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# The Determinants of Consumers' Inflation Expectations: Evidence from the US and Canada

by Charles Bellemare,[1] Rolande Kpekou Tossou[2] and Kevin Moran[1]

[1]Department of Economics, Université Laval, Québec, Quebec G1V 0A6

[2]Canadian Economic Analysis Department
Bank of Canada, Ottawa, Ontario, Canada K1A 0G9

cbellemare@ecn.ulaval.ca, rkpekoutossou@bankofcanada.ca,
kevin.moran@ecn.ulaval.ca



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# Abstract

We propose and estimate a dynamic and individual model of expectations formation that links individual consumers' inflation expectations to their own lagged forecasts as well as proxies for the rational expectation forecasts. The model builds on the existing rational inattention literature and extends it in several dimensions. We explicitly model the expectations updating rule which consumers use to incorporate new information in their experience and take seriously heterogeneity in inflation expectations extensively documented in the literature. We estimate the model using data from two important new surveys — the Federal Reserve Bank of New York's Survey of Consumer Expectations and the Bank of Canada's Canadian Survey of Consumer Expectations. We find that inflation expectations appear to correlate more strongly to measures of rational expectations forecasts in Canada than in the US, and conversely less to lagged expectations. More specifically, the median respondent assigns overall weights of roughly 75% to proxies for the rational expectation forecasts and 25% to lagged expectations in Canada, while these weights are around 50-50 for the US. We show that these differences in weights are not explained by differences in the characteristics of their stand-in consumers. Given this finding, one candidate explanation could be related to the explicit inflation target in Canada in comparison to the dual mandate in the US.



*Topics: Central bank research; Econometric and statistical methods; Inflation and prices; Inflation targets*
*JEL codes: C33, D83, D84, E31*

# 1 Introduction

Consumer expectations about future inflation are of central importance for public policy and monetary authorities. Most macroeconomic models assume that households make consumption, saving, and labor market decisions based on their perception of future inflation levels, which in turn determine outcomes in the real economy and inflation. In addition, managing these expectations becomes an important alternative monetary policy tool when interest rates are near the zero lower bound (Coibion et al., 2020). As such, assessing how inflation expectations are formed, evolve through time, and react to economic events remains an essential part of monetary policy research.

While conventional models assume that households form full-information rational expectations, a number of recent papers have introduced the notion of "rational inattentive" behavior (Sims, 2003) to analyze the formation of inflation expectations. A seminal contribution in this literature is Carroll (2003), which develops and estimates an expectation-formation model wherein households stochastically adopt professionals' forecasts rather than form their own rational forecasts. This approach, drawn from the epidemiology literature, provides promising microfoundations for sticky information models (Mankiw and Reis, 2002). Reis (2006) and Lanne et al. (2009) build on these insights, considering frameworks in which consumers update their information set sporadically or form their expectations as hybrids based partly on naive interpolations from recently released inflation rates and partly on professional forecasts. More recently, Easaw et al. (2013) develop a model where households' inflation expectations are linked to professional forecasts, as well as to actual and perceived inflation rates in addition to the monetary authorities' targeted rate. However, their model is estimated using aggregate and repeated cross-section data, which lacks the rich information needed to estimate the individual-specific dynamic relationships that play key roles in both sticky-information and epidemiological expectation models.[1]

The present paper develops a dynamic and individual-specific model of expectations formation that can account for significant heterogeneity in the process by which different consumers form and adapt their inflation expectations. In the model, a household's expectations are determined by their own lagged expectations, as well as by proxies for the rational expectations forecasts, obtained either by learning over realized inflation rates during the household's tenure in the survey or through a publicly available signal about future inflation. The public signal is measured by the mean response from the survey of professional forecasters, and each household assigns a specific

[1]Their data are drawn from the monthly Italian Consumers Survey (ISTAT), which does not have repeated participation by individuals; the authors use a pseudo panel approach to deal with these limitations.

weight to each of these components. We estimate the model using data from two important new surveys – the Federal Reserve Bank of New York's Survey of Consumer Expectations (SCE) and the Bank of Canada's Canadian Survey of Consumer Expectations (CSCE) – that both contain rich information sets about these expectations. Both surveys notably feature repeated (in consecutive periods) participation from the same individuals and have access to several socio-economic markers of these respondents.

Our results are as follow. First, inflation expectations are importantly shaped by realized rates of inflation experienced during households' tenure on a survey. This effect is, however, more important for Canadian consumers. This finding may be explained by the presence of a more explicit inflation target in Canada throughout the sample covered, in comparison to the dual mandate of monetary authorities in the US; alternatively, differences in the two surveys' design could cause it. In addition, the degree to which new inflation realizations are incorporated in respondents' experience during their tenure decreases as they become familiar with the survey, but it decreases faster in the US and becomes essentially zero after five months of repeated participation. This result may suggest that US respondents, after they have been surveyed four or five months, stop incorporating new values in their updating rule.

Second, both US and Canadian consumers' inflation expectations are positively linked to the publicly available signal about future inflation, represented in our benchmark specification by the mean response from the survey of professional forecasters. This finding is consistent with Lanne et al. (2009) and Easaw et al. (2013), who find that households form their expectations partly from professional forecasts and partly from recently released inflation. However, the weight assigned to these professional forecasts by the median Canadian respondent is higher than the one chosen by its US counterpart. We also find that households' own lagged expectations, i.e., what they reported in the previous period, accounts for their views about the future direction of inflation, especially for the US respondents. This pattern may arise because as US survey respondents are surveyed monthly and up to 12 consecutive times, there is more scope for a high dependence to lagged expectations to install itself in the US survey.

Lastly, we observe substantial socio-economic heterogeneity in how respondents weight inflation experience and public information to form their expectations. Specifically, female, young, or middle-aged Canadian participants assign lower weights to their own lagged expectations. This finding is consistent with Madeira and Zafar (2015), who report using Michigan survey data that these demographic groups' expectations are revised more.

Our contribution adds to the previous literature along several dimensions. First, we explicitly model how new inflation realizations are incorporated to the respondents' experience during the survey. Hence, in contrast to previous approaches, our analysis uses an adaptive learning process similar to those popularized by Evans and Honkapohja (2001) to account for the history of realized inflation rates during respondents' tenure on the survey. This allows us to measure the learning effect from the repetitive participation.[2]

Next, comparing consumers' inflation expectations between US and Canada represents an important innovation that is not addressed in the prior literature due to the lack of data on Canadian households' expectations.[3] Even if the economies of Canada and the US are very similar, important differences in monetary policies remain, and it is important to assess how they affect the formation of inflation expectations. Canada adopted an inflation target in 1991 and has a symmetric target around 2%, while by contrast the US did not have a specific numerical target for inflation before 2012. The Federal Reserve's mandate also differs from that of the Bank of Canada in that it has a dual mandate – price stability and maximum sustainable employment – while the Bank of Canada has a single mandate – price stability – which is perhaps simpler and easier for the general public to understand. Finally, the Federal Reserve target is specified in terms of the Personal Consumption Expenditure (PCE) deflator, not the Consumer Price Index (CPI), as is the case for the Bank of Canada. As the CPI is used for income indexation, it is likely more followed by the general public than the PCE deflator.

Our approach also speaks about and adds to the literature documenting and studying the considerable heterogeneity contained in inflation expectations (Bryan and Venkatu, 2001; Souleles, 2004; Bruine de Bruin et al., 2010; Malmendier and Nagel, 2015; Madeira and Zafar, 2015). Specifically, by allowing the weight on each determinant to depend on a respondent's demographic characteristics (gender, education, age, and numeracy), our approach has the potential to account for and analyze this sizeable extent of heterogeneity, identify which factor is more important for different demographic groups, and, possibly, inform monetary policy makers about the effectiveness of their

[2] As such, this aspect of our modeling strategy is related to the literature studying the impact of personal experience on inflation expectations exemplified by work like Malmendier and Nagel (2015) and Madeira and Zafar (2015). They consider that one's lifetime experience with inflation is an important determinant of the cross-section heterogeneity in reported inflation expectations. A consumer having experienced high rates of inflation in the 1970s will then likely appreciate recent realized rates in a different manner than a younger consumer who grew up with low rates. Our paper uses this idea to argue that one's survey tenure experience with inflation also accounts for consumer views about future inflation. In line with this literature, Ehrmann et al. (2017) investigate whether some household groups in the Michigan survey update their expectations more often than others and find that the financial situation of participants has a bearing on the frequency of update.

[3] Comparative studies of inflation expectations in Canada and the US to date concentrated on professional forecasts and financial markets' measure of inflation expectations (Yetman, 2017).

communication strategies across demographic groups.

Finally, our paper also represents a contribution to the 'noisy information' literature. Coibion and Gorodnichenko (2015) proposed a model linking expectations to their lagged values as well as to proxies for the rational expectation forecast by assuming that consumers face environments with noisy signals and/or have limited attention. Their approach leads to a predicted relationship between the ex post mean forecast error across agents and the ex ante mean forecast revision, which holds only at aggregate level. They found, using the Michigan survey, that consumers assign a weight of 0.41 to their previous forecasts, which is similar to our median weight (0.43) for US consumers. However, our approach allows us to study how this weight varies across different demographic groups (our estimated values range from 0.2 to 0.6 for the US, and from 0 to 0.5 for Canada). Vellekoop and Wiederholt (2019) developed a similar model and assumed unobservable heterogeneity only for the intercept, while our approach allows socio-demographic heterogeneity for all the parameters. They estimated a weight of 0.6 on households' lagged expectations using the DNB Household Survey, conducted annually since 1993 and administered by CentERdata at Tilburg University.

The remainder of the paper is structured as follows. Section 2 describes the data contained in the SCE and the CSCE and provides a descriptive analysis of the heterogeneity that these data contain. Section 3 then develops our model of expectation formation and the econometric approach we employ to assess it quantitatively. Section 4 reports and discusses our benchmark results, while Section 5 explores the robustness of these results through various sensitivity analyses. Section 6 then summarizes our results and concludes.

## 2 Data and descriptive analysis

### 2.1 Data

Our data are drawn from the SCE, conducted by the Federal Reserve Bank of New York, and the CSCE, which is undertaken by the Bank of Canada. Both surveys are nationally representative, internet-based queries of rotating panels of more than 1,000 household heads. The SCE is conducted monthly and was launched in June 2013, after a six-month initial testing phase. Respondents are drawn each month from the American Community Survey and participate in the survey for up to 12 consecutive months. The CSCE, whose structure is based on that of its US counterpart, was introduced in the fourth quarter of 2014. The main difference between the two surveys is that the CSCE is conducted quarterly (in February, May, August, and November), and repeated

participation is limited to 4 quarters.

The rotating panel approach of the SCE and the CSCE, combined with their rich information set about participants' socio-demographic characteristics (education, gender, income, age, or region of residence), allows for a detailed analysis of how consumers form and update their expectations.[4]

In addition to asking participants about their expectations of future rates of aggregate inflation, both the SCE and the CSCE elicit opinions about future increases in the price of specific goods (gas, food, etc.) as well as a broader range of expectations related to consumer economic behavior, such as current and prospective labour market conditions, say, or household finances. The present paper singles out the participants' expectations about the inflation rate in the next 12 months, which is phrased as follows in the survey: *What do you expect the rate of inflation/deflation to be over the next 12 months?*

The monthly frequency of the SCE implies that this produces a monthly measure for each participant $i$ corresponding to $E_{it}\left[100\left(P_{t+12}/P_t - 1\right)\right]$ for $t$ from June 2013 to March 2017. By contrast, the quarterly frequency of the CSCE implies our expectations' data is for $E_{it}\left[100\left(P_{t+4}/P_t - 1\right)\right]$, with data from $2014Q4$ to $2018Q1$.[5] Our total sample represents $41,472$ responses for the SCE and $7,671$ for the CSCE.

Below, these expectations are compared with realized rates of inflation, which we compute using the all-items CPI levels (the monthly year-over- rate for the US and the (quarterly) year-over-year rate for Canada). In addition, our analysis employs expectations' data from professional forecasters: for the US, these data are obtained from the (quarterly) Survey of Professional Forecasters (SPF) conducted by the Federal Reserve Bank of Philadelphia, while for Canada we use the Survey of Forecasters conducted by the Conference Board of Canada.[6]

## 2.2 Descriptive analysis

Figure 1 plots the median (across all survey participants) one-year-ahead point forecasts for inflation in the SCE (top panel of the figure) and the CSCE (bottom panel) from 2015 to 2018, alongside the realized rates one year hence. The horizontal axis refers to the endpoint of the forecast horizon, as opposed to the time the forecast was made. Three features stand out in the figure. First, the median

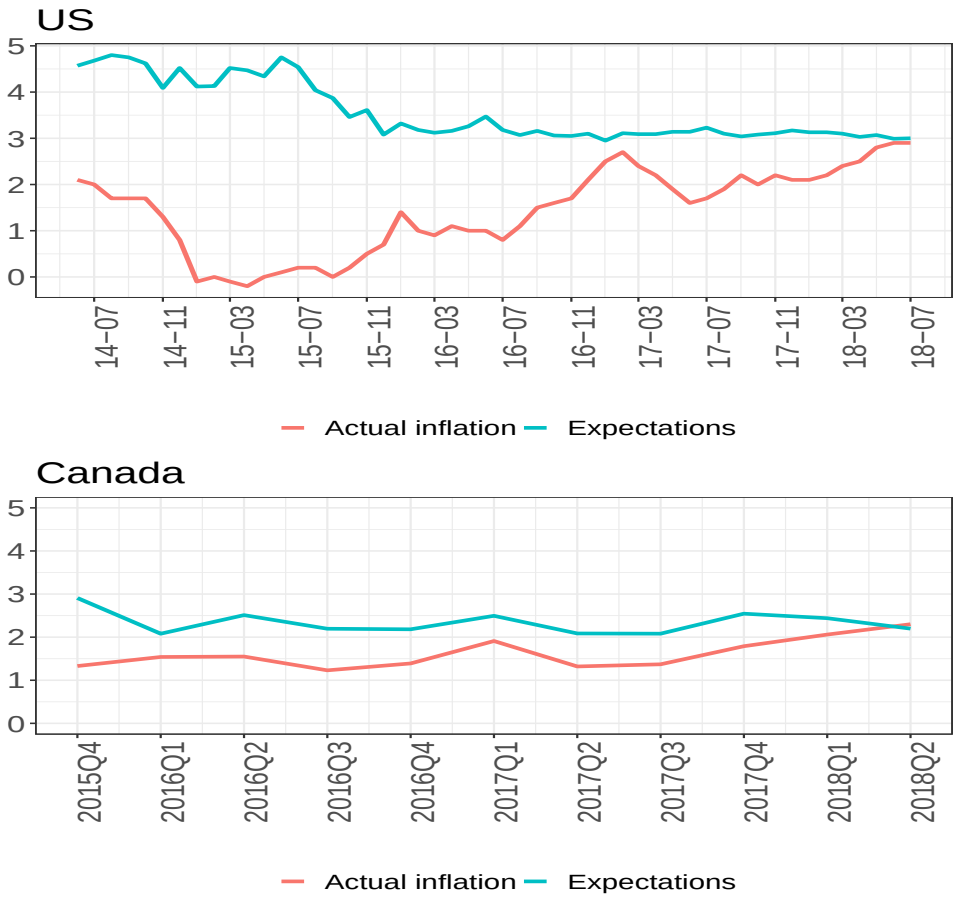
[4] See Armantier et al. (2016) for an overview of the SCE and Gosselin and Khan (2015) for details about the CSCE.

[5] We restrict our sample to participants remaining in the panel for at least 6 months (SCE) or 2 quarters (CSCE) to avoid selection effects due to respondents failing to complete the survey more than once. In addition, we exclude from the analysis respondents with unusually high (greater than 50%) or low (less than -50%) inflation expectations.

[6] We use a quadratic mean matched approach to convert the (US) quarterly expectations of forecasters to a monthly frequency.

expected inflation rate in both surveys is higher than the realized rates throughout the period. This occurs during an episode of subdued inflationary pressures, with realized inflation either falling (for the US, beginning of the sample) or being consistently below the monetary authorities' target (Canada).[7] Second, this median over-estimation of inflation appears to be more modest in Canada, with the gap between the median expectation and the realized rate being consistently under 1.5 percentage points, whereas its US counterpart is sometimes over 4 percentage points.[8] Third, the pattern whereby median expectations are consistently above realized rates appears to be waning through time, and towards the end of the sample, median expectations and realized rates overlap.

Figure 1: One-year-ahead inflation expectations vs realized inflation



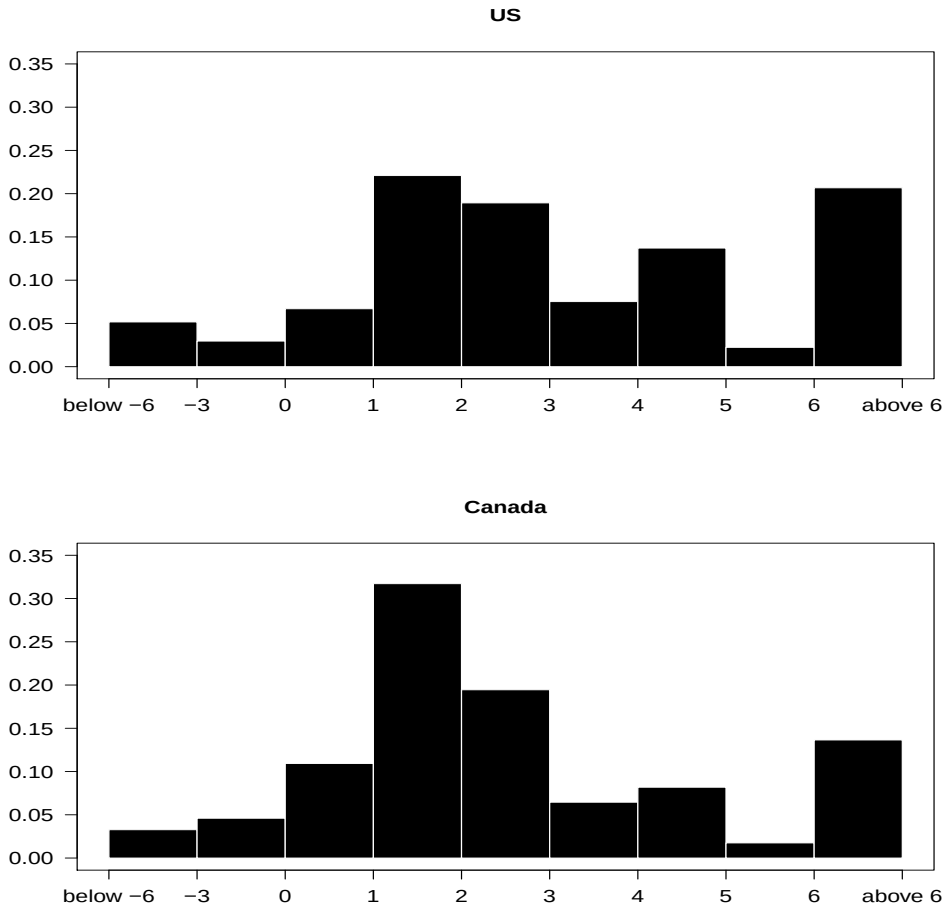

**Note:** Median response for all participants for the question *What do you expect the rate of inflation/deflation to be over the next 12 months?* for the SCE (top panel) and the CSCE (bottom panel), in green. Realized rate of inflation one year hence (all items CPI) is in red.

[7] Upwards biases in consumers' inflation expectations are also present in other recent data, notably from the Michigan survey. See the analysis in Armantier et al. (2016) and Ehrmann et al. (2017).

[8] Interestingly, the median expectation for Canada remains within the official inflation targeting band (between 1% and 3%) used by the Bank of Canada throughout.

## 2.3 Descriptive analysis: Heterogeneity

Figure 2: Distribution of inflation expectations




**Note:** Cross-section distribution for all years for the SCE (top panel) and the CSCE (bottom panel).

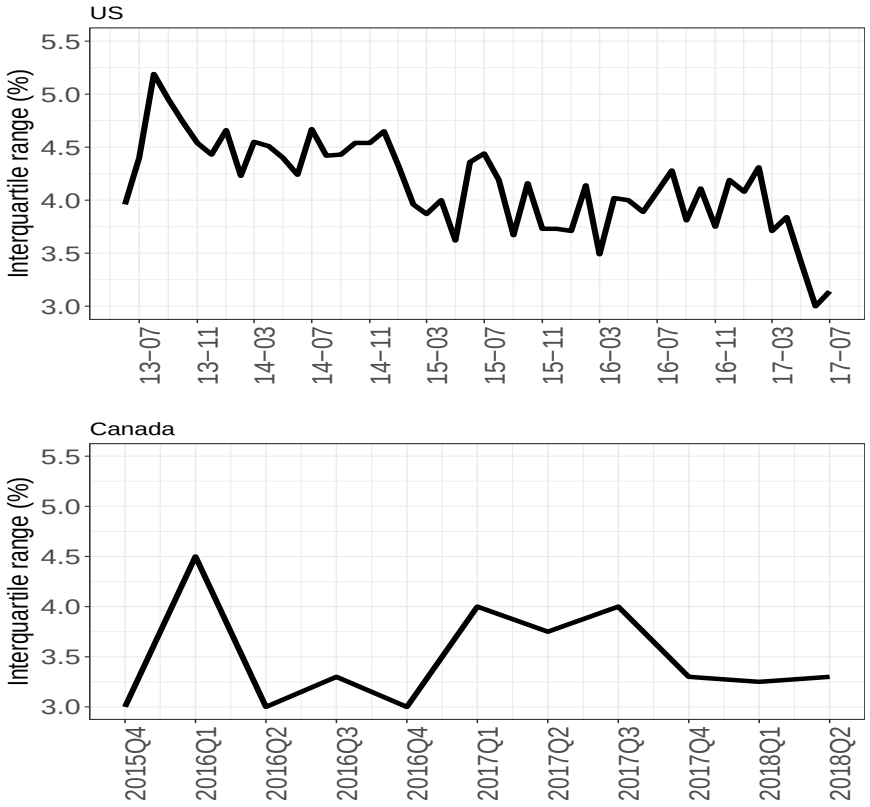
The median expectations reported in Figure 1 mask the considerable heterogeneity present in the data from the SCE and the CSCE. One way to assess this heterogeneity is through Figure 2, which presents the distribution of all reported expectations, without conditioning on the time period. At first glance, expectations appear more tightly distributed in Canada, with over 50% of expectations notably falling within the official 1% to 3% target range of the Bank of Canada. As such, this long-established inflation targeting policy appears to anchor the forecasting framework of many consumers.[9] By contrast, inflation targeting remains relatively recent in the US, and the

[9] An analysis of the time dimension of the distribution of responses reveals that in the Canadian survey, the 25th quantile expectation remains very close to the realized rate throughout the sample.

Federal Reserve does not emphasize a range around its 2% target.[10] Perhaps as a result, reported expectations appear more dispersed.

Figure 3 confirms the higher dispersion in the expectations of US consumers. The figure reports the evolution of the interquartile range for all responses and shows this range to be hovering around 4.0-5.0% in the US, at least during the first few years following the survey's inception, while the corresponding range for Canadian consumers is 3.0-4.5%. Note also that these differences appear to be waning later in the sample, with both interquartile ranges settling around the 3% mark.

Figure 3: Disagreement in inflation expectations: Interquartile range




**Note:** Interquartile ranges in reported one-year-ahead inflation expectations for the SCE (top panel) and the CSCE (bottom panel).

To assess this heterogeneity in more detail, Table 1 regresses reported one-year-ahead inflation expectations on the current inflation rate at the time of the survey and on dummy variables conditioning on important socio-demographic characteristics of participants: gender, age, numeracy,[11] and education.[12] The table indicates that most of these characteristics affect reported expectations

[10] https://www.federalreserve.gov/newsevents/pressreleases/monetary20120125c.htm

[11] To gauge the respondents' numeracy, they are asked 5 questions based on numbers.

[12] The dummy variables take the value 1 if the attribute applies, so that the regression constant represents expec-

in a statistically significant manner. Indeed, the table shows that all things being equal, female consumers, as well as those with low numeracy, lower education, or low income, report higher expectations for inflation in both surveys. This is consistent with previous findings using the Michigan survey for the United States

Table 1: Heterogeneity in inflation expectations

| | One-year-ahead inflation expectation | |
|---|---|---|
| | US | Canada |
| Current realized rate | 0.234*** | 0.534*** |
| | (0.052) | (0.192) |
| Female | 1.249*** | 1.345*** |
| | (0.083) | (0.130) |
| Young | -0.973*** | 0.758*** |
| | (0.111) | (0.163) |
| Middle-aged | -0.444** | 0.612*** |
| | (0.091) | (0.150) |
| Low numeracy | 0.737*** | 1.803*** |
| | (0.094) | (0.145) |
| High school | 1.304*** | 0.459** |
| | (0.109) | (0.189) |
| Some college | 0.821*** | 0.135 |
| | (0.105) | (0.171) |
| Low income | 1.925*** | 2.044*** |
| | (0.114) | (0.190) |
| Middle income | 0.586*** | 0.536*** |
| | (0.112) | (0.148) |
| Constant | 2.457*** | 0.805** |
| | (0.119) | (0.327) |
| Observations | 41,472 | 13,502 |
| R-squared | 0.043 | 0.044 |

*Notes*: Regression of reported one-year-ahead inflation expectations on current realized rates and characteristics of survey participants for the SCE (left of the table) and the CSCE (right). Standard errors are in parentheses below estimates, with *** p<0.01, ** p<0.05, * p<0.1. Young = 18-34 years old, middle-aged = 35-54. Low numeracy implies less than 4 correct answers to 5 questions on respondents' numeracy knowledge. High school = high school or less, some college = college and less than BA. Low income=< 50,000, middle income= 50,000 – 100,000.

Interestingly, Table 1 reports that all things being equal, younger participants in the CSCE (right side of the table) report higher expectations, whereas the left-hand side of the table shows an inverse relation between age and expectation in the US. This is an intriguing result because young people are associated with higher reported inflation expectations in other data from the US, such as those arising from the Michigan survey and analyzed by Madeira and Zafar (2015). As such, the

tations when all attributes are turned off, i.e., when the survey participant is an old, affluent, high-numeracy and educated male.

US data from the SCE appear to be the outliers here.[13]

Finally, notice that a positive relationship exists between current realized inflation and consumers' expectations in both countries, but that this impact is significantly larger in Canada. Specifically, an increase of one percentage point in the current inflation rate is associated with an increase of 0.5 percentage point in the expectation of the generic Canadian consumer, while it leads to an increase of only 0.2 point in US expected inflation. To summarize, Table 1 shows that when the current inflation rate is 2%, the generic (all socio-economic attributes turned off) consumer reports an inflation expectation just under 2% in Canada but significantly higher (just under 3%) in the US. Further, belonging to most of the specific socio-demographic groups highlighted in the table increases reported expectations in a statistically significant manner.

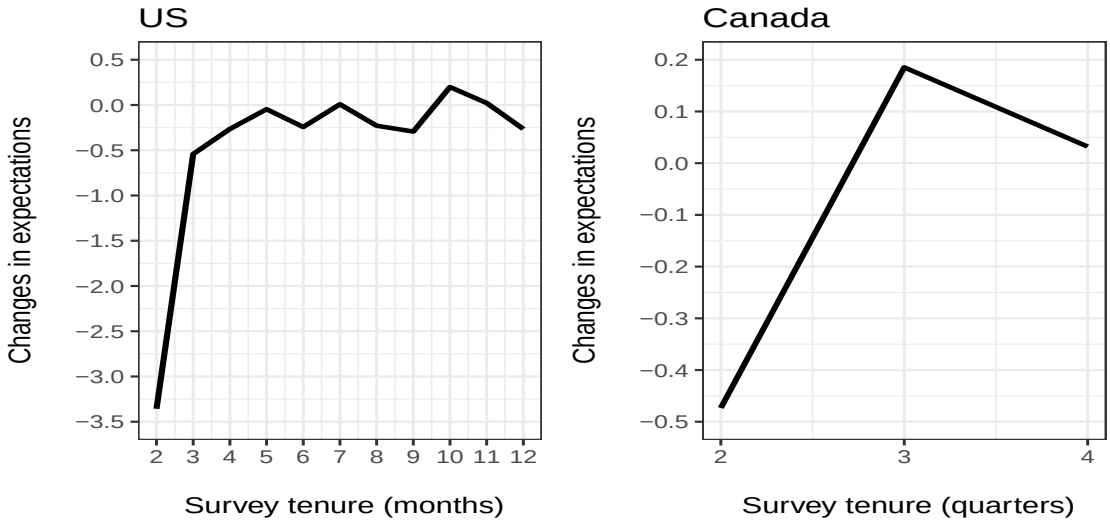
### 2.3.1 Updating of expectations

The second defining feature of the SCE and CSCE is repeated participation for a given consumer: the SCE queries participants for up to 12 consecutive months, while Canadian participants remain in the survey for up to 4 quarters. To give a first look at the importance of repeated participation for reported expectations, Figures 4 and 5 report the average and median *change* in reported expectation, respectively, conditional on tenure in the survey. Consistent with the apparent over-forecasting of inflation reported above, the figures both depict negative changes in reported expectations, especially in the periods immediately following the first participation in the surveys. As such, the figures show that many participants revise their expectation for inflation downwards, sometimes considerably. Interestingly, this effect appears more important quantitatively for the average change to expectations in the SCE (Figure 4), which sees a full 3-percentage-points decrease on average between first and second participation, while the corresponding figure for the CSCE is only 0.4 percentage point. This is consistent with the pattern exhibited above, whereby inflation expectations in the US appear more dispersed and exhibit a bigger upwards bias: many such consumers will react to these over-predictions by updating their expectations downwards.

Importantly, both Figure 4 and Figure 5 show that revising effects appear short-lived, as changes to reported expectations quickly become very modest with subsequent participation. As such, these figures provide suggestive evidence that many participants quickly update what appear to be initial over-forecasts for inflation and rapidly converge to a "settled" state of expectations: by the third or

[13] Bruine de Bruin et al. (2010) report a tendency for younger people to report higher inflation expectations in precursors to the SCE.

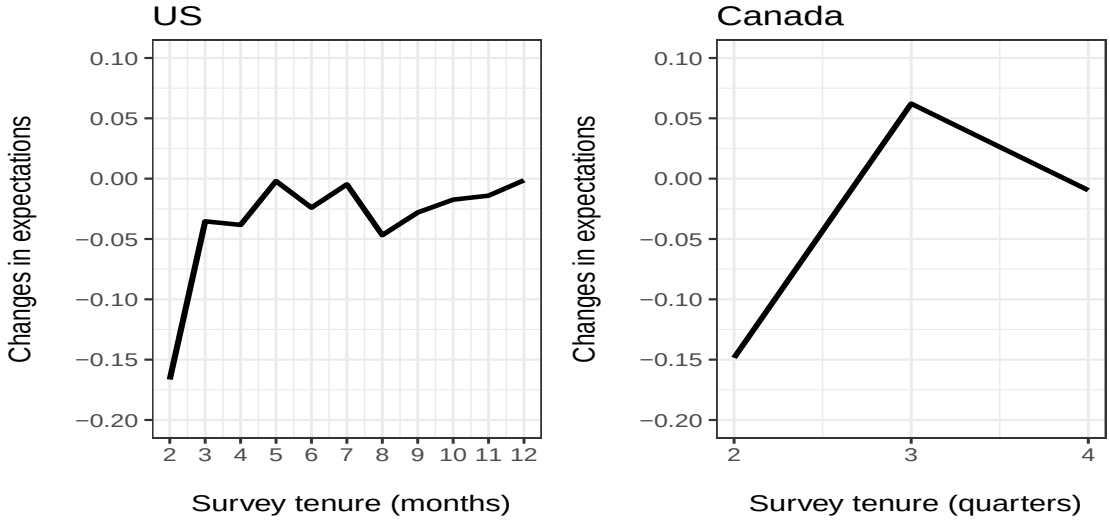
Figure 4: Average change in one-year-ahead inflation expectations




**Note:** Average *change* to the one-year-ahead inflation expectations, conditional on tenure (repeated participation) in the SCE (top panel) and the CSCE (bottom panel).

fourth participation in the SCE survey, the average or median month-to-month change to reported expectations becomes close to zero. The model developed in the next section will analyze this updating behavior and the heterogeneity discussed above in a systematic manner.

Figure 5: Median change in one-year-ahead inflation expectations




**Note:** Median *change* to the one-year-ahead inflation expectations, conditional on tenure (repeated participation) in the SCE (top panel) and the CSCE (bottom panel).

# 3 The determinants of consumers' inflation expectations in the US and in Canada

This section formulates a model to describe and estimate the process by which participants in the SCE and the CSCE form their inflation expectations.

## 3.1 Model

Consider respondent $i$, participating for the $s^{th}$ time in the survey at time $t$. We assume that this respondent's reported expectation, denoted $\pi^e_{it,s}$, arises from his or her own lagged expectations and two proxies for the rational expectations forecasts: a history of realized rates over the participant's tenure in the survey and a public signal about future inflation. The following empirical specification is used[14]:

$$\pi^e_{it,s} = c + \delta_i \pi^e_{it-1,s-1} + \beta_i f_i(\pi_t^{survey}) + \tau_i z_t + \eta_{it,s} \tag{1}$$

where $\pi^e_{it,s} = \mathbb{E}_{it,s}\left[100\left(\frac{P_{t+12}}{P_t} - 1\right)\right]$ is the reported one-year-ahead inflation expectations, $s$ is survey tenure ($s = 1, \ldots, 12$, or $s = 1, \ldots, 4$, respectively, for the US and Canadian survey), $f_i(\pi_t^{survey})$ reflects the history of realized inflation rates during the survey tenure, and, finally, $z_t$ is a publicly available signal about future inflation. The coefficients $\beta_i$, $\delta_i$, and $\tau_i$ measure the relative contribution of each of these three sources and (as discussed in section 3.2 below) our estimation allows them to depend on respondents' socio-economic characteristics. Finally, $\eta_{it,s}$ is a disturbance term such that $\eta_{it,s} \sim \mathcal{N}(0, \sigma_{i,s})$, thus also allowing for idiosyncratic volatility.

The specification (1) is inspired by the work in Coibion and Gorodnichenko (2015) or Vellekoop and Wiederholt (2019), who motivate similar expressions linking expectations to their lagged values as well as to proxies for the rational expectation forecast by assuming that consumers face environments with noisy signals and/or have limited attention. In turn, (1) allows for the public signal linked to the rational expectation forecast to be either a forecast based on least-squares learning using actual realized rates $f_i(\pi_t^{survey})$ (see below) or from an easily observable public signal $z_t$ (the median response from the survey of professional forecasters in our benchmark work). This is also coherent with work by Carroll (2003) and Easaw et al. (2013), who study how expectations from experts such as those surveyed in the SPF get gradually incorporated into the expectations of consumers.

The component $f_i(\pi_t^{survey})$ is driven by the history of realized inflation rates during one's tenure

[14] We tested for individual-specific constant in equation (1) by replacing $c$ by $c_i$; the results remain similar.

on the survey. It represents the forecast that a participant would obtain if (i) observing actual rates without error and (ii) using an adaptive learning process similar to those popularized by Evans and Honkapohja (2001). We use a simple such adaptive learning scheme, whereby participants consider inflation to be an i.i.d process whose mean they try to estimate. As such, the best forecast for future inflation from realized rates is their estimate of this mean, denoted $a_t$, ie. $f_i(\pi_t^{survey}) = a_t$, where $a_t$ evolves according to the least-square learning rule

$$a_t = a_{t-1} + \gamma_{t,s}(\pi_t - a_{t-1}), \tag{2}$$

and the gain $\gamma_{t,s}$ represents the weight given to forecasting errors that obtain when forecasting with this rule. Possible specifications for the gain $\gamma_{t,s}$ include the standard least squares formulation, $\gamma_{t,s} = 1/s$, which implies that all past information gets equally weighted, or the constant gain $\gamma_{t,s} = \gamma$, which overweights recent realizations relative to the past.

Such a learning process is used in recent contributions by Madeira and Zafar (2015) and Malmendier and Nagel (2015) when studying the inflation expectations contained in the Michigan survey. These authors consider that one's lifetime experience with inflation is an important determinant of the cross-section heterogeneity in reported inflation expectations. As such, a consumer having experienced high rates of inflation in the 1970s is likely to appreciate recent realized rates in a different manner than a younger consumer who grew up with low rates. They thus suppose that the gain $\gamma_{t,s}$ decreases with the respondents' age, similar to least-squares learning, by specifying $\gamma_{t,s} = \theta/age$, with $\theta > 0$ determining the general shape of the weights on past inflation ($\theta = 1$ representing strict least-squares learning).

We follow the spirit of Madeira and Zafar (2015) and Malmendier and Nagel (2015) but consider that the learning described in (2) occurs during one's tenure in the survey. As such, the gain $\gamma_{t,s}$ now represents the degree to which an agent who has already participated $s$ times in the survey continues to update beliefs when surveyed again after updated news on realized inflation has been made publicly available. We use a flexible specification that allows, but does not impose, a decreasing relationship between tenure and the gain (see below).

### 3.2 Estimation

To take into account the considerable heterogeneity in reported expectations, we condition the different elements of the empirical model on the vector of individual characteristics $\mathbf{X_i}$, which

includes income, education, gender, numeracy, and age. We also allow for expectations to become less volatile as respondents become more experienced by indexing the variance $\sigma^2_{i,s}$ in the residuals to (1) on survey experience $s$ as well as on individual characteristics. As such, the parameter vector to be estimated from (1) is then defined $\Theta = \{\theta, \delta, \beta, \tau, \sigma_{i,s}\}$, where the following applies:

$$\gamma_{i,s} = \exp(\alpha_\gamma \mathbf{X_i} + \lambda_1 s + \lambda_2 s^2) \tag{3}$$

$$\delta_i = \alpha_\delta \mathbf{X_i} + \delta_0 \tag{4}$$

$$\beta_i = \alpha_\beta \mathbf{X_i} + \beta_0 \tag{5}$$

$$\tau_i = \alpha_\tau \mathbf{X_i} + \tau_0 \tag{6}$$

$$\sigma_{i,s} = \exp(\alpha_{\sigma_i} \mathbf{X_i} + \alpha_s) \qquad s = 2, \ldots, 11 \tag{7}$$

Note that the specification employed for the gain $\gamma_{i,s}$ depends on a respondent's socio-economic characteristics $\mathbf{X_i}$ as well as on survey tenure $s$, as indicated above. This allows both for heterogeneity within respondents and an exploration of how repeated participation influences reported expectations.[15] Further, the specification of $\sigma_{i,s}$ allows heterogeneity within the individuals (captured by $\alpha_{\sigma_i}$) and variability over time for the same individual (captured by $\alpha_{\sigma_s}$). Finally, note that the public information $z_t$ in our benchmark analysis is measured by the median expectations of professional forecasters.[16]

The model is estimated by maximum likelihood. Our data set consists of an unbalanced panel where the number of observations varies between 6 and 12 observations for each participant to the US survey, and between 2 and 4 for those in the Canadian survey. If one lets $\pi^e_{i,1}, \ldots, \pi^e_{i,t_i}$ be the reported expectations by respondent $i$ for his $t_i$ survey, the conditional likelihood of responses for this participant is written

$$f_i(\pi^e_{it,s} | \pi^e_{it-1,s-1}, \pi_t^{survey}, z_t, \Theta_i) = \prod_{s=2}^{t_i} \left[ \frac{1}{\sqrt{2\pi\sigma^2_{i,s}}} \exp\left[ -\frac{1}{2\sigma^2_{i,s}} \left( \pi^e_{i,s} - \delta \pi^e_{i,s-1} - \beta f_i(\pi_t^{survey}) - \tau z_t \right)^2 \right] \right],$$

[15] The exponential form ensures $\gamma_{i,s} > 0$.

[16] This follows Malmendier and Nagel (2015) and Madeira and Zafar (2015). We use the quarterly Survey of Professional Forecasters (SPF) conducted by the Federal Reserve of Philadelphia for the US and a quadratic-match-average (QMA) method to convert quarterly data into monthly data. QMA fits a local quadratic polynomial for each observation of the low-frequency series and uses this polynomial to fill in all observations of the high-frequency series associated with the period. For Canada, we use the quarterly Survey of Forecasters conducted by the Conference Board of Canada.

where $\Theta_i = \{\theta, \delta, \beta, \tau, \sigma_{i,s}\}$ and the population log-likelihood function for all agents $i = 1, \ldots, N$ is

$$L = \sum_{i=1}^{N} \sum_{s=2}^{t_i} \log f_i(\pi^e_{it,s} | \pi^e_{it,s-1}, \pi_t^{survey}, z_t, \Theta_i).$$

# 4 Benchmark results

We first assess our benchmark results alongside the general heterogeneity dimension, while the next subsection discusses heterogeneity as it specifically affects the process of updating expectations.

## 4.1 Heterogeneity across socio-economic factors

Table 2 first summarizes what Madeira and Zafar (2015) denote as "broad" heterogeneity in estimates. To do so, the table reports the population percentiles for the estimated parameters (recall that parameters are allowed to vary by individual survey participant).

The first striking feature in the table concerns the importance of inflation experience for explaining reported expectations, the parameter $\beta$. The American panel of the table features fairly low estimates for this parameter, with a median $\beta$ of only 0.08, while the 25th-75th interval is [0 0.2]. By contrast, the median such estimate for Canadian data is 0.45 and the 25th-75th interval is [0.3 0.8]. This first result can be summarized by stating that consumers' perceptions of the history of realized inflation rates during their tenure in the survey play a greater role in explaining the reported inflation expectations of Canadian consumers.

Intuitively, Table 2 then reports that the low weight of the history of realized inflation rates for American consumers is counterbalanced by a greater weight of their own lagged expectation, the parameter $\delta$. Indeed, the median estimate for that parameter is 0.43 for American consumers, while it is only 0.27 for their Canadian counterparts. In addition, the 25th- 75th percentile interval is [0.4 0.5] for the United States data and [0.2 0.4] for Canada. This pattern may arise because as US survey participants are surveyed monthly and up to 12 consecutive times, there is more scope for a high dependence to lagged expectations to install itself in the US survey.

Table 2: Distribution of estimated parameters

| | | One-year-ahead inflation expectations | | | | |
|---|---|---|---|---|---|---|
| | | 10% | 25% | 50% | 75% | 90% |
| | | **US** | | | | |
| $\beta$ | Inflation experience y/y | -0.15 | -0.01 | 0.08 | 0.20*** | 0.31*** |
| | | (0.12) | (0.09) | (0.07) | (0.06) | (0.07) |
| $\delta$ | Previous expectations | 0.35*** | 0.39*** | 0.43*** | 0.48*** | 0.53*** |
| | | (0.03) | (0.02) | (0.02) | (0.03) | (0.03) |
| $\tau$ | SPF | 0.07 | 0.13** | 0.32*** | 0.63*** | 0.93*** |
| | | (0.08) | (0.08) | (0.08) | (0.08) | (0.09) |
| | | **Canada** | | | | |
| $\beta$ | Inflation experience y/y | -0.04 | 0.27 | 0.45* | 0.84** | 1.14** |
| | | (0.20) | (0.23) | (0.31) | (0.41) | (0.55) |
| $\delta$ | Previous expectations | 0.11 | 0.17** | 0.27*** | 0.36*** | 0.49*** |
| | | (0.09) | (0.08) | (0.06) | (0.06) | (0.04) |
| $\tau$ | SPF | -0.01 | 0.20 | 0.43** | 0.71*** | 1.03*** |
| | | (0.19) | (0.19) | (0.19) | (0.19) | (0.20) |

*Notes*: Population percentiles of estimated parameters across all the participants in the SCE (top panel) and CSCE (bottom panel). In parentheses, standard deviation computed by simulation. $***, **, *$ denote significance at 1%, 5%, and 10%, respectively. Note that the median respondent has similar characteristics in both countries.

Next, the table shows that the other source of proxies for the rational expectations forecasts about future inflation rates – the median reported expectation by the professional forecasters – also plays a smaller role in explaining inflation expectations for American consumers. Indeed, the table shows that the median $\tau$ estimate is 0.32 (25th-75th percentile interval [0.1 0.6]) in the US, while it is 0.43 ([0.2 0.7]) in Canada. These results are consistent with the previous finding that consumer' expectations are substantially correlated with those of professional forecasters (Carroll, 2003; Macallan et al., 2011; Armantier et al., 2016).

To summarize, inflation expectations appear to correlate more strongly to measures of rational expectations forecasts in the CSCE than in the SCE and conversely less to lagged expectations. The median estimates of each parameter thus assign overall weights of roughly 1/4 to lagged expectations and 3/4 to proxies for the rational expectations forecasts in the CSCE (0.27 versus $0.45 + 0.43$), while those weights are around 50-50 in the SCE (0.43 versus $0.32 + 0.08$). We now assess which socio-economic characteristics explain these differences.

### 4.2 Differences across demographic groups

We report in Tables 3 and 4 how estimated parameters for $\beta$, $\delta$, and $\tau$ and $\sigma$ vary across demographic groups. Recall that the socio-demographic markers indicate when the attribute is present, so that the estimate for an older male with high income and high educational attainment would simply be the constant.

First, Table 3's left panel reveals that the relatively high weights given by Canadian consumers to the history of realized inflation, as reflected by the parameters $\beta$, appear to arise from female and young participants in the survey; these attributes have estimated impacts of 0.484 and 0.702, respectively, which contribute to push the $\beta$ higher. Conversely, the right panel of the same table shows that female, young, or middle-aged Canadian participants assign lower weights to their own lagged expectations. Note that a finding whereby young and female participants report expectations that are less correlated with their lagged values is consistent with Madeira and Zafar (2015), who report using Michigan survey data that these demographic groups' expectations are revised more.

By contrast, the table shows that for the United States, the higher-median distribution of weights for lagged expectations (the parameter $\delta$) discussed above in Table 2 is attributable to the influence of low- to middle-income participants. Conversely, the lower weights given to the history of inflation realizations is also attributable to young, female, and low-income participants. Indeed, most socio-economic attributes in the US are associated with decreases in the parameters $\beta$; as such, the reference participant (high-income and older male) in the US actually exhibits a higher $\beta$ than its Canadian counterpart.

Next, the first two columns of Table 4 report how household characteristics are associated with the observed heterogeneity in how public information – proxied by the median expectation of professional forecasters – affects a household's expectations. In both surveys, this weight increases for low-income, low-education, and low-numeracy participants, albeit from a relatively low "no-attribute" level of 0.07 in the US and a higher one in Canada (0.23). Interestingly, the "female" and "young" attributes have opposite effects in both surveys, although estimates are not statistically significant for Canada.

Recall that our specification of $\sigma_{is}$ allows the unexplained variability in inflation expectations to vary across respondents and over time (see (7)). The last two columns of Table 4 thus report the heterogeneity in the variance of error terms across demographic groups: we find that in both surveys, women, younger, as well as less-educated and lower-income participants all feature higher dispersion in expectations (i.e., larger estimated $\sigma_{is}$). Essentially, every other category of survey

Table 3: Weights on realized inflation and lagged expectations: *Cross-section heterogeneity*

| | Inflation experience ($\beta_i$) | | Lagged expectations ($\delta_i$) | |
|---|---|---|---|---|
| | **US** | **Canada** | **US** | **Canada** |
| Female | -0.005 | 0.482** | 0.013* | -0.146*** |
| | (0.012) | (0.224) | (0.008) | (0.026) |
| Young | -0.074 | 0.702* | -0.071*** | -0.225*** |
| | (0.066) | (0.459) | (0.012) | (0.033) |
| Middle-aged | -0.132** | 0.091 | -0.038*** | -0.165*** |
| | (0.058) | (0.194) | (0.009) | (0.029) |
| Low numeracy | -0.092* | 0.029 | -0.106*** | -0.044* |
| | (0.070) | (0.080) | (0.010) | (0.031) |
| High school | -0.260** | -0.038 | -0.032** | 0.009 |
| | (0.154) | (0.099) | (0.015) | (0.040) |
| Some college | -0.004 | 0.187 | 0.068*** | -0.009 |
| | (0.066) | (0.356) | (0.009) | (0.035) |
| Low income | -0.119** | -0.137 | 0.077*** | 0.103*** |
| | (0.066) | (0.174) | (0.011) | (0.037) |
| Middle income | 0.115** | 0.307* | 0.032*** | 0.070*** |
| | (0.061) | (0.232) | (0.011) | (0.029) |
| Constant | 0.201*** | -0.038 | 0.426*** | 0.424*** |
| | (0.048) | (0.069) | (0.010) | (0.034) |
| Observations | 41,472 | 7671 | 41,472 | 7671 |

*Notes*: Heterogeneity in the weight on inflation experience and on lagged expectations. Standard errors are in parentheses below estimates, with *** p<0.01, ** p<0.05, * p<0.1. Young = 18-34 years old, middle-aged = 35-54. Low numeracy implies less than 4 correct answers to 5 questions on respondents' numeracy knowledge. High school = high school or less, some college = college and less than BA. Low income=< 50,000, middle income= 50,000 – 100,000.

participant, beyond the benchmark older male with high income and high education, has more volatile reported expectations, a result consistent with Madeira and Zafar (2015).

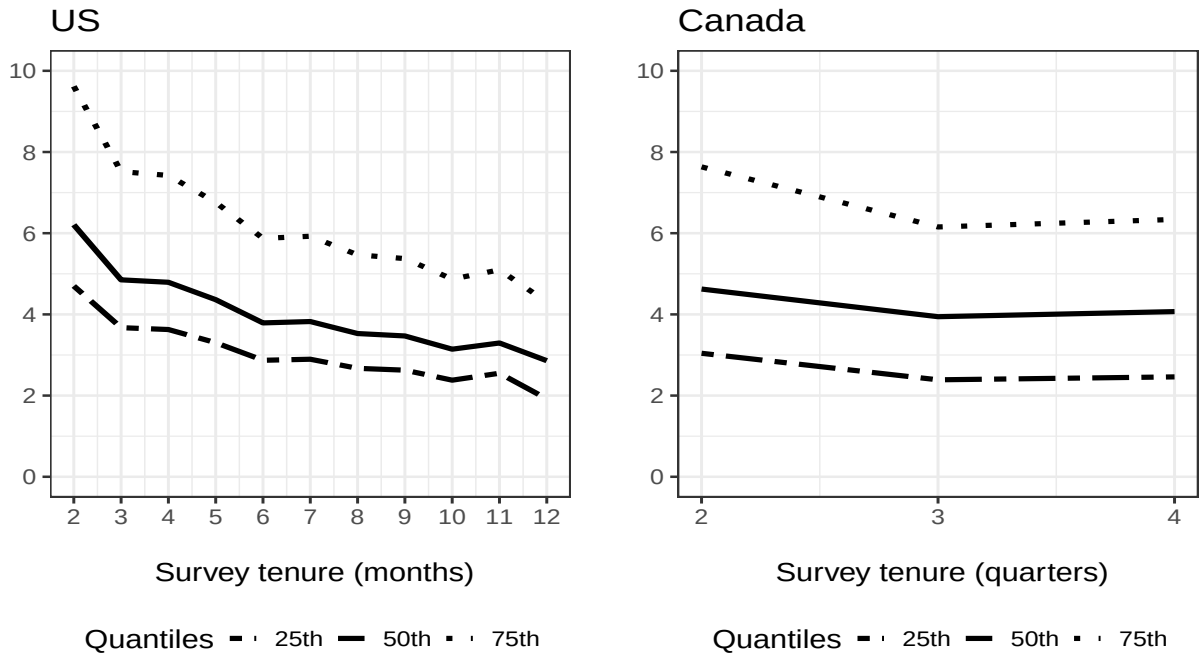
Table 4: Weights on public signal and individual volatility: *Cross-section heterogeneity*

| | Public signal (SPF) ($\tau_i$) | | Volatility ($\sigma_i$) | |
|---|---|---|---|---|
| | **US** | **Canada** | **US** | **Canada** |
| Female | 0.150*** | -0.114 | 0.459*** | 0.501*** |
| | (0.029) | (0.185) | (0.007) | (0.021) |
| Young | -0.076** | 0.026 | 0.039*** | 0.744*** |
| | (0.046) | (0.381) | (0.010) | (0.029) |
| Middle-aged | 0.065* | 0.322** | 0.181*** | 0.572*** |
| | (0.040) | (0.164) | (0.008) | (0.024) |
| Low numeracy | 0.511*** | 0.570*** | 0.503*** | 0.656*** |
| | (0.060) | (0.140) | (0.009) | (0.024) |
| High school | 0.445*** | 0.218* | 0.476*** | 0.222*** |
| | (0.108) | (0.147) | (0.013) | (0.032) |
| Some college | -0.011 | -0.025 | 0.232*** | 0.230*** |
| | (0.045) | (0.298) | (0.008) | (0.028) |
| Low income | 0.272*** | 0.349** | 0.421*** | 0.596*** |
| | (0.048) | (0.188) | (0.009) | (0.031) |
| Middle income | 0.046 | -0.216 | 0.216*** | 0.272*** |
| | (0.041) | (0.198) | (0.009) | (0.024) |
| Constant | 0.066 | 0.227 | - | - |
| | (0.089) | (0.247) | - | - |
| Observations | 41,472 | 7671 | 41,472 | 7671 |

*Notes*: Heterogeneity in the weight on public signal and on estimated volatility. Standard errors are in parentheses below estimates, with *** p<0.01, ** p<0.05, * p<0.1. Young = 18-34 years old, middle-aged = 35-54. Low numeracy implies less than 4 correct answers to 5 questions on respondents' numeracy knowledge. High school = high school or less, some college = college and less than BA. Low income=< 50,000, middle income= 50,000 – 100,000.

Next, Figure 6 plots the evolution of the estimated volatility over time (survey tenure). It shows that as survey respondents become experienced ($s$ increases), the residual in reported expectations becomes less volatile in both countries, but that this effect is particularly present in the US survey.

Figure 6: Estimated volatility




**Note:** Distribution of the estimated volatility across all respondents conditional on tenure (repeated participation) in the SCE (left panel) and the CSCE (right panel).

### 4.3 Updating of expectations

Our discussion of how consumers update expectations has emphasized the gain $\gamma_{i,s}$, which governs the extent to which recent realized rates of inflation are incorporated into each respondent's inflation history $f_i(\pi_t^{survey})$. This gain parameter was specified using the form

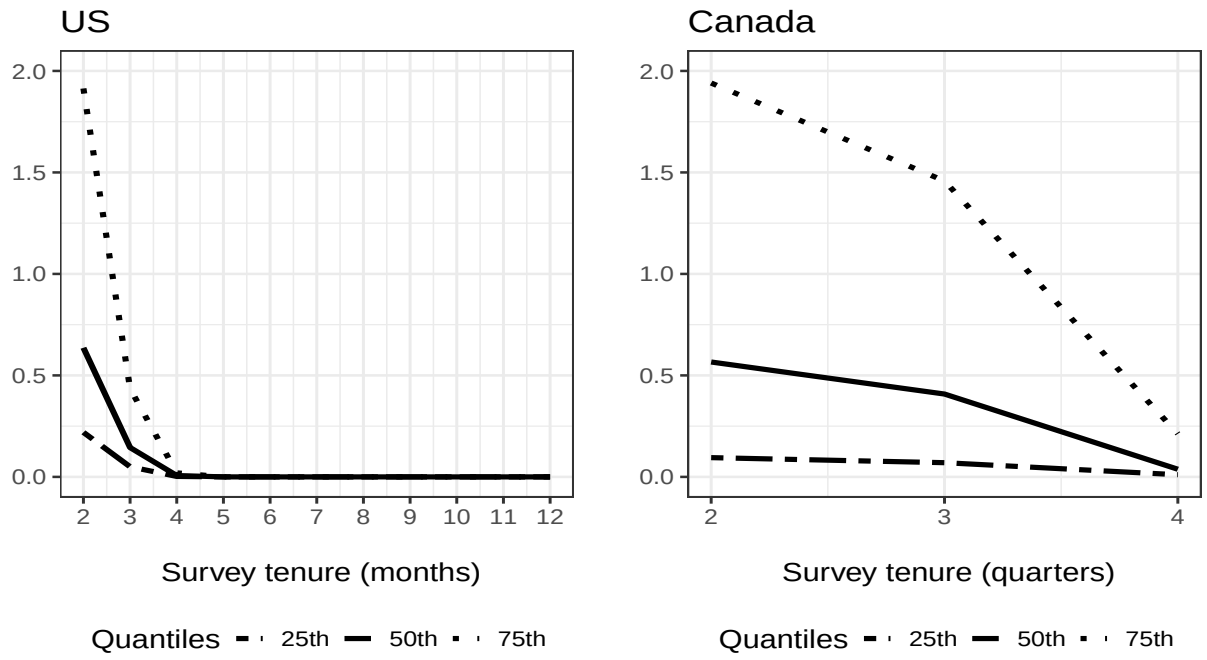
$$\gamma_{i,s} = \exp(\alpha_\gamma \mathbf{X_i} + \lambda_1 s + \lambda_2 s^2), \tag{8}$$

thus allowing to control for socio-economic heterogeneity and dependence on survey tenure $s$ (with the estimated values for of $\lambda_1$ and $\lambda_2$ determining the general shape of the gain).

In that context, consider Figure 7, which plots some quantiles of the distribution of estimates for $\gamma_{i,s}$. It shows that the first stages of updating are fairly similar for the two surveys: indeed, the median gain between the 1st and 2nd participation is around 0.6 for both surveys, and the 25th-75th interval covers similar ranges.

In addition, estimated gain parameters decrease for all respondents as they become familiar with the survey and $s$ rises. However, the gain appears to decrease faster in the US and becomes essentially zero after five months of repeated participation. By contrast, the gain decreases more

Figure 7: Estimated gain parameters, by quantiles




slowly in Canada. This may suggest that US respondents, after they have been surveyed four or five months, stop incorporating new values in their updating and is coherent with results whereby the responsiveness of expectations to survey experience ($\beta$) is lower in the US. Differences in survey frequency relative to tenure (one year for both, but with 12 monthly repetitions for US participants and 4 quarterly ones for their Canadian counterparts) might influence these results, a topic we return to in the next section.

The parameters $\alpha_\gamma$, $\lambda_1$, and $\lambda_2$ are jointly estimated with the other parameters and are presented in Table 5. The estimated values of $\lambda_1$ and $\lambda_2$ give us the nature of the relationship between the gain parameter and the survey tenure, while the parameters $\alpha_\gamma$ determine the source of the heterogeneity in the population observed on Figure 7. The table shows that, as noticed in Figure 7, the influence of tenure quickly becomes a substantial force, reducing the gain for American consumers (the lower estimated value for $\lambda_1$ becoming quickly dominated by the square of $\lambda_2$). In addition, the table reveals that in the US as well as in Canada, young, middle-aged, or lower-income participants have, all things being equal, lower gain. As such, very recent realized rates of inflation are given less weight in these participants' least-square learning about inflation's data generation process. By contrast, female participants in the US assign more weight to the most recent realizations, while in

Canada their behavior is not statistically different from those of men.

Table 5: Heterogeneity in estimated gain $\gamma_{i,s}$

| | Influence of tenure | |
|---|---|---|
| | US | Canada |
| $\lambda_1$ | 0.918*** | 2.011*** |
| | (0.361) | (0.570) |
| $\lambda_2$ | -0.800*** | -0.779*** |
| | (0.094) | (0.172) |
| | Influence of individual characteristics | |
| Female | 0.809*** | -0.022 |
| | (0.238) | (0.524) |
| Young | -1.451*** | -1.088*** |
| | (0.444) | (0.443) |
| Middle-aged | -1.635*** | -0.569** |
| | (0.465) | (0.296) |
| Low numeracy | 1.788*** | 1.014*** |
| | (0.424) | (0.186) |
| High school | -2.642*** | 0.018 |
| | (0.683) | (0.145) |
| Some college | -2.064* | -1.210** |
| | (1.261) | (0.730) |
| Low income | 1.493*** | -0.437** |
| | (0.562) | (0.259) |
| Middle income | -0.278 | -3.491 |
| | (0.283) | (3.149) |
| Observations | 41,472 | 7671 |

*Notes*: Influence of survey tenure on gain parameter et heterogeneity across population in the SCE (left panel) and CSCE (right panel). In parentheses, standard deviation with $***, **, *$ denoting significance at 1%, 5%, and 10%, respectively.

Overall, our benchmark results uncover interesting facts about the formation of inflation expectations by consumers in Canada and in the United States. American consumers appear to put more weight on their own lagged expectations and less on proxies for the rational expectation forecast, relative to their Canadian counterparts. This is particularly the case for young and female participants in the Canadian survey. Expectations also become less volatile as time passes, in the sense that the variance of the residual decreases with survey tenure: in the language of Madeira and Zafar (2015), disagreement decreases with tenure. Finally, the least-square learning process (2), by which one proxy for the rational expectation forecast is established, exhibits lower gain for the US, particularly for young and less-educated participants.

# 5 Sensitivity analysis

This section presents a sensitivity analysis designed to study the robustness of our results. First, we assess the sensitivity of our benchmark results to changes to (1), our specification for the formation of expectations. Next, we study the sensitivity of our findings to survey tenure duration and frequency. We also investigate whether other proxies for publicly available macroeconomic signals about future inflation, such as gas or food price inflation, would modify our results. This allows us to test the hypothesis that prices of frequently purchased, homogenous goods influence inflation expectations.

## 5.1 Main specification for estimation

The formulation of expectations underlying our benchmark results is that of (1), which sources reported expectations from their own lagged values as well as two possible proxies for the rational expectation forecast: a forecast arising from least-square learning on realized rates ($f_i(\pi_t^{survey})$) and the median reported forecast in the SPF ($z_t$). We now assess the robustness of our results to changes in (1) that maintains as constant those three sources.

Specifically, we investigate the following alternative to (1):

$$\pi^e_{it,s} = \delta_i \pi^e_{it-1,s-1} + (1-\delta_i)\left[c + \beta_i f_i(\pi_t^{survey}) + \tau_i z_t\right] + \eta_{it,s}, \tag{9}$$

whose form is reminiscent of those used in empirical work assessing Taylor-type monetary policy rules. As such, the coefficient $\delta$ indexing the weight on lagged expectations also has a direct and symmetric impact on both $f_i(\pi_t^{survey})$ and $z_t$, via the inclusion of the term $1-\delta$. Furthermore, the coefficient $\delta$ is now constrained to be between 0 and 1 in the estimation.

Table 6 presents the first results. A comparison with those depicted in Table 2 reveals that many results are similar. The distribution of estimated weights on lagged expectations $\delta$, for example, remains higher in the US, with an interquartile range of 0.4 to 0.5 relative to the one in Canada (0.15 to 0.35). The last two lines of Table 6 report the equivalent numbers according to the benchmark specification, which do not square with those in Table 2 because each estimate is individual and so the median for $(1-\delta_i)\beta_i$ is not the median estimate for $(1-\delta)\beta$. The weight on the public signal remains higher in the Canadian survey, while the weight on inflation experience is now similar between the two countries. Similarly, Table 10 and Table 11, in the Appendix, show that overall, the cross-section heterogeneity results are similar to those obtained in the benchmark estimation

and discussed above in Table 3-4. Finally, Figure 8 and Table 12 (also in the Appendix) show that under this alternative specification, patterns whereby estimated gains decrease quite rapidly in the US data, whereas these decreases are much more gradual in Canada, continue to be present in the data.

Table 6: Distribution of estimated parameters: *Alternative specification*

| | | Quantiles in the distribution of estimates | | | | |
|---|---|---|---|---|---|---|
| | | 10% | 25% | Median | 75% | 90% |
| | | **US** | | | | |
| $\delta$ | Previous expectations | 0.36 | 0.39 | 0.43 | 0.48 | 0.53 |
| $(1-\delta)*\beta$ | Inflation experience y/y | -0.02 | 0.05 | 0.11 | 0.19 | 0.29 |
| $(1-\delta)*\tau$ | Public information (SPF) | 0.08 | 0.16 | 0.33 | 0.60 | 0.88 |
| | | **Canada** | | | | |
| $\delta$ | Previous expectations | 0.11 | 0.14 | 0.26 | 0.34 | 0.52 |
| $(1-\delta)*\beta$ | Inflation experience y/y | 0.00 | 0.01 | 0.13 | 0.18 | 0.21 |
| $(1-\delta)*\tau$ | Public information (SPF) | 0.09 | 0.19 | 0.44 | 0.85 | 1.25 |

*Notes*: Population percentiles of estimated parameters across all the participants in the SCE (top panel) and CSCE (bottom panel). In parentheses, standard deviation computed by simulation. $***, **, *$ denote significance at 1%, 5%, and 10%, respectively.

## 5.2 Impact of survey tenure duration and frequency

In the previous analysis, we found that in the US as well as in Canada, consumers' inflation expectations are sensitive to the history of inflation realizations during their tenure in the survey. However, the impact of inflation experience was found to be bigger for Canadian consumers, whereas for their US counterparts, the weight on lagged expectations was seen to be more important. Overall, among the three identified drivers of reported inflation expectations, the inflation experienced during their survey tenure appears to be the most important source in Canada (Table 2), which is not the case in the US.

This section investigates whether this finding may be due to frequency differences, about survey tenure duration and frequency. Recall that respondents to the SCE participate for up to 12 consecutive months, whereas their Canadian counterparts do so for up to 4 consecutive quarters. For this purpose, we re-estimate our benchmark specification on US data using the first observation in each quarter for each respondent leading to a maximum of four observations, to make the US survey artificially similar to the Canadian one.

Table 7 reports the distribution of our parameters by comparing the initial estimation to the

estimations obtained by using the first observation in each quarter for the SCE. It shows that the median weight on inflation history increases from 0.08 in our initial findings to 0.14. In addition, the median weight on lagged expectations decreases from 0.43 to 0.32, which is closer to the 0.27 figure obtained from the Canadian survey. The overall weights on proxies for the rational expectations forecasts is now about 3/4 $(0.14 + 0.56)$ even if the impact of the history of inflation during the tenure ($\beta$) remains lower than in the CSCE. Indeed, the consecutive 12-month participation partly explains the higher dependence to lagged expectations in the US survey.

Table 7: Distribution of estimated parameters: *impact of survey frequency*

| | | Quantiles in the distribution of estimates | | | | |
|---|---|---|---|---|---|---|
| | | 10% | 25% | Median | 75% | 90% |
| | | **US, first observation in each quarter** | | | | |
| $\beta$ | Inflation experience y/y | -0.06 | 0.01 | 0.14 | 0.22 | 0.26 |
| $\delta$ | Previous expectations | 0.15 | 0.27 | 0.32 | 0.35 | 0.37 |
| $\tau$ | Public signal (SPF) | 0.23 | 0.40 | 0.56 | 0.85 | 1.10 |
| | | **US, all observations (benchmark)** | | | | |
| $\beta$ | Inflation experience y/y | -0.15 | -0.01 | 0.08 | 0.20 | 0.31 |
| $\delta$ | Previous expectations | 0.35 | 0.39 | 0.43 | 0.48 | 0.53 |
| $\tau$ | Public signal (SPF) | 0.07 | 0.13 | 0.32 | 0.63 | 0.93 |
| | | **Canada (benchmark)** | | | | |
| $\beta$ | Inflation experience y/y | -0.04 | 0.27 | 0.45 | 0.84 | 1.14 |
| $\delta$ | Previous expectations | 0.11 | 0.17 | 0.27 | 0.36 | 0.49 |
| $\tau$ | Public signal (SPF) | -0.01 | 0.20 | 0.43 | 0.71 | 1.03 |

*Notes*: First panel: Population percentiles of estimated parameters across all the participants in the SCE using the first observation in each quarter instead of all monthly data. Second and third panels report benchmark results for the SCE and CSCE.

### 5.3 Alternative to the SPF: Quarter-over-quarter changes in gasoline and food prices

In this section, we study whether other proxies for publicly available macroeconomic signals about future inflation would modify our results. We test for quarter-over-quarter changes in gasoline and food prices. We find that the weight on inflation experience remains higher for Canadian consumers. In addition, we show that reported inflation expectations are shaped by changes in food prices, but less so for Canadian consumers. Indeed, Tables 8 and 9 show that the median weight on changes in food prices is 0.24 (25th-75th percentile interval [0 0.7]) in the US, while it is only 0.08 ([0.01 0.5])

in Canada. This is consistent with Clark and Davig (2008). However, inflation expectations do not appear to be correlated to changes in gasoline prices in both countries. This differs from the results found in Coibion and Gorodnichenko (2015) on the Michigan survey. This could be due to several factors: first, our sample is more recent, from 2013 and 2014, respectively, for the US and Canada. Second, we do not use the same measure of gasoline price: they use oil price West Texas Intermediate, while we use month-over-month (quarter-over-quarter) changes in CPI gasoline (all types).[17]

Table 8: Distribution of estimated parameters: *Changes in gas price*

| | | One-year-ahead inflation expectations | | | | |
|---|---|---|---|---|---|---|
| | | 10% | 25% | 50% | 75% | 90% |
| | | US | | | | |
| $\beta$ | Inflation experience y/y | 0.03 | 0.19*** | 0.32*** | 0.67*** | 0.98*** |
| | | (0.03) | (0.05) | (0.04) | (0.06) | (0.08) |
| $\delta$ | Previous expectations | 0.36*** | 0.40*** | 0.43*** | 0.49*** | 0.52*** |
| | | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) |
| $\tau$ | q/q change in gasoline prices | -0.01* | 0.00* | 0.01*** | 0.02*** | 0.04*** |
| | | (0.004) | (0.002) | (0.002) | (0.003) | (0.01) |
| | | Canada | | | | |
| $\beta$ | Inflation experience y/y | -0.02 | 0.39*** | 0.79*** | 1.28*** | 1.67*** |
| | | (0.10) | (0.11) | (0.13) | (0.18) | (0.24) |
| $\delta$ | Previous expectations | 0.10*** | 0.17 | 0.28*** | 0.38*** | 0.50*** |
| | | (0.04) | (0.04) | (0.03) | (0.03) | (0.02) |
| $\tau$ | q/q change in gasoline prices | -0.10*** | -0.06*** | -0.01 | 0.02** | 0.05*** |
| | | (0.03) | (0.02) | (0.01) | (0.01) | (0.02) |

*Notes*: Population percentiles of estimated parameters across all the participants in the US (top panel) and Canada (bottom panel) using changes in gasoline price as public signal about inflation. In parentheses, standard deviation computed by simulation. $***, **, *$ denote significance at 1%, 5%, and 10%, respectively.

## 6 Conclusion

The rich heterogeneity and repeated participation features in the Survey of Consumer Expectations (SCE) and the Canadian Survey of Consumer Expectations (CSCE) are employed to study the inflation expectations of American and Canadian consumers. We show that American consumers put more weight on their own lagged expectations when forming their inflation expectations, whereas

[17] These statistics are from the US Bureau of Labor Statistics for the US and Statistics Canada for Canada.

Table 9: Distribution of estimated parameters: *Changes in food price*

| | | One-year-ahead inflation expectations | | | | |
|---|---|---|---|---|---|---|
| | | 10% | 25% | 50% | 75% | 90% |
| | | US | | | | |
| $\beta$ | Inflation experience y/y | -0.02 | 0.16*** | 0.33*** | 0.60*** | 0.90*** |
| | | (0.05) | (0.07) | (0.08) | (0.09) | (0.14) |
| $\delta$ | Previous expectations | 0.36*** | 0.40*** | 0.43*** | 0.49*** | 0.52*** |
| | | (0.02) | (0.02) | (0.02) | (0.02) | (0.02) |
| $\tau$ | q/q change in food price | -0.39*** | -0.22*** | 0.24*** | 0.71*** | 1.25*** |
| | | (0.03) | (0.03) | (0.03) | (0.03) | (0.05) |
| | | Canada | | | | |
| $\beta$ | Inflation experience y/y | -0.11 | 0.26** | 0.53*** | 0.95*** | 1.28*** |
| | | (0.10) | (0.13) | (0.15) | (0.17) | (0.22) |
| $\delta$ | Previous expectations | 0.13** | 0.18*** | 0.27*** | 0.37*** | 0.48*** |
| | | (0.06) | (0.06) | (0.04) | (0.04) | (0.04) |
| $\tau$ | q/q change in food price | -0.03 | 0.01 | 0.08 | 0.47*** | 0.59*** |
| | | (0.11) | (0.09) | (0.11) | (0.16) | (0.19) |

*Notes*: Population percentiles of estimated parameters across all the participants in the US (top panel and Canada (bottom panel) using changes in food price as public signal about inflation. In parentheses, standard deviation computed by simulation. $***, **, *$ denote significance at 1%, 5%, and 10%, respectively.

proxies for the rational-expectation forecasts, such as a least-square learning forecast or the median response in the survey of professional forecasters, play a bigger role in the expectations of Canadian consumers. We also show that these differences stem from differentiated expectations of specific socio-economic groups, such as females or young respondents in the surveys. In addition, an experiment that uses only some of the repeated observations from the American survey suggests that the larger weight on lagged expectations may arise because of the 12 monthly consecutive appearances in the survey. As such, it may be that the consumers surveyed by the SCE stop incorporating new information about inflation after having participated for a few months. The observed differences in the two countries may also reflect differences in monetary policy regimes and communication. Ongoing further work is considering some comparative text analytic, analyzing the communications of the Bank of Canada and the Federal Reserve to explore this hypothesis.

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# Appendix

Table 10: Weights on realized inflation and lagged expectations
*Alternative Specification*

| | Inflation experience ($\beta_i$) | | Lagged expectations ($\delta_i$) | |
|---|---|---|---|---|
| | **US** | **Canada** | **US** | **Canada** |
| Female | -0.016 | -0.024 | 0.036 | -0.945*** |
| | (0.020) | (0.032) | (0.036) | (0.156) |
| Young | -0.157* | 0.019 | -0.284*** | -1.218*** |
| | (0.118) | (0.052) | (0.049) | (0.198) |
| Middle-aged | -0.234** | -0.002 | -0.162*** | -0.889*** |
| | (0.102) | (0.007) | (0.039) | (0.158) |
| Low numeracy | -0.204** | 0.006 | -0.456*** | -0.415** |
| | (0.123) | (0.011) | (0.045) | (0.191) |
| High school | 0.025 | 0.005 | -0.151** | -0.030 |
| | (0.029) | (0.009) | (0.065) | (0.208) |
| Some college | 0.062 | -0.012 | 0.270*** | -0.137 |
| | (0.186) | (0.047) | (0.039) | (0.177) |
| Low income | -0.123 | 0.018 | 0.306*** | 0.449** |
| | (0.115) | (0.305) | (0.047) | (0.206) |
| Middle income | 0.238** | -0.222* | 0.118*** | 0.334** |
| | (0.104) | (0.174) | (0.045) | (0.159) |
| Constant | 0.326*** | 0.242* | -0.275*** | -0.108 |
| | (0.084) | (0.184) | (0.043) | (0.178) |
| Observations | 41,472 | 7671 | 41,472 | 7671 |

Table 11: Weights on public signal and individual volatility
*Alternative Specification*

| | Public signal (SPF) ($\tau_i$) | | Volatility ($\sigma_i$) | |
|---|---|---|---|---|
| | **US** | **Canada** | **US** | **Canada** |
| Female | 0.309*** | 0.103 | 0.460*** | 0.501*** |
| | (0.043) | (0.097) | (0.007) | (0.021) |
| Young | -0.313*** | 0.336** | 0.039*** | 0.749*** |
| | (0.075) | (0.148) | (0.010) | (0.029) |
| Middle-aged | -0.005 | 0.257*** | 0.181*** | 0.576*** |
| | (0.065) | (0.089) | (0.008) | (0.024) |
| Low numeracy | 0.495*** | 0.745*** | 0.502*** | 0.654*** |
| | (0.090) | (0.153) | (0.009) | (0.024) |
| High school | 0.359*** | 0.326** | 0.475*** | 0.219*** |
| | (0.096) | (0.165) | (0.013) | (0.032) |
| Some college | 0.188** | 0.220** | 0.232*** | 0.228*** |
| | (0.106) | (0.128) | (0.008) | (0.029) |
| Low income | 0.712*** | 0.718*** | 0.421*** | 0.594*** |
| | (0.079) | (0.303) | (0.009) | (0.031) |
| Middle income | 0.150*** | 0.409*** | 0.215*** | 0.265*** |
| | (0.066) | (0.157) | (0.009) | (0.024) |
| Constant | 0.132 | -0.138 | - | - |
| | (0.158) | (0.335) | - | - |
| Observations | 41,472 | 7671 | 41,472 | 7671 |

Table 12: Heterogeneity in estimated gain $\gamma_{i,s}$
*Alternative specification*

| One-year inflation expectations | | |
|---|---|---|
| | Gain parameters | |
| | US | Canada |
| $\lambda_1$ | 0.996** | 1.449*** |
| | (0.462) | (0.496) |
| $\lambda_2$ | -0.847*** | -0.766*** |
| | (0.098) | (0.196) |
| Cross-section parameters | | |
| Female | 0.687*** | 1.063*** |
| | (0.186) | (0.267) |
| Young | -1.835*** | -1.248** |
| | (0.585) | (0.879) |
| Middle-aged | -1.896*** | -0.643** |
| | (0.518) | (0.300) |
| Low numeracy | 2.037*** | 1.182*** |
| | (0.516) | (0.225) |
| High school | -0.278 | -0.098 |
| | (0.250) | (0.129) |
| Some college | -1.439 | -1.078 |
| | (2.545) | (1.140) |
| Low income | 1.588** | -0.552 |
| | (0.712) | (0.538) |
| Middle income | -0.446 | 1.418*** |
| | (0.414) | (0.606) |
| Observations | 41,472 | 7671 |

Figure 8: Estimated gain parameters, by quantiles
*Alternative specification*