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The evolution of inflation expectations in Canada and the US

James Yetman[1]

Abstract

We model inflation forecasts as monotonically diverging from an estimated long-run anchor point towards actual inflation as the forecast horizon shortens. Fitting the model with forecaster-level data for Canada and the US, we identify three key differences between the two countries. First, the average estimated anchor of US inflation forecasts has tended to decline gradually over time in rolling samples, from 3.4% for 1989-1998 to 2.2% for 2004-2013. By contrast, it has remained close to 2% since the mid-1990 for Canadian forecasts. Second, the variance of estimates of the long-run anchor is considerably lower for the panel of Canadian forecasters than US ones following Canada's adoption of inflation targets. And third, forecasters in Canada look much more alike than those in the US in terms of the weight that they place on the anchor. One explanation for these results is that an explicit inflation targeting regime (Canada) provides for less uncertainty about future monetary policy actions than a monetary policy regime where there was no explicit numerical inflation target (the US before 2012) to anchor expectations.

Keywords: Inflation expectations, decay function, inflation targeting

JEL classification: E31, E58

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1. Introduction

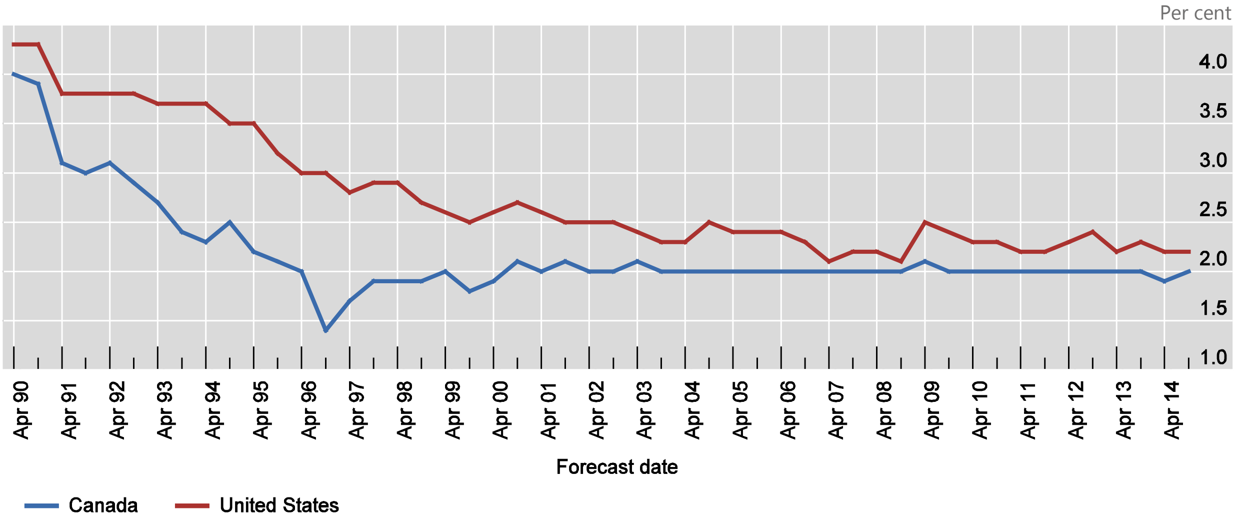
Central bank transparency can improve the transmission of monetary policy. A clear understanding of how monetary policy will respond to shocks might reduce uncertainty about future policy responses. One measure that could be helpful in this regard is having a credible numerical objective for monetary policy. Combined with a model of the economy, this may enable economic agents to accurately predict how monetary policy will respond to economic developments, thereby contributing to macroeconomic stability.

One way to assess the success of a monetary policy regime in this regard is to examine the behaviour of macroeconomic forecasts. If forecasters seek to produce timely, accurate estimates of future outcomes, then these should reflect beliefs about future monetary policy decisions. We carry out such an assessment here. We focus on two large economies, one of which is an inflation targeter (Canada) and one of which, at least until recently, had no explicit numerical inflation objective (the US). This paper is therefore related to the rich literature examining the effect of inflation targeting on inflation forecast performance, as summarised in the next section.

A common way to analyse forecasts is to focus on mean values across a panel of forecasters, some of which are available at very long horizons. Graph 1 contains 6-10 year ahead mean forecasts for Canada and the US from Consensus Economics. The date on the horizontal axis is when the forecasts were made.

Forecasts of long-run inflation

6-10 years ahead | Graph 1



Source: Consensus Economics©.

Even from a cursory glance, it is clear that long-run inflation expectations in the two countries have behaved quite differently from each other. Those in the US have trended down over most of the sample period but have remained relatively volatile throughout. By contrast, those for Canada fell rapidly early in the sample period, after which they have remained close to two percent.

However, looking only at these average forecasts ignores a lot of relevant information. First, they are available only twice a year (whereas shorter term forecasts are available at a monthly frequency).

Second, and more importantly, only average forecasts are available. These suppress useful information on the degree of diversity across the panel of individual forecasters, as has been documented elsewhere, for example Giordani and Söderlind (2003) and Batchelor and Dua (1995).

We therefore focus on the forecasts of individual forecasters at shorter horizons, and examine how these vary over time. We apply the empirical model first introduced in Mehrotra and Yetman (2014) to these data. Inflation forecasts for each forecaster are modelled as being the weighted sum of two components: a long-run forecaster-specific anchor that is estimated, and the latest available actual inflation rate at the time that the forecast was made, with the weights summing up to one. The weight on the anchor is modelled with a flexible decay function, so that inflation forecasts monotonically diverge from their estimated anchor towards actual inflation as the forecast horizon shortens.

The motivation for considering a model of this nature is easy to see from looking at the behaviour of panels of forecasts through time. Graph 2 displays the forecasts from the four most frequent forecasters for the 2004-2013 period from each country. The horizontal axes are the forecast horizons, which run from h = 24 (forecasts made at the start of January, 24 months before the completion of the calendar year being forecast, the longest horizon at which Consensus Economics makes individual forecaster-level forecast data available) to h = 1 (made in December of the calendar year being forecast). The figures confirm our prior regarding the behaviour of expectations. The forecasts across the different years for a given forecaster are much more similar to each other at longer horizons than shorter ones. They increasingly diverge as the horizon shortens, and at short horizons look a lot like the distribution of inflation outcomes (not shown).

When we compare the distributions of estimates of both the long-run anchors and the decay paths between Canada and the US, we identify three important differences between the two countries:

i) In rolling samples, the average estimated anchor declines gradually over the sample period for US forecasters. By contrast, it declined early in the sample period for Canadian ones and then remained at its new low level, very close to the midpoint of the announced inflation target of two percent;

ii) The variance of estimates of the long-run anchor for US forecasters has remained at roughly the same level over time. For Canadian ones it declined from levels comparable to those for the US early in our sample period to around one-quarter of the US level by the end;

iii) And the distribution estimated weights on the long run anchor varies between the countries, especially later in the sample. Whereas the decay functions look similar for Canadian forecasters, they are bimodal for US forecasters. For the latter country, some forecasters place a high weight on the inflation anchor at all horizons beyond 12 months, while for others the weight decays more uniformly.

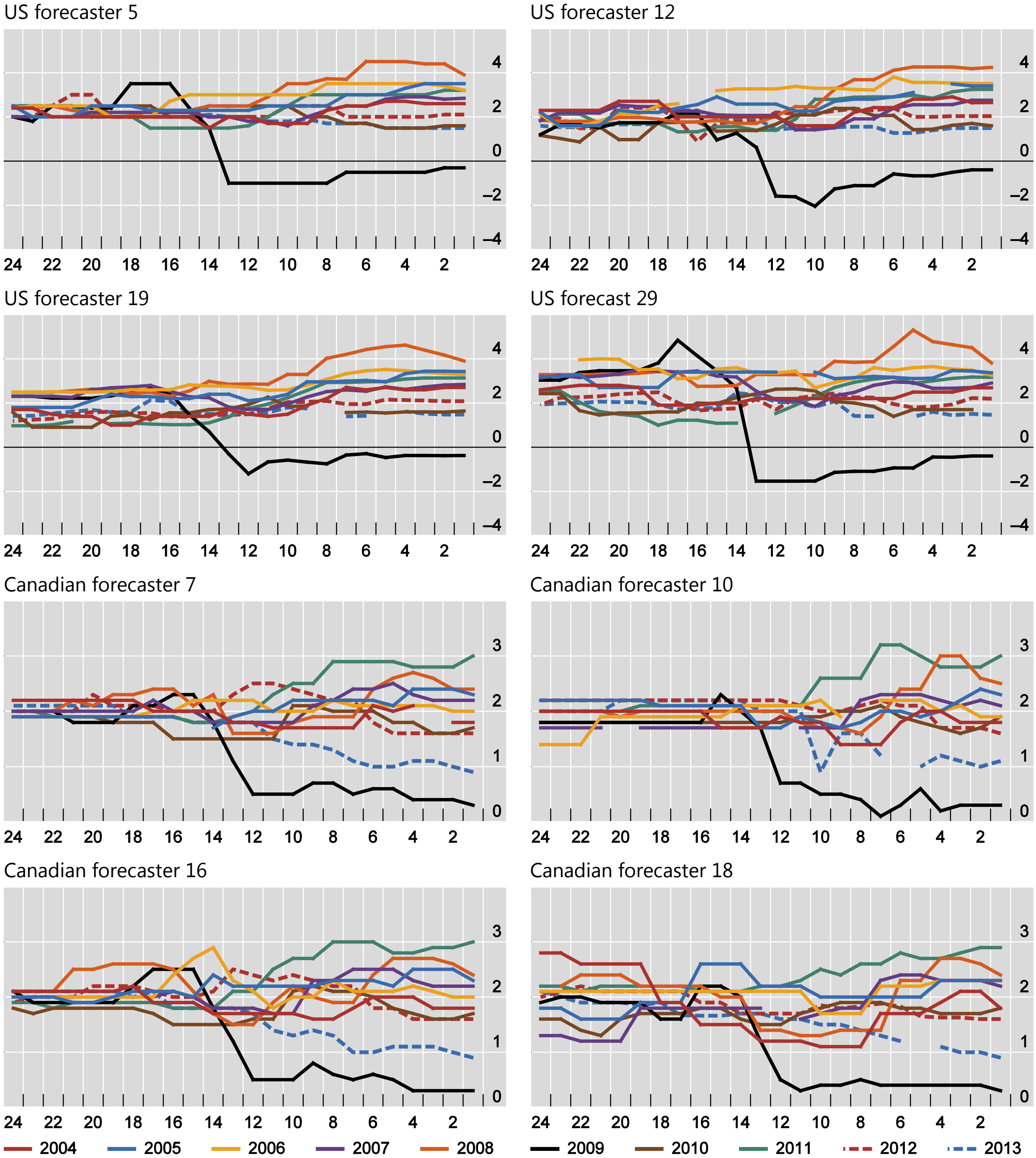
In the next section we discuss the related literature. Section 3 discusses the evolution of the inflation objective for monetary policy across the two countries. Section 4 outlines the methodology and describes the data. Section 5 reports the results, and section 6 concludes.

2. Related literature

In this paper, we use the empirical model of Mehrotra and Yetman (2014) to assess inflation forecast anchoring in the US and Canada, focusing on forecaster-level data. In doing so, we build on a substantial existing literature, much of it comparing the behaviour of inflation forecasts in economies with an inflation target, like Canada, with others where there is no explicit numerical target, like the US (prior to 2012).

Forecasts of headline inflation at different horizons

In per cent | Graph 2



Label on the horizontal axis corresponds to the number of months before the completion of the year being forecast, ie 24 indicates forecasts made in January for the following calendar year.

Source: Consensus Economics©.

Most of this literature considers median or mean forecasts as a summary measure of the level of expectations, and/or the standard deviation or inter-quartile range as a measure of forecast dispersion. Levin et al (2004) find that longer-term inflation forecasts are less correlated with lagged inflation in five economies with explicit inflation targets than in seven economies without. Davis (2014) finds that the sensitivity of inflation expectations to oil price and inflation shocks has declined in inflation targeting economies, but not in others, in a sample of 36 economies based on forecasts from Consensus Economics.

Johnson (2002) compares inflation forecasts for five inflation targeters with six non-targeters and finds that inflation targeting lowered the level of inflation expectations but had no effect on the variability of expected inflation. Cecchetti and Hakkio (2009) argue that the effect of inflation targeting on the dispersion of inflation forecasts has been small. They focus on the standard deviation of inflation forecasts from Consensus Economics for 15 countries. Capistrán and Ramos-Francia (2010) also focus on the effect of inflation targeting on the dispersion of inflation expectations, measured using the inter-quartile range, in a 25-country panel. They find that longer-term expectations are less dispersed in inflation targeting emerging market economies, with a cumulative effect that builds over the first three years following the adoption of inflation targets, but find little effect for advanced economies.[2] In contrast to these three papers, we compare two advanced economies and find a significant difference between them. One possible explanation for this is that these authors all cluster different forecast horizons into two groups: "current year" and "following year". Rather than modelling the effect of a shortening horizon on forecasts as reflecting a change in the relevance of current information about inflation, as we do, they treat it econometrically as a form of seasonality. Within each group they add monthly dummy variables to their estimation. Given the complex dynamics across forecast horizons displayed in Graph 2, this assumption may not be innocuous: at the very least, it may reduce the econometric power of tests of changes in inflation forecast dispersion compared with the model that we employ.

Siklos (2013) also focuses on median forecasts from Consensus Economics, but combines these with forecasts from other sources including central banks, international organisations and surveys in order to focus on what explains forecast dispersion. He finds that central bank transparency is associated with greater disagreement, while inflation targeting has little effect on forecast dispersion. One distinction between his approach and the one taken here is that we use a richer empirical model that allows us to assess how dispersion varies across horizons, whereas he uses a weighted average of two fixed-event forecasts to approximate fixed-horizon 1-year ahead forecasts.[3] We also focus on individual professional forecasters, rather than forecasts from the more diverse set of sources that Siklos studies.

Another set of papers examine mean or median forecasts solely for the US, one of the countries that we also examine. Mankiw, Reis and Wolfers (2004) consider four different survey measures of US inflation expectations and assess what explains the degree of disagreement, measured by the inter-quartile range, within each of the measures. They find that forecast disagreement is positively correlated with both the level of inflation and the absolute change in the level of inflation over time. Clark and Nakata (2008) use a survey-based measure of long-term inflation forecasts (5-10 years ahead) to show that the effect of an unexpected inflation increase on inflation expectations has weakened. Thus they suggest that the anchoring of expectations has improved, although the effect is

2 Capistrán and Ramos-Francia (2010) define inflation expectations as "anchored when individual expectations with a forecast horizon equal to or greater than the central bank's control lag are at or very close to the inflation target, even if inflation […] is not at or close to the target". Our model can be interpreted as a generalisation of this idea in the sense that the control that the central bank has over inflation outcomes is a monotonically increasing function of the forecast horizon, rather than assuming complete control over inflation beyond some specific horizon.

3 See Mehrotra and Yetman (2014) for a more detailed critique.

quantitatively small, driven in part by a reduction in the size of shocks, rather than changes in underlying structural relationships. Similarly, we will find that the increase in the degree to which inflation forecasts are anchored in the US is limited, in stark contrast to Canada.

While studies using mean or median forecasts are most prevalent, they can mask forecaster-level variability in the data. Dovern et al (2015) illustrate the importance of this for GDP forecasts. Examining data for 36 economies, they show that data from individual forecasters displays much less rigidity than that in average forecasts. In the context of inflation forecasts, Johnson (2003) focuses on data at the forecaster level. He approximates fixed-horizon 1-year ahead forecasts using forecasts for the current and following year and then estimates the effect of the introduction of inflation targeting on the behaviour of inflation forecasts, controlling for key macroeconomic variables, using forecaster-level data. He finds that the introduction of inflation targeting was followed by a reduction in the level of inflation forecasts in four of the five economies he studies. In this study we will use forecaster-level data to focus on a broader range of questions about the behaviour of inflation expectations for two economies, one of which is an inflation targeter.

Assessing the degree to which expectations are anchored requires a definition of anchoring that may be taken to the data. Here we follow the approach of Mehrotra and Yetman (2014). They model forecasts as monotonically diverging from an estimated long-run anchor point, using a decay function, towards actual inflation as the forecast horizon shortens. Applying this model to median forecasts for 44 economies, they find that inflation expectations have become more tightly anchored over time in both inflation targeting economies and in those with other monetary policy regimes. However, they find that inflation targeting regimes have seen a greater change along three dimensions: the level of the long-run anchor has fallen further; the tightness of anchoring has increased more; and the relationship between the long-run anchor and actual inflation outcomes has weakened to a greater degree.

Alternative definitions of anchoring have also been considered. Most of these are based on break even inflation rates from a comparison of nominal and real bonds. One advantage of this data source is that observations of expected long-run inflation are available at much higher frequency (typically daily data is examined), in comparison with long term professional forecasts.[4] These can be used to examine how anchoring is changing over time.

For example, Galati et al (2011) examine the volatility of break-even inflation rates and also the sensitivity of rates to macroeconomic news. They find that both of these increased beginning in 2007, especially for the US, consistent with a decline in anchoring, but to a lesser extent for the UK and euro area. Autrup and Grothe (2014) also find greater anchoring of inflation expectations in the euro area than the US in recent years, using a similar approach.[5] Meanwhile, Nautz and Strohsal (2015) allow for multiple break-points in the effects of news on break even inflation in the US, and find that there is little evidence of a re-anchoring of inflation expectations following a decline in anchoring at the start 2009, at least up until the end of their sample (mid-2014).

Strohsal and Winkelmann (2015) also use daily financial data, but measure anchoring in a way that is more comparable with the approach we take. They estimate a long-run anchor, using an exponential smooth transition autoregressive (ESTAR) model, and assess the degree of anchoring based on the speed of mean reversion to the anchor. In contrast to much of the previously cited

4 Note, however, that the difference between nominal and real bond yields is influenced by more than just expected inflation, potentially contaminating the data; see Hördahl (2009) for one discussion of these issues.

5 Focusing on a slightly earlier period, Gürkaynak et al (2010) show that the volatility of break-even inflation rates for the US over 1998-2005 compare with those for the UK before the Bank of England gained independence in 1997.

literature, they report stronger anchoring for the US than the UK, and very persistent deviations and a high inflation anchor in the latter.

Others also use the idea of decay functions in empirical models of forecasts, but along different dimensions that our focus here. For example, Gregory and Yetman (2004) use a polynomial decay function and Blue Chip survey data to model how forecasts by different forecasters converge towards a consensus as the forecast horizon shortens. And Faust and Wright (2013) find that a model with long-term and near-term expectations derived from surveys, together with a simple exponential decay path between them, does very well in terms of forecasting performance.

3. The evolution of the inflation objective in Canadian and US monetary policy

We will focus on how inflation expectations behave in two economies whose monetary policy frameworks have evolved in quite different ways over the sample period we examine, 1989-2013. Canada was one of the earliest adopters of a formal inflation target, although the precise nature of that target has evolved over its life. Further, the Bank of Canada adopted an inflation target at a time when it was seeking to lower the inflation rate. In contrast, the US did not have a specific numerical target for inflation before 2012, and its adoption of a target occurred following a period when inflation had been unusually low.

3.1 Canada

January 1988 has been identified as a key date in the adoption of formal inflation targets in Canada. Then, the governor of the Bank of Canada made it clear in a speech that he believed that the longer-run objective of monetary policy in Canada should be price stability (Crow (1988)). In February 1991 this was formalised when the Government of Canada and the Bank of Canada jointly announced explicit inflation targets. The objective entailed a declining inflation rate, from an initial level of 4-5 percent, to 3 percent by the end of 1992, and then declining linearly to 2 percent by the end of 1995 (Bank of Canada (1991)).

The inflation targets were subsequently extended at frequent intervals, with announcements in 1993, 1998, 2001, 2006 and 2011. While the basic parameters of the inflation target remained unchanged throughout this period, there was some fine-tuning of the language used to describe the target. For example, the first formal statement of the target mentioned only the midpoint, with discussion of a target band of "plus or minus one percentage point" relegated to a supplementary background note. By contrast, the next target statement, released in December 1993 and applying to the 1995-1998 period, paid greater focus to the range ("maintain the objective of holding inflation inside the range of 1 to 3 per cent (mid-point 2 per cent)", Bank of Canada (1993)). When the target was extended for a further three year period in February 1998, the objective was "holding inflation inside the range of 1 to 3 per cent", with no explicit mention of the mid-point (Bank of Canada (1998)).

At the time of the next renewal, in May 2001, there were two changes. The agreement applied to a longer, five-year period (2001-2006), and mention of the mid-point of the target range returned ("The inflation-control target range will continue to be 1 to 3 per cent; within this range monetary policy will continue to aim at keeping the trend of inflation at the 2 per cent target midpoint", Bank of Canada (2001)). Later renewals, in 2006 and 2011, retained both the longer 5-year life-span, and also continued to mention both the mid-point and two percentage-point range (Bank of Canada (2006a, 2011a)).

In addition to these subtle changes in the wording of the targets, some announcements also contained hints of possible future evolution of the target that were not followed through ex post, but might have weighed on longer term expectations. For example, the initial announcement in 1991 included the statement that beyond 1995, "the objective would be further reductions in inflation until price stability is achieved", with existing research on what this suggesting that this required "a rate of increase in consumer prices that is clearly below 2 per cent". However, aside from the minor changes in language outlined above, the mid-point of the target range remained unchanged, at two percent, in all subsequent agreements.

Additional possible changes were hinted at in the agreements in 2006 and 2011, when "The Bank will continue its ongoing research into potential improvements in the monetary policy framework" was added to the press release. Background information indicate that the key questions being alluded to were a possible lowering of the inflation target and replacing the inflation target with a price level target in 2006, with the extent to which monetary policy should take account of financial stability considerations added to the research agenda in 2011 (Bank of Canada (2006b, 2011b)).

Taken together, these elements indicate that, while the inflation target of the Bank of Canada has remained essentially unchanged since its introduction, it is plausible that expectations of long-run inflation, especially beyond the end of the agreement in force at any given point in time, may have continued to evolve. Not only does the announced inflation target apply to a finite horizon, varying language focusing on the mid-point versus the range of the target could have been interpreted as reflecting varying degrees of comfort over time with allowing the inflation rate to deviate from two percent. And other statements included in inflation target announcements could have reasonably been interpreted as implying that changes in the inflation target would be made at future points in time.

3.2 US

The evolution of the inflation objective for monetary policy in the US has been very different from that in Canada. Since 1977, the statutory objectives of monetary policy in the US have been maintaining "maximum employment, stable prices, and moderate long-term interest rates," without any numerical targets being specified (Federal Reserve Reform Act (1977)). Over time, however, there has been a gradual shift towards greater transparency of where policymakers expected inflation to trend. From 1979, the Federal Reserve's semi-annual "Monetary Policy Report to the Congress" had included projections of inflation, among other variables. Beginning in late 2007, the frequency with which Federal Open Markets Committee (FOMC) projections was released was doubled, in the form of their quarterly "Summary of Economic Projections", and the projection horizon lengthened, from two years to three (Federal Reserve Board (2007)). Longer-run projections were later added (Bernanke (2014)).

Publishing inflation projections is one way of communicating a numerical target for inflation: to the extent that inflation outcomes are driven by monetary policy, projections at a sufficiently long horizon by those setting monetary policy may be interpreted as the inflation rate that they are targeting. But at shorter horizons, inflation projections reflect a combination of the anticipated effects of shocks together with the outcomes desired by policymakers.[6]

[6] Bernanke (2007) outlined other differences between the Federal Reserve approach at that time and a formal inflation target: namely the formal accountability for two objectives (rather than just inflation), and publishing projections for individual committee members rather than a single forecast for the institution. Previously, Chairman Greenspan had rejected the idea that inflation targeting would result in an improvement in policymaking in the US on multiple occasions (eg Greenspan(2001); Bloomberg (2003)).

Following its January 2012 meeting, the FOMC first published a precise objective for long-run inflation. In contrast to Canada, this followed a period when inflation had been unusually low. For much of 2009, year-on-year CPI changes at monthly frequency were negative. The following year, inflation increased but remained generally below 2%. However, in the year immediately preceding the announcement, inflation had spiked, averaging over 3% for 2011 as a whole.

The Federal Reserve's announcement stated that "the Committee judges that inflation at the rate of 2 percent (as measured by the annual change in the price index for personal consumption expenditures, or PCE) is most consistent over the longer run with the Federal Reserve's statutory mandate" (Federal Reserve Board (2012)). The statement also indicated the intention of the board to update its longer-term goals annually. In subsequent updates, except for minor changes in language, the long-run inflation goal has been unchanged (Federal Reserve Board (2013, 2014, 2015)).

3.3 Summary

We have outlined the very different paths taken by the central banks of Canada and the US in communicating their long-run inflation objectives. In the remainder of this paper, we will explore how the degree of anchoring of inflation expectations has varied, both across the two countries and over time, and see if this is correlated with the evolution of the inflation objectives of the central banks.

4. Methodology and data: forecaster-level data

4.1 Functional form

We adopt the same parsimonious framework for fitting inflation forecasts used in Mehrotra and Yetman (2014) that fully utilises the multiple-horizon dimension of the available forecast data. The basic assumption behind this framework is that, if inflation expectations are well anchored at a particular level, inflation forecasts made sufficiently far in advance should be equal to their anchor. Then, over time, as the forecast horizon shortens and forecasters learn about the realisation of shocks that will affect inflation outcomes, even well-anchored inflation expectations will eventually start to deviate from their long-run anchor towards the level of actual inflation.

We apply this model to the forecasts made by individual institutions as follows. The forecast of inflation for year t made at horizon h, denoted $f(t,t-h)$, is assumed to follow:

$$f(t,t-h) = \alpha(h)\pi^* + [1-\alpha(h)]\pi(t-h) + \varepsilon(t,t-h). \qquad (1)$$

In (1), h is measured in months before the end of the year that is being forecast and π^* is the level that long-run inflation expectations are anchored to, which will be estimated. $\pi(t-h)$ is the level of actual inflation observed at the time when the forecast is made and $\varepsilon(t,t-h)$ is a residual term. To correct for the publication lag in inflation data, we use the 12-month growth rate in monthly CPI lagged by one month as the actual inflation rate. This also helps to address any potential endogeneity issues between expected inflation and inflation out-turns.

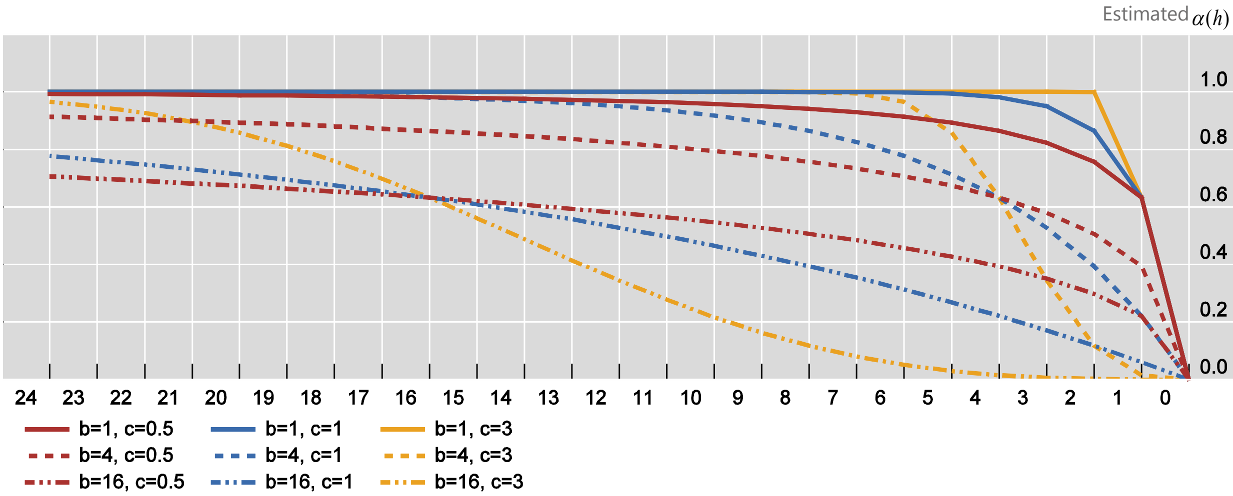
$\alpha(h)$ denotes a decay function. We require a functional form for this that captures the idea that inflation expectations are equal to the anchor at sufficiently long horizons ($\alpha(\infty)=1$), move increasingly towards inflation outcomes as the horizon shortens ($\alpha'(h)<0$), and converge to actual outcomes when the horizon is zero ($\alpha(0)=0$). We model the decay function as:

$$\alpha(h) = 1 - \exp\left(-\left(\frac{h}{b}\right)^c\right), \qquad (2)$$

which is based on the cumulative density function of the Weibull distribution, and provides for a wide variety of possible decay paths for different values of b and c, as illustrated in Graph 3.

Weibull decay functions

Graph 3



Note: Horizontal axis represents the forecast horizon *h*, which is the number of months before the end of the calendar year being forecast.

Source: Authors' calculations

The variance of the residual in (1) is modelled using a flexible functional form that allows it to vary across the forecasting horizon with minimal restrictions:

$$V\big(\varepsilon(h,t)\big) = \exp(\delta_0 + \delta_1 h + \delta_2 h^2). \qquad (3)$$

We also allow for forecasts for the same inflation outcome made at two different horizons, h and k, to be more highly correlated the closer the horizons are, by assuming that:

$$Corr\big(\varepsilon(t,t-h), \varepsilon(t,t-k)\big) = \phi_0 - \phi_1|h-k|, \qquad (4)$$

implying that the off-diagonal elements of the variance-co-variance matrix take the form:

$$Cov\big(\varepsilon(t,t-h), \varepsilon(t,t-k)\big) = \left[\sqrt{V\big(\varepsilon(t,t-h)\big)V\big(\varepsilon(t,t-k)\big)}\right][\phi_0 - \phi_1|h-k|]. \quad (5)$$

4.2 The data

Mehrotra and Yetman (2014) applied the above framework to median inflation forecasts across 44 economies. The innovation in this paper is that we apply the framework at the forecaster-level. We estimate the model outlined above for Canada and the US, forecaster-by-forecaster, and examine the distribution of the estimates across the different forecasters. As we will show, not all forecasters are alike, but this variation is likely to be masked when summary statistics such as medians are examined, instead of looking at the underlying forecaster-level data.

We use the model outlined in the previous section to examine several different aspects of inflation forecast anchoring. In terms of the anchor, we estimate its level and the degree of dispersion in these estimates across the panel of forecasters. In addition, we examine the estimated path away from the anchor as the forecast horizon shortens.

In applying our framework to inflation forecast data from Consensus Economics, we first need to identify forecasters.[7] Ideally, we'd like to identify the individuals making the forecasts and, if they were to move from one organisation to another, follow them in our sample. However, this is impractical since there is no available database that identifies the key individual(s) behind the forecasts. Instead, we follow institutions over time, under the assumption that forecasts from a given institution are likely to be made by similar people, using similar methods, from one month to the next.

Taking the full panel of US forecasts of inflation for the 1989-2013 sample period, there are 133 distinct institutions listed. However, this is likely to overstate the number of distinct forecasting identities, since name changes due to reorganisations, mergers and acquisitions may result in little change to the underlying forecasting process. Thus we combine different names wherever two conditions are satisfied: (i) there is plausible evidence that the underlying entities are the same, via corporate websites, news stories or elsewhere; and (ii) the timing of the name change lines up with the departure and arrival of the associated names from the panel. For example, Amoco Corporation was present in the panel from the beginning of the sample until February 1999, and BP Amoco starting in March 1999, consistent with the timing of the merger of Amoco and BP.[8] We also drop individual forecasters completely if the resulting panel is too short or incomplete, based on conditions that we outline later, or if there is a considerable break with no forecasts.[9]

A full set of the 33 US forecasters we use in our estimation is given in Table 1, with the names that were dropped from the estimation listed in the appendix. To point out one peculiarity in the dataset, "Wells Fargo" appears twice in the table, as the name of Forecaster 3 that emerged from the merger between Wachovia Corporation by Wells Fargo and Company on December 31, 2008[10] and also as the name of Forecaster 33, sandwiched between two entries of "Wells Fargo Bank" before the forecaster name was changed to "Wells Capital".

We repeat the same process with Canadian forecasters, ending up with a panel of 22, as listed in Table 2 (with the dropped names again listed in the appendix). As with "Wells Fargo" for the US, "National Bank of Canada" appears twice in the Canadian panel: early in the sample (Forecaster 15) and later, after a 10 year absence, as the descendant of "National Bank Financial", which was itself formed from the merger of "First Marathon" and "Lévesque Beaubien Geoffrion Inc" (Forecaster 13).[11]

Consensus Economics starts collecting forecasts for calendar-year inflation outcomes in January of the preceding year ($h = 24$). They generally collect these forecasts each month until December of the year being forecast ($h = 1$), for a total of 24 monthly forecasts of the same outcome.

7 Dovern et al (2015) follow a similar process to match forecasters in their study of GDP forecasts.

8 See http://www.bp.com/en/global/corporate/about-bp/our-history/history-of-amoco.html.

9 For example, Lehman Brothers was present in the panel twice: 03/1991-02/1994 and 12/2001-09/2008. We treat these as two separate forecasters, given the 8 year gap between them. We then drop the first period, as it is too short, but include the second, combined with Barclays Capital who took over their North American operations in September 2008 (http://www.theguardian.com/business/2008/sep/16/barclay.lehmanbrothers1), as Forecaster 16 in our panel.

10 See https://www.wellsfargo.com/about/press/2009/20090101_Wachovia_Merger/.

11 See http://www.nbc.ca/en/about-us/our-organization/the-bank/portrait-of-the-bank/history.html.

US Forecasters

Table 1

1	Amoco Corporation 10/1989-02/1999	BP Amoco 03/1999-04/1999			
2	Chrylser 04/1994-11/1998	Daimler Chrysler 12/1998-11/2007	Chrylser 12/2007-11/2008		
3	Core States 10/1989-05/1995	CoreStates Fin Corp 07/1995-04/1998	First Union Corp 06/1998-10/2001	Wachovia Corp 11/2001-06/2009	**Wells Fargo(1)** 07/2009-12/2013
4	CRT Govt Securities 09/1990-07/1993	NationsBank 08/1993-08/1998	Bank America Corp 11/1998-02/2009		
5	DuPont 10/1992-12/2013				
6	Eaton Corporation 11/1991-12/2013				
7	Econ Intelligence Unit 11/2003-12/2013				
8	Fannie Mae 10/1993-12/2013				
9	First Boston 10/1989-10/1994	CS First Boston 11/1994-04/1998	Credit Suisse First Boston 05/1998-10/2004	Credit Suisse 01/2009-12/2013	
10	Ford Motor 10/1989-12/2013				
11	General Motors 10/1989-12/2013				
12	Georgia State University				
13	Goldman Sachs 02/1999-12/2013				
14	Griggs & Santow 11/1989-09/2001				
15	Inforum - Univ of Maryland 04/1998-12/2013				
16	**Lehman Brothers** 12/2001-09/2008	Barclays Capital 01/2009-12/2013			
17	Macroeconomic Advisers 03/2000-12/2013				
18	Merrill Lynch 10/1989-04/2009	Bank of America - Merrill 05/2009-12/2013			
19	Morgan Guaranty 10/1989-07/1993	J P Morgan 08/1993-12/2013			
20	Morgan Stanley 10/1989-12/2013				
21	Mortgage Bankers Assoc 10/1993-05/2005				
22	Natl Assoc of Home Builders 10/1993-12/2013				
23	Northern Trust 10/1989-12/2013				
24	Oxford Economics 10/1997-12/2013				
25	Prudential Insurance 12/1993-04/2001	Prudential Financial 05/2001-10/2002			
26	Regional Financial Assocs 05/1994-01/2001	Economy.com 02/2001-11/2005	Moody's Economy.com 12/2005-05/2010	Moody's Analytics 06/2010-12/2013	
27	Smith Barney 10/1989-06/1993	Smith Barney Shearson 08/1993-06/1994	Smith Barney 07/1994-10/1997		
28	Standard & Poors 07/1990-12/2013				
29	The Conference Board 10/1993-12/2013				
30	The University of Michigan 10/1993	Univ of Michigan - RSQE 11/1993-12/2013			
31	The WEFA Group 07/1991-10/2001	DRI-WEFA 11/2001-11/2002	Global Insight 12/2002-10/2008	IHS Global Insight 11/2008-12/2013	
32	U.S. Trust 10/1993	United States Trust 11/1993-09/2007			
33	Wells Fargo Bank 01/1993-09/1994	**Wells Fargo(2)** 11/1994-02/1996	Wells Fargo Bank 04/1996-01/2000	Wells Capital 02/2000-06/2009	Wells Capital Mgmt 07/2009-12/2013

Source: Consensus Economics; Author's calculations.

Canadian Forecasters

Table 2

1	Bank of Montreal 10/1989-01/2007			
2	Bank of Nova Scotia 10/1989-05/1998	Scotia Economics 06/1998-12/2013		
3	Caisse de Depot, 10/1989-06/2012	Caisse de Depots		
4	CIBC 10/1989-08/1999	Canadian Imperial Bank 09/1999-02/2002		
5	Conf Board of Canada, Conference Board 10/1989-12/2013			
6	Desjardins 08/2004-12/2013			
7	Economap 11/1999-12/2013			
8	EDC Economics 07/2003-12/2013			
9	Global Insight 12/2002-10/2008	IHS Global Insight 11/2008-12/2013		
10	Informetrica 11/1992-12/2013			
11	Institute of Policy Analysis 10/1995-11/1995	University of Toronto 12/1995-12/2013		
12	JP Morgan Canada 07/1995-08/1996	JP Morgan 11/1996-06/2008		
13	Levesque Beaubien 11/1993-08/1999	National Bank Financial 09/1999-06/2012	**National Bank of Canada(1)** 07/2012-12/2013	
14	Merrill Lynch Canada 11/2000-03/2012			
15	**National Bank of Canada(2)** 10/1989-04/2002			
16	Nesbitt Thomson 10/1989-08/1994	Nesbitt Burns 09/1994-02/2000	BMO Nesbitt Burns 03/2000-06/2006	BMO Capital Markets 07/2006-12/2013
17	RBC Dominion Securities, RBC Dominion, RBC - Dominion Securities 10/1989-04/2000			
18	Royal Bank of Canada 10/1989-12/2013			
19	Scotia McLeod 10/1989-03/1998			
20	Sun Life 10/1989-11/1998			
21	Toronto Dominion Bank 04/1999-12/2013			
22	Wood Gundy 10/1989-10/1995	CIBC Wood Gundy 11/1995-08/1999	CIBC Markets 09/1999-12/1999	CIBC World Markets 01/2000-12/2013

Source: Consensus Economics; Author's calculations.

5. Results

For many of the forecasters, the panel of forecasts is unbalanced, as is clear from Tables 1 and 2, and is visible as gaps in the series plotted in Graph 2. We take explicit account of this in our estimation by setting the contribution to the likelihood function to zero for missing observations.

The model is estimated by maximum likelihood, forecaster-by-forecaster, using 10-year rolling samples (where years are defined in terms of the inflation rate being forecast, rather than when the forecasts are made) to allow for the degree of anchoring to evolve over time. We include all rolling samples where more than 50% of the possible 240 observations are present in the sample for each forecaster and there is a forecast available for at least one horizon of both the first and last years of the rolling sample. We consider 40 different possible starting values for each sample, and maximise the likelihood function using the hill-climbing method of Broyden, Fletcher, Goldfarb and Shanno (see Shanno (1985) for details) for each, until the estimates converge. We then choose the estimates with the highest loglikelihood function value where the parameters of the decay function and the inflation target are identified ($b > 0, c > 0, V(b) > 0, V(c) > 0,\ V(\pi^*) > 0$). In most cases, a majority of the starting values considered lead to virtually identical parameter estimates; in all cases, our selection criteria lead to unique estimates for each rolling sample – forecaster combination.

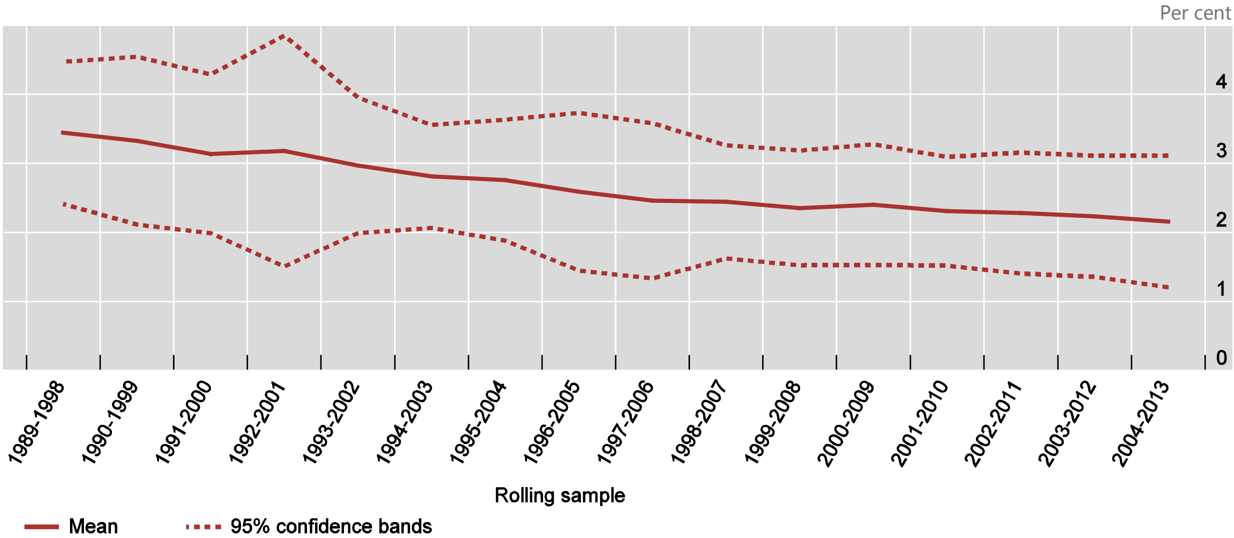
5.1 The estimated inflation anchor

We first present results on the estimates of the inflation anchors across our panels. For each rolling sample we have one estimate of the inflation anchor for every forecaster.

Graph 4 provides the mean, together with 95% confidence bands (based on the standard deviation of estimates for each forecaster), of the inflation anchor estimates for the US. There are a minimum of 11 forecasters in each rolling sample, with the number of forecasters increasing over early samples and stabilising at 22-24 forecasters beginning 1993-2002.

Estimated US inflation anchors

Mean and 95% confidence bands | Graph 4



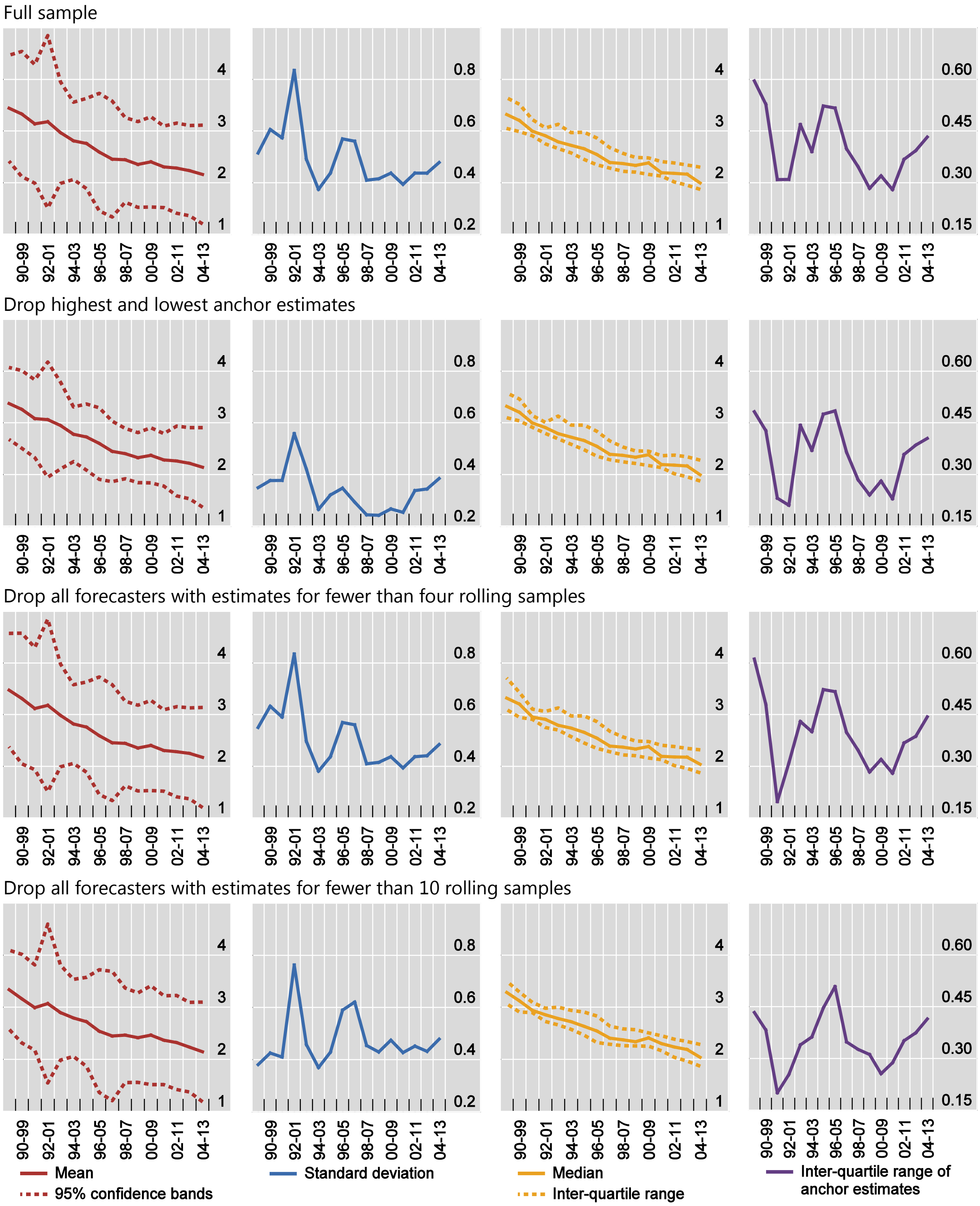
Source: Author’s calculations.

The results indicate that the average estimated inflation anchor has come down steadily over time, from around 3.5% to just above 2% by the final rolling sample. The width of the confidence bands around the forecasts, a measure of uncertainty about the future inflation rate, has remained approximately constant over the sample.

We demonstrate the robustness of the results in a number of different ways. We consider dropping the forecasters with the highest and lowest anchor estimates from each rolling sample. We also drop all forecasters who are present for only a small number of rolling samples, to reduce the influence of forecasters who are not always present in the panel, with two different thresholds. We first exclude all forecasters who are present for less than four rolling samples, followed by ten rolling samples. In the latter case, our sample consists of 8-17 forecasters, 6 of whom are present in every sample.

Estimated US inflation anchors: robustness checks

In per cent | Graph 5



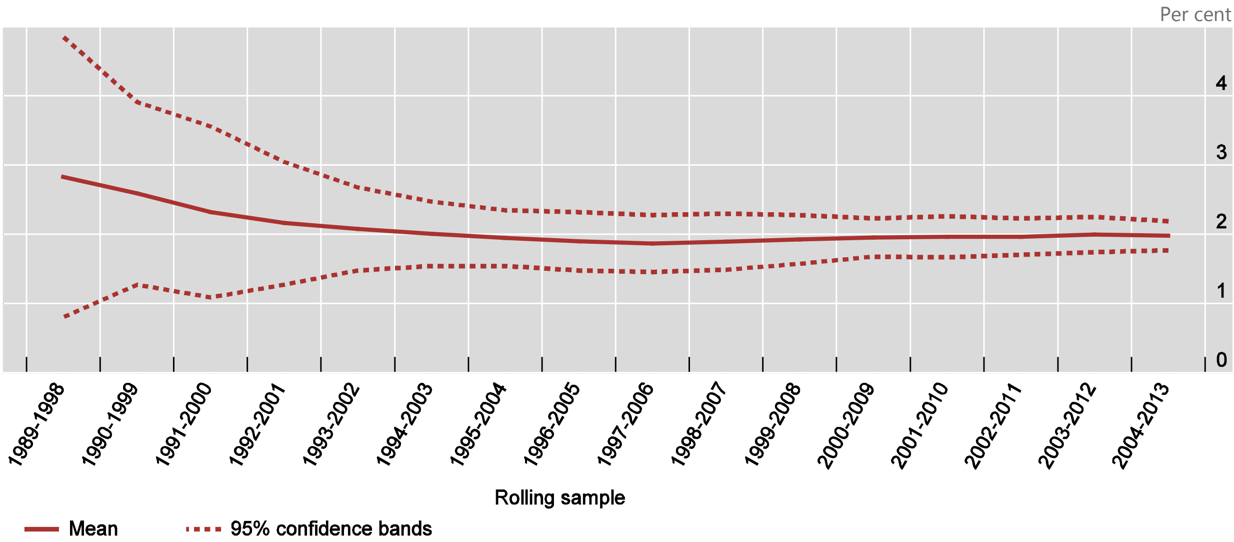
Source: Author's calculations.

We also consider the median as an alternative summary measure of the level of the inflation anchor, and the inter-quartile range in place of the standard deviation. A full set of results for all of these measures is given in Graph 5. In all cases, the results are consistent with those reported above: the inflation anchor has trended down, while uncertainty about the inflation anchor has no clear trend over time. One exception to this is that there has been an increase in the degree of uncertainty across all of these measures in the final few rolling samples.

Turning to Canada, Graph 6 is the analogue of Graph 4. For the Canadian sample, there are 10-12 forecasters present in the first 10 rolling samples, increasing to 16 for the final sample. As with the US, the inflation anchor has declined by close to one percentage point over the sample. But, in contrast to the US case, nearly the entire decline occurred early in the sample. Indeed, by the 1993-2002 rolling sample, the mean of the anchor estimates was within 0.2 percentage points of the midpoint of the Bank of Canada's inflation target, where it remains for all later estimates.

Estimated Canadian inflation anchors

Mean and 95% confidence bands — Graph 6



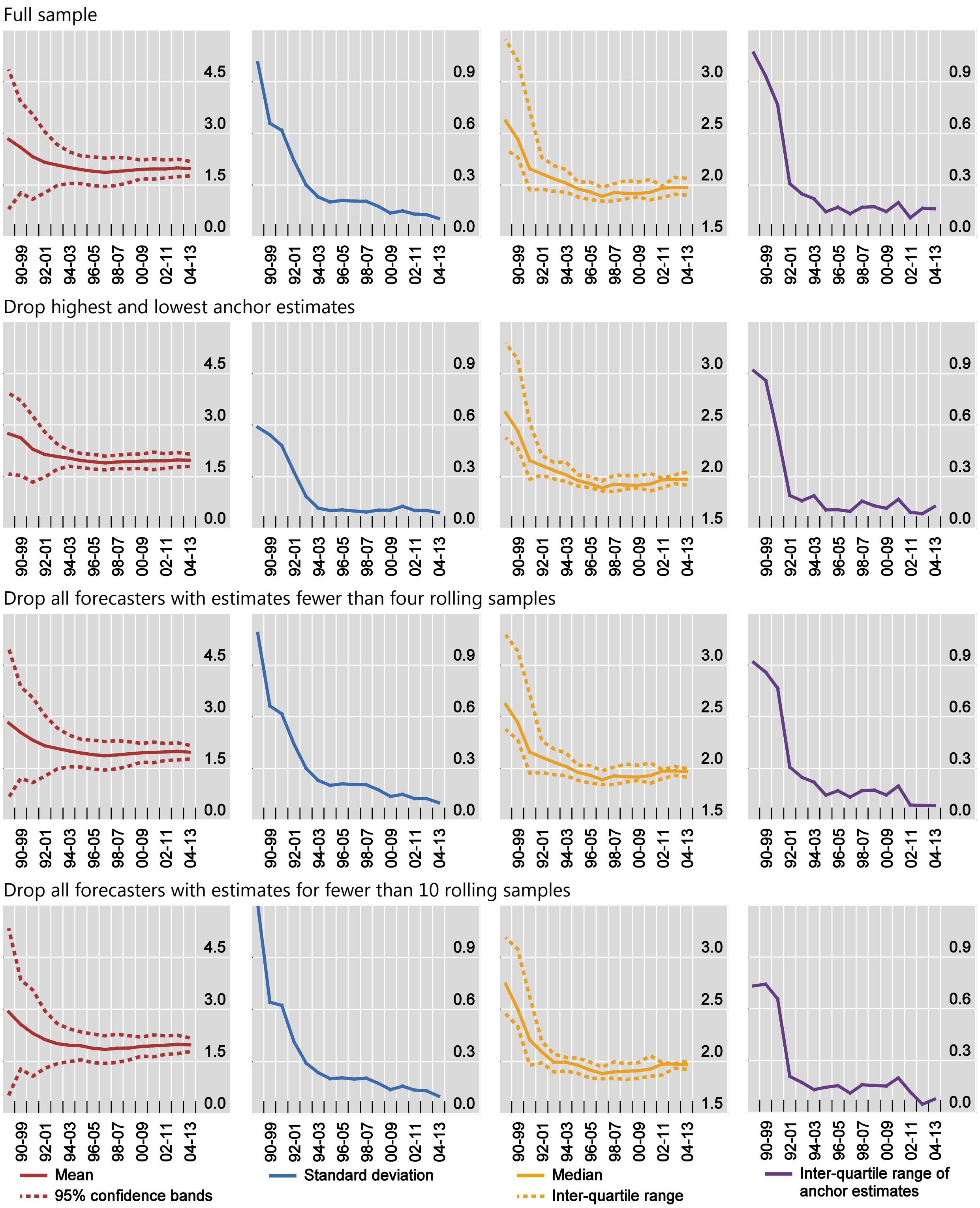
Source: Author's calculations.

There is also a substantive difference between the variance of the inflation anchor estimates for Canada relative to the US. Whereas in the case of the US the standard deviation remained a similar magnitude across all rolling samples, for Canada there is a significant decline, concentrated in the early part of the sample. For the earliest rolling samples, the level of the standard deviation is similar for both countries. But in Canadian samples it falls rapidly, by a factor of around five, over the first six rolling samples, and continues to decline after that, until it is around one-quarter of the level for the US by the final rolling sample.

Figure 7 displays robustness checks for Canada. Again, the main results are not sensitive to the different trimming criteria we consider for selecting forecasters or alternative summary measures of the level or variability of anchor estimates. The only exception to this story is that a continuing decline in the measure of anchor uncertainty in the latter half of the rolling samples is not a robust feature of the results.

Estimated Canadian inflation anchors: robustness checks

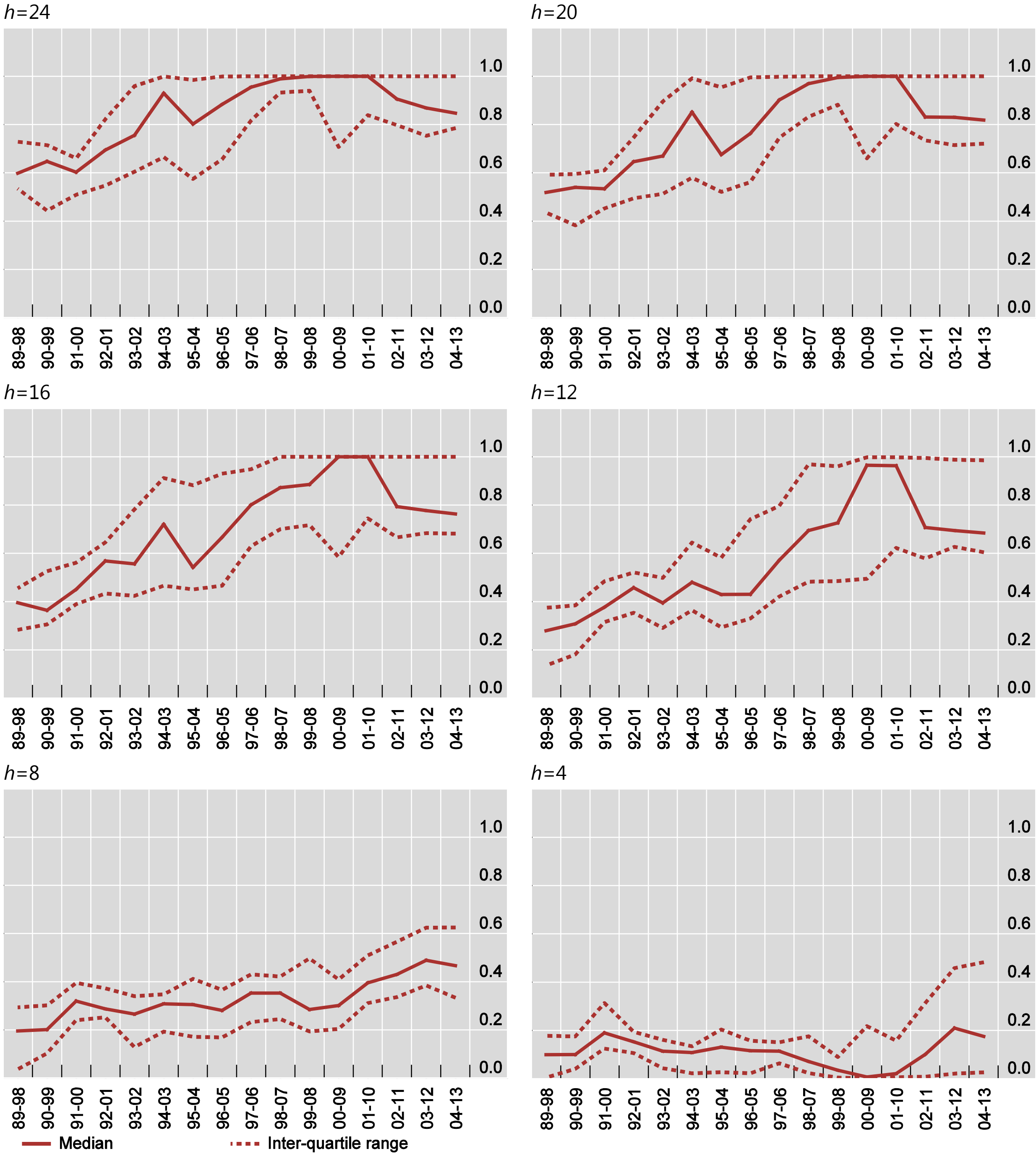
In per cent Graph 7



Source: Author's calculations.

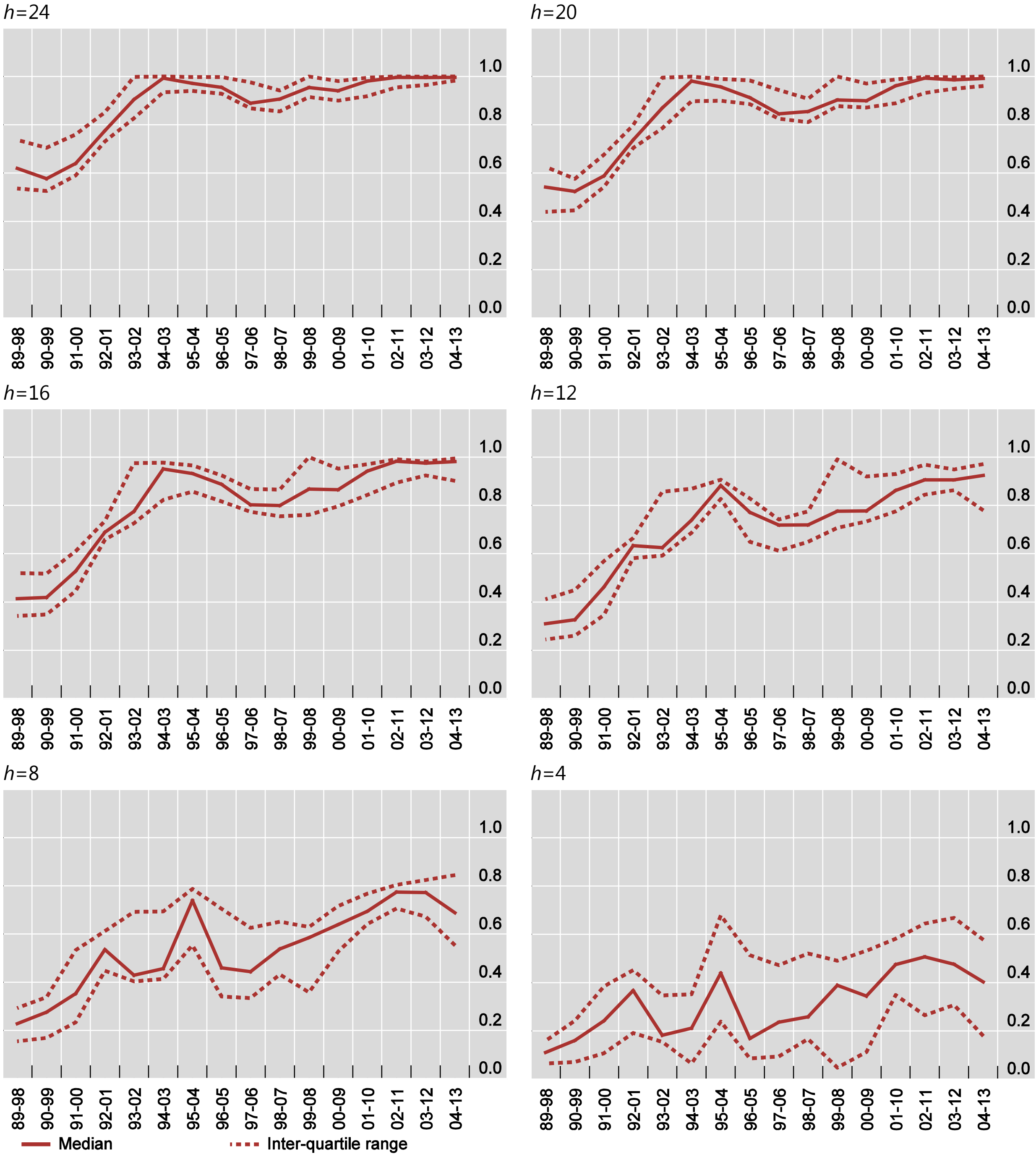
Another difference between the two countries is apparent if we focus on the very end of the sample. The final rolling sample contains many observations from the recent financial crisis period, when policy rates have been close to zero. In the Canadian case, the confidence band and inter-quartile range continued to narrow or remained stable. In contrast, all measures of the variability of the estimated anchors for the US widened.

Estimated weight on inflation anchor for US forecasters, $\alpha(h)$ Graph 8



Source: Author’s calculations.

Estimated weight on inflation anchor for Canadian forecasters, $\alpha(h)$ Graph 9



Source: Author's calculations.

5.2 The decay path

Thus far we have focused on estimates of the inflation anchor, and demonstrated some important differences in these between Canadian and US forecasters. We also have estimates of how forecasts move away from the anchor, as its importance in explaining forecasts decays with a shortening forecast horizon, to which we now turn.

Our estimates of b and c provide for a wide range of possible decay paths, as illustrated earlier in Graph 3. We use the estimates of these for each forecaster to compute the full decay function path for all horizons and then calculate the median and inter-quartile range of the weight on the inflation anchor, $\alpha(h)$, for different horizons, h. These are displayed for the US in Graph 8, and for Canada in Graph 9.

For the US, at all except the very shortest horizons, the weight on the anchor has increased over time. At the longest horizons illustrated here, for $h = 20$ and $h = 24$, $\alpha(h)$ is close to one for the latter rolling sample, versus around 0.6 earlier.

For Canada, it is a similar story, but in general with much less dispersion (as measured by the inter-quartile range). The weight on the anchor increased considerable early in the sample for all $h > 10$, consistent with a reduction in the degree of uncertainty about how future monetary policy would play out over time.

As with the estimated anchor point, there is also a difference between the two countries that becomes apparent towards the end of the sample, once forecasts made during the recent financial crisis are included in the sample. For US forecasters, the median weight on the long-run anchor declines noticeably at all longer horizons, while there is no obvious change in the case of Canadian ones.

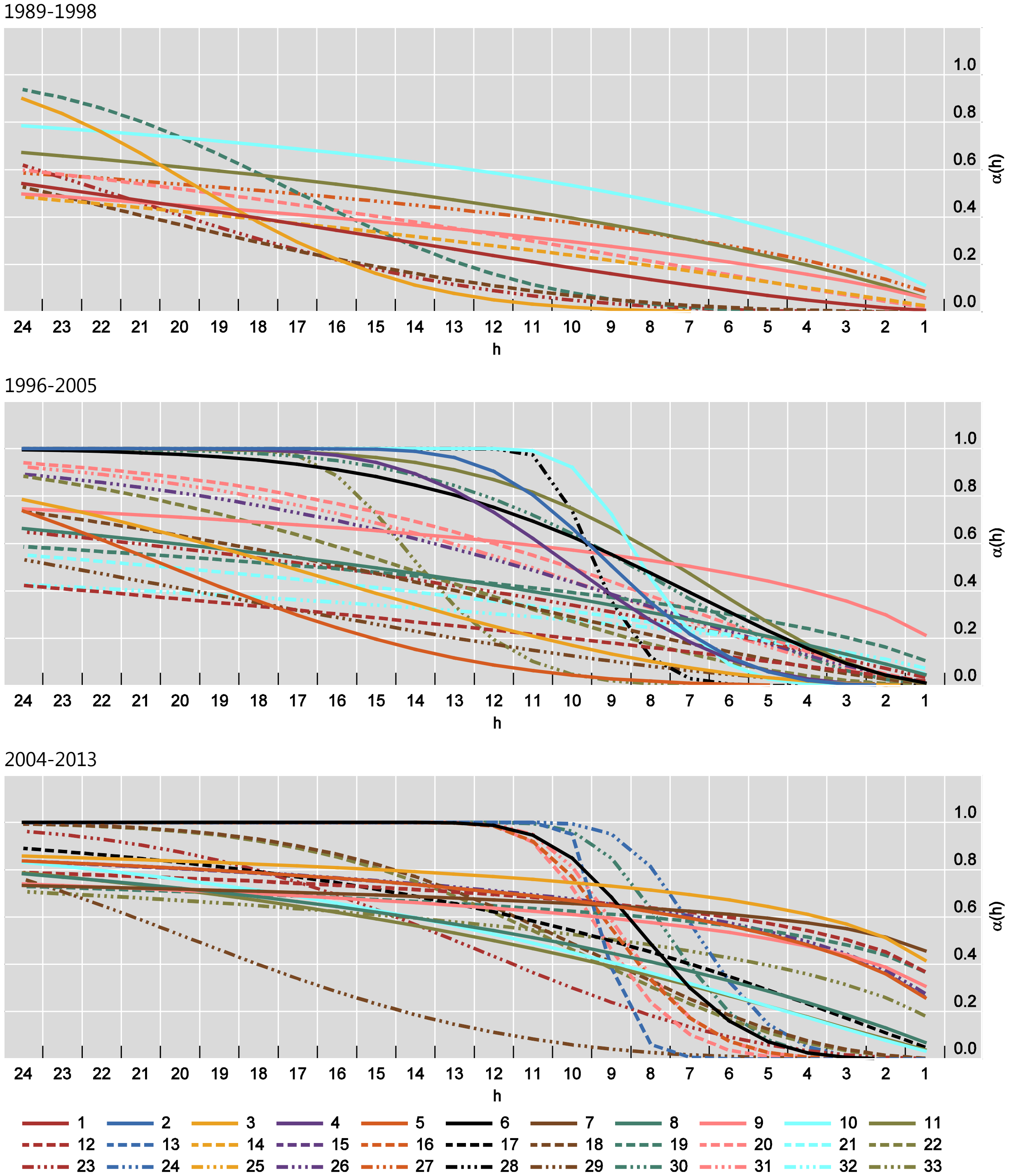
Finally, we examine the decay paths for each of the individual forecasters, since summary measures discussed above may mask some important aspects of forecaster heterogeneity. We focus on three different rolling samples, spread over our sample period. The results for the US are given in Graph 10. Of the three samples displayed, the decay paths are qualitatively the most similar across the forecasters in the earliest rolling samples, in the top panel. At the longest horizons the weight on the anchor varies between 0.5 and 0.9. It then falls as the horizon shortens and lies at around half its initial value when $h = 10$.

Rolling samples in the middle panel, based on estimates over 1996-2005, display much greater dispersion. At the longest horizons, the weight on the anchor varies between 0.4 and 1.0, and the weight on the anchor remains close to 1.0 for the first 12 horizons for a small subset of forecasters. Focusing on the forecasters who are present in both of these earlier panels, the two car makers, Ford and GM (forecasters 10 and 11 respectively), display the greatest increase in the estimated weight on the anchor. At $h = 12$ in the first panel, their weights on the anchor were around 0.5. At the same horizon for the middle panel they both exceed 0.85. For other forecasters present in both panels, the change in the weight on the anchor is relatively smaller. Others for whom, like the car manufacturers, the estimated weight on the anchor is close to one at longer horizons, include a diverse cast of characters: banks (Bank America Corp and its predecessor, Nations Bank, (4); Wells Fargo / Wells Capital (33)), the University of Michigan (30), Standard and Poor's (28) and Eaton Corporation (6), a power management company.

The lower panel displays the estimated weights on the anchor for the final rolling sample of 2004-2013. The estimated weights on the anchor at the longest horizons now exceed 0.7 for all forecasters. Except for the conference board (29), an outlier for whom the estimated weight on the anchor falls away quickly, forecasters now fall more clearly into two categories: those whose estimated weight on the anchor remains high for all $h > 12$, and the remainder where the weight on the anchor lies between 0.45 and 0.8 for $h = 12$. There is no apparent pattern to explain who belongs to each group. The former includes some of those with a high weight on the target in the previous, earlier panel who remain in the sample (6, 30), but not others (10, 11, 28, 33), some who were present in the previous sample but with a much lower weight on the anchor for $h > 12$ (Morgan Stanley (20), and IHS Global Insight / Global Insight (31)), and three new-comers (Goldman Sachs (13), Lehman Brothers / Barclays Capital (16) and Oxford Economics (24)). Taken together, the evidence suggests that there is considerable variation in the estimated weight on the anchor across the panel of forecasters across the sample for the US, even at the end of our sample period, which defies simple characterisation.

US estimated decay paths by forecaster

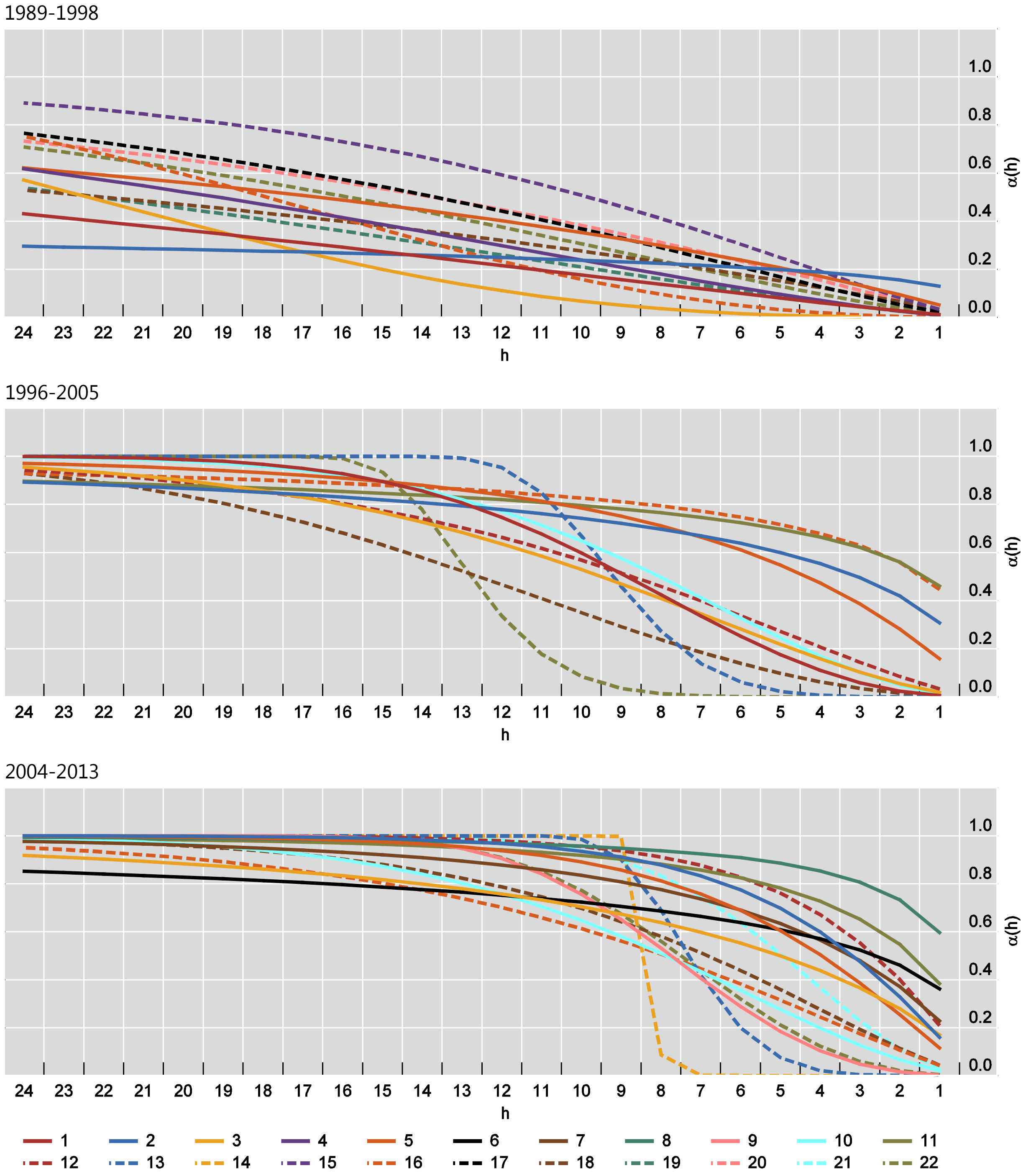
Graph 10



Forecaster numbers correspond to Table 1.

Source: Author's calculations.

Canadian estimated decay paths by forecaster Graph 11



Forecaster numbers correspond to Table 2.

Source: Author's calculations.

By way of contrast, Graph 11 displays comparable output for Canada. The earliest rolling samples look a lot like those for the same period for the US. The weight on the anchor varies widely at long horizons and declines smoothly as the horizon shortens. But the later rolling samples, in the middle and lower panels, display much less dispersion, both across time and forecasters, than in the equivalent panels for US forecasters. The estimated weight on the anchor exceeds 0.8 at the longest horizons and it declines in tandem, for all forecasters, as the horizon shortens.

6. Conclusion

In this paper, we have modelled the behaviour of inflation forecasts using a decay function. Inflation forecasts are assumed to monotonically diverge from an estimated anchor towards actual inflation as the forecast horizon shortens. Fitting the data on forecaster-level data for Canada and the US, we have identified three key differences in the behaviour of forecasters between the two countries:

i) In rolling samples, the average estimated inflation anchor for US forecasters declined gradually over the sample period, whereas that for Canadian forecasters declined early in the sample and then remained at its new low level, close to the midpoint of the inflation target of two percent;

ii) The variance across forecasters of the estimates of the inflation anchor has remained at similar levels for US forecasters over time, whereas for those in Canada it declined from levels comparable to those for the US early in the sample to much lower levels;

iii) And the estimates of the weights that the forecasters place on their estimated anchors vary between the countries, especially later in the sample. By the end of the sample, the distribution for the US looks bimodal, with some forecasters placing a high weight on the inflation anchor at horizons exceeding one year, while the weight for others decays more uniformly and lies between 0.45 and 0.8 at a 12 month horizon. In contrast, there is much less dispersion across Canadian forecasters: the estimated weight on the anchor at a two year horizon exceeds 0.85 for all forecasters, and 0.7 at a one year horizon.

What explains these diverse results between the two economies? One possibility is the composition of forecasters. However, while there are some differences between them (there are no car makers among the Canadian forecasters and two among the US, for example), the results do not appear to be driven by this. Even if we were to focus only on banks and financial services firms in the two economies, for example, the systematic differences between them remain.[12] Instead, it seems more likely that differences in the monetary policy regimes are responsible.

Canada adopted an inflation target early in our sample period, with a symmetric target around 2%. Over time forecasters appear to have adjusted their forecasts so that they are strongly anchored at the target level, with only small deviations at forecast horizons exceeding one year. In contrast, the US has not had a clear quantitative target for inflation for most of the sample period, leaving forecasters with no clear anchor for their expectations.

Another important difference between the two economies is the degree to which they were affected by the recent crisis, and the extent to which the monetary policy response was constrained by the zero lower bound. For the US, the Federal Funds Rate has been close to zero percent since late 2008. For Canada, with the exception of the March 2009-June 2010 period, the Bank Rate never dropped below one percent. The zero lower bound may be especially likely to impact on inflation expectations if the central bank is thought to lack adequate tools to stabilise inflation, as Ehrmann

[12] At the 12 month horizon for 2004-2013, for example, for 4 out of 9 US banks and financial services firms the estimated weight on the target exceeds 0.7. The comparable ratio for Canada is 10 out of 10.

(2014) discusses. And the use of alternative tools, like quantitative easing, may increase forcaster uncertainty about future inflation rates, as discussed in Hofmann and Zhu (2013). Perhaps not surprisingly, then, there has been a small but noticeable increase in the variability of estimated inflation anchors across US forecasters, and a decrease in the median weight on the anchor at longer horizons, once forecasts made during the crisis are included, changes that are absent from the Canadian estimation results.

Looking forward, to the extent that the publication of an explicit long-run goal for inflation by the US central bank acts like an inflation target, our results suggest that inflation forecasts for the US might be expected to become more strongly anchored to 2%, and the variation seen across forecasts to decline, at least once policy rates are no longer constrained by the zero bound. The latest available consensus forecasts (for July 2015) provide us with evidence consistent with these predictions. At the current juncture, US inflation rates are well below the stated target. Average inflation expectations for 2015 of 0.2% reflect this. However, those at a longer horizon indicate a return to near target levels next year (the average forecast for 2016 is 2.2%). This is consistent with our model of forecasts being more strongly anchored the longer the forecast horizon. Additionally, the standard deviation of those longer horizon US forecasts (0.26%) almost matches that for Canada (0.29%), in contrast to past experience.

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Dropped Forecasters

Table A1

US

Action Economics	Chase Manhattan Bank	First Trust Advisors	Mellon Bank	Roubini Global Econ
American International Group	Chemical Bank	HSBC	Nat Assn of Manufacturers	Sears Roebuck
Bank of Boston	Chemical Banking	Kemper Financial	Nomura	Shawmut Bank
Bank One Corp	Citigroup	**Lehman Brothers, 03/91-02/94**	Paine Webber	Shawmut National
Bankers Trust	Continental Bank	Manufacturers Hanover	PNC Bank	Shearson Lehman
Bear Stearns	Dun & Bradstreet	Marine Midland	PNC Financial Services	Swiss Re
Bethlehem Steel	First Chicago	Mass Financial Services	Provident Bank	UBS
Brown Brothers	First Fidelity	Metropolitan Life	RDQ Economics	US Chamber of Commerce
Brown Brothers Harriman				

Canada

Bank of America - Merrill	Centre for Spatial Economics	Econ Intelligence Unit	Merrill Lynch - Canada	**Toronto Dominion, 10/89-07/92**
Burns Fry	Citigroup	HSBC	Oxford Economics	UBS
Bunting Warburg	DRI Canada	Loewen Ondaatje	Richardson Greenshields	WEFA Canada
Capital Economics	Du Pont	McLean McCarthy	Royal Trust	

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