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MONETARY POLICY

Inflation after the Crisis: What's the Story?

by

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- Since the 2008–09 global financial crisis, inflation has presented economists with two puzzles: “missing disinflation” during a period of slumping major economies that lasted from 2009 to 2011, and “missing inflation” despite the economic expansion that has occurred since then.
- This E-Brief explores a hypothesis that links the breadth of the economic recovery to inflation’s puzzling behaviour in Canada, with missing disinflation occurring when economic growth, though low, was spread across many industries, and missing inflation occurring when growth was higher but concentrated in a smaller set of industries.
- These findings suggest that the industries that contribute to economic growth matter for inflation behaviour, and as a result, matter for monetary policy.

Over the past decade, inflation has both confused and attracted the attention of economists. After the 2008–09 global financial crisis, when the world’s major economies were slumping, inflation was higher than expected – a “missing disinflation” puzzle that lasted from 2009 to 2011. For much of the time since, despite the economic expansion, inflation has remained low, giving rise to a second puzzle, dubbed “missing inflation.” These puzzles also apply to Canada. Work on these puzzles is ongoing:¹ as Friedrich and Gosselin (2015, p. 1) note, “[t]he post-crisis experience has shown that models need to be regularly supplemented with additional sources of information.”

In this E-Brief, we examine a hitherto unexplored hypothesis linking the breadth of the economic recovery to inflation’s puzzling behaviour in Canada, particularly after the 2008–09

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1 See, among others, Bobeica and Jarociński (2017); Coibion and Gorodnichenko (2015); Cukierman (2013); Ferroni and Mojon (2014); Friedrich (2016); Gilchrist et al. (2015); Kronick and Ambler (2018); Meh and Moran (2008); Williams (2010).



crisis. We show that during the missing disinflation period, growth in the economy, although low overall, spread across many industries. In contrast, during the missing inflation period, when economic growth was higher, it was more concentrated and limited to a smaller set of industries. We confirm this relationship between economic breadth and inflation behaviour during and after the crisis with a series of econometric tests. The robustness of this link suggests that the industry makeup of economic growth matters for inflation behaviour, and as a result, matters for monetary policy.

Literature

To understand the two post-crisis inflation puzzles, it is helpful to explore the theoretical models that underpin inflation. Economists mostly agree that the quantity theory of money (see Friedman 1968) holds in the long run. In other words, changes in the money supply eventually drive changes in spending behaviour and, therefore, prices. The central sticking point is how one defines the long run. For monetarists, any deviations from trend are considered minor and short lived, meaning that central banks can affect inflation through a change in the money supply. Inherent in this view is the assumption that transaction velocity – how quickly money changes hands and its corresponding impact on overall spending in the economy – is stable and/or predictable.

In contrast, the Bank of Canada, as seen for example in Friedrich (2016), takes the Keynesian view that price and wage rigidities are critical to inflation dynamics. Velocity is largely unstable and unpredictable, and the focus of monetary policy, therefore, should be on the demand for goods and services and bringing the economy back to full employment. This widespread view has led to extensive theoretical models of inflation, most of which boil down in their basic form to the three-equation New Keynesian model – see Rowe (2014) for a brief summary of the history and development of this model. We do not take a stand on either view, but given the prevalence of New Keynesian modelling at the Bank, we follow the same methodology in analyzing the behaviour of inflation in Canada.

The Two Puzzles

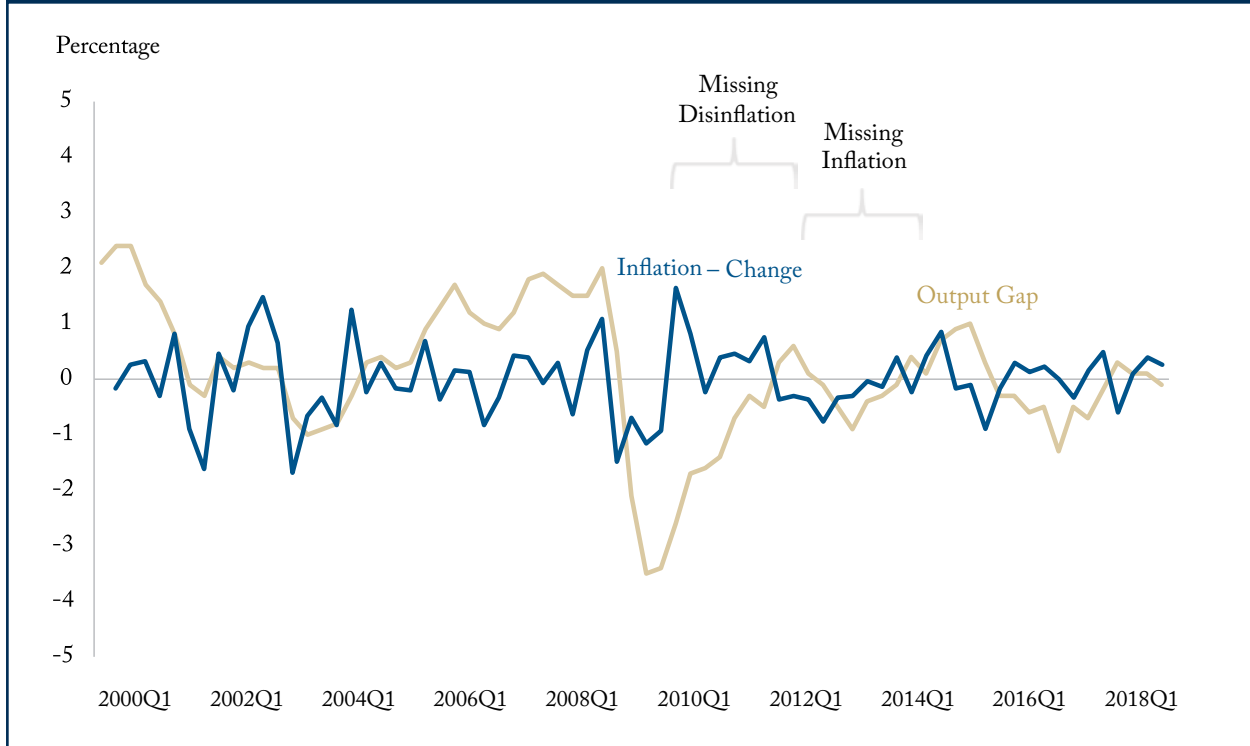
In the post-crisis period, many advanced countries, including Canada, have experienced the puzzles of both missing disinflation and missing inflation (Figure 1). Missing disinflation is generally regarded to have lasted from late 2009 to the end of 2011 (Friedrich and Gosselin 2015), and was characterized by constant or even increasing inflation, despite significant economic slack from the global financial crisis. The missing inflation puzzle, which has lasted much of the time since, has the exact opposite description: despite economic rebounds and closing output gaps, headline inflation remains below target for many inflation-targeting central banks. In Canada's case, inflation has averaged 1.56 percent since 2012,² well below the Bank of Canada's 2 percent target.

Much work has been done to explain these two puzzles. In this E-Brief, we focus on one paper in particular: Friedrich (2016), who shows that the New Keynesian Phillips curve (NKPC) does a poor job of explaining global inflation – in particular, after the financial crisis. He evaluates a series of variables to determine which ones help explain this post-crisis gap between global inflation and the predictions of the curve (for more detail, see [Appendix A, available online](#)), and finds that household inflation expectations, the government's fiscal policy stance and the growth of world energy prices all help to explain global inflation behaviour during the puzzle periods.

In this E-Brief, we test whether the same variables similarly explain the gap between Canada's actual inflation and inflation estimated by the NKPC, and find that these variables, although relevant, are not sufficient in Canada's case to explain inflation behaviour during the puzzle periods nor during the depths of the financial crisis. We

2 Average from Jan. 2012 to the end of May 2019.

Figure 1: Output Gap and Changes to Inflation, Canada, 2000–2018



Note: Inflation refers to headline inflation, which includes items with more volatile prices, such as food and energy.

Sources: Bank of Canada, Statistics Canada and authors' calculations.

therefore ask what additional variable(s) might explain the remaining gap, with a particular focus on the breadth of economic growth.

Broad-based Growth

Because monetary policy is evaluated and executed at a national level, researchers use country aggregates to evaluate the response of macroeconomic variables. If we take the NKPC, for example, the output gap is a country-aggregate measure of actual output minus potential output. Similarly, inflation expectation forecasts involve aggregate economy-wide inflation – that is, headline inflation. This means it is difficult to model any nuance about the type of economic growth we are seeing and what that implies for inflation. For example, we know that different goods and services have different price sensitivities (Cravino, Lan, and Levchenko 2018), and we also know that different income groups purchase different goods and services (Almås 2012). Therefore, we might end up with the same degree of economic growth but with vastly different implications for inflation depending on who, as well as what industries, are taking part in the income gains associated with an expanded economy. Cravino, Lan, and Levchenko (2018) show that the response of the consumer price index to monetary policy is 22 percent lower for higher-income households than for middle-income households. So, if more resources are

concentrated in higher-income households, the effect of monetary policy on inflation is likely to be more muted, due to this group's lower marginal propensity to consume.

One nuanced way of looking at economic growth and its effect on inflation is to study how broad is the growth – in other words, to ask whether economic growth is concentrated in one or two sectors or is more widespread. It is possible that the more widespread, or less concentrated, growth is, the more resources are spread across different income quintiles, rather than concentrated at the top. This implies that, with increased breadth, an increase in economic growth would cause an increase in the marginal propensity to consume, leading to increased inflation sensitivity to a monetary policy shock.³

To test this possibility, we use diffusion indices found in Kronick (2016) as measures of broad economic growth.⁴ When comparing these diffusion indices to inflation (Figure 2), it appears that broad-based economic growth is positively correlated with inflation and, in fact, is a leading indicator. Broad-based growth also appears to have fallen during the collapse in inflation in the 2008–09 financial crisis, risen in the missing disinflation period and retreated during the missing inflation period, at least the early part.

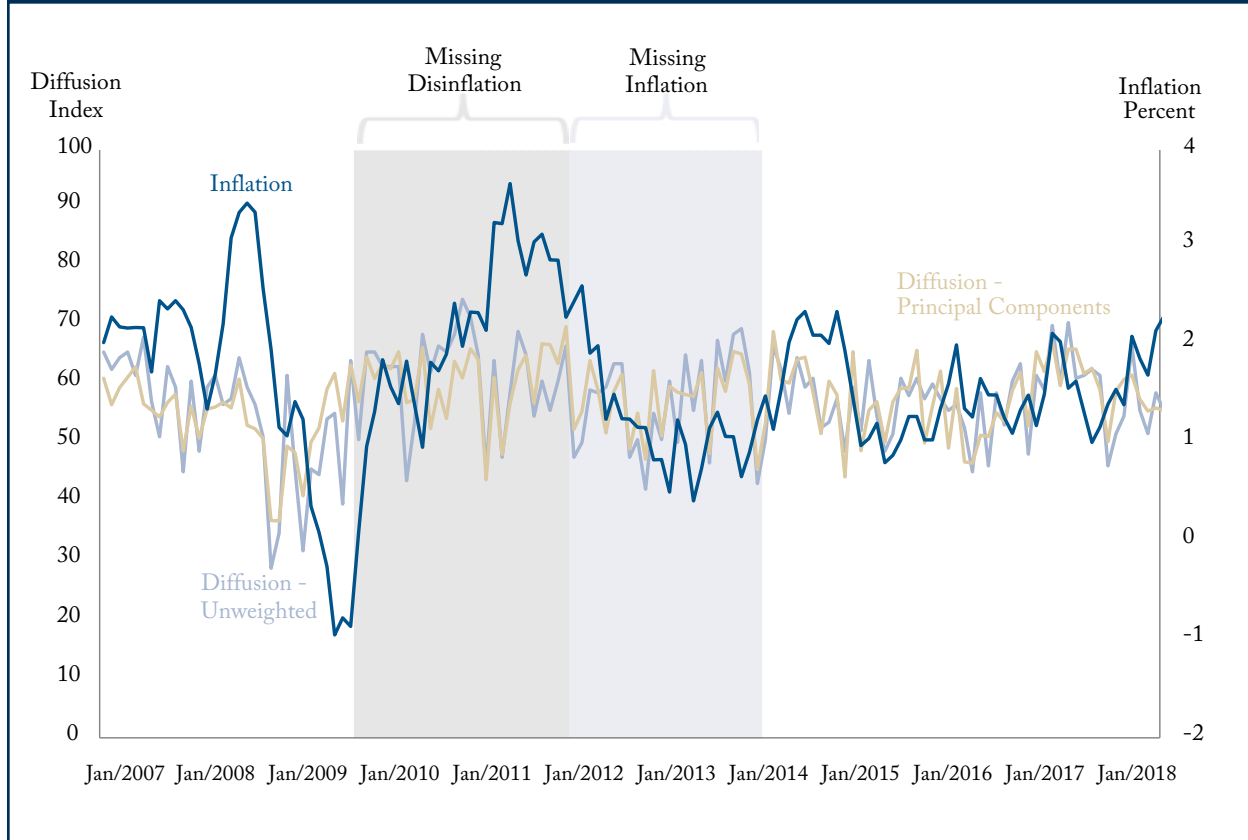
Identifying the specific sectors behind the evolution of the diffusion index during the puzzle periods further supports its potential importance in explaining inflation behaviour post-crisis (Table 1). Lower-income households – with higher marginal propensities to consume – disproportionately spent on sectors that grew the most,⁵ and propped up inflation, during the missing disinflation period. The lowest-income households allocated 34 percent of their spending toward these sectors, whereas the highest-income households allocated 21 percent. Similarly, sectors that contracted the most, thereby dampening inflation, during the missing inflation period, were those where lower-income households typically spend relatively more (22 percent versus 20 percent).

Empirical Methodology and Results

We began our empirical work, using Friedrich's (2016) methodology,⁶ by testing whether the NKPC does a good job of explaining inflation in Canada, with a focus on the post-crisis puzzle periods. It did not. We then tested

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- 3 Of course, it is also possible that an economy in which a few sectors are experiencing strong excess demand might generate more price pressures than an economy with equivalent aggregate demand but in which demand is spread equally across all sectors, but with some distance from potential.
 - 4 We focus on the unweighted diffusion index, which measures whether most Canadian industries – not weighted by their economic importance – have grown or not, on balance, in a particular quarter. Kronick (2016) also describes a principal components analysis version of the diffusion index that focuses on the underlying trend and co-movements of data across industries. The issue in using this version for the formal analysis in this E-Brief is the limitation of the sample, which begins only in 2007. See Kronick (2016) for more detail on the different indices and methodologies.
 - 5 To determine which sectors grew the most (or least) during the two puzzle periods, we first counted the number of months a sector grew (or contracted) during a particular puzzle period using our diffusion index industry breakdown. We then calculated the average number of months with positive (or negative) growth during that period. Sectors that grew (or contracted) more than the average plus one standard deviation make up our two samples. See Kronick and Villarreal (2019) for a description of how to calculate sectoral percentage spending by income quintile.
 - 6 We acknowledge that single-equation statistical evidence for the NKPC, as used in Friedrich, has been mixed. For example, Nason and Smith (2008) estimate the NKPC for the United States since 1955, and find the expected positive coefficients, but with wide confidence intervals. Estimates of the NKPC using surveys of forecasters for expected inflation give very different results than those using instrumental variables, indicating endogeneity concerns.

Figure 2: Inflation and Diffusion Indices of Economic Growth, Canada, 2007 to 2018



Sources: Statistics Canada, Kronick (2016) and authors' calculations.

whether Friedrich's explanatory variables sufficiently explain the gap for Canada, and whether other variables, including the diffusion index, provide value added.

We first estimated inflation in Canada using the simple NKPC – equation (1) in online Appendix A – over the period between the first quarter of 1995 and the third quarter of 2018, referring to it as the “baseline.” The simple NKPC states that inflation is a function of people's expectations about future inflation and how successful the economy is at producing to its potential. Our measure of economic slack is the Bank of Canada's output gap measure.⁷ Unfortunately, in Canada, there are no time-series data for household inflation expectations, and publicly available professional forecast data provide only a range of expectations. We therefore employed long-term forecasts of financial markets using the implicit spread between long-term nominal and real bond yields.⁸

- 7 Our primary specification uses the integrated framework, although we did replace it with the extended framework in our robustness tests, with no significant changes to the results.
- 8 Friedrich and Gosselin (2015, fig. 6) compare professional forecasters' data to the same long-term spread between nominal and real bond yields we used here. Although the latter is not a perfect match with the former, alternatives for Canada are not publicly available as far as we can tell.

Table 1: Expanding (Contracting) Sectors during the Missing Disinflation (Inflation) Puzzle

Expanding Sectors – Missing Disinflation	Contracting Sectors – Missing Inflation
Water and sewage for principal accommodation	Pet expenses
Repairs and maintenance for owned living quarters	Natural gas for principal accommodation
Tenants' repairs and improvements	Clothing (women and girls ages 4 years and over)
Gas and other fuels (all vehicles and tools)	Clothing (men and boys ages 4 years and over)
Air Transportation	Gas and other fuels (all vehicles and tools)
Other automobile, van and truck operation services	Paper, plastic and foil supplies
Rent	Meat
Mortgage paid for owned living quarters	Fish and seafood
Health care services	Dairy products and eggs
Tuition fees	Bakery products
Textbooks and school supplies	Cereal grains and cereal products
	Fruit, fruit preparations and nuts
	Vegetables and vegetable preparations
	Alcoholic beverages
	Tobacco products and smokers' supplies
	Tuition fees
	Textbooks and school supplies

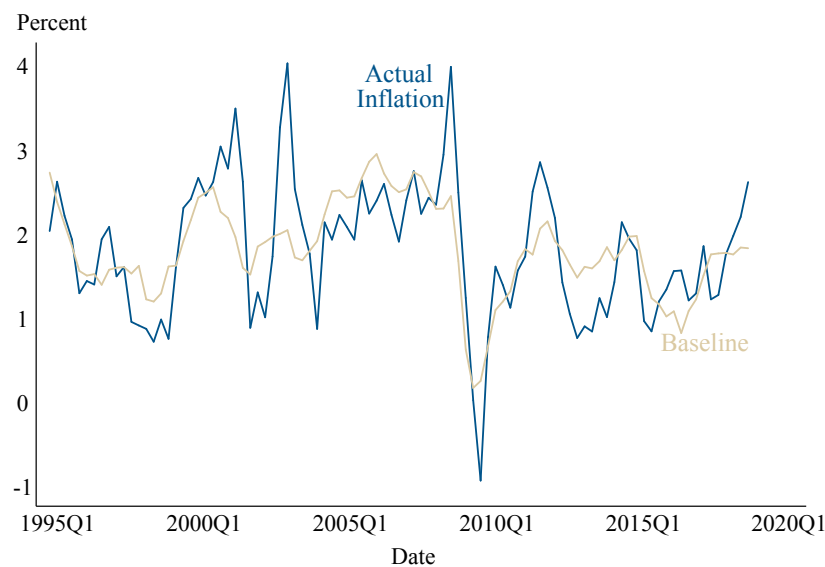
Sources: Statistics Canada and authors' calculations.

We found that significant gaps exist between estimated and actual inflation, including during the crisis and post-crisis puzzle periods (Figure 3).⁹

There also appears to have been a change in inflation behaviour before, versus during and after the financial crisis. To investigate, we created a scatterplot of surprise inflation (the difference between inflation and inflation expectations) and the output gap. Consistent with Friedrich's (2016) findings, during the post-crisis period there is both a steeper slope and a higher intercept (Figure 4). What this means is that surprise inflation was more sensitive to movement in economic slack, but it was also on a different plane, for reasons that have nothing to do with economic slack. Omitted variables are thus at play in explaining inflation's post-crisis behaviour.

⁹ Appendix B, available online, contains all the variables and sources used throughout this E-Brief.

Figure 3: Actual versus Baseline Estimated Inflation, Canada, 1995:Q1-2018:Q3



Note: “Baseline” is the in-sample estimated inflation for the baseline New Keynesian Phillips curve specification

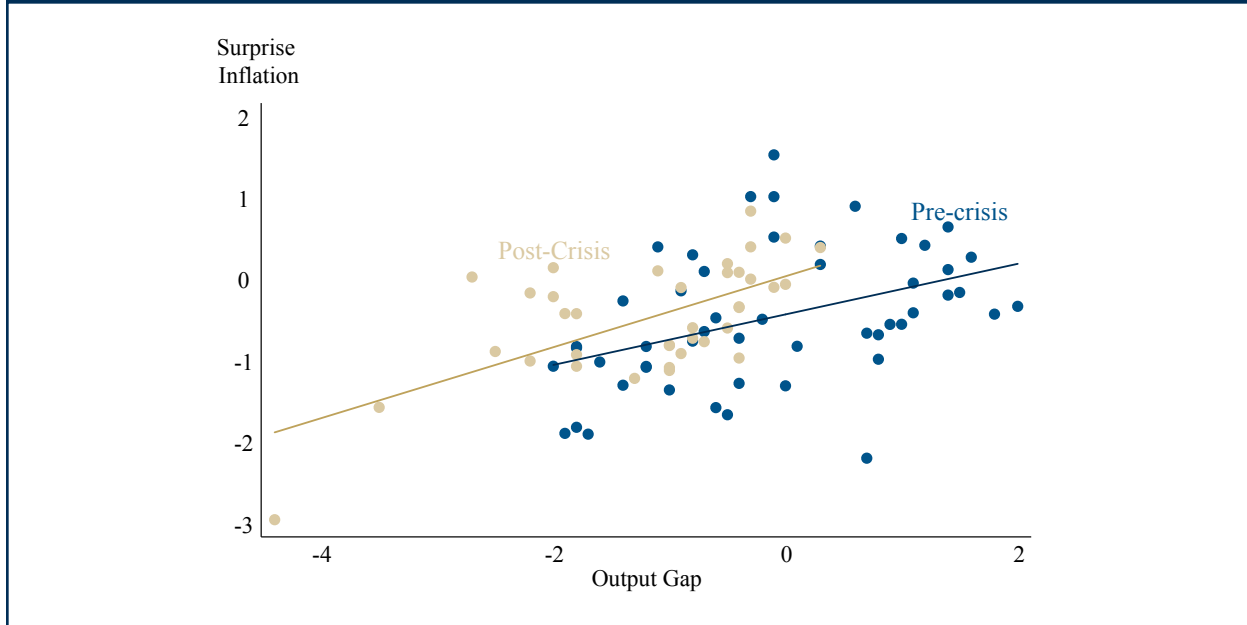
Given this post-crisis change in inflation behaviour, we inserted a puzzle dummy covering the period between 2009:Q3 and 2013:Q4 in the baseline NKPC.¹⁰ We inserted this dummy variable independently, and also had it interact with our output gap and inflation expectations variables. This allowed the coefficients on the output gap and inflation expectations to differ pre- and post-crisis – see equation (2) in online Appendix A. Inserting this puzzle dummy variable led to a much better fit for inflation during the 2009:Q3–2013:Q4 period (Figure 5). The definition and significance of the dummy variable means some structural change occurred over the two distinct periods. The question then becomes: for what variable(s) is this dummy proxying? There is a long list of potential candidates – see Friedrich (2016) for an exhaustive list.

To answer this question, we began by taking Friedrich’s (2016) findings as given at the global level, and tested whether they hold in Canada. To test different candidates, Friedrich replaces the puzzle dummy with each of his variables – equation (3) in online Appendix A. He then ranks them by their mean squared error over the full sample period (lowest to highest).¹¹ He finds that the dummy, at the global level, is proxying for household inflation expectations, the fiscal policy stance and growth in world energy prices – equation (4) in online Appendix A. Unfortunately, Canada does not have publicly available household inflation expectations data. To

10 Although, in a few pre-crisis instances – particularly in the early 2000s – the NKPC did a poor job of explaining inflation as well, our focus is on the puzzle periods.

11 Mean squared error measures the average of the squares of the errors – the difference between the estimated values and what is being estimated.

Figure 4: Surprise Inflation - Output Gap Relationship, Canada, Pre- and Post-Crisis



Note: The lines are lines of best fit passing through the scatter points.

Sources: Bank of Canada, Statistics Canada and authors' calculations.

compensate, we added agriculture price inflation data from the Bank of Canada, since, as Friedrich points out, household inflation expectations are most likely a proxy for “energy- and food-price dynamics,” and we added energy prices separately in the analysis.¹²

Figure 6 shows the results of adding Friedrich’s variables to our baseline estimation.¹³ These variables help to explain some of the fall in inflation during the financial crisis, but only a bit of the missing disinflation puzzle and almost none of the missing inflation period.¹⁴

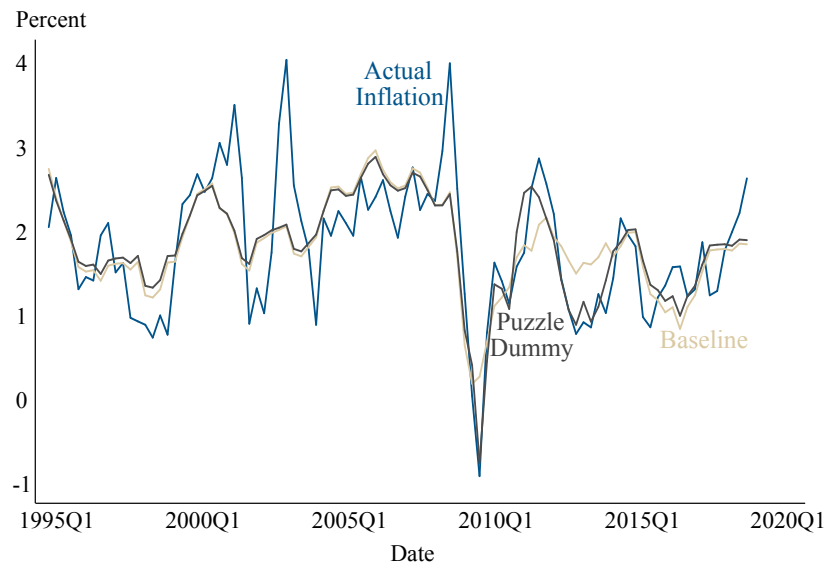
This finding suggests that other variables are relevant in Canada’s case. We tested whether the breadth of economic growth can explain part of the remaining story by adding the diffusion index variable to equation (4) in Appendix A, which includes Friedrich variables. We ran the new equation both with the diffusion index on its

12 We note that making inflation expectations data in Canada more accessible to the public would be helpful for the broader research community.

13 We found that Canada’s fiscal policy stance had no significance, either in the regression (on its own or with the other Friedrich variables) or in the in-sample fit, so we removed it for parsimony’s sake. Doing so did not change the results, which are available upon request.

14 We note that Friedrich’s variables do explain the pre-crisis inflation behaviour better than does the basic NKPC.

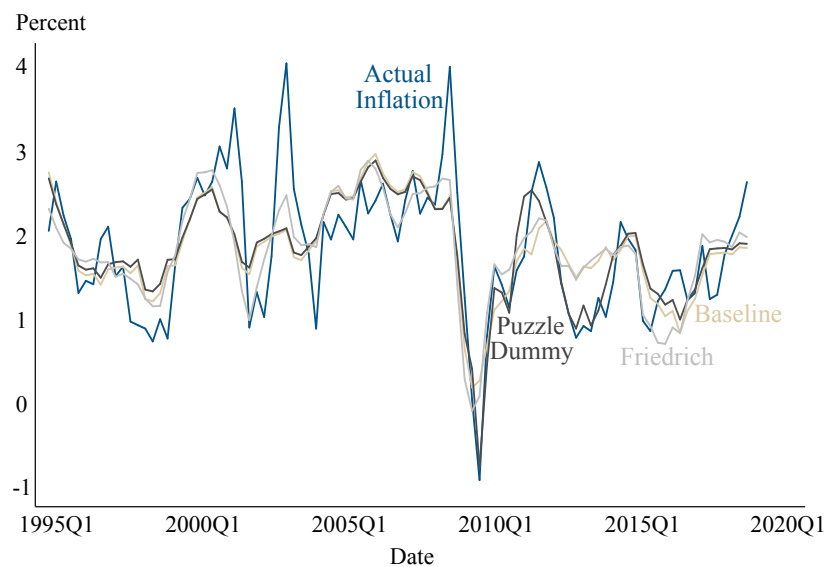
Figure 5: Estimated Inflation with a Puzzle Dummy, Canada, 1995:Q1–2018:Q3



Note: “Puzzle Dummy” is the in-sample estimated inflation for the baseline NKPC specification with a dummy that equals 1 during the puzzle periods, and 0 otherwise.

Sources: Bank of Canada, Statistics Canada and authors’ calculations.

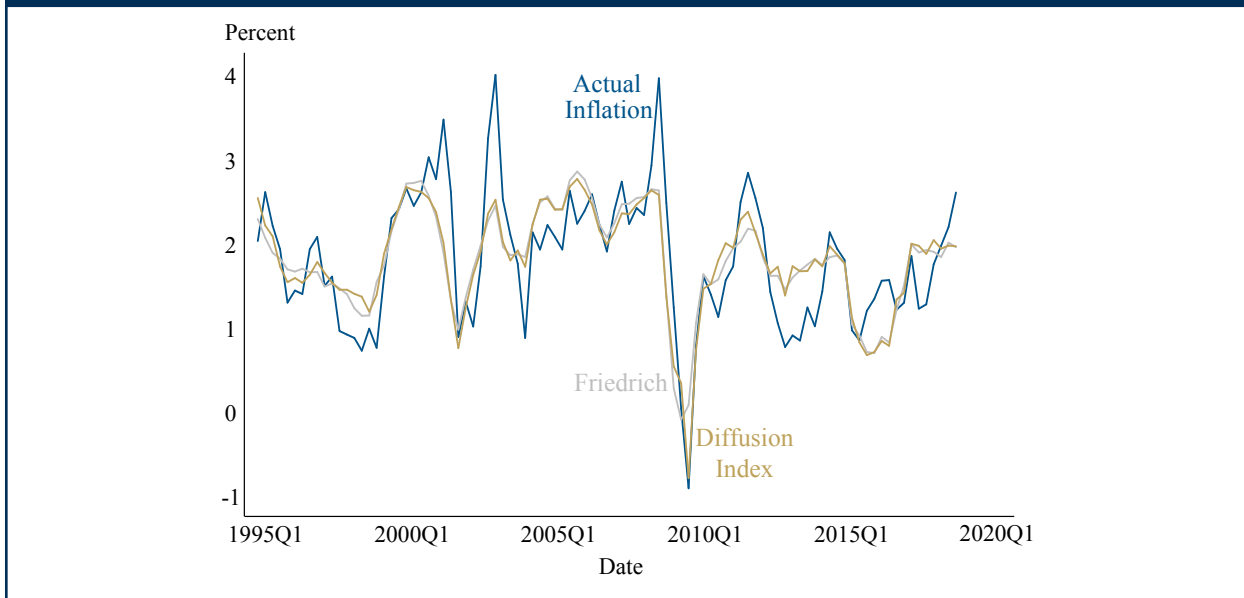
Figure 6: Estimated Inflation with Variables from Friedrich (2016), Canada, 1995:Q1–2018:Q3



Note: “Friedrich” is the in-sample estimated inflation for the baseline NKPC specification with food prices proxying for households’ inflation expectations and world energy prices.

Sources: Bank of Canada, Statistics Canada and authors’ calculations.

Figure 7: Estimated Inflation with Friedrich's (2016) Variables and Diffusion Index, Canada, 1995:Q1-2018:Q3



Note: "Diffusion Index" is the in-sample estimated inflation for the baseline NKPC specification with Friedrich's variables, in addition to our measure of broad-based growth.

Sources: Bank of Canada, Statistics Canada, Kronick (2016) and authors' calculations.

own and interacted with the output gap and inflation expectations variables (Figure 7).¹⁵ The results indicate that the diffusion index is critical in explaining the remaining decline in inflation during the crisis, and improves the explanation of the missing disinflation period. Although it improves the fit only marginally (if at all) during the missing inflation period, it does better capture inflation's higher-frequency dynamics.

Robustness, Sensitivity and an Extension

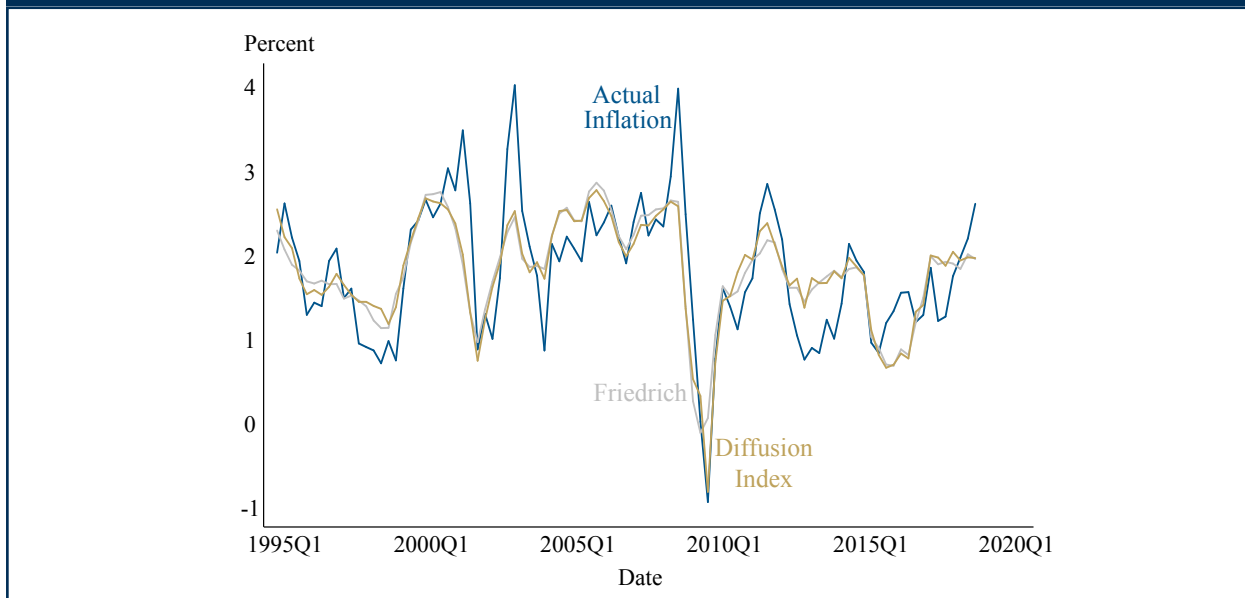
We conducted a series of robustness checks and sensitivity analyses on the relevance of the diffusion index, and present two here. The first robustness check involved replacing the output gap measure with a different measure of economic slack: the deviation from the trend of unemployment.¹⁶ As shown in Figure 8, the importance of the diffusion index continued to hold, indicating its robustness to the choice of economic slack variable.¹⁷

15 Note that the coefficient when the diffusion index is on its own is of the expected sign (positive), but when it is interacted, the sign on its interaction with the output gap is negative – see Table C1 in online Appendix C. This is accompanied by a big increase in the coefficient on the output gap itself. This suggests that, as the diffusion index increases (or decreases), the effect of the output gap on inflation diminishes (or gets larger). We leave further investigation of this issue for future research.

16 We calculated deviation from the trend with a Hodrick-Prescott time-series filter with a smoothing parameter of 1,600.

17 We also tested unemployment in levels, and the extended framework output gap, with no change to the main conclusion.

Figure 8: Replacing the Output Gap with the Deviation from the Unemployment Trend, Canada, 1995:Q1-2018:Q3



Note: “Friedrich” and “Diffusion Index” are the in-sample estimated inflation for the same specifications as in Figures 6 and 7, but we replaced the output gap variable with a measure of the deviation from unemployment’s trend.

Sources: Bank of Canada, Statistics Canada, Kronick (2016) and authors’ calculations.

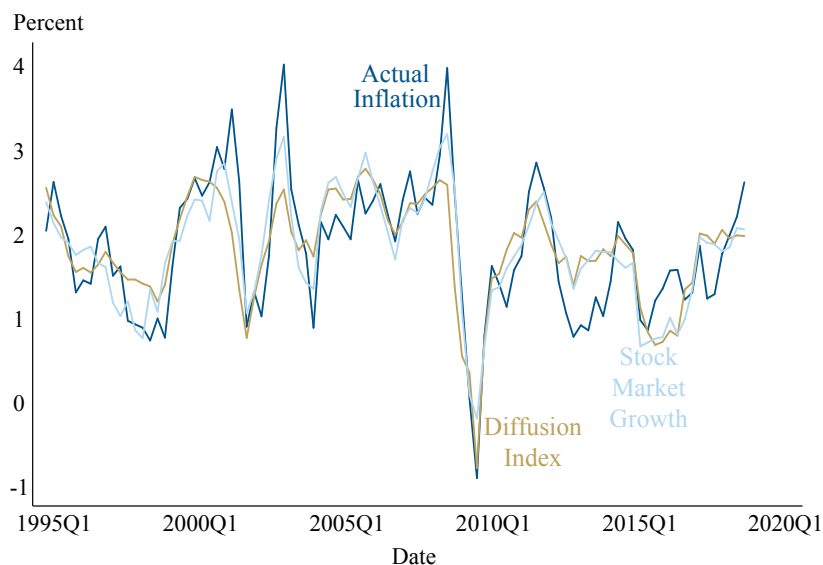
Second, instead of arbitrarily adding the diffusion index, we added the variable with the lowest mean squared error, as in Friedrich (2016). Two variables rank ahead of the diffusion index in terms of having the lowest mean squared error: stock market growth and financial market uncertainty – see Table C2 in online Appendix C. We tested these variables to see if they produced a better in-sample fit than the diffusion index.

The results are mixed. Using stock market growth, we found an improvement in the in-sample fit pre-crisis, but it did not do as well in explaining the crisis collapse and did about the same as the diffusion index in explaining the puzzles (Figure 9). On the other hand, financial market uncertainty better explains the missing disinflation period, while the diffusion index better explains the collapse. Both were comparable during the missing inflation period, but the diffusion index did better capturing the higher-frequency dynamics (Figure 10).

As an extension, we estimated a simple structural vector autoregression (SVAR)¹⁸ to determine whether the diffusion index had the hypothesized effect on inflation – that is, caused inflation to increase following a positive shock and to decrease following a negative shock. Appendix D, available online, has further details, but suffice it to say here that we tested the impact on inflation resulting from a shock to each of the standard NKPC determinants (output gap and inflation expectations), to Friedrich’s variables (global agriculture price inflation, global energy price inflation and fiscal policy stance), and to the diffusion index.

18 A model used to explore linear interdependencies over multiple macroeconomic time series variables.

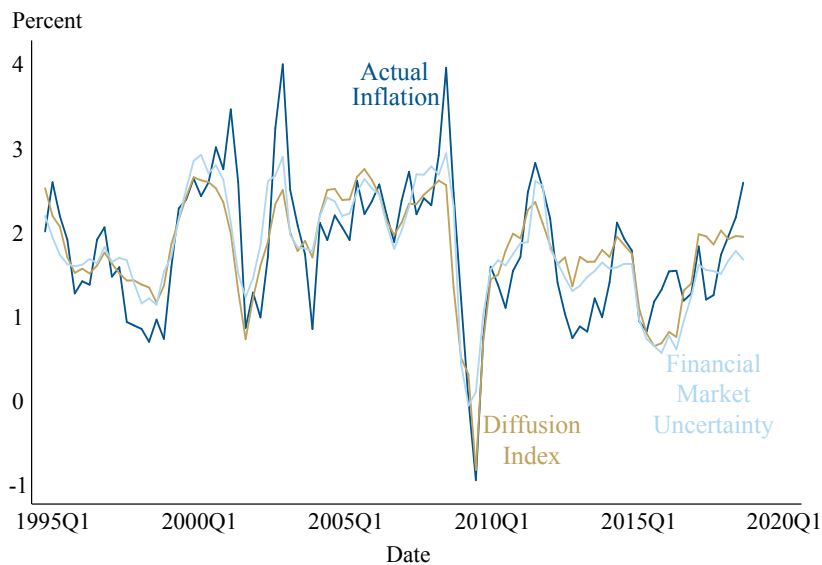
Figure 9: Replacing the Diffusion Index with Stock Market Growth, Canada, 1995:Q1-2018:Q3



Note: We return to using the output gap variable as in the primary specification.

Sources: Bank of Canada, Statistics Canada, Kronick (2016), MSCI and authors' calculations.

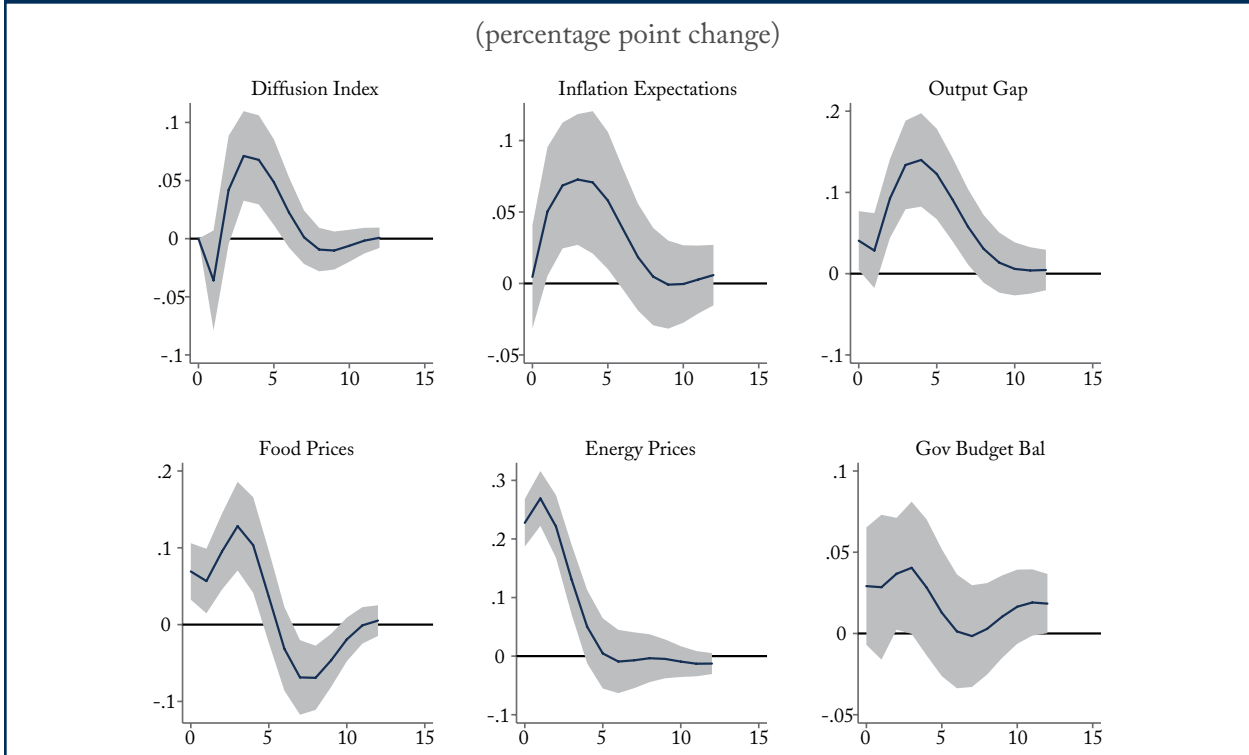
Figure 10: Replacing the Diffusion Index with Financial Market Uncertainty, Canada, 1995:Q1-2018:Q3



Note: We return to using the output gap variable as in the primary specification.

Sources: Banks of Canada, Statistics Canada, Kronick (2016), Chicago Board Options Exchange and authors' calculations.

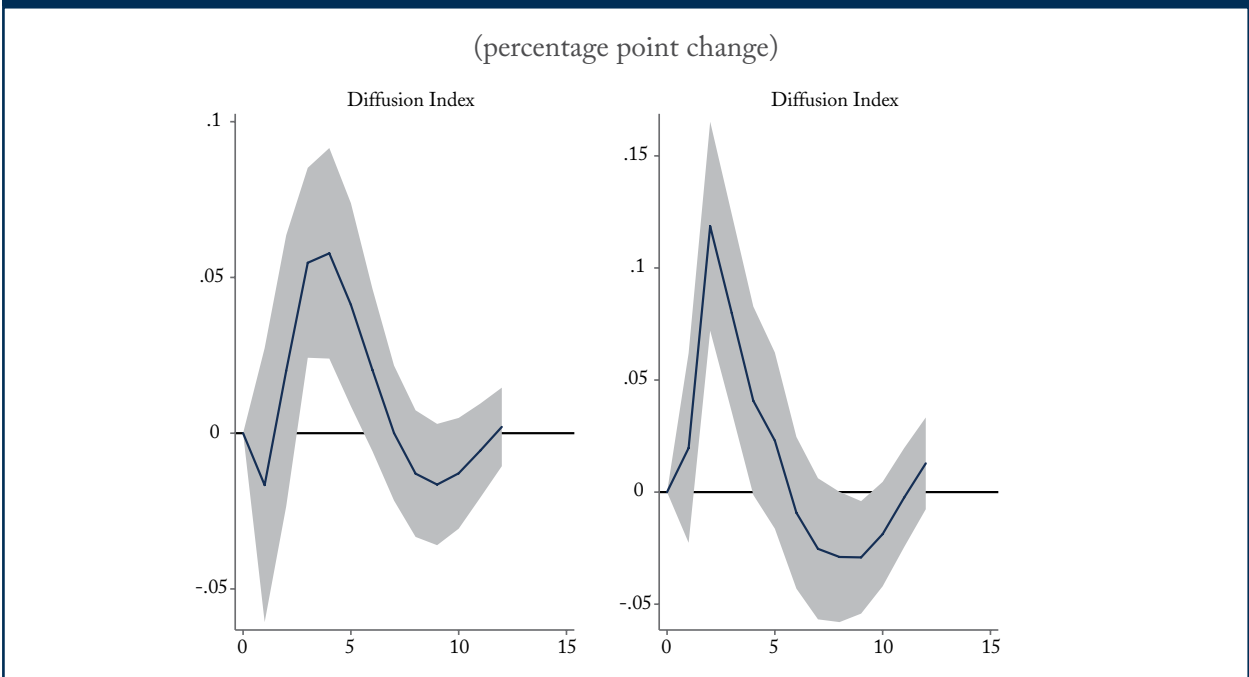
Figure 11: Structural Vector Autoregression Results on Inflation



Note: Shaded area = confidence interval.

Sources: Bank of Canada, Statistics Canada, Kronick (2016) and authors' calculations.

Figure 12: Structural Vector Autoregression Results on Inflation, Pre- and Post-Crisis



Note: Shaded area = confidence interval.

Sources: Bank of Canada, Statistics Canada, Kronick (2016) and authors' calculations.

Figure 11 displays the results of a positive shock (forecast out 12 quarters), although the effects of a negative shock are symmetric. The results indicate that the diffusion index had the expected effect on inflation – an increase with a lag following a positive shock – while the effect of other variables also followed conventional wisdom.¹⁹ We also ran the SVAR from the beginning of our sample to 2008:Q3, and from 2009:Q3 on (that is, pre- and post-crisis) in order to test whether the diffusion index played an outsized role during the post-crisis period. Looking at the impulse responses in Figure 12, the peak coefficients were higher in the post-crisis environment (12 basis points versus 6 basis points).

Conclusion

The monetary policy transmission mechanism continues to be a challenge in the post-crisis, low-inflation, low-interest-rate environment. With inflation in many countries still below target, however, the riddle has not been solved. We show in this paper that broad-based growth, or the lack thereof, is an important factor in explaining inflation behaviour in Canada during the puzzle periods. The implication for the Bank of Canada is that the industrial composition of economic growth is important when considering the likely effect of a monetary policy shock.

19 Note the SVAR results are not sensitive to different lags or different orderings. Also, note that the expected sign for a government budget balance shock on inflation is negative, and while the point estimate in the SVAR is positive, it is largely insignificant, consistent with our primary regression specification findings.

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