Inflation Dynamics in the Post-Crisis Period

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- Inflation rates in advanced economies experienced two unusual patterns during the period following the global financial crisis—relatively high inflation with respect to the size of the output gap from the end of 2009 to 2011 and relatively low inflation from 2012 to the middle of 2014.

- There are a variety of explanations for these patterns, such as variation in the relationship between inflation and economic slack over time, the impact of movements in commodity prices or the evolution of inflation expectations.

- While the pattern of inflation dynamics in Canada appears, for the most part, similar to that in other advanced economies, Canadian inflation in the post-crisis period was also affected by elevated competition in the retail sector.

- The post-crisis experience has shown that models need to be regularly supplemented with additional sources of information. When modelling inflation, this means paying greater attention to inflation expectations from various sources.

The Bank of Canada conducts monetary policy by targeting 2 per cent inflation. Given delays in the transmission of monetary policy, it is important for the Bank to identify factors that are likely to have a persistent effect on inflation. While the output gap, defined as the difference between actual output and potential output, is the main driver of cyclical movements in inflation, many other drivers influence the assessment of inflation developments, such as the transitory effects of exchange rate variations on import prices or sector-specific price changes. Understanding the behaviour of inflation since the global financial crisis has been challenging because inflation evolved differently from what these drivers would suggest. In this article, we analyze the post-crisis behaviour of inflation and provide explanations for its evolution.

The Behaviour of Inflation

Inflation in advanced economies has fluctuated significantly since the onset of the global financial crisis. The period from the first quarter of 2006 to the second quarter of 2014 can be roughly divided into four distinct episodes (**Chart 1**):

(i)   **Pre-crisis period** (2006Q1 to 2007Q3). Inflation rates were relatively stable, and Canada's inflation rate was in line with the median inflation rate of a large sample of advanced economies.[1]

(ii) **Crisis period** (2007Q4 to 2009Q3). Inflation rates were very volatile but with a high synchronicity across countries. While Canadian inflation was slightly lower than the median in 2008, it joined the common inflation dynamics of the multiple-country sample afterward. The common dynamics of total inflation during this period was largely due to the significant swings in global oil prices and widening output gaps. The falling inflation rates during the crisis were well explained by Phillips curve predictions in many advanced countries (**Box 1**). This, however, changed in the post-crisis period, when inflation developments became increasingly inconsistent with output gap dynamics.

(iii) **Early post-crisis period** (2009Q4 to 2011Q4). Inflation rates picked up and increased steadily. With few exceptions, this trend was common across countries, and Canada's inflation rate aligned strongly with the median inflation rate of the sample of advanced economies. The combination of constant or even rising inflation rates and the high level of economic slack constitutes the **first puzzle** of post-crisis inflation dynamics.

◄ *The combination of constant or even rising inflation rates and the high level of economic slack constitutes the first puzzle of post-crisis inflation dynamics*

Chart 1:   Inflation dynamics around the global financial crisis

Headline inflation rates on a year-over-year basis

— Canada   — Median   — 3rd-highest and -lowest values in sample
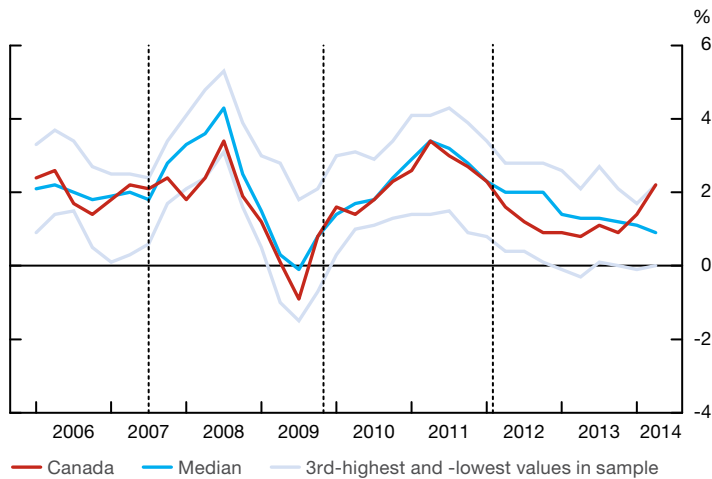
Note: The sample includes the countries listed in footnote 1, below, with the exception of Iceland and Ireland. Their inflation rates are excluded because they both contain outliers during the sample period. However, both countries will be included in the empirical analysis later on, where such differences can be taken into account.

Source: Organisation for Economic Co-operation and Development   Last observation: 2014Q2

1   The countries in the sample are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, South Korea, Spain, Sweden, Switzerland, the United Kingdom and the United States.

Box 1

The Phillips Curve

The Phillips curve characterizes the relationship between inflation, inflation expectations and a measure of economic slack that represents the impact of the business cycle. In empirical studies, the measure of economic slack is often replaced by the output gap (i.e., the difference between actual and potential GDP) or deviations of the unemployment rate from its trend. Inflation expectations are usually approximated using inflation expectations of professional forecasters. The Phillips curve can contain additional terms to capture supply-side factors (e.g., commodity price inflation) or international factors (e.g., import price inflation or exchange rate variations). In this article, we describe inflation dynamics at two different levels of aggregation: at the global level and in Canada. In both cases, we rely on the following stylized Phillips curve specification to identify the drivers of inflation:

$$\pi_t = a + E_t(\pi_{t+1}) + bygap_t + c\Delta er_t + \epsilon_t$$

This specification contains an intercept, a; inflation expectations, $E_t(\pi_{t+1})$; a measure of economic slack, $ygap_t$; and changes in the exchange rate, Δer_t.[1] Any other factor not captured by these determinants will be reflected in the error term, ϵ_t.

1   The measure of exchange rates is included only in the Canadian analysis, since exchange rate dynamics would cancel out at the global level. The parameters b and c represent coefficients that capture the relationship between inflation and its drivers.

(iv) **Late post-crisis period** (2012Q1 to 2014Q2). Inflation rates in advanced economies experienced a clear downward trend. Canadian inflation was somewhat different from the sample median, showing a stronger decline in 2012–13 followed by an increase in 2014. Overall, falling inflation rates were rather surprising at this point, since we observed gradually declining amounts of economic slack for many of the countries in the sample.[2] This is the **second puzzle** of post-crisis inflation dynamics.

◄ *The downward trend in inflation rates, along with gradually declining amounts of economic slack in advanced economies, is the second puzzle of post-crisis inflation dynamics*

Given the close appearance of the two puzzles, we refer to them jointly as the **twin puzzle**. The twin puzzle also exists for global core inflation dynamics, i.e., total inflation minus inflation in energy and food prices. Core inflation rates remained elevated globally, despite large amounts of economic slack during the first part of the post-crisis period, and started falling, despite the onset of the global recovery shortly after.[3]

The Twin Puzzle at the Global Level

Why were inflation dynamics inconsistent with the evolution of economic slack during the post-crisis period? To shed light on this question, we review potential explanations from the literature and highlight the results of recent work carried out at the Bank of Canada.[4]

2   European countries were notable exceptions, since output gaps were still widening in light of the European debt crisis.

3   While there are many different measures of core inflation, we use the definition excluding food and energy prices for international comparability.

4   Although it would be preferable to assess both total and core inflation dynamics internationally, data on expectations for core inflation are generally not available; thus, the analysis focuses on total inflation only.

Explanations for the first puzzle

The **first puzzle** of inflation dynamics was initially noted in the context of U.S. inflation. Williams (2010) refers to a missing disinflation puzzle, noting that, "based on the experience of past severe recessions," he would have expected "inflation to fall by twice as much as it has." Empirical studies have subsequently provided explanations for the U.S. case: time variation in the sensitivity of inflation to economic slack (Ball and Mazumder 2011; Murphy 2014) and too little weight attributed to the impact of commodity price movements (Gordon 2013). In addition, Coibion and Gorodnichenko (2015) show that replacing inflation expectations by professional forecasters with inflation expectations by households restores the Phillips curve in the United States.[5]

Potential explanations for the first puzzle discussed in the theoretical literature include the following: the dependence of inflation on expected future marginal costs instead of the current level of economic activity (Del Negro, Giannoni and Schorfheide 2014); the impact of a firm balance-sheet channel that induces firms with weak balance sheets to raise prices and sacrifice future sales in order to boost current cash flows (Gilchrist et al. 2014); and the combination of a fall in productivity with rising costs of capital leading to upward pressure on inflation (Christiano, Eichenbaum and Trabandt 2014).

The generalization of the first puzzle internationally was documented by the International Monetary Fund (2013), which argued that stable inflation expectations arising from the credibility of the inflation-targeting efforts of central banks over the previous decades and a long-term decline in the sensitivity of inflation to economic slack were key explanatory factors of the observed resilience in inflation in the early post-crisis period.

Explanations for the second puzzle

Since it is a more recent phenomenon, the **second puzzle** has, to date, received less attention from academic researchers. Ferroni and Mojon (2014) examine the predictive content of global inflation for domestic inflation. They find that demand (rather than supply) shocks, which contain varying contributions of global and domestic components across countries, are likely the main drivers of inflation dynamics after 2009. Riggi and Venditti (2014) maintain that the failure of forecasts in the second part of the post-crisis period was caused by a break in the cyclicality of inflation. They argue that the sensitivity of inflation to the output gap has recently increased, owing to a decline in the average duration of price shocks and fewer strategic complementarities in price setting resulting from a smaller number of firms in the economy.

Are the two puzzles connected?

Given the close appearance of the two puzzles, the Bank has examined whether they could be connected. Following Friedrich (2014), we calculate a "global" measure of inflation based on information from the 25 countries in the sample. The global measure is obtained by extracting a common component among national inflation rates.[6] In line with the evidence just discussed, our measure of global inflation rises at the beginning of the post-

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5   This could reflect the possibility that small firms form their inflation expectations in a similar way to households, which, in turn, have inflation expectations that are highly dependent on oil price dynamics. See Ehrmann, Pfajfar and Santoro (2014).

6   The common component has been extracted through a static factor model. More details on this method and alternative extraction procedures are documented in Friedrich (2014).

Chart 2:   Global inflation, Canadian inflation and the twin puzzle
Quarterly data
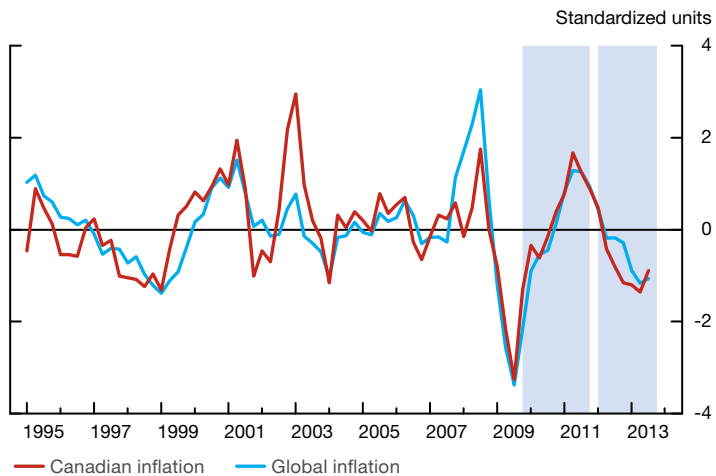
Note: Both the global measure of inflation dynamics and the measure of Canadian inflation have been standardized by subtracting the mean and dividing by the standard deviation. The measure of global inflation has been identified using the first factor of a static factor model with inflation rates for the same set of 25 advanced countries. The chart also marks the presence of the twin puzzle (shaded areas).

Source: Bank of Canada   Last observation: 2013Q3

crisis period, i.e., during the first puzzle period, and trends downward during the second part of the post-crisis period, i.e., during the second puzzle period (**Chart 2**).

This measure of global inflation is then used to specify a global Phillips curve, whose determinants are also aggregated to the global level. As explained in **Box 1**, the analysis requires two frequently used determinants: inflation expectations by professional forecasters for the next calendar year and a measure of economic slack represented by the unemployment rate. Using data from the first quarter of 1995 to the third quarter of 2013, subtracting the inflation expectations of professional forecasters from the actual inflation rate, and thus abstracting from the behaviour of inflation expectations, we plot the resulting global Phillips curve (**Chart 3**). For the remainder of this section, we refer to this newly constructed variable as "surprise inflation."

The blue line in **Chart 3** indicates that surprise inflation has a negative relationship with economic slack in the years leading up to and including the pre-crisis period, i.e., positive inflation surprises are associated with less unemployment, consistent with economic theory. The green line suggests that the relationship between surprise inflation and economic slack during the crisis period is not very different from before the crisis. The red line, however, shows that the slope of the global Phillips curve is significantly steeper in the post-crisis period, indicating that surprise inflation has become more sensitive to economic slack.

A very good description of the data can be provided by estimating a global Phillips curve with inflation expectations by professional forecasters and a measure of economic slack that can take on a different slope and a different intercept during the post-crisis period. To give the variable used to let the slope and the intercept of the global Phillips curve differ during the post-crisis period (2009Q4 to 2013Q3)—the "post-crisis dummy"—an economic interpretation, a broad set of variables is added to the Phillips curve on a

◄ *The analysis in this article builds on two frequently used determinants: inflation expectations by professional forecasters for the next calendar year and a measure of economic slack represented by the unemployment rate*

Chart 3:   The global Phillips curve
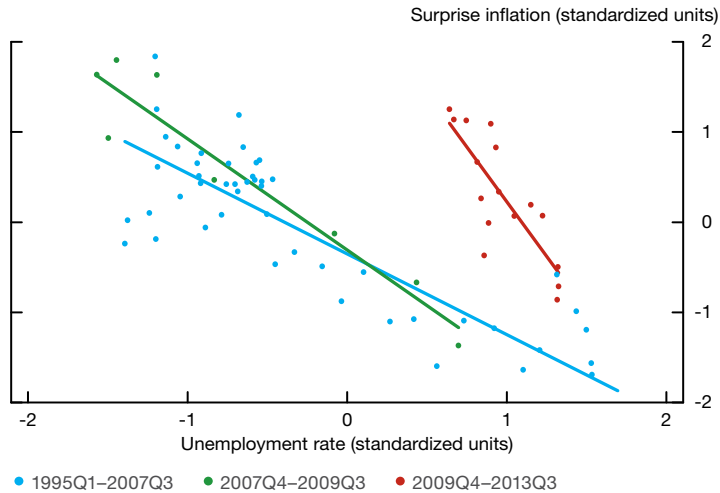
Note: Surprise inflation is defined as the difference between the first factor of headline inflation and the first factor of inflation expectations by professional forecasters for the next calendar year. The unemployment rate represents the first factor of national unemployment rates. A first factor is defined as the common component of a variable in all sample countries.

Source: Friedrich (2014)

one-by-one basis. These variables include alternative measures of inflation expectations and economic slack, commodity prices, measures of crisis-related government policies, and financial variables.[7]

After conducting an empirical analysis that considers the explanations presented earlier, we find that the variable that most improves the in-sample fit of the global Phillips curve with the advanced-economy data is inflation expectations by households. While moving in similar directions to inflation expectations by professional forecasters, inflation expectations by households show higher amplitudes around the crisis and therefore can largely replicate the effect seen in the post-crisis dummy. The finding that inflation expectations by households significantly improve the in-sample fit is close to that of Coibion and Gorodnichenko (2015).[8]

The variable that most improves the in-sample fit of the global Phillips curve with the advanced-economy data is inflation expectations by households
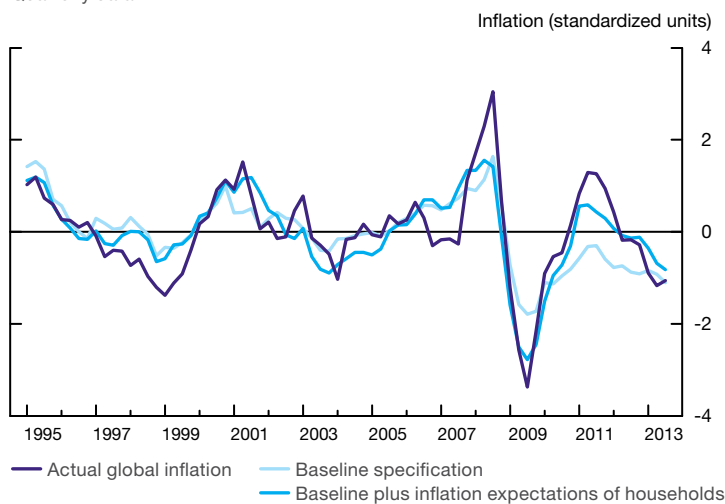
While household inflation expectations are highly correlated with food and energy prices and thus explain headline inflation dynamics well, there appears to be an orthogonal component in household inflation expectations that supplies additional information and might also be relevant for core inflation dynamics.[9] Furthermore, the post-crisis experience showed that core inflation was also affected by the twin puzzle in many countries; it is therefore not sufficient to include commodity prices in the analysis to explain the behaviour of inflation.

Although it is firms' expectations that matter for inflation (since they are the ones that set prices), without measures of firms' expectations, household expectations may be a better proxy than the expectations of professional forecasters. In addition, since households are demanders of final goods and

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7   Increasing trade with China has likely affected global inflation dynamics as well. However, this effect seems to play out over a longer horizon than only the post-crisis period. This potential driver was therefore not considered for the analysis.

8   While the analysis in this article confirms the importance of household inflation expectations in general, it suggests adding them to the Phillips curve rather than using them as the only measure of inflation expectations.

9   Household inflation expectations remain highly significant even if we control for energy or food price inflation.

Chart 4:   The in-sample fit of the resulting global Phillips curve

Quarterly data

Inflation (standardized units)

— Actual global inflation   — Baseline specification
— Baseline plus inflation expectations of households

Note: The chart shows actual global inflation (purple), defined as the first factor of standardized national inflation rates, together with two different global Phillips curve specifications. The first one (light blue) includes global aggregates of the unemployment rate and inflation expectations by professional forecasters. The second one (blue) includes additional global measures of inflation expectations. Details on the methodology and the underlying reasoning can be found in Friedrich (2014).

Source: Friedrich (2014)   Last observation: 2013Q3

suppliers of labour, there might be other effects that may not be fully accounted for by focusing exclusively on firms' inflation expectations. Identifying which of these explanations is dominant is an empirical question that should be investigated using microdata, which is beyond the scope of this article.

Chart 4 shows two different estimates of a global Phillips curve and actual global inflation dynamics (purple line). The first global Phillips curve or "baseline specification" (light blue line) includes aggregates of the unemployment rates and inflation expectations by professional forecasters (as seen in **Chart 3**) but fits the actual data rather poorly. The second global Phillips curve (blue line) adds a global measure of household inflation expectations to the specification and is significantly better at capturing post-crisis inflation dynamics.[10, 11]

The Twin Puzzle in Canada

Canada was not immune to the twin puzzle because inflation remained steady, despite a sizable output gap in the early post-crisis period, and then declined as the economy started to recover. In line with the framework used for the analysis of inflation at the global level, we follow the Phillips curve relationship described in **Box 1** to analyze the behaviour of Canadian inflation in the post-crisis period.

◄ *Canada was not immune to the twin puzzle, since inflation remained steady despite a sizable output gap in the early post-crisis period and then declined as the economy started to recover*

10 Currently, there is no data source for household inflation expectations that covers all sample countries. Therefore, the "global" measure of household inflation expectations is based on harmonized data from 11 European countries—the largest set of countries for which consistent data are currently available. However, the results also hold when inflation expectations by U.S. households are used instead.

11 The remaining gap between actual inflation and the second specification that includes household inflation expectations can be explained by additional variables that have played an important role in the post-crisis period (e.g., government budget balances and energy prices). For details on the identification procedure and the associated economic interpretation, see Friedrich (2014).

Economic slack

The global recession created a large amount of unused resources in the Canadian economy. Historical estimates suggest that the output gap reached a trough of -3 to -4 per cent in 2009 (**Chart 5**). Although it started to close in the following year, the output gap has remained persistently negative, largely as a result of the weak recovery in Canadian exports.

Chart 5:   Material excess capacity in the Canadian economy

— Structural approach   — Statistical approach
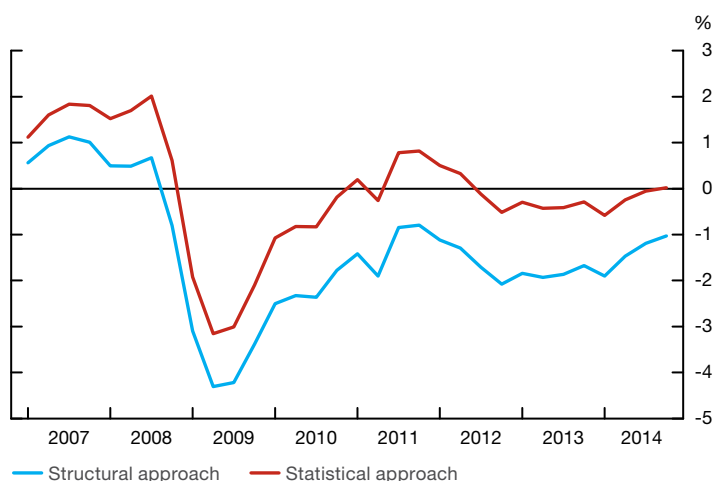
Notes: The structural estimate of the output gap refers to the integrated framework, while the statistical approach refers to the extended multivariate filter. For details, see L. Pichette, P. St-Amant, B. Tomlin and K. Anoma, "Measuring Potential Output at the Bank of Canada: The Extended Multivariate Filter and the Integrated Framework," Bank of Canada Discussion Paper No. 2015-1.

Source: Bank of Canada *Monetary Policy Report* (April 2015).   Last observation: 2014Q4

This economic slack translated into significant disinflationary pressure. Empirical work at the Bank has estimated the coefficient on the output gap to be around 0.3 in the Canadian Phillips curve (Bank of Canada 2014a). Conditional on this estimate, the Phillips curve relationship would predict an average drag of roughly 0.3 percentage points coming from the output gap in the post-crisis period. Based on this contribution alone, it is difficult to explain the entire path of steady and then falling inflation observed in Canada during this period. While time variation in the sensitivity of inflation to economic slack could explain part of the post-crisis behaviour of inflation in other advanced economies, this finding does not seem to apply to Canada. Rolling estimates of the Canadian Phillips curve do not indicate a change in the sensitivity of inflation to economic slack in recent years.[12] And even if we take into account the significant uncertainty around estimates of economic slack, it is difficult to fully explain the dynamics of inflation over this period using only the output gap.

◄ *Based on the output gap alone, it is difficult to explain the entire path of steady and then falling inflation observed in Canada during the post-crisis period*

Exchange rate pass-through

In addition to its impact on economic activity through net exports, the value of the Canadian dollar plays an important role in determining import prices. However, the extent and timing of the pass-through of movements in the exchange rate from import to consumer prices will depend on many factors,

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12 A similar explanation could be related to the possibility that the sensitivity of inflation to the output gap increases as the gap becomes more persistent. However, empirical work incorporating the persistence of the output gap into various Phillips curve equations finds only a marginal improvement in the performance of inflation forecasts.

such as the share of imports in the CPI basket, the size and persistence of the exchange rate movement, the duration of currency hedges, and the expected response by the monetary authority. Recent evidence indicates that, while the exchange rate fell significantly during the recession, the depreciation was short-lived and did not likely fuel inflation in a material way in the early post-crisis period. The Canadian dollar remained close to parity with the U.S. dollar over the 2010–12 period and began to depreciate in 2013. The path of stable and then falling inflation observed between 2010 and 2013 is not in line with these exchange rate movements and therefore they provide little justification for the twin puzzle. The exchange rate depreciation that began in 2013 did, however, play a role in pushing inflation up in 2014.

◄ *While the exchange rate fell significantly during the recession, the depreciation was short-lived and did not likely fuel inflation in a material way in the early post-crisis period*
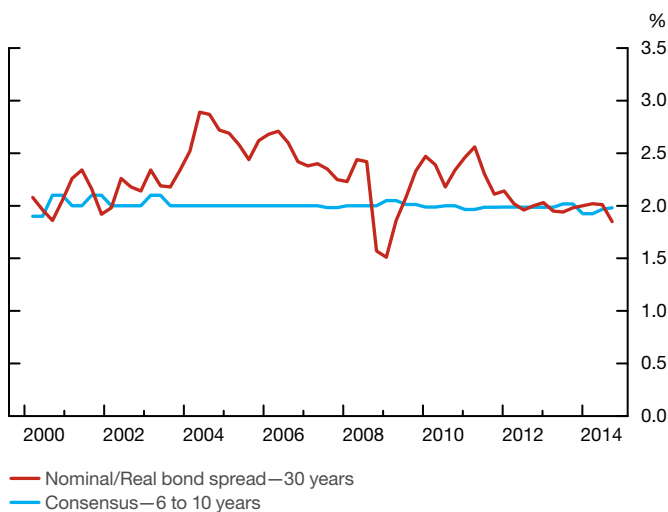
Inflation expectations

Since there are no historical time-series data on household inflation expectations for Canada, we cannot assess their role in driving Canadian inflation in a straightforward way. However, when assessing other measures of inflation expectations for Canada, we observe that they have remained relatively close to the target (**Chart 6**). Long-term inflation expectations of professional forecasters and financial markets have remained close to 2 per cent in the post-crisis period. In addition, since 2009, more than 80 per cent of firms have expected inflation to remain within the Bank's 1 to 3 per cent target range over the coming two years. This stability in inflation expectations has likely contributed to the resilience of inflation in the early part of the post-crisis period and could help to explain the first puzzle. However, while we cannot determine whether household inflation expectations played a role, the second puzzle does not seem to be caused by a downward shift in firms' expectations in Canada.

◄ *The stability in inflation expectations could help to explain the first puzzle*

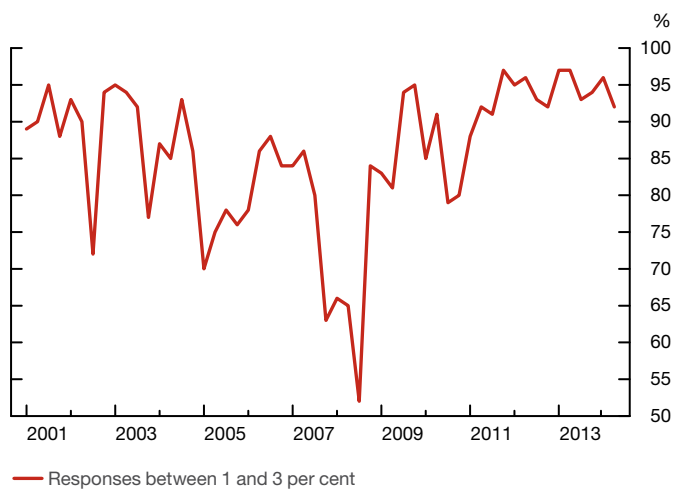**Chart 6: Inflation expectations**

a. Financial markets and professional forecasters

b. *Business Outlook Survey*

— Nominal/Real bond spread—30 years
— Consensus—6 to 10 years

Sources: Concensus Economics
and Bank of Canada calculations   Last observation: December 2014

— Responses between 1 and 3 per cent

Note: Percentage of firms indicating that they
expect inflation to be between 1 and 3 per cent
over the next two years.   Last observation: December 2014

Increased competition in the retail sector

In the Phillips curve framework, other factors that could explain inflation behaviour will be captured by the error term. A wide range of evidence points to the effects of increased competition in Canada's retail sector as a potential driver of negative inflation errors in 2012–13. Competitive pressures in this sector intensified in the post-crisis period with the appearance of new and bigger retailers.

Walmart, for example, transformed many of its stores into supercentres that offer food as well as general merchandise. This new retailing strategy, as well as Walmart's pricing, increased the competitive pressures on traditional retailers. In addition, a number of other U.S. retailers entered the Canadian marketplace, and increased cross-border and online shopping were possibly reinforcing factors.

The effects of competition have been reflected in the unusual softness in the prices of food and non-durable goods, two sectors where anecdotal evidence suggests that competition has intensified. Canadian food price inflation (excluding meat) remained persistently lower than suggested by global prices for agricultural products (**Chart 7**), while prices for non-durable goods fell in the post-crisis period. Because of its impact on food and non-durable goods prices, more intense competition likely subtracted around 0.3 percentage points from inflation during this period (Bank of Canada 2014b). As discussed in Macklem (2014), more intense retail competition creates "good" disinflation, provided that inflation expectations remain well anchored. Consumers benefit from lower prices, and increased competition is likely to mean higher productivity in the sector—both of which are good things.

◄ *More intense competition likely subtracted around 0.3 percentage points from inflation during the late post-crisis period*

Chart 7: Food price inflation in Canada has been weaker than suggested by global developments
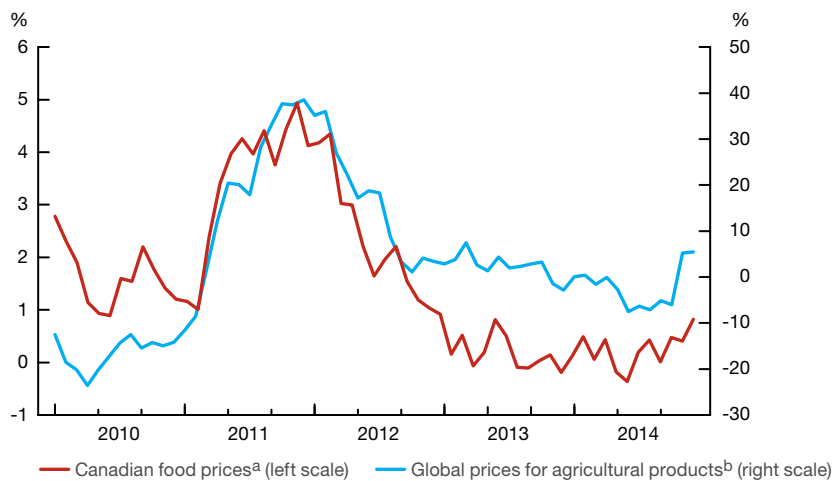
a. CPI for core food purchased from stores (excluding meat)
b. BCPI agricultural products (Can$, lagged 8 months)
Sources: Statistics Canada and Bank of Canada calculations   Last observation: December 2014

To sum up, while persistent economic slack can explain part of the weakness in inflation observed in the late post-crisis period, the evidence suggests that the remaining dynamics of steady and then falling inflation in Canada could be explained by the resilience of inflation expectations in the earlier period, followed by a persistent drag coming from increased retail competition thereafter.

Conclusion

Advanced economies experienced two consecutive puzzles following the global financial crisis—high inflation relative to measures of economic slack from the end of 2009 to 2011 and relatively low inflation from 2012 to the middle of 2014. Our analysis indicates that looking at the behaviour of household inflation expectations provides a better understanding of the evolution of global inflation during this period. Given that firms are ultimately responsible for setting prices in the economy, it is possible that inflation expectations of households could serve as a good proxy for inflation expectations of small businesses that may not be able to afford professional forecasting services. It could also be that household inflation expectations play a role through other channels that may not be fully captured by firms' inflation expectations. However, it is difficult to identify the relative contribution of both explanations with aggregated data at the international level. Studying how closely household and firm expectations move together using micro-level data could shed light on this question.

These findings highlight two important practical considerations with respect to the Phillips curve framework used to analyze inflation. First, the post-crisis experience has shown that the Phillips curve relationship is subject to frequent shocks. As a result, models of inflation need to be regularly supplemented with additional sources of information. Second, household inflation expectations seem to add value to the Phillips curve relationship over and above what is already captured by the expectations of professional forecasters. While central banks monitor inflation expectations from various sources, it could be beneficial to formalize this approach when it comes to modelling inflation. As discussed in Côté (2015), the recent launch of a regular survey measuring household inflation expectations in Canada should help our understanding of inflation behaviour and eventually translate into improved models of inflation.

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