measure of Underlying Inflation for Canada." Bank of Canada Staff Working Paper No. 2013-35.

Khan, M., L. Morel and P. Sabourin. 2015. "A Comprehensive Evaluation of Measures of Core Inflation for Canada." Bank of Canada Staff Discussion Paper No. 2015-12.

Macklem, T. 2001. "A New Measure of Core Inflation." *Bank of Canada Review* (Autumn): 3–12.

Mendes, R. R. 2025. "Underlying Inflation: Separating the Signal from the Noise." Speech at Ivey Business School, London, Ontario, October 2.

Stock, J. H. and M. W. Watson. 2016. "Core Inflation and Trend Inflation." *Review of Economics and Statistics* 98 (4): 770–784.

Sullivan, E. 2022. "Examining Recent Revisions to CPI-Common." Bank of Canada Staff Analytical Note No. 2022-15.

Wolman, A. L. 2011. "The Optimal Rate of Inflation with Trending Relative Prices." *Journal of Money, Credit and Banking* 43 (2/3): 355–384.