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Carola Binder, Wesley Janson, and
Randal Verbrugge

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Thinking Outside the Box: Do SPF Respondents Have Anchored Inflation Expectations?

Carola Binder, Wesley Janson, and Randal Verbrugge

Despite the stability of the median 10-year inflation expectations in the Survey of Professional Forecasters (SPF) near 2 percent, we show that not a single SPF respondent's expectations have been anchored at the target since the Federal Open Market Committee's (FOMC) enactment of an inflation target in January 2012, or even since 2015. However, we find significant evidence for "delayed anchoring," or a move toward being anchored, particularly after the federal funds rate lifted off in December 2015.

Keywords: inflation expectations, persistent disagreement, credibility, delayed anchoring.

JEL Codes: E37, E31, E7, E52.

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Carola Binder is at Haverford College (cbinder1@haverford.edu). Wesley Janson is at the Federal Reserve Bank of Cleveland (Wesley.Janson@clev.frb.org). Randal Verbrugge is at the Federal Reserve Bank of Cleveland (Randal.Verbrugge@clev.frb.org). The authors thank Todd Clark, Domenico Giannone, Chengcheng Jia, Ed Knotek, Kurt Lunsford, Robert Rich, Tom Stark, Saeed Zaman, and the other participants at the brownbag seminar for their helpful comments.

1 Introduction

Inflation expectations play a crucial role in economic decision making and inflation dynamics, and survey measures of inflation expectations are strong predictors of future inflation (Friedman, 1968; Phelps, 1967; Ang et al., 2007; Faust and Wright, 2013; Binder, 2015). Central bankers are tasked with controlling inflation, so they see it as essential that inflation expectations be anchored at the policy target (Bernanke, 2007; Yellen, 2015; Draghi, 2018). Indeed, central bankers now commonly make statements like: "Well-anchored expectations are an indicator of the success and the credibility of a price stability-oriented monetary policy" (European Central Bank, 2012, p. 65).

But what does "anchored" mean? Researchers and policymakers often compare (average or median) long-run inflation expectations to the inflation target (see of England (2010); European Central Bank (2012)), and the most common interpretation of anchored expectations is that average inflation forecasts across agents, especially at long horizons, remain stable and close to the inflation target (Ball and Mazumder (2018); Kumar et al. (2015)). Most formal tests focus on the insensitivity of median or average expectations to "news" or incoming economic data (see e.g., Beechey et al. (2011), or Carvalho et al. (2017) for a theoretical treatment). We take a simpler and more direct tack. We focus on individual forecasters, because aggregate statistics can, for example, obscure divergent anchoring points or large swings in the expectations of an individual forecaster's panel. We argue that for an individual's expectations to be well-anchored,[1] they should remain near the central bank's target. In rational expectations models, if agents know the central bank's target and are certain of its commitment to that goal, their long-run expectations will be perfectly anchored to that target.

We use panel data from the Survey of Professional Forecasters (SPF), a long-running quarterly survey of macroeconomic forecasts in the United States that is currently conducted by the Federal Reserve Bank of Philadelphia.[2] SPF respondents provide forecasts for both PCE and CPI inflation at 5-year and 10-year horizons, from which we compute implied 5-year/5-year-forward forecasts, i.e., forecasts for average inflation over 6 to 10 years ahead, which we refer to as long-run forecasts.[3] A central bank will typically choose a single inflation measure to target. But if other inflation measures have a reasonably well-behaved relationship to this target measure, and if longer-run expectations of the other measures are not anchored, this would cast doubt on whether inflation expectations are truly anchored at all—even if expectations of the target measure appear anchored. Respondents whose forecasts support financial market interactions could well focus most of their attention on the consumer price index (CPI). CPI inflation is used as the reference rate for Treasury inflation protected securities (TIPS) and other financial assets, in addition to its widespread use in other contexts such as indexing Social Security payments (Haubrich and Millington, 2014). In this paper, we consider a forecaster's expectations to be "anchored" if these long-run forecasts for *both* inflation rates remain within a "box" close to the target, as we will define below.

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[1] Our definition is related to the definition of "ideally ε-anchored" in Kumar et al. (2015), except that we apply it on an individual by individual basis; it is also similar to the "absolute anchoring" concept of Rich (2018), a concept focused on individual anchoring; and it is consistent with the viewpoint expressed in Ball and Mazumder (2018).

[2] In previous work (Binder, 2015; Binder and Verbrugge, 2016; Binder, 2017b) we have examined household inflation expectations. At least in the U.S., there are no long panel data on the inflation expectations of households, although the short panels that are available still yield important insights (Binder, 2017a).

[3] We provide the formula in the appendix; see page 60 of the SPF documentation for details. We focus on this horizon because it removes the impact of low (or high) current inflation, and because the "5-year, 5-year-forward inflation expectation rate" is a closely watched expected inflation statistic computed from the yields of nominal and inflation-adjusted Treasury securities at 5-year and 10-year horizons. (In the appendix, we demonstrate that our results hold if we instead use the 10-year projections.)

Figure 1 displays *median* long-run forecasts since 2007. Over the period of 2007-2018, the median PCE forecast was 2.1 percent with a standard deviation of 0.47, while the median CPI was 2.35 percent with a standard deviation of 0.54. Since 1980, CPI inflation itself has averaged 0.4 percentage points above PCE inflation, though this differential varies over time (see, e.g., Hakkio (2008); Binder et al. (2019)).[4]

As indicated in figure 1, median long-run inflation forecasts have been quite stable and near 2 percent since 2007. This suggests that inflation expectations are well anchored. But this stability of the median obscures significant individual heterogeneity, volatility, and persistent disagreement.[5] At the individual level, we find that when taking the post-2012 period as a whole, not a single SPF respondent is anchored. Some forecasters have expectations that vary substantially over time. Others have consistent upward or downward biases with little variation—effectively, these respondents have expectations that are anchored, but at the wrong spot.

We take for granted that SPF respondents are fully aware of the January 2012 FOMC announcement, and its implications. Hence, persistent disagreement must therefore stem from different views about either the FOMC's commitment, or ability, to deliver on its promises.[6] As Binder (2017b) suggests, there appears to be a disconnect between FOMC communications and intent, and inflation expectations. However, in this regard, we find evidence of "delayed anchoring": Respondents have generally moved toward the box since 2012, particularly after the first federal funds rate hike in late 2015. By 2018, 64 percent of responses were in the box.

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[4] While both the CPI and PCE price indexes are based on the prices of a basket of consumer goods, they differ somewhat in scope (the goods and services in the basket), in weights on different items, and in the formula used in their computation. See Binder et al. (2019) for analysis and a brief synopsis, and Clark (1999) for a more thorough discussion.

[5] Disagreement is not the same as uncertainty, see Rich and Tracy (2018). Mailath and Samuelson (2019) argue that persistent disagreement likely derives from different prediction models, which accords with the conclusions of Patton and Timmermann (2010). See also Branch (2004), Stark (2013), and Döpke et al. (2017) for evidence. While the persistent forecast differences we identify could arise from dissimilar strongly held prior views, Mailath and Samuelson (2019) suggest that dissimilar priors "impose virtually no discipline on the relationship of the beliefs of different agents... In contrast, model-based reasoning insures that agents' beliefs about the events they deem relevant are firmly anchored to the data." In their stylized environment, they demonstrate that "the wisdom of crowds" can hold and information can aggregate when Bayesian agents use different prediction models.

[6] A different approach might assume that agents must learn about the monetary policy rule actually being followed by the FOMC; see, e.g., Ball (1995), Bullard and Mitra (2002), Branch and Evans (2006) or Nunes (2009). This seems more relevant when a central bank has not revealed its inflation target, unless there is doubt about the truthfulness of the FOMC communication. To the extent that a forecaster relies upon a statistical prediction for her long-run PCE inflation forecasts, or thinks she must learn an actual inflation target that may differ from the stated target, we view this as a tacit vote of distrust that the FOMC will achieve its stated target. Among respondents who fully trust the FOMC's ability to achieve its stated target, long-run CPI inflation forecasts might differ, but only to a modest extent that is related to different views about the CPI-PCE differential.

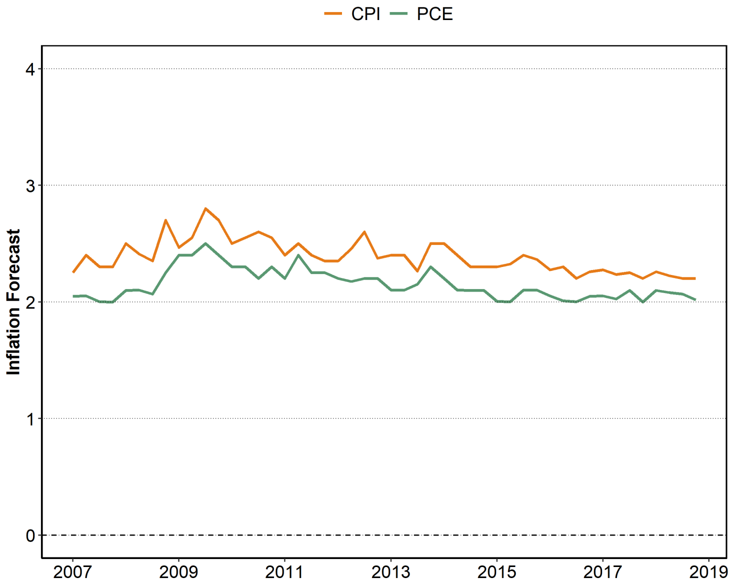

Figure 1: Median forecast for 5-year/5-year forward CPI and PCE inflation. Data from the SPF.

2 “In the Box” Expectations

Figure 2 is a “box figure” that plots each long-run CPI and PCE inflation forecast from 2012 to 2018 for the 35 forecasters who provided at least 14 forecasts of both. The shaded box corresponds to expectations that are anchored close to the FOMC target; to be anchored, both long run PCE and CPI forecasts must remain in the box. What does “close” mean? Somewhat arbitrarily, we define “close” to mean that long-run PCE forecasts are within ± 0.2 ppt from the FOMC target, and that CPI forecasts that are within ± 0.5 ppt from the implied CPI target–where we apply a long-run CPI/PCE differential of 0.2 ppt, based upon Binder et al. (2019), with a wider CPI band to account for differences in opinion about the long-run CPI/PCE differential.[7] (As will be clear below, our results are insensitive to modest changes in these ranges.) When we pool forecasts across respondents and quarters, 47 percent of the forecasts are in the box.

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[7] The analysis of Binder et al. (2019) indicates that reasonable year-ahead forecasts of the CPI/PCE differential (in ppts) over the post-2012 period will lie within [0.1,0.4]. Among SPF respondents, CPI and PCE long-term forecasts have a correlation of 0.89, the median difference between CPI and PCE forecasts is 0.2 percentage points, and the difference is rarely below 0 or above 0.5. Furthermore, our CPI range also nests the “equivalent percentile” range: 48 percent of PCE responses lie between 1.8 and 2.2 percent, and 48 percent of long-run expected CPI inflation responses lie between 2.1 percent and 2.5 percent. However, our results are insensitive to the size of this differential.

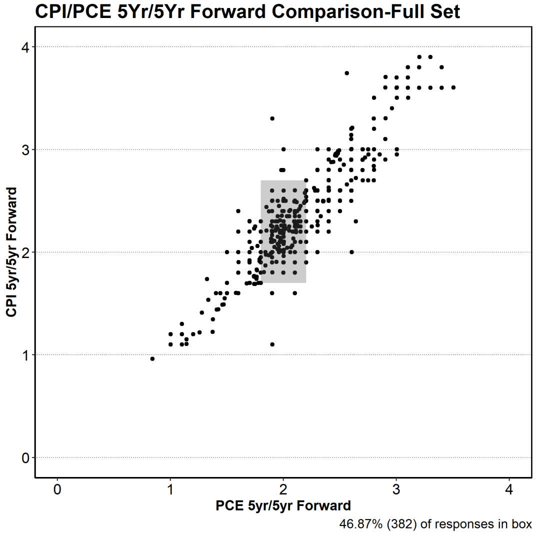

Figure 2: Long-run PCE and CPI inflation forecasts for SPF respondents who have made at least 14 forecasts of each from 2012 to 2018. (35 respondents and 815 observations in total.)

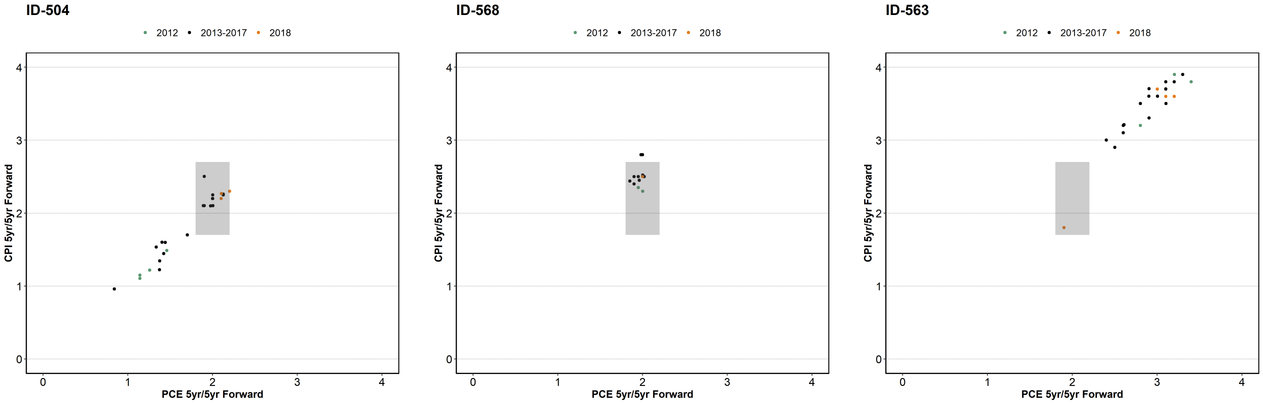

Figure 3: Box figure plots for three particular respondents demostrate heterogeneity in expectations; each dot represents a quarterly forecast for each individual.

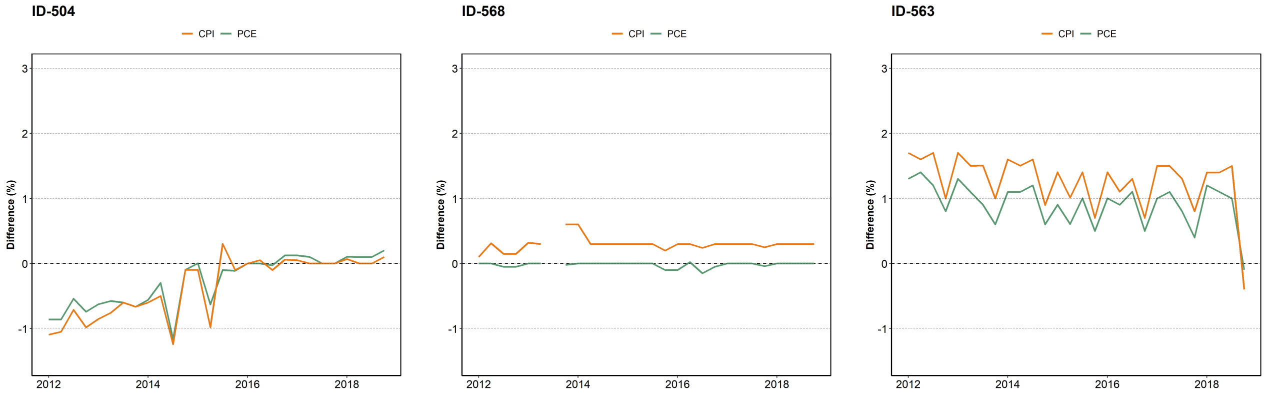

Figure 4: Time series of CPI- and PCE-divergence from target for three respondents are not anchored, but display signs of delayed anchoring.

We also produced box figures for each individual respondent. Figure 3 displays the box for three representative respondents.[8] Strikingly, there is not a single respondent who is anchored over the entire 2012-2018 period.[9]

That said, some are much closer than others. Figure 4 depicts the long-run inflation expectations of the same three representative respondents, as a time series (plotted as deviations from the center of the box). Figures 3 and 4 indicate both the diversity of views between respondents and also how expectations have (in some cases) moved notably over time. Respondent 568, whose responses are depicted in Figures 3b and 4b, is the respondent who is closest to being anchored. Respondent 504, depicted in Figures 3a and 4a, began 2012 with very low inflation expectations (1 ppt below target), but this respondent's views have been in the box since mid-2015. Respondent 563, depicted in Figures 3c and 4c, began 2012 with very high inflation expectations (1 ppt above target), and they remained consistently above target until 2018:Q4.

To provide some visual evidence about delayed anchoring for the respondents in aggregate, Figure 5 depicts our box figure for 2007, 2009, 2012, 2015, and 2018. In 2009, the response spread was greatest.[10] In 2012, respondents still had a remarkable diversity of views, with only 31 percent of responses in the box. In 2015, 54 percent of responses were in the box. By 2018, almost two-thirds of all responses (64 percent) were in the box. Formally, to assess the change in "spread" we computed a multivariate measure of the standard deviation of responses, the scaled covariance determinant ($\sqrt{|\Sigma|^{1/k}}$).[11] This fell from a peak of 0.48 in 2009, to 0.12 in 2012, to 0.09 in 2015, and ending 2018 at 0.05. (In Figure 10 in the appendix, we present a time series of the covariance determinant of responses over the entire period.) Figures 4 and 5 and Table 1 tell the same story: The years of the Great Recession caused a big dispersion in forecasters' beliefs, but subsequent to the announcement of the FOMC inflation target in 2012 and the first post-Great Recession rate hike in 2015:Q4, these beliefs have seen convergence toward the FOMC inflation target.

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[8] An exhaustive set of these individual forecaster plots can be found in the appendix

[9] In the appendix, we explore various notions of "almost anchored," such as "who needs only a slightly bigger box?', and how this "requisite box size" distribution has changed over time. Also, since anchoring is often assessed by insensitivity to incoming data and low volatility, in the appendix we provide two multivariate measures that correspond to the notion of volatility, and display how these distributions have changed over time.

[10] Consistent with this, Chan and Song (2018) find, on the basis of high-frequency financial market data, that inflation expectations uncertainty spiked dramatically in 2009.

[11] The determinant of the covariance matrix, $|\Sigma|$, is central to information theory and statistical inference. For k-dimensional data, a normalization of the covariance determinant is often suggested: $|\Sigma|^{1/k}$ (e.g., Tatsuoka and Tyler (2000)). Assuming a uniform distribution of responses, our box has a scaled covariance determinant of 0.024.

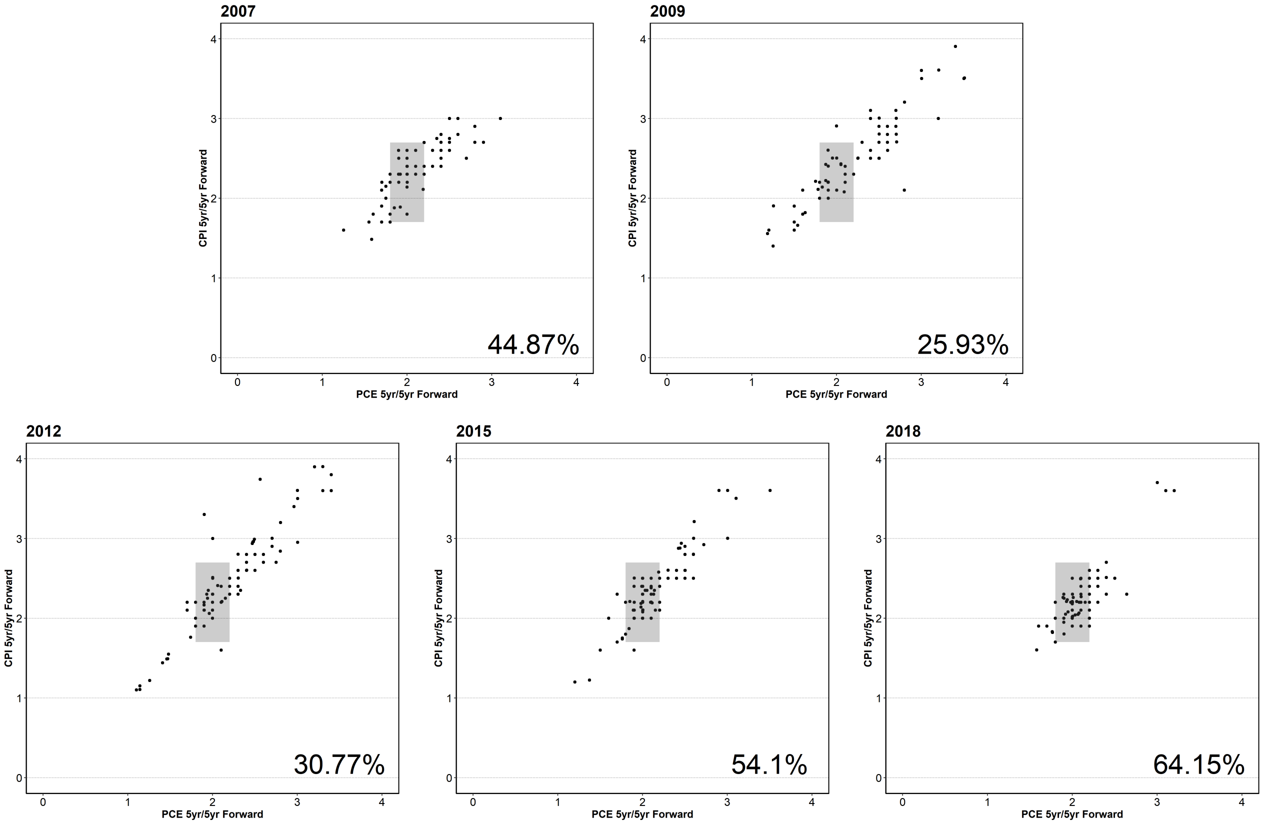

Figure 5: The spread of forecasts has seemed to tighten over time since the Fed's inflation target announcement in 2012, but 2015 was the first year when over 50 percent of responses were in the box.

What might these changes over time be attributed to? One candidate explanation is variation in trust. Christelis et al. (2016) find that trust in the central bank is a key determinant of inflation expectations, independent of respondents' financial sophistication and knowledge of central bank functions. The years of the Great Recession provoked a large dispersion in forecasters' beliefs. As the crisis began to unfold in the fall of 2007, the Federal Reserve began aggressively cutting the federal funds rate, which subsequently dropped from 5.25 percent to its zero lower bound. The monetary base expanded dramatically. Inflation, meanwhile, fell below zero. Financial and macroeconomic uncertainty was high. The first of the large-scale asset purchasing programs generated concerns of high future inflation for some, while, for others, given the amount of slack in the economy, prolonged low inflation seemed likely.[12]

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[12] In 2007:Q4, the SPF included a special question about inflation targeting. At that time, roughly half of the respondents believed that the Fed had an implicit (core PCE) inflation target; but comments reveal serious doubts

In 2010, not only did the policy rate stay at zero, but unconventional monetary policy actions were undertaken; PCE inflation briefly rose above 2 percent, but then fell notably. There were sizable revisions to policymakers' forecasts and to data releases, revealing substantial uncertainty about the duration and depth of the recession (see, e.g., Alessi et al. (2014)). The policy actions and forecast revisions may have led some forecasters to conclude that the FOMC would be unwilling or unable to rein in inflation going forward. In January 2012, the FOMC explicitly stated its policy target of 2 percent inflation in the PCE price index. However, Figure 5, which plots responses after this announcement, suggests that it had only a modest effect on the number of forecasters in the box. Based on a special survey question in the SPF in mid-2012, respondents who were "above-the-box" reported concerns about the Fed's balance sheet, food and energy inflation, and fiscal imbalances.[13] Throughout 2015, numerous forecasters continued to expect quite high inflation over the next 10 years. But in December of that year, the first rate increase occurred. The actual tightening of monetary policy may have convinced some of the forecasters who were worried about high inflation that the FOMC would indeed act to rein in inflation, if that became necessary.[14] [15]

To investigate this hypothesis, we consider a regression specification that is motivated by related specifications in Rich and Tracy (2017) and Fuhrer (2018). Rich and Tracy (2017) find that forecasters–especially forecasters with greater disagreement–tend to revise their forecasts toward the median forecast of the previous period. Fuhrer (2018) studies short-run inflation expectations and similarly finds forecast revisions toward the median. In an imperfect information context, where different forecasters might have different information, the median forecast might provide useful information about the current medium-frequency trend in a variable.[16] However, in this paper we study the long-run inflation expectations of well-informed forecasters, which are really about trust in the central bank's ability to achieve its (known) inflation target. We thus focus on that target per se, and whether expectations are approaching the target over time. We also ask whether this became more pronounced starting in 2016:Q1. We continue with our multivariate approach: "Moving toward target" means that *both* the CPI and the PCE inflation forecasts are moving toward target. Thus, defining $f_{i,t}^{CPI}$ as the long-run inflation expectations of respondent i (and defining $f_{i,t}^{PCE}$ similarly), our panel regression specification is:[17]

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about its commitment to attaining that target.

[13] Nechio (2015) provides further context. We find that the accuracy of one-quarter-ahead and four-quarter-ahead PCE inflation forecasts relative to CPI inflation forecasts improved after 2012, consistent with a view that forecasters began to focus more attention on PCE inflation after the FOMC announcement.

[14] The reduction in high inflation responses is not due to attrition, as is evident from the figures in the appendix. For a recent model featuring persistent disagreement via different levels of trust and different forecasting models, see Hachem and Wu (2017). In this study, inflation expectations do not immediately converge to the central bank's target, because credibility must be earned, beliefs propagate via social dynamics, and agents care about forecast accuracy. The more stubborn are beliefs, the longer it will take for expectations to converge.

[15] During 2015, financial markets began to anticipate a rate increase. Uncertainty, however, remained high until shortly before the December meeting. See Appendix A.2

[16] Demertzis and Viegi (2009) model monetary policy as an information game played between individuals and the central bank featuring strategic complementarity. In that framework, optimal policy responds to average expected inflation, and optimal expected inflation can be a function of average expected inflation.

[17] As discussed above, we take 2.2 percent to be the implied CPI target. See Binder et al. (2019) for more analysis.

$$(f_{i,t}^{CPI} - 2.2) = \delta_i + \lambda_i (I^{t \geq 2016Q1}) + \beta (f_{i,t-1}^{CPI} - 2.2) + \rho_1 (I^{t \geq 2016Q1} (f_{i,t-1}^{CPI} - 2.2)) + \varepsilon_{i,t}^{CPI} \tag{1}$$

$$(f_{i,t}^{PCE} - 2.0) = \gamma_i + \mu_i (I^{t \geq 2016Q1}) + \phi (f_{i,t-1}^{PCE} - 2.0) + \rho_2 (I^{t \geq 2016Q1} (f_{i,t-1}^{PCE} - 2.0)) + \varepsilon_{i,t}^{PCE} \tag{2}$$

There are mathematically equivalent ways to re-specify this regression, but (1) and (2) are particularly transparent. A "perfectly anchored" respondent would have "small" β and ϕ coefficient estimates, and all other coefficient estimates would be 0.

We find significant evidence that responses are moving into the box after 2016; by "a move into the box after 2016," we mean that after 2016, both responses are in the box in expectation.[18,19] We can compute respondent i's expected response by generalizing the usual AR(1) formula: If $y_{t+1} = \alpha + \beta y_t + \varepsilon_t$, then $EY = \frac{\alpha}{(1-\beta)}$. It is thus straightforward to determine the expected response of respondent i pre- and post-2016. Prior to 2016, 17 of the 35 respondents (49 percent) had expected responses outside the box; after 2016, 11 of the respondents (31 percent) did. Using Euclidean distances, the average response distances from the center of the box fell by nearly 40 percent. (Note that if respondents are generally "becoming more anchored," we would also expect to see lower average persistence over time. We cannot easily compute respondent-specific persistence estimates, since many respondents have significant gaps in their responses.) In (1), $\hat{\beta}$ fell from 0.376 to 0.167; in (2), $\hat{\phi}$ fell from 0.452 to 0.161.

Further motivated by studies such as Rich and Tracy (2017) and Christelis et al. (2016), we also investigate whether movement toward anchoring differs, depending on the nature of disagreement prior to 2012. In particular, we partition respondents into three groups: undershooters, near the target, and overshooters.[20] Undershooters have average responses below the box; overshooters have average responses above the box; and near the target had average responses in the box.[21] Both overshooters and those initially near the target display notably less persistence in responses after 2016. Note that Table 2 does not depict individual intercept terms δ_i, λ_i, γ_i, and μ_i. In unrestricted regressions these were generally statistically significant, and for many, $\lambda_i \to -\delta_i$ and $\mu_i \to -\gamma_i$; responses moved towards the target after 2016.

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[18] While we believe a break sometime in 2015:Q1 or 2016:Q1 is defensible on a priori grounds, we conducted a search to determine the most likely break-date between 2014 and 2017 (if any). Regression fit is maximized for a break occurring in 2016:Q1. As noted above, an F-test confirms the statistical significance of this break.

[19] Nautz and Strohsal (2015) confirm previous studies that found de-anchoring of inflation expectations during the crisis, and ask whether inflation expectations had become re-anchored by the end of 2014. They conclude that they had not. Our results are consistent with this study, in that we find wide dispersion of expectations and relatively few responses in the box in 2009, and we find that a pronounced shift toward the box occurred after 2015.

[20] Six of our respondents entered in 2012, and thus could not be assigned to a group using our methods. They remain in the full set analysis, however.

[21] Group 1 was omitted from a regression as there were only three respondents. For more details on how the partitioning was conducted, see the appendix.

Table 1: Inflation Regressions

	Model 1	Model 2	Model 3
Control	Full Set	Group 2	Group 3‡
5yr/5yr CPI Deviation from Target			
β (Lagged Deviation)	0.376***	0.758***	0.592***
	(3.28)	(5.14)	(5.61)
ρ_1 (Lagged Deviation 2016 Onward)	-0.209**	-0.476***	-0.403***
	(-2.05)	(-4.50)	(-5.17)
$\overline{\delta_i}$ (Constant†)	0.071***	0.032***	0.09***
	(6.21)	(5.28)	(3.70)
$\overline{\lambda_i}$ (2016 Onward†§)	-0.117***	-0.009**	-
	(2.34)	(1.90)	-
5yr/5yr PCE Deviation from Target			
ϕ (Lagged Deviation)	0.452***	0.830***	0.560***
	(3.98)	(5.21)	(6.13)
ρ_2 (Lagged Deviation 2016 Onward)	-0.291**	-0.673***	-0.317***
	(-2.10)	(-5.03)	(-3.83)
$\overline{\gamma_i}$ (Constant†)	0.076***	0.005***	0.108***
	(8.41)	(-6.54)	(4.61)
$\overline{\mu_i}$ (2016-Onward†§)	0.027***	-0.004	-
	(2.02)	(0.89)	-
N	780	244	311
# of Respondents	35	11	14

Significance at 0.1, 0.05, and 0.01 is denoted as *, **, and ***. Except when explicitly mentioned in §, t-statistics are shown in parenthesis.

† We report the average of δ_i, λ_i, γ_i, and μ_i as the average coefficient. There is considerable dispersion of these respondent-specific intercept terms.

§ In lieu of a t-statistic, the F-test statistic from the test for joint significance of the relevant respondent-specific terms is reported.

‡In Group 3, we drop respondent 563, whose responses are sufficiently different that they influence parameters notably. Including 563 would lead to the conclusion that this respondent group did not move into the box after 2016. For this group, we omit the $\overline{\lambda}$ and $\overline{\mu}$ terms from the regression specification, since these were not statistically significant.

3 Conclusion

Are long-run inflation expectations anchored? We provide an intuitive new metric to answer this question. We find that there is not one SPF respondent whose long-run inflation expectations have been absolutely anchored since 2012, or even since 2015. However, we find evidence that respondents are steadily moving into our box, what might be termed "delayed anchoring." Thus our study makes two points. First, despite the steadiness of the median 10-year forecast, individual SPF respondents are not anchored to the Fed's target (a finding consistent with Binder (2017b) and Coibion et al. (2019)). Second, notable progress has been made in expectations becoming anchored (in keeping with Doh and Oksol (2018)).

What accounts for these findings? We offer only tentative conclusions. Anchoring is about knowledge of central bank objectives or trust. Either information from the FOMC is not being heard (or at least not understood clearly), or it has been met with skepticism. As this study focuses on professional forecasters, we are inclined to believe the latter. Based on our view that an anchored respondent must respond within the box, we conclude that over one-third of professional forecasters continue to doubt that the FOMC will attain its target at the 5-to-10 year horizon.

As noted above, we believe that persistent disagreement in SPF expectations stems from the use of different models. One interesting direction for future work would be to build on the recent work of Berge (2018) and attempt to categorize respondents in terms of similar models, perhaps exploiting information across several variables. We leave this, and the exploration of the relationship between long-run inflation forecasts and inflation forecast accuracy at shorter horizons, for future work.

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A Appendix

A.1 Robustness Checks for Significance

The overwhelming majority of individual’s intercepts and 2016 onward variables are significant, but do we observe joint significance for these variables? We perform F-tests on both the ID-specific constants and the ID-specific post-2016 dummy terms and locate evidence for joint significance. In particular, the restricted equation in Test 1 (for CPI) is:

$$(f_{i,t}^{CPI} - 2.2) = \delta_i + \beta(f_{i,t-1}^{CPI} - 2.2) + \varepsilon_{i,t}^{CPI} \tag{3}$$

,

The restricted equation in Test 2 is:

$$(f_{i,t}^{CPI} - 2.2) = \delta_i + \lambda_i(I^{t \geq 2016Q1}) + \beta(f_{i,t-1}^{CPI} - 2.2) + \varepsilon_{i,t}^{CPI} \tag{4}$$

The unrestricted equation in both tests is

$$(f_{i,t}^{CPI} - 2.2) = \delta_i + \lambda_i(I^{t \geq 2016Q1}) + \beta(f_{i,t-1}^{CPI} - 2.2) + \rho_1(I^{t \geq 2016Q1}(f_{i,t-1}^{CPI} - 2.2)) + \varepsilon_{i,t}^{CPI} \tag{5}$$

We also perform a test for poolability in panel data to see if the panel can be combined, i.e. “pooled,” into one single constant-coefficient model. Using our 2016-onward dummy variable as the variable in question, we employed the Roy-Zellner test for poolability, as described in Vaona (2008). At the α=0.05 level, we reject the null of poolability. This provides further evidence that there is a break in the data around 2016.

Table 2: F-Tests on Inflation

Model	CPI	PCE
Test 1		
F-Stat	2.34***	2.02***
P-Value	0.000	0.001
Test 2		
F-Stat	3.78***	3.64***
P-Value	0.000	0.000

Table 3: Roy-Zellner Tests

	CPI	PCE
χ^2	34.48***	34.48***
P-Value	0.000	0.000

As mentioned in the body, we believed there to be a structural break sometime around 2015 or 2016. In our search for the optimal break-date, we iteratively ran regressions with a quarterly dummy variable similar to λ_i and μ_i found in equations (1) and (2), but widening our potential dates to any quarter between 2013:Q1-2017:Q4. We found a global maximum in the R^2 for both the PCE and the CPI in 2016:Q1 (when using annual dummy variables, 2016 is selected as well) at 0.62 and 0.68, respectively. During this process, we discovered that 2015:Q4 proves to be a bit of an anomaly. For instance, when using 2015:Q4 as the break-date, our lagged deviation coefficient estimate flips positive (though our inferences about moving into the box are unchanged). This proves to be a one-off, however: If we omit this quarter from estimation or choose later break-dates, this coefficient estimate is well-behaved. We view this as confirmatory evidence that the end of 2015 was a period during which uncertainty changed for a number of respondents.

A.2 Market Anticipation of Federal Funds Movement

Above, we show that both theory and statistical evidence support the finding that a structural break occurred in 2016:Q1. Here we demonstrate that a break at the end of 2015, owing to a reduced uncertainty about the Federal Reserve commitment to its 2 percent inflation target, is consistent with the expectations of financial market participants about FOMC actions.[22] Financial market data indicate that as early as the spring of 2015, market participants (some of whom may also be respondents in the SPF) began to believe that the Federal Reserve would honor its commitment to its 2 percent inflation target. As seen in Figure 6, the uncertainty regarding actions that might be undertaken by the FOMC during 2015 greatly fell throughout the year.[23] In late October, financial market participants had serious doubts about whether the Fed would take action that year. But by the December meeting, the market felt it almost certain that a rate increase (the first movement of any sort since the massive rate cuts in the fall of 2008) would take place during that month's meeting.

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[22] For this purpose, we adopt methods used by CME Group that calculate the probabilities of changes in the Federal Funds rate, and adjust for the term premium. Documentation of CME's methodology can be found here: https://www.cmegroup.com/education/demos-and-tutorials/fed-funds-futures-probability-tree-calculator.html

[23] We thank George Nurisso for these calculations.

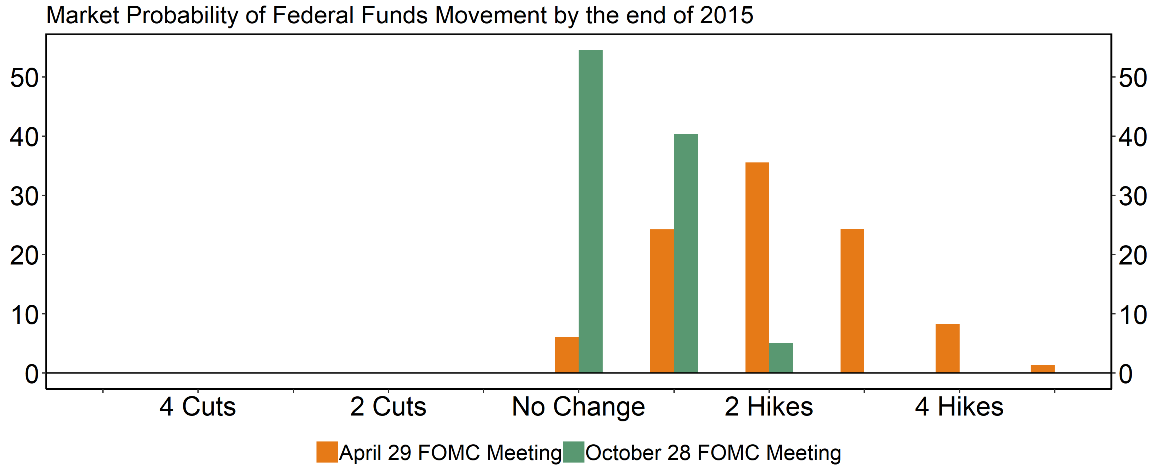


Figure 6: Market uncertainty of federal funds movement greatly fell during the months between the April 29 and October 28, 2015 meetings. By December 9, 2015, the probability of a rate increase was 96 percent, with a 4 percent probability of no rate change. **Source**: Federal Reserve Bank of New York/Haver Analytics and Chicago Board of Trade/Haver Analytics.

A.3 5Yr/5Yr Forward Rate, and Comparison to 10-Year Forecasts

SPF respondents do not report 5year/5year-forward forecasts. If they had been asked, it is possible that a given respondent would have reported something different than the forecast implied by their 5-year and 10-year forecasts. Thus, as a robustness check, we investigate whether our results would be different if we treated the ten-year forecast as a proxy for the 5year/5year-forward forecast. Below we present a table comparing the number of respondents who are absolutely anchored using the implied 5year/5year-forward forecast, as opposed to the number who are absolutely anchored using the 10-year forecast. We do this both for the full sample, and for the period after 2012, i.e., after the FOMC's inflation target announcement. Under this definition of absolutely anchored, our qualitative findings are quite similar: A tiny fraction of respondents are absolutely anchored over the entire period, while less than 20 percent are absolutely anchored if we restrict attention to the post-2012 period. The formula for converting 5-year and 10-year forecasts into 5year/5year-forward forecasts goes as follows:

$$CPIF5_{i,t} = 100\left[\frac{\left(1+\frac{CPI10_{i,t}}{100}\right)^2}{\left(1+\frac{CPI5_{i,t}}{100}\right)} - 1\right]$$

$$PCEF5_{i,t} = 100\left[\frac{\left(1+\frac{PCE10_{i,t}}{100}\right)^2}{\left(1+\frac{PCE5_{i,t}}{100}\right)} - 1\right],$$

where $PCE10_{i,t}$ is respondent i's 10-year-ahead forecast for PCE inflation made in quarter t, etc.

	Full Sample	2012 Onward
5Year/5Year-Forward	1/45	0/35
10-Year Forecast	2/45	5/35

Table 4: Although there are some respondents absolutely anchored using the 10-year inflation forecast, that number remains a small portion of the total number of respondents.

Using the same specification (1) and (2) on the full set of respondents using the 10-year forecasts yields similar results to those in Table 2; see Table 6. Likewise, F-tests for joint significance, as in Appendix A.1, yielded statistically significant results; see Table 7.

Table 5: 10-Year Forecast Regressions

10-Year Deviation from Target		
	CPI	PCE
β,ϕ (Lagged Deviation)	0.494***	0.451***
	(5.32)	(4.99)
ρ_1,ρ_2 (Lagged Deviation 2016 Onward)	-0.275**	-0.225**
	(-2.85)	(-1.97)
$\overline{\delta_i}$, $\overline{\gamma_i}$ (Constant†)	0.049***	0.037****
	(12.50)	(15.00)
$\overline{\lambda_i}$, $\overline{\mu_i}$ (2016-Onward†§)	0.000***	0.029***
	(2.80)	(2.79)
N	780	780
# of Respondents	35	35

Significance at 0.1, 0.05, and 0.01 is denoted at *, **, and ***.

[†] We report the average of δ_i, λ_i, γ_i, and μ_i as the coefficient. There is considerable dispersion of these respondent-specific intercept terms.

[§] In lieu of a t-statistic, the F-test statistic from the test for joint significance of $\overline{\lambda_i}$, $\overline{\mu_i}$ is reported.

F-tests for joint significance were also undertaken, and came back with significant results, in tandem with those done on the 5year/5year-forward rates.

Table 6: F-Tests on 10-Year Inflation

Model	CPI	PCE
Test 1		
F-Stat	3.47***	3.66***
P-Value	0.000	0.000
Test 2		
F-Stat	2.80***	2.79***
P-Value	0.000	0.000

See section A.1 for the specification of F-tests.

A.4 CPI/PCE Gap Reverting to the Mean

Taking all respondents as a group, does the CPI/PCE gap revert to the mean? This can be answered with the following regression specification. We find evidence for mean-reversion in this gap.

$$(f_{i,t}^{CPI} - f_{i,t}^{PCE} - 0.2) = \alpha_{i,t} + \rho(f_{i,t-1}^{CPI} - f_{i,t-1}^{PCE} - 0.2) + \varepsilon_{i,t} \tag{6}$$

Table 7: CPI/PCE Gap

ρ (AR(1) Term)	0.563***
	(13.61)
α (Constant)	0.002
	(0.32)

Significance at 0.1, 0.05, and 0.01 is denoted at *, **, and ***.
T-statistics are reported in parenthesis.

A.5 Stock-Watson UCSV Model

In this section, we create a fictitious respondent who uses the Stock and Watson (2007) UCSV model. This respondent is not anchored and spends most of the period below the box.

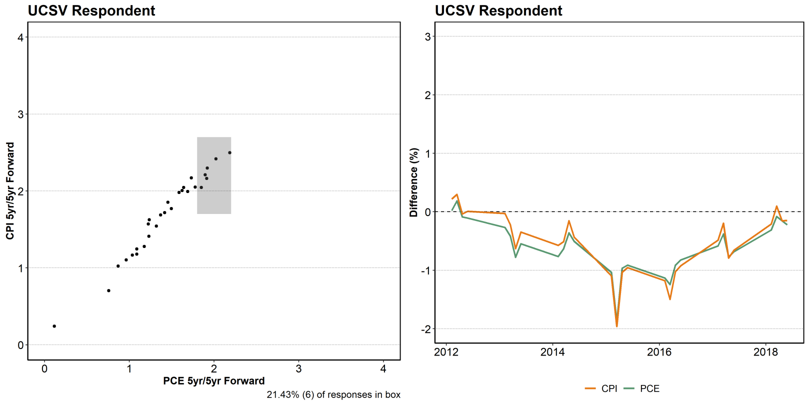


Figure 7: Creating a "forecaster" using the Stock-Watson UCSV model shows a respondent with below-the-box forecasts, but over time, they have converged to target from 2016 onward.

A.6 Grouping Respondents

In Table 2, we display results for two subsets of respondents. As noted above, we grouped respondents based on their responses between 2007-2011. Respondent *i*'s average inflation was computed by taking the average of PCE and the (un-biased) average of CPI, using this formula:

$$\text{Average Inflation}_i = \frac{((\text{Average CPI}_i - 0.2) + \text{Average PCE}_i)}{2} \tag{7}$$

$$Group_i = \begin{cases} 1 & \text{if Average Inflation}_i < 1.8 \\ 2 & \text{if } 1.8 \leq \text{Average Inflation}_i \leq 2.2 \\ 3 & \text{if Average Inflation}_i > 2.2 \end{cases}$$

A.7 Inflation Differential

We provide a post-2007 plot of a five-year moving average of the CPI/PCE inflation differential, along with the median estimate of the 5year/5year-forward CPI/PCE inflation differential derived from the SPF. The median differential hovers at or just above 0.2 ppt. As noted above, there is time-variation in this differential, and long-run forecasts of the differential vary to some extent. But as will be immediately evident, our results are rather insensitive to our treatment of this differential. Hence, in this paper we suppress any time variation in the differential.

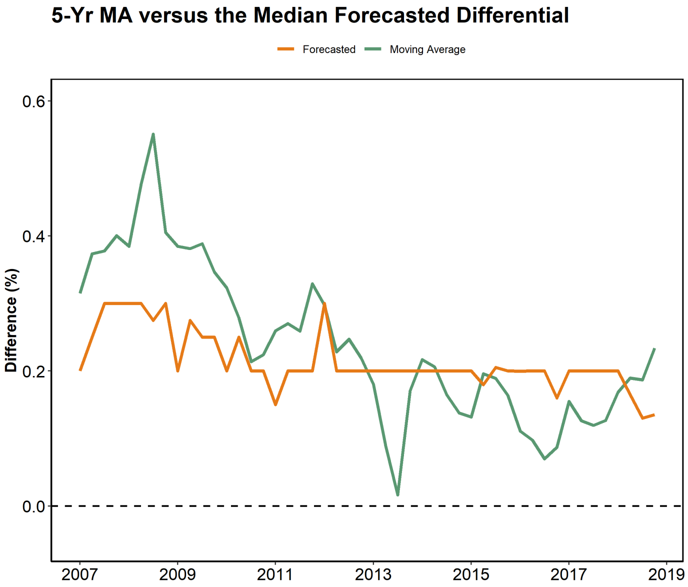


Figure 8: The CPI/PCE differential: 5-year moving average and median forecaster.

A.8 Contemporaneous Forecast

One might wonder whether 5year/5year-forward forecasts are correlated with near-term forecasts. In particular, do respondents who are below the box typically forecast inflation rates that are lower than the median, and do respondents who are above the box typically forecast inflation rates that are higher than the median? The answer is yes.

	Group 1	Group 2	Group 3
CPI	1.53	2.05	2.10
PCE	1.21	1.76	1.90
Difference	0.32	0.29	0.20
Number of Respondents	3	11	15

Table 8: Median one-quarter-ahead forecasts versus position relative to the box.

A.9 Requisite Box Composition

As an alternative measure of observing how forecasters' behavior has changed over time, we investigate how large would forecaster *i*'s box have had to be in order for *i* to have been considered absolutely anchored (year by year). How has the distribution of requisite box sizes changed over time? In particular, for each forecaster *i*, and in parallel to equation 1, we compute

$$\sqrt{A}_{i,t} = ([max|PCE_{i,t} - 2| * [max|CPI_{i,t} - 2.2|])^{1/2} \tag{8}$$

This formula is identical to equation (1), except that boxes are constructed relative to the center of our box (2.0,2.2). In (2), $PCEmax_{i,t}$ and $CPImax_{i,t}$ are now the inflation predictions that are farthest, in absolute value, from the center of the box, over the time period in question.

In Figure 9, we plot the distribution of box areas from equation (2), for five different years. Our new requisite box has an area of ≈ 0.316. Thus, the first column in each figure essentially represents the percent of respondents that year who were in our box, i.e., absolutely anchored. In 2007, as the Great Recession began to unfold, 38 percent of the responses were in our box; but the distribution has a notable right tail, and encompassing 90 percent of responses would have required a box 137 percent larger. In 2010, the distribution of requisite box sizes had spread out considerably. Only 40 percent of responses were absolutely anchored, and many responses were far from the box; encompassing 90 percent of responses would have required a box **5** times larger (for an area of 1.58) than the original one. In 2012, to encompass 90 percent of responses, one would require a box 262 percent times larger than the standard box. For 2015, a box 184 percent larger would be needed in order to contain 90 percent of responses.

By 2018, the majority of responses were in the box, and 95 percent of responses had requisite box sizes under 0.5.

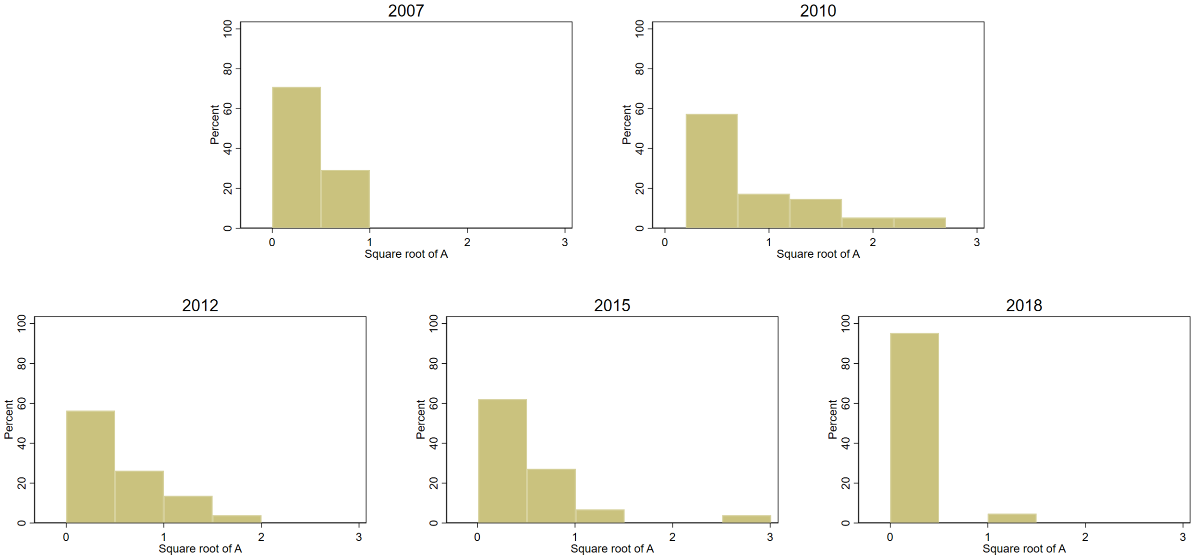


Figure 9: Forecasters as a collective have changed their behavior over time.

A.10 Spread of Responses

As noted above, the covariance matrix's squared determinant is a multivariate gauge of the spread of responses in PCE/CPI. We depict this statistic for each year, 2007-2018, along with a common univariate metric, the interquartile range (IQR), for the CPI and PCE separately. All three measures attain their maximum in 2009, a time of profound uncertainty and dispersed beliefs about what the future would hold.

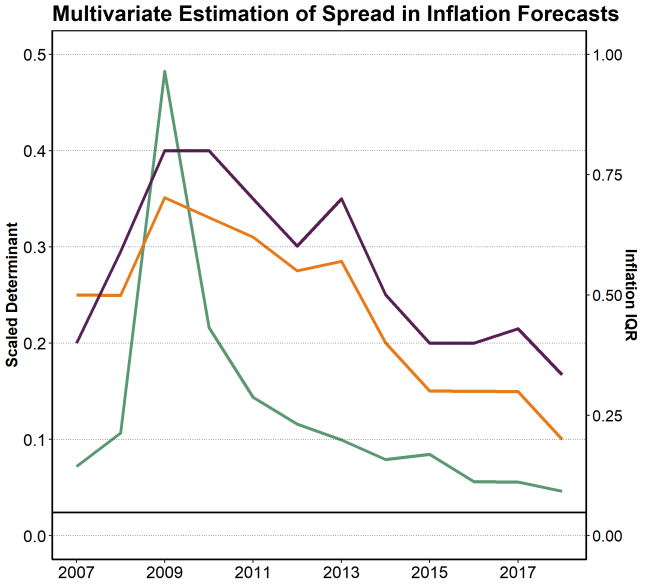


Figure 10: The scaled covariance determinant of inflation forecasts peaks in 2009 (before the inflation target was announced), but has steadily dropped since 2012. In tandem, the IQR for both CPI (purple) and PCE (orange) has fallen.

	2007	2008	**2009**	2010	2011	**2012**
$\sqrt{\text{Covariance Determinant}}$	0.072	0.107	0.482	0.216	0.144	0.116
	2013	2014	**2015**	2016	2017	**2018**
$\sqrt{\text{Covariance Determinant}}$	0.099	0.079	0.085	0.056	0.056	0.046

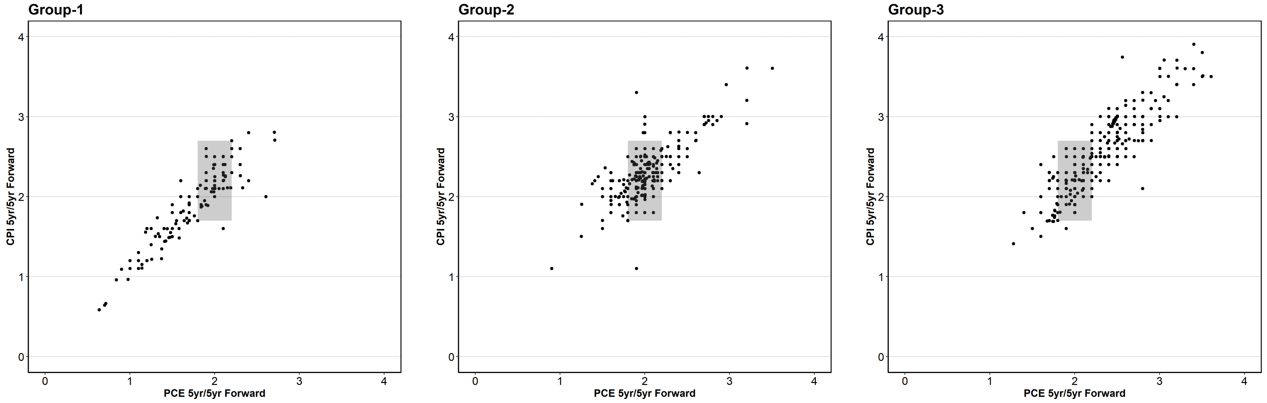
A.11 Respondents Almost in the Box

As we note above, none of the respondents have expectations that were anchored over the entire period. In this section, we explore what "almost anchored" might entail–or equivalently, the sensitivity of our results to the particulars of our definition. Two definitions of "almost in the box" were used: One in which the PCE range was expanded to 1.7-2.3 percent, and the other in which each respondent was allowed one "bad" response for every 14 (which amounts to insisting upon a 92.86 percent "success" rate). We excluded participants with less than 14 responses. Table A.11 below indicates that even with these expanded definitions, depending on which one, only three or one respondent(s) stayed in the box during the entire period.

Method	Anchored Respondents
Expanded PCE Range	3/35 (8.57%)
“Success” Rate	1/35 (2.86%)

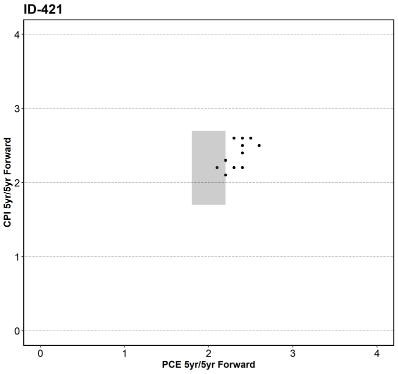
A.12 Group Scatterplots of 5year/5year-Forward Forecasts

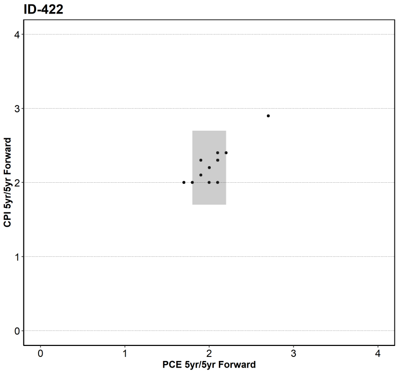
Box plots for each of the respondent groups over the full sample period, 2012:Q1 through 2018:Q4.

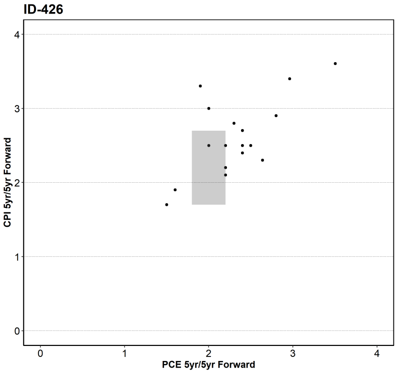


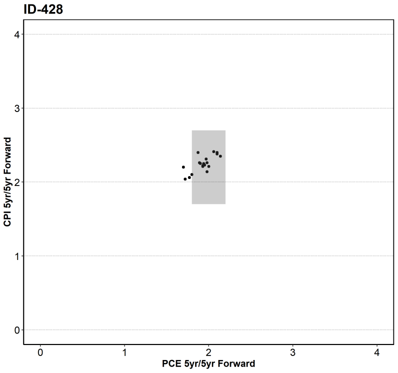
A.13 Individual Respondents 5year/5year-Forward Forecasts

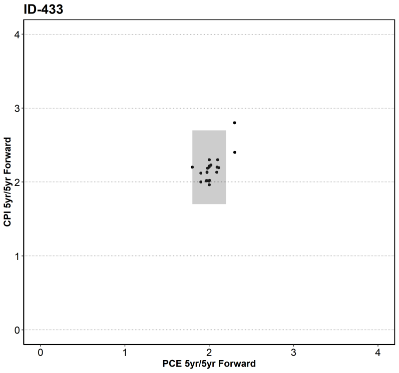
Box plots for each SPF respondent, parallel to Figure 3.

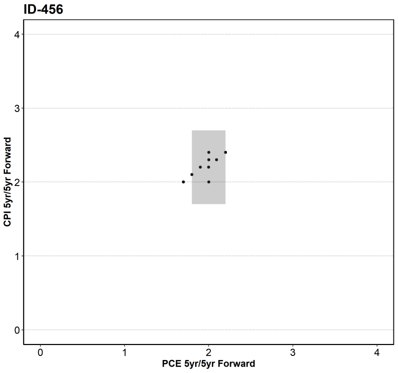


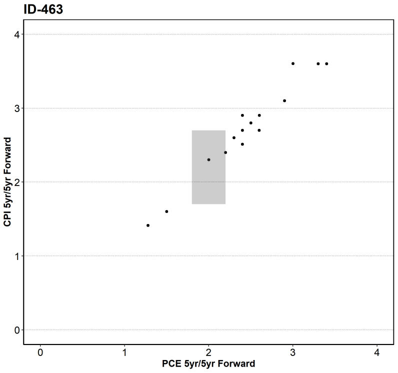


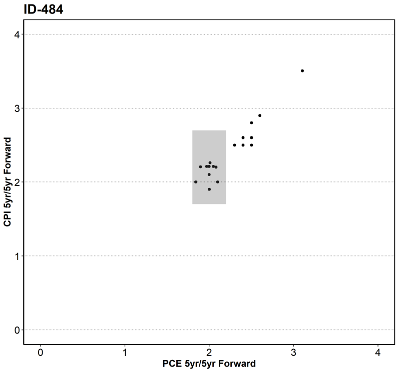


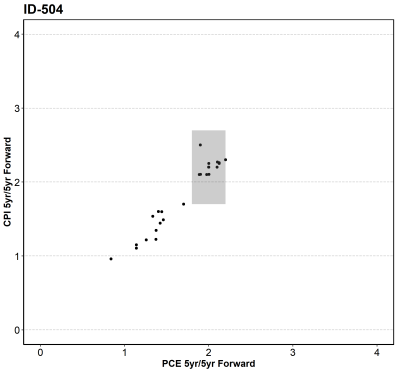












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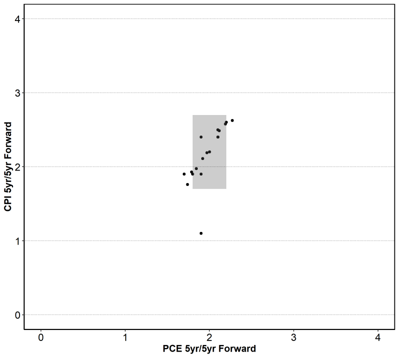

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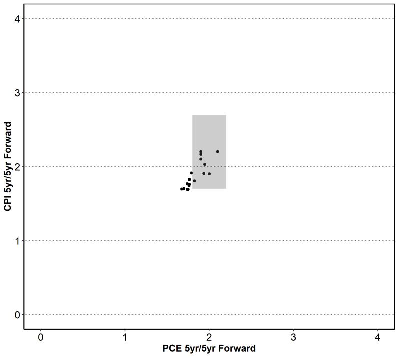

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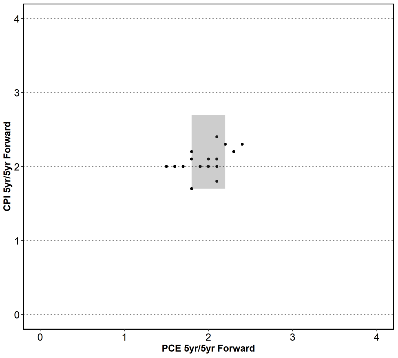

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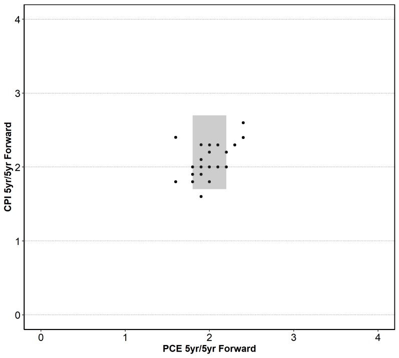

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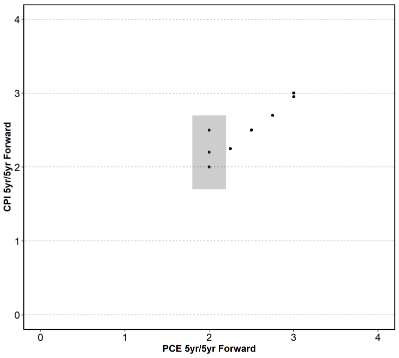

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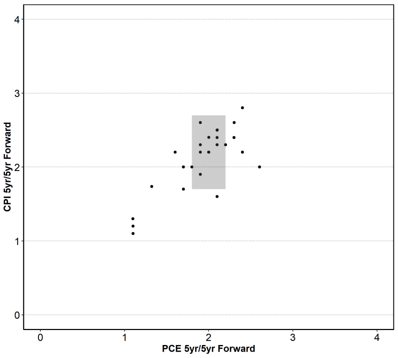

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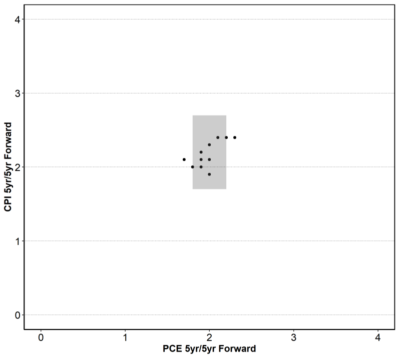

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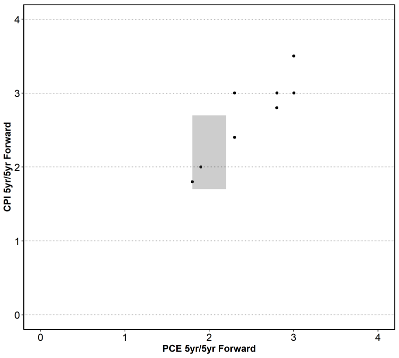

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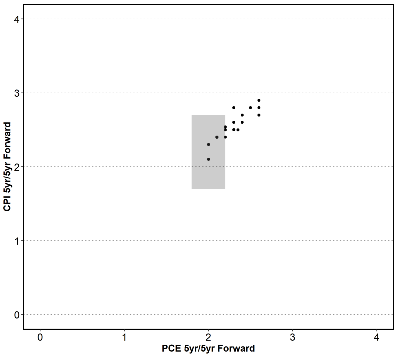

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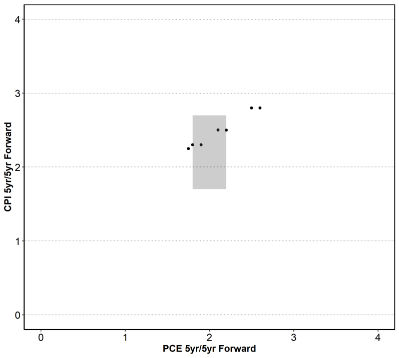

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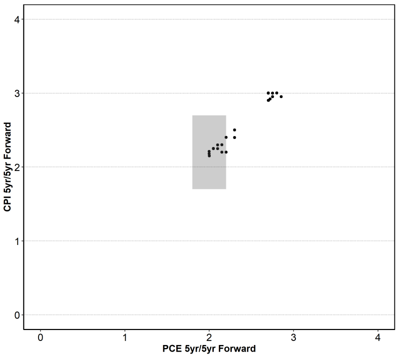

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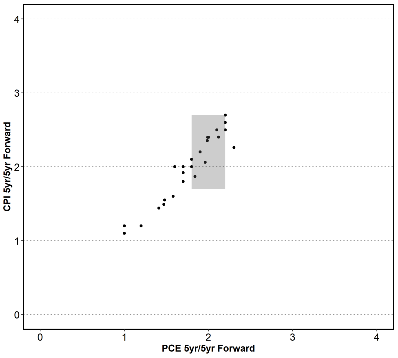

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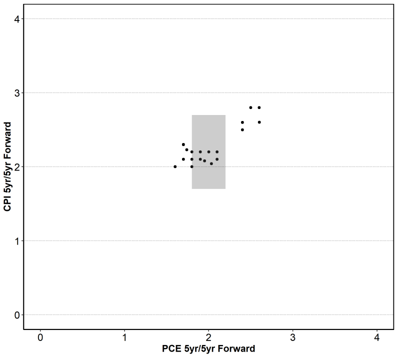

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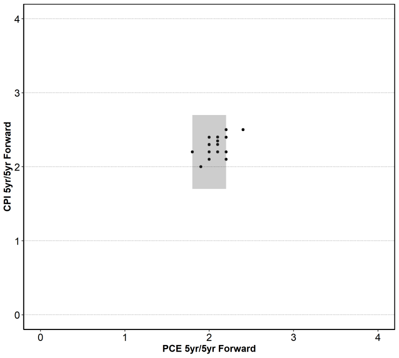

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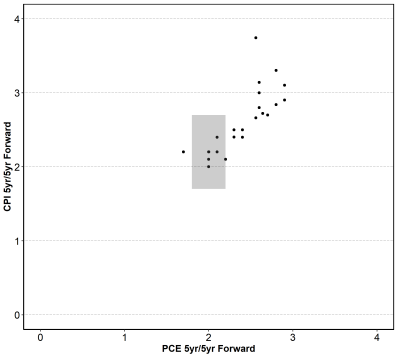

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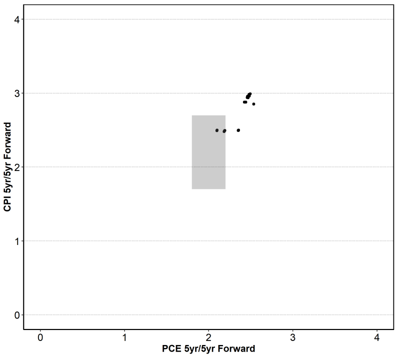

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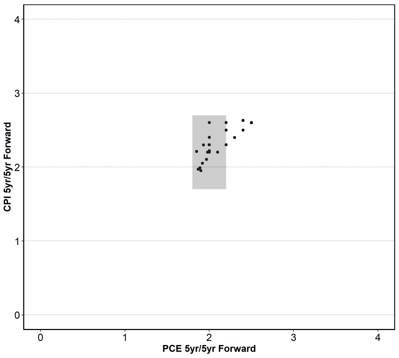

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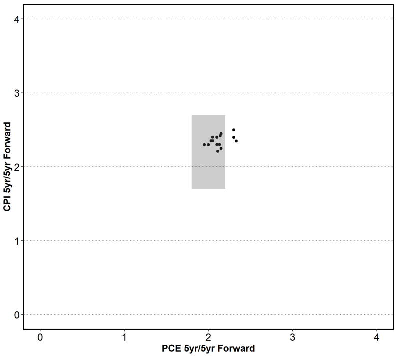

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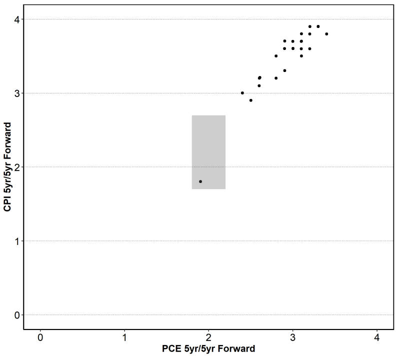

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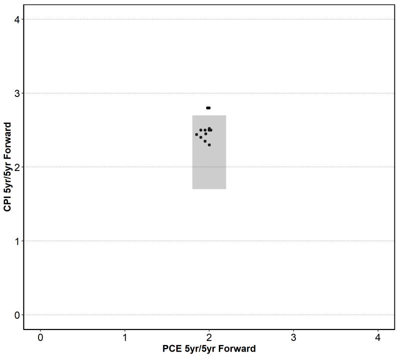

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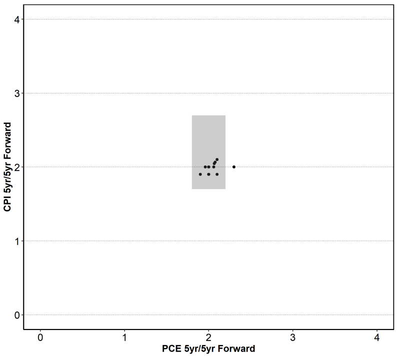

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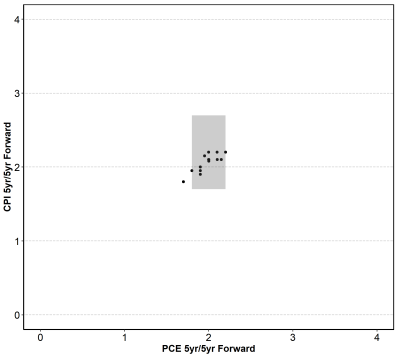

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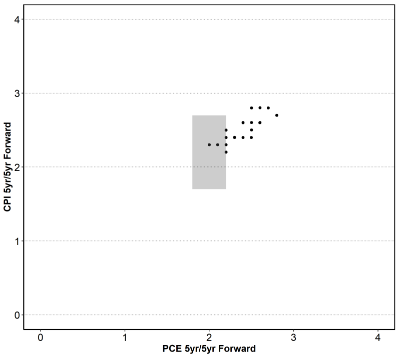

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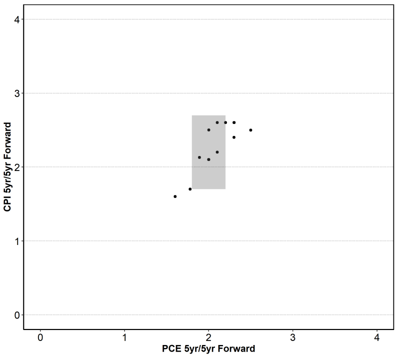
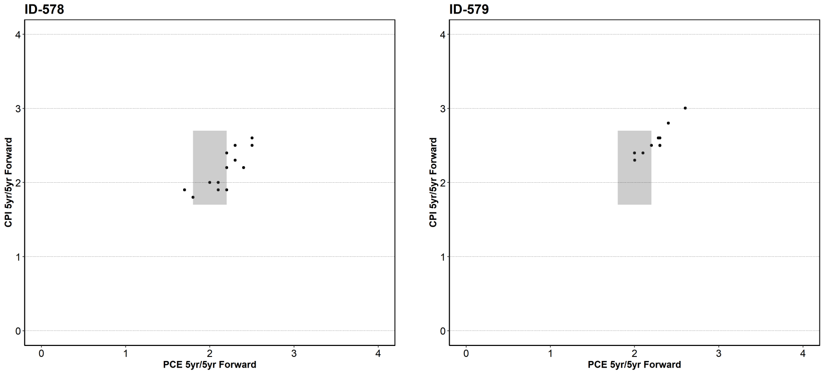
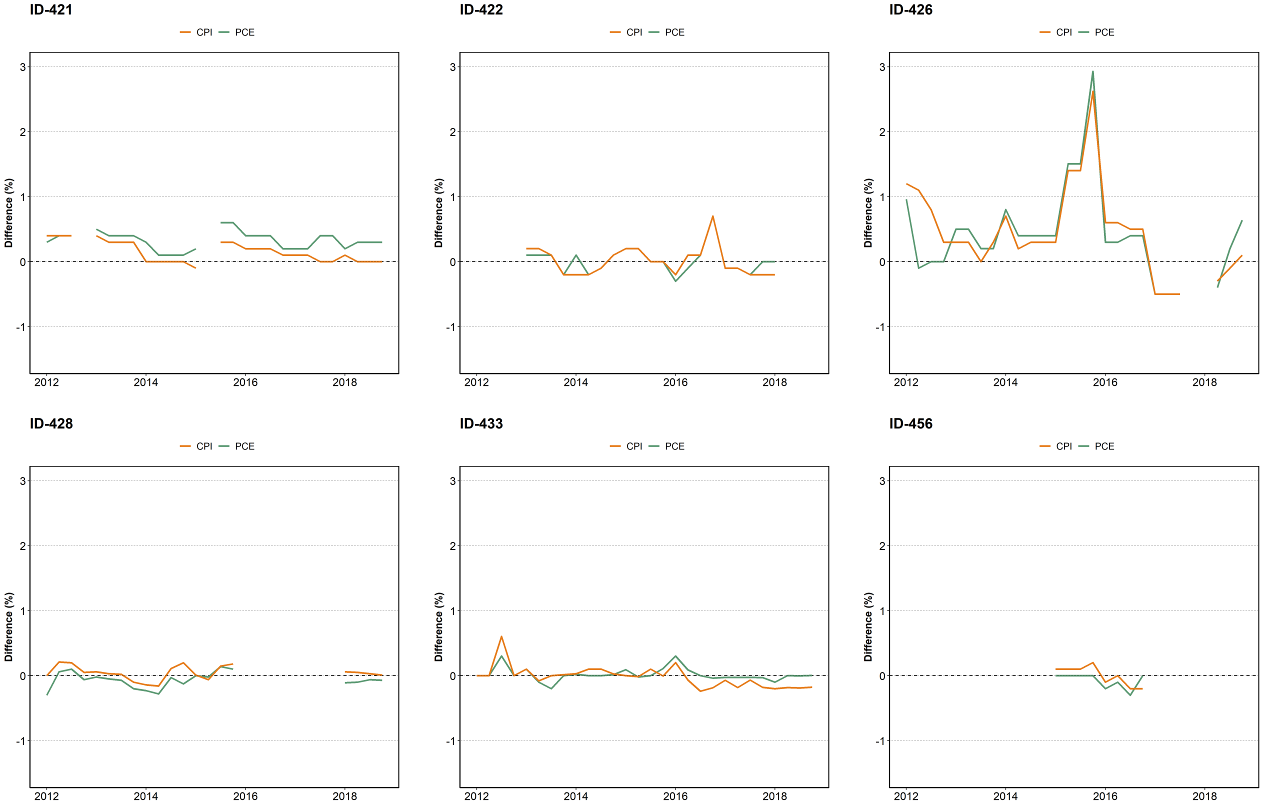




A.14 Individual Respondents Deviation-from-Target Time Series

Time-series plots of responses for each SPF respondent, parallel to Figure 4.



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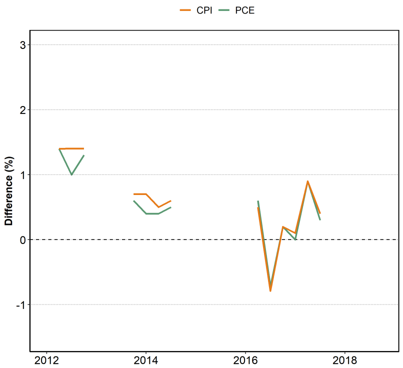

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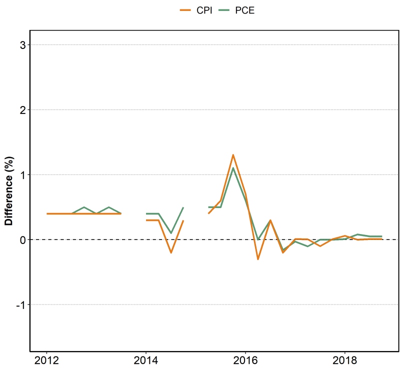

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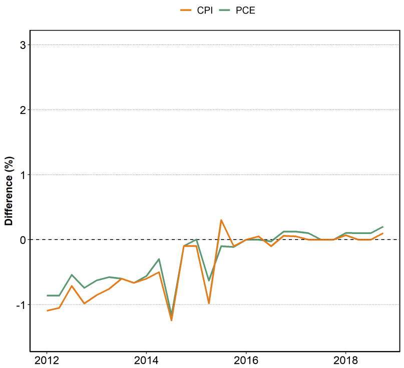

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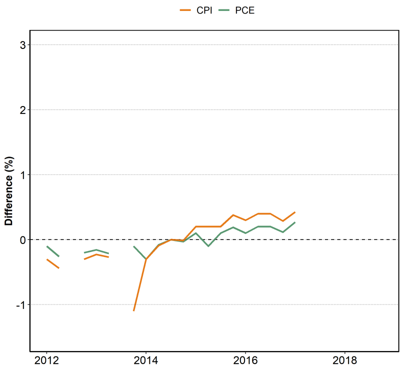

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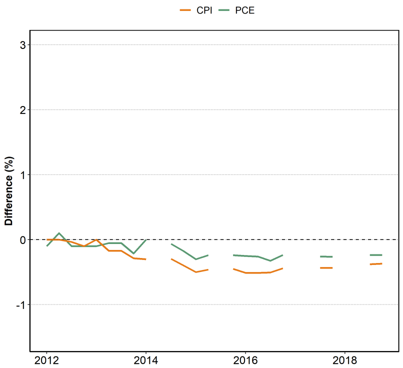

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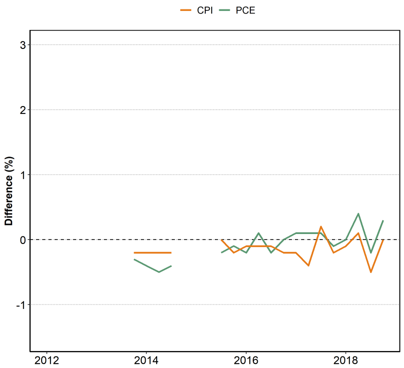

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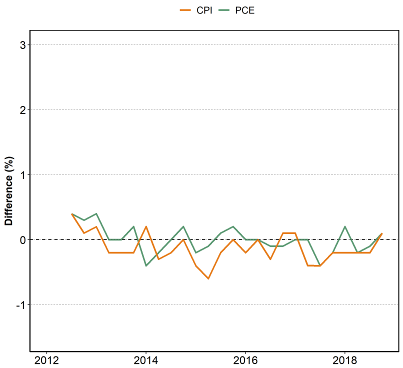

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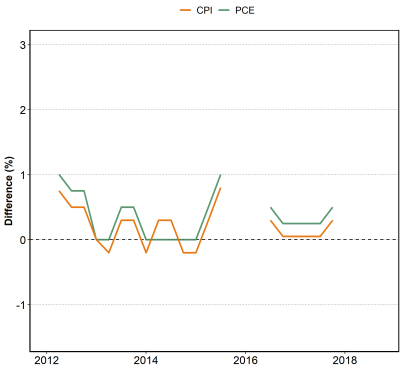

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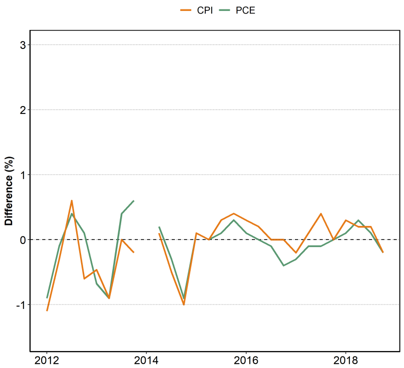

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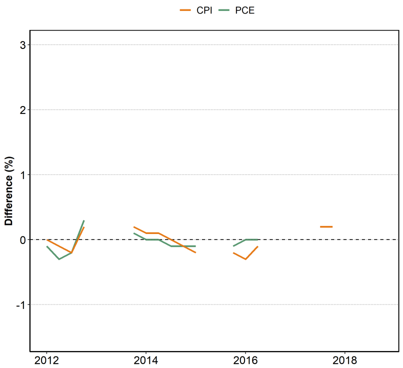

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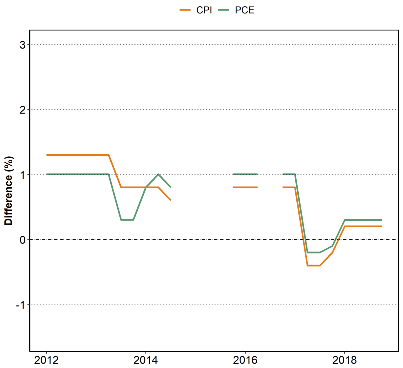

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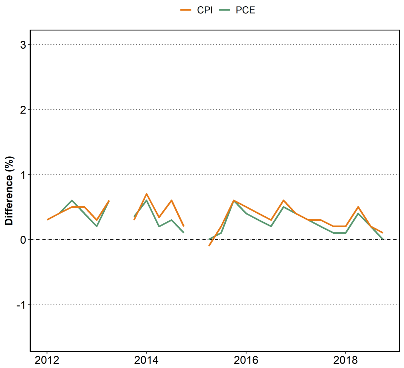

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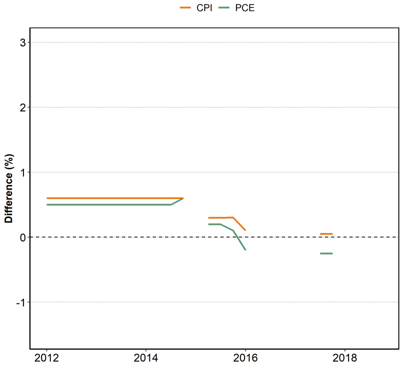

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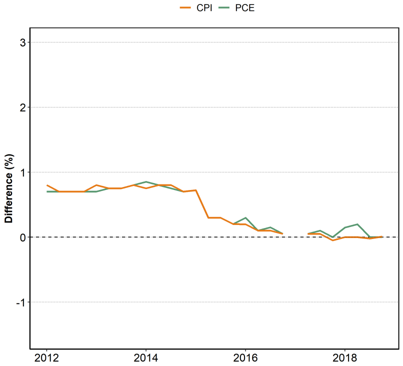

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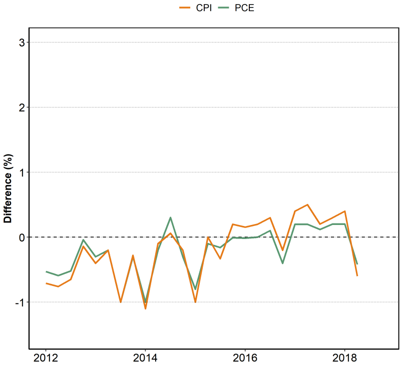

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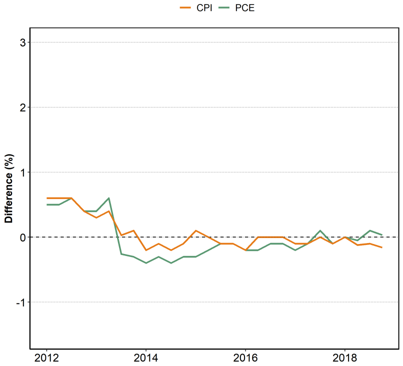

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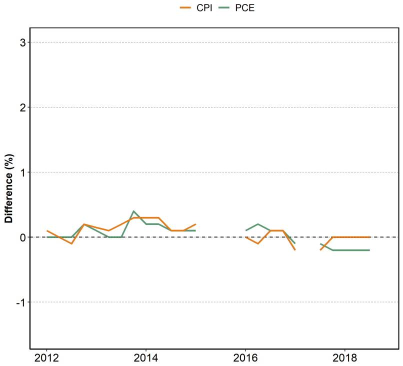

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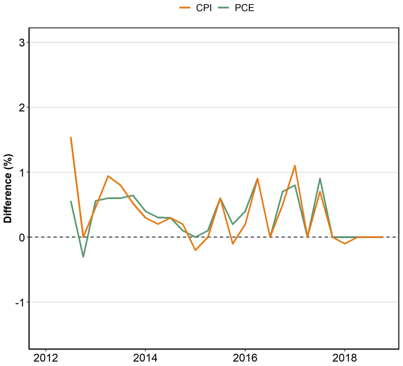

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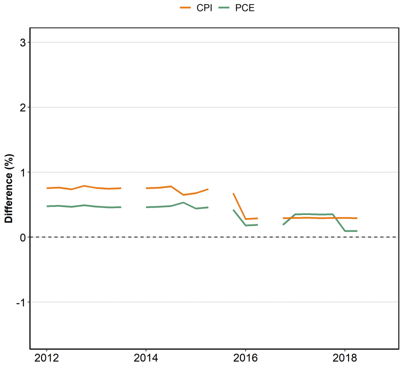

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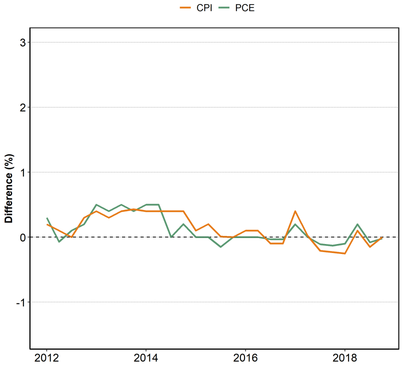

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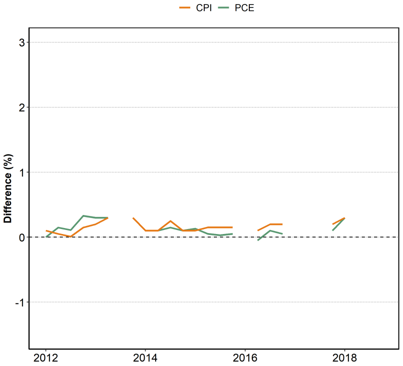

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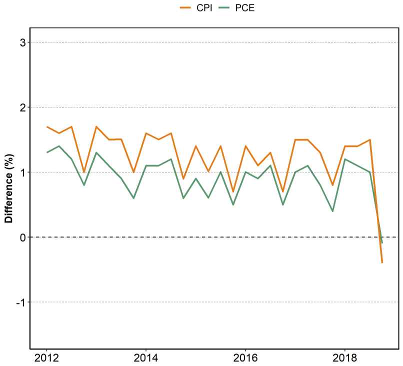

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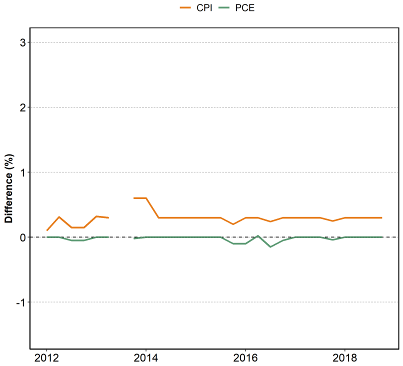

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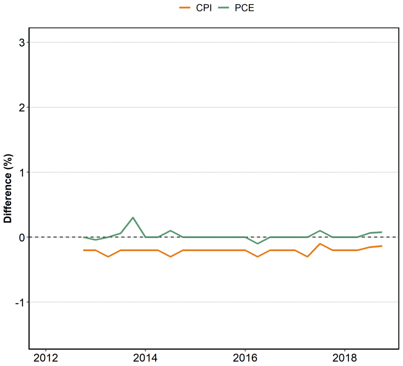
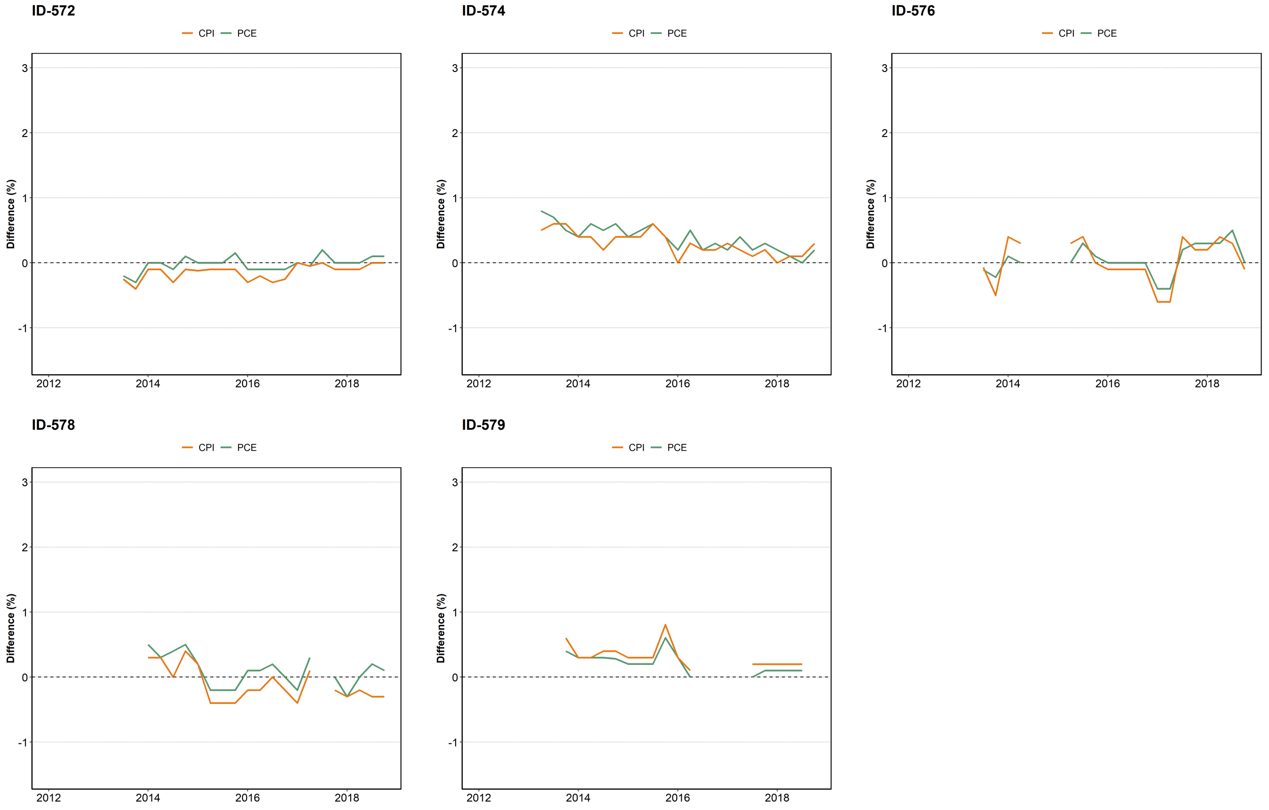
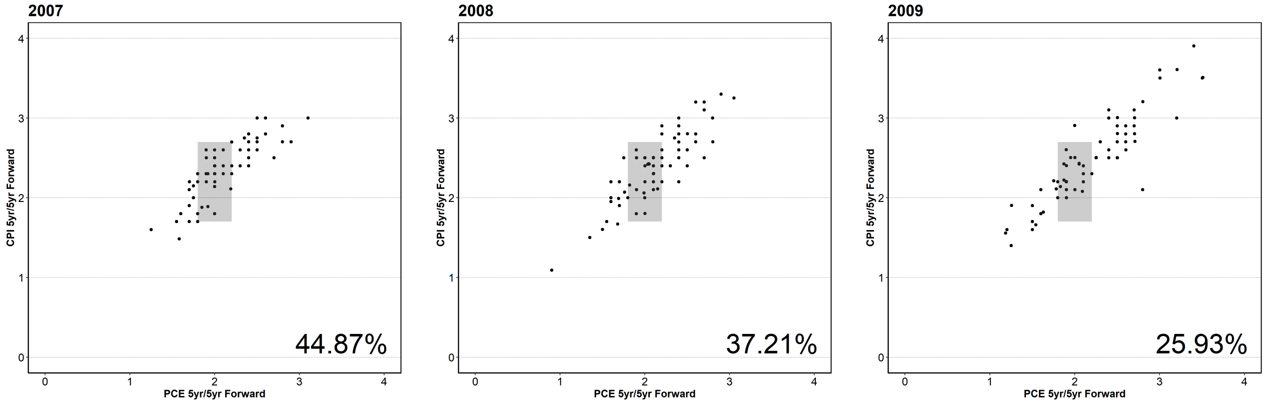
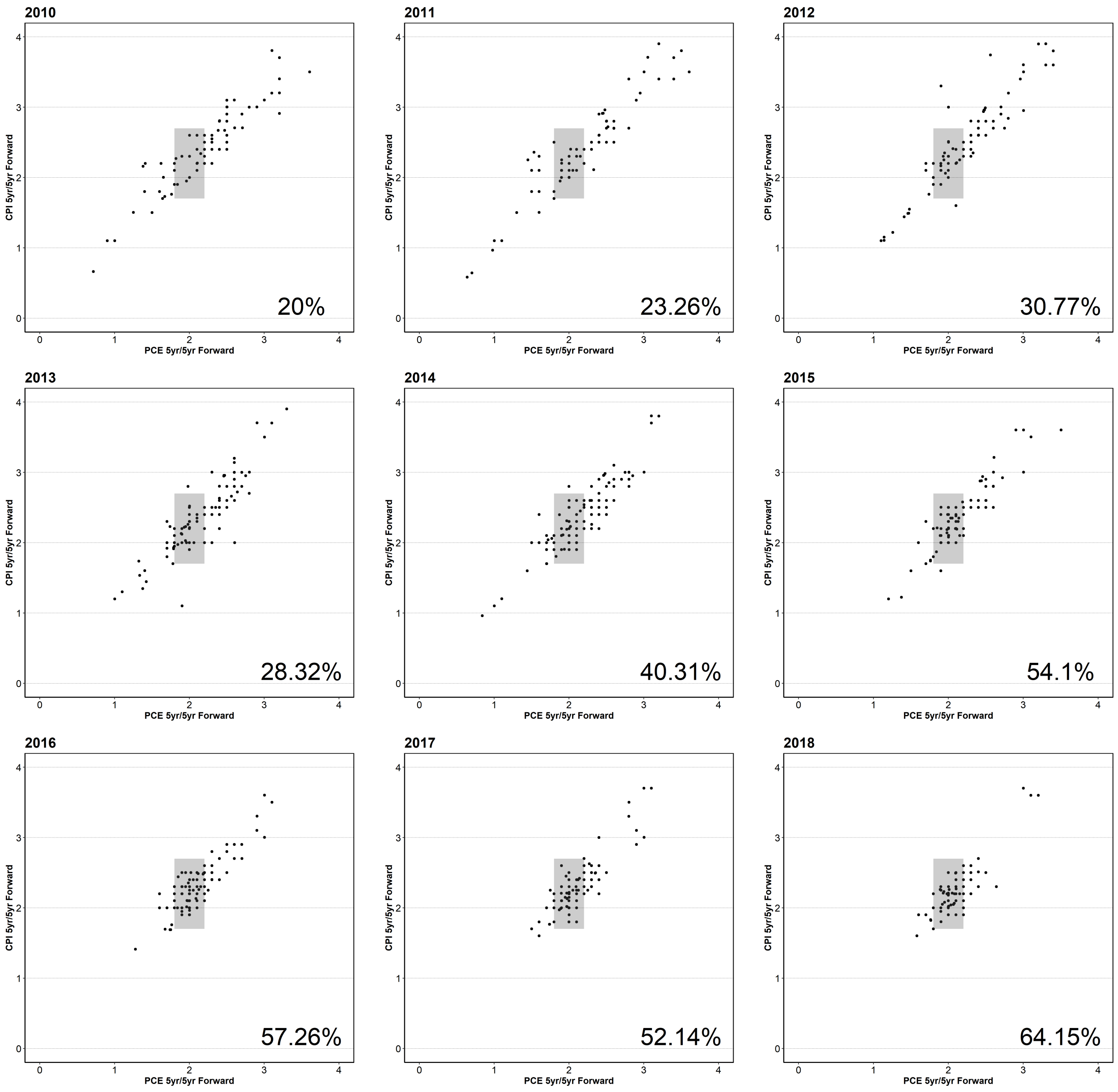




A.15 Annual Scatterplots of Respondents

Annual scatterplots of forecaster responses, parallel to Figure 5.




2010
CPI 5yr/5yr Forward
PCE 5yr/5yr Forward
0
1
2
3
4
20%
2011
23.26%
2012
30.77%
2013
28.32%
2014
40.31%
2015
54.1%
2016
57.26%
2017
52.14%
2018
64.15%