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Abstract

This paper uses data from surveys of expected inflation to learn how the expectations formation processes of households and professionals have changed following a change in the inflation process in the early part of this decade. Households do not appear to have recognized the change in the process, and are placing substantially more weight than appears warranted on recent inflation data when forming expectations about inflation over the next year. Professional forecasters do appear to have changed how they predict inflation in recent years, in a way that appears consistent, at first, with the finding that the 'core' inflation process has not changed as much as the 'headline' inflation process has. But the professionals appear to be placing too much weight on lagged core inflation data, and over recent sample periods professional forecasts of headline CPI inflation are noticeably worse than the alternatives. Some other evidence is consistent with the hypothesis that they are now focusing on the core CPI.

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In the first half of 2008, some U.S. surveys showed noticeable increases in expected inflation, leading to concerns about a possible increase in the inflation rate and also about the credibility of the Federal Reserve. Such concerns can be justified on the basis of a number of recent studies. For instance, Ang, Bekaert and Wei (2007) show that survey measures of expected inflation provide better forecasts of inflation than any other alternative that they consider, including about a dozen variants each of Phillips curve and term structure models, as well as simple regime switching models. Mehra and Herrington (2008) use a VAR specified by Leduc, Sill and Stark (2007) to examine what happened to measures of survey expectations following the change in the monetary policy regime that took place around the end of the 1970s. They find that the expectations process changed in a way that is consistent with the change in the inflation process that took place at about the same time, suggesting that survey participants are able to detect changes in the inflation process relatively quickly.[1] And Bernanke, Laubach, Mishkin and Posen (2001) discuss how the behavior of survey forecasts relative to the monetary authority's inflation target provides information about credibility.[2]

Though the rationality of survey forecasts has been debated (see Croushore, 1998, for a discussion and a defense), they are generally well regarded, especially the forecasts made by the professionals. For instance, Carrol (2003) argues that forecasts from the Society of Professional Forecasters pass all the important tests for rationality and goes on to model households' forecasts as adjusting gradually to the forecasts of professionals. Ang, et. al., (ABW) are positive about both household and professional forecasts: "That the median Livingston and SPF forecasts do well is perhaps not surprising…However, even participants in the Michigan surveys who are consumers, not professionals, produce accurate out-of-sample forecasts, which are only slightly worse than those of the professionals." They go on to speculate that the superior performance of the professionals may result from their ability to recognize structural change more quickly than mechanical model forecasts can.

This paper argues that neither households nor professional forecasters are as sophisticated as these arguments make them out to be. The evidence suggests that there have been some

[1] There is a debate about the nature of the change in the inflation process that took place at this time. This issue is taken up below.

[2] This in no way exhausts the list of uses to which inflation survey data have been put. For instance, Mankiw, Reis and Wolfers (2003) and Orphanides and Williams (2005) use these data to inform aspects of model specification. For an extensive discussion of how various kinds of survey data are used for modeling expectations and testing hypotheses about expectations formation see Pesaran and Weale (2006).

changes in the inflation process since the beginning of this decade, but neither households nor professionals have responded appropriately.

More specifically, the evidence suggests that the inflation process has become noticeably less persistent since the beginning of the decade. As with the change in the inflation process around the end of the 1970s, this change can be modeled as a change in the autoregressive coefficients of the inflation process or as a change in the variance of the shocks to the process. We argue below that in either case, the change in the inflation process should show up as a change in the relationship between survey expectations data and realized inflation. But the survey data suggest that there has been little, if any, change at all in the way that households react to inflation data. In particular, even though forecasts based on household survey data continue to be quite accurate, it appears that households are placing too large a weight on recent inflation data when forming expectations.

On the other hand, professional forecasters do appear to have changed the way in which they forecast inflation of late, but this change is not fully consistent with the observed change in the inflation process. This result is confirmed by the finding that their forecasts have deteriorated in both absolute and relative terms. The evidence suggests that the professionals are now implicitly forecasting the core CPI, instead of the headline CPI (which is what they are asked to forecast). This switch is consistent with the argument put forward by Blinder and Reis(2005) that then-Chairman Greenspan's advocacy of the core inflation concept has shifted U.S. public discourse about inflation from headline inflation to core.

If professional forecasters have indeed begun to forecast core CPI because of Chairman Greenspan's advocacy, then this switch provides unusual evidence on the Federal Reserve's (Fed's) credibility.[3] This finding can also be seen as augmenting the findings of Orphanides and Williams, whose analysis suggests that the professional forecasters are backward looking (as their forecasts can be approximated with a Kalman filtered version of past inflation data). Our results suggest that the professionals are sensitive to other aspects of the environment as well, though this may not always lead to improved forecast accuracy.

[3] The SPF forecasts provide more conventional evidence of Fed credibility as well: The 10-year ahead inflation forecast has shown almost no change since before the beginning of this decade.

1. The data

The Survey of Consumers was initiated in 1946 and is currently conducted monthly by the University of Michigan's Survey Research Center. Each month, a randomly selected sample of approximately 500 American households are asked (in telephone interviews) about expected changes to key macroeconomic variables such as inflation, interest rates, and unemployment. The sample is designed to be "rotating," in that for any one survey, approximately 60% of respondents are new and the remaining 40% of respondents are interviewed for a second time.

Since 1977, respondents have been asked the following question about inflation:

"By about what percent do you expect prices to go (up/down) on the average, during the next 12 months?"

Continuous monthly data on the answers to this question are available since January 1978. Quarterly data are available prior to that, but not for every quarter; we do not use these data here.

The Survey of Professional Forecasters was first conducted in the fourth quarter of 1968 by the American Statistical Association and the National Bureau of Economic Research. It has been conducted by the Philadelphia Fed since the second quarter of 1990. Sample size has varied noticeably over time; as of this writing, their website identifies more than 50 respondents and there are some anonymous respondents as well. Beginning in 1981Q3, participants were asked to forecast quarterly and annual CPI.

Figure 1 plots data on expected inflation over the next year from both the Michigan and the SPF surveys. In recent years, the SPF forecasts have been noticeably below the expectations from the Michigan survey. Especially noticeable is the spike in the Michigan data at the end of the sample, which is 2008Q2.

2. The household survey of expected inflation

Do survey respondents use the information in recent inflation data in ways that are consistent with the inflation process? To answer this question, two projections are compared: the projection of expected inflation on recent inflation data and the projection of actual inflation over the same horizon on recent inflation data. Changes over time in the latter allow one to see how the inflation process has changed. The next step is to determine whether similar changes show up in the projections involving inflation expectations.

The starting point is a regression of future CPI inflation on the inflation rate for the current quarter and 3 lags. The estimated equation is

$$\pi_{t,t+4} = \alpha_0 + \sum_{i=1}^{4} \alpha_i \pi_{t-i,t-i+1} + \varepsilon_{1t} \qquad (1)$$

where $\pi_{t,t+4}$ measures inflation from *t* to *t+4*, i.e., over the next year, which is the same horizon as in the Michigan survey. Quarterly data are used here to allow for easy comparison with the results for the SPF forecasts below. Very similar results were obtained when two or four more lags of inflation were included in the regression above, when monthly data were used instead of quarterly, and when a four quarter average of inflation was used as the explanatory variable.

The first column of Figure 2 shows that it has become harder to predict future inflation over time. Each point on the middle line plotted in the upper left hand panel of Figure 2 is the value of $\sum_{i=1}^{4} \alpha_i$ (that is, the sum of the coefficients on inflation) when the regression described above is estimated over a 15-year window that ends in the quarter against which the point is plotted. Also shown are two-standard-error bands, based on HAC standard errors. The lower left hand panel shows how the fit of this equation changes over time. The two panels on the left hand side of the Figure reveal that contemporaneous and lagged inflation data contain less and less information about future inflation as time goes on. For sample periods whose endpoint lies within the last three years or so, even the point estimate (that is, $\sum_{i=1}^{4} \alpha_i$) is more or less zero, while the adjusted-R^2 is negative. The decline appears to have taken place in two steps; first, over the first half of the 1990s and the second over the last five years or so of the sample. The first decline appears related to the early 1980s dropping out of the sample; for instance, if a 10-year rolling window is used in place of a 15-year window, the first drop in the sum of the coefficients is complete by the early 1990s, instead of the additional 5 years or so that it takes in the plot shown in Figure 2. These results suggest a decline in the persistence of inflation, though the left hand side variable is not what traditionally would be used in a regression meant to examine changes in persistence.[4]

The second column of Figure 2 shows what happens when the exercise above is repeated based on the following equation:

[4]Regressing 1-quarter-ahead inflation on current and lagged quarterly inflation (which would be the traditional specification) leads to results that are very close to those shown in Chart 2.

$$E_t^H \pi_{t,t+4} = \beta_0 + \sum_{i=1}^{4} \beta_i \pi_{t-i,t-i+1} + \varepsilon_{2t} \qquad (2)$$

where $E_t^H \pi_{t,t+4}$ denotes the 1-year-ahead expected inflation from the Michigan survey.[5] The top panel in that column shows that while the sum of lagged coefficients did decline in the mid-1990s (just as is the case in the panel on the left hand side), there is no evidence of any decline since the late 1990s. Thus, it appears that---when forming expectations about inflation over the next year---households have continued to place a large weight upon recent inflation data till the very end of the sample. The adjusted-R^2 does show a decline towards the end of the sample, though it remains quite high.

More formal tests on the stability of the two equations provide consistent results. Table 1 shows how the coefficients in equations (1) and (2) change over the two halves of the 1978Q1-2008Q2 sample. Specifically, a dummy variable that is 0 until the end of 1992 and 1 afterwards is included both by itself and after being interacted with the inflation terms. In the first column (where realized inflation is the dependent variable), three of the four inflation coefficients decline in the second half of the sample; in fact, the sum of the coefficients on the inflation dummies (-0.72) is large enough to offset the sum of the coefficients on inflation (which is 0.76) over the full sample. And the null that the inflation dummies can be dropped from the equation can be rejected at almost the one percent level. The results for the expected inflation equation are very different. Only one of the inflation dummies is significant at 10 percent; and the hypothesis that all the inflation dummies can be dropped from the equation is barely rejected at 10 percent. Note that the inflation dummies sum to -0.16, so even if were to accept this sum as significantly different from zero, the sum of the inflation coefficients in the second half of the sample would be 0.48.

An alternative procedure to test the stability of the equations is to use the Bai-Perron tests, where both the date of the break and the number of breaks is assumed to be unknown.[6] For the realized inflation regression, the WDMax test statistic is 130.2, compared to a 1 percent critical value of 24.8. Thus, the null of no break is decisively rejected. The sequential test finds

[5] In view of the distinction between core and headline inflation that comes up when the SPF forecasts are examined below, it is worth pointing out that no evidence was found to suggest that household inflation expectations are more (or less) sensitive to oil or food prices than to other kinds of inflation. More specifically, terms representing increases in the price of oil, the price of food or the level of non-core inflation (as defined below) were almost always insignificant at the 10 percent level when included in equation (2).

[6] These tests are discussed in Bai and Perron (1998).

four breaks at the five percent level: in 1981Q1, 1986Q1, 2004Q2 and 1990Q2 (in that order). In contrast, for the expected inflation regression, the value of the WDMax statistic is 15.8, compared to a 10 percent critical value of 18.1. And the sequential test finds no breaks at the 10 percent level. Thus, the results from the Bai-Perron tests reinforce the findings in Table 1.

A straightforward interpretation of the decline in the sum of the coefficients on lagged inflation shown in the first column of Figure 2 is that inflation is becoming less persistent over time, with a noticeable change in persistence having taken place in the early part of this decade. Given this result, the second column of charts suggests that in forming expectations about inflation over the next year, households are placing substantially more weight than they should on recent quarterly inflation data.[7]

The recent decline in inflation persistence could well be part of a trend of declining persistence that has been in place since the 1980s. Among others, Taylor (2000), Cogley and Sargent (2005) and Levin and Piger (2004) have argued that the persistence of inflation has declined. Along the same lines, Blanchard and Gali (2007) and Mishkin (2007) argue that there has been a change in the way inflation responds to shocks. And, as noted above, both Leduc, Sill and Stark (2007) and Mehra and Herrington (2008) conclude that (roughly) since the 1980s, U.S. inflation has been a stationary process.

Many of these authors have suggested that the change in the inflation process represents a change in the conduct of policy. But there has been considerable debate about this. As pointed out by Sims (1999), what appears to be time variation in the estimated coefficients could really be the result of changes in the shocks hitting the system; this argument has been elaborated in Sims and Zha (2006). Using the Cogley-Sargent technology, Clark and Nakata conclude that a reduction in the size of the shocks hitting the economy is largely responsible for the reduction in the volatility of inflation and inflation expectations in recent years. In a similar vein, Pivetta and Reis (2007) argue that inflation persistence has not changed much over the postwar period

[7] It is worth pointing out that longer term household inflation expectations also appear to be excessively sensitive to recent inflation data. When expected inflation over the 5-to-10 year horizon is regressed on the current and 3 lags of quarterly inflation (for a 10-year rolling window whose right end point moves from 2000 to 2008), for instance, the sum of the coefficients is positive and almost always significantly different from zero and the adjusted-R^2 is always positive. By contrast, in the regression for actual inflation over the same horizon, the sum of coefficients on quarterly inflation is always negative and insignificantly different from zero after the first two years or so and the adjusted-R^2 is negative. Because of data availability, the two sets of regressions do not span exactly the same period. However, similar results are obtained when a single regression is run (for each of the two specifications) over the 9-year overlapping sample period.

because there has been little change in the size of the largest root in the inflation process since the 1960s. Stock and Watson (2007) provide a reconciliation of these findings in a model where inflation has both a permanent and a temporary component. In this model, a reduction in the variance of the innovation to the permanent component implies that a given change in inflation is more likely to be reversed than before, even though there has been no change in the largest root of the process.

The Stock and Watson (SW) model provides a characterization of the inflation process which is very different from the univariate autoregressions presented above. It is therefore interesting to see how their specification interprets recent changes in the inflation process. SW postulate a model in which inflation has two components: a stochastic permanent component and a serially uncorrelated temporary component. The variance of the disturbance terms is allowed to change over time. Specifically, their (unobserved components-stochastic volatility) model is given by:

$$\begin{aligned} \pi_t &= \tau_t + \eta_t, & \eta_t &= \sigma_{\eta,t}\zeta_{\eta,t} \\ \tau_t &= \tau_{t-1} + \varepsilon_t, & \varepsilon_t &= \sigma_{\varepsilon,t}\zeta_{\varepsilon,t} \\ \ln\sigma^2_{\eta,t} &= \ln\sigma^2_{\eta,t-1} + \upsilon_{\eta,t} \\ \ln\sigma^2_{\varepsilon,t} &= \ln\sigma^2_{\varepsilon,t-1} + \upsilon_{\varepsilon,t} \end{aligned}$$

where $\zeta_t = (\zeta_{\eta,t}, \zeta_{\varepsilon,t})$ is i.i.d. N(0,I_2) and $\upsilon_t = (\upsilon_{\eta,t}, \upsilon_{\varepsilon,t})$ is i.i.d. N(0, γI_2). ζ_t and υ_t are independently distributed, and γ is a scalar parameter.

The estimates of $\sigma_{\eta,t}$ and $\sigma_{\varepsilon,t}$ (the standard deviations of the shocks to the temporary and permanent components) are plotted in Figure 3, together with an estimate of τ_t, the permanent component of inflation. As pointed out by SW, the standard deviation of the permanent component of inflation (shown in the middle panel) rose significantly from the 1960s to the early 1980s, before declining sharply over the remainder of that decade. The standard deviation of this component has moved relatively little since the mid-1990s. The standard deviation of the temporary component has moved in almost the opposite way; it did not move around very much prior to 2000, especially when compared to that of the permanent component. However, it has been rising quite steadily since the beginning of this decade, and by the end of the sample is about three times as large as the standard deviation of the permanent component.

As discussed by SW, the decline in the persistence of inflation after 1980 can be explained by the drop in the variance of the permanent component; as this variance declined over the second half of the 1980s and the early 1990s, movements in CPI inflation came to be dominated by the temporary component. Inflation became harder to forecast, even as the variance of inflation was falling. The relative importance of the permanent component has fallen even further in this decade—thus making inflation even harder to forecast—but that's happened because the variance of the temporary component has increased.[8]

Assume, now, that the only change that has taken place in the inflation process recently is an increase in the variance of the temporary component. Intuitively, this means that the current level of inflation has become a more noisy indicator of future inflation than before. The literature on inference suggests that when a signal becomes more noisy one should pay less attention to it.

To see how this intuition applies to the case at hand, suppose (first) that the inflation process is given by the Stock-Watson specification. For simplicity, also assume that households know the inflation process and the current period temporary shock. Expected inflation next period is then given by:

$$E_t \pi_{t+1} = \tau_t = \pi_t - \eta_t$$

Regressing this forecast of next period's inflation rate on today's inflation rate (an exercise similar to regression (2) above) leads to the following estimated coefficient:

$$1 - \frac{var(\eta)}{t\ var(\varepsilon) + var(\eta)}$$

where *t* is the sample size. For the fixed sample size used in the rolling regressions above, this coefficient will decline as the variance of the temporary component (η) increases. Alternatively,

[8] The finding that the increase in variability is concentrated at the high frequencies does not hinge upon the functional form that is imposed upon the inflation process, but is evident in the raw inflation data itself. For instance, if a 10-year rolling window is used to calculate the variance of monthly inflation, there is a noticeable drop in the variance of inflation beginning (with samples that end) in the mid-1990s (which is the same time that the regression coefficients change in the charts above) and a smaller increase beginning in the mid-2000s. This increase is much more obvious when one looks at the difference of inflation, which tends to emphasize higher frequency movements. When the same exercise is repeated at the annual frequency, there is no evidence of an increase in the variance of either inflation or the difference of inflation in recent years. The results at the quarterly frequency lie in between.

if one assumes that the long lived component of inflation is autoregressive of order one with a root $1/\alpha$ that is close to, but not equal to, one, regressing expected inflation next period on today's inflation rate leads to the coefficient

$$1 - \frac{\text{var}(\eta) + (1-\alpha)\,\text{var}(\tau)}{\text{var}(\eta) + \text{var}(\tau)}$$

which, again, will be smaller in a regime where the variance of the temporary shock is higher. Thus, even if the change in the inflation process is better modeled as an increase in the variance of the temporary component, the sum of coefficients plotted in the top panel on the right hand side of Figure 2 should decline over time.

3. The forecasts from the SPF survey

This section examines the forecasts from the survey of professional forecasters. The left hand column of charts in Figure 4 repeats –for the SPF forecasts--the exercise seen in Figure 2 above, that is, it shows what happens when the year-ahead SPF inflation forecasts are regressed on current and lagged inflation. The results turn out to be very similar to those for actual inflation (see left hand column in Figure 2). Thus, the forecasters in the SPF panel appear to be placing less weight on recent inflation data, and one could conclude that the professionals have recognized the change that has taken place in the inflation process, much as hypothesized by ABW.

But a closer look at the data reveals that there is another dimension along which the forecasters' behavior has not changed at all. The charts on the right hand side of Figure 4 show what happens when the SPF forecasts are projected on core CPI inflation data. If anything, the SPF forecasts have become more sensitive to core CPI data in recent years, though---given the size of the two-standard-error band--- one cannot reject the argument that there has been no change in their response to these data over the entire sample. Table 2 provides more direct evidence on these issues. The first column presents the estimates from a full sample regression of the SPF forecasts on quarterly CPI inflation , in which the constant and the coefficients on the inflation terms are allowed to change approximately midway through the sample (specifically, at the end of 1992, to allow comparison with the results in Table 1). The coefficients on the inflation term interacted with the dummy are all negative, and three of the four are individually

significant at the 5 percent level. As a group, the null that the four terms can be dropped from the equation is rejected at 1 percent. The results in the second column, where the SPF forecast is regressed on core CPI inflation, are quite different from those in the first. Consistent with the top right hand side chart in Figure 4, the coefficients on the inflation terms that have been interacted with the dummy are positive but not significant. Note that the fit of this equation is better than the first (in which the forecasts are projected on headline inflation measures).

One way to reconcile these results is to argue that the SPF forecasters used to pay attention to both the core and non-core components of inflation until recently and now pay attention only to the former.[9] Some evidence in favor of this hypothesis can be found from rolling regressions of the SPF forecasts that are similar to those in Figure 4---except that the core and non-core[10] components of CPI inflation are entered separately. It turns out that for almost all samples except for those ending after mid-2006, the null that non-core inflation does not belong in the equation is easily rejected. After this date, that null is never rejected at the 10 percent level, and cannot be rejected at even the 20 percent level for any sample but one.

Why would professional forecasters suddenly stop paying attention to the non-core component of the CPI? One possibility is that the increased noise identified earlier in the CPI is concentrated in the non-core component, which would suggest that one should reduce the weight one attaches to that component but continue to pay attention to the core inflation rate.

In order to see if the data are consistent with this hypothesis, Figure 5 shows the results obtained when the SW specification is imposed upon the core CPI inflation process. The decline in the variance of the permanent component is similar to what can be seen in the case of the headline CPI. Importantly, while the variance of the temporary component has been going up recently, the increase is nowhere near as marked as it was for headline CPI inflation.[11]

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[9] An alternative argument is that the SPF forecasters always paid attention to the core CPI and not the headline, but this has only become obvious following the recent decline in the correlation between core and headline CPI inflation. This explanation is not consistent with the results below.

[10] Non-core inflation is defined as the rate of headline inflation relative to core, following Stock and Watson (2008).

[11] It is worth noting that the relatively small increase in the variance of the temporary component in recent years (Chart 7) is associated with noticeable decreases in the persistence of the core CPI inflation process by some measures. For instance, the impulse response function from a 4 lag autoregression of core CPI estimated over the post-2002 period falls to zero by the second quarter after the shock. By contrast, when the equation is estimated over the previous five years, it takes an additional 3 years for the impulse response to fall to zero. Similarly, when year-ahead core-CPI inflation is regressed on current and lagged core inflation, the results are similar to those in Chart 2, though the decline (either in the sum of the inflation coefficients or in the fit of the equation) is not as pronounced as the decline observed for the headline CPI.

Thus, an argument can be made that because of recent changes in the inflation process, it is appropriate to pay less attention to the non-core component of CPI inflation.[12] But that does not justify the SPF forecasters practice of continuing to place a large weight on core inflation data when predicting headline inflation. Figure 6 demonstrates this point, by showing what happens when headline CPI inflation over the next year is regressed upon core CPI inflation, similar to the rolling regressions seen earlier. As can be seen, the relationship between headline and core inflation has deteriorated quite noticeably in recent years. For samples ending in the last three to four years, core CPI inflation data provide no information about future headline inflation, which is almost exactly the same result shown in Figure 2 (where the right hand side variable was headline CPI inflation). This result could not be more different from that in Figure 4, where the SPF forecasts of headline inflation appear to have become more sensitive to core inflation data in recent years.

One reason why forecasters may be paying too much attention to core CPI inflation has been put forward by Blinder and Reis (2005):

> "Another Greenspan innovation, which is rarely mentioned but is likely to prove durable, is the way he has focused both the Fed and the financial markets on core, rather than headline, inflation. This aspect of Federal Reserve monetary policy contrasts sharply with the concentration on headline inflation at the ECB and to the stated inflation targets of most other central banks, which are rarely core rates."

Blinder and Reis go beyond asserting that it is better to focus on core rather than headline inflation. They argue that even if one is interested in headline inflation, it is better to generate forecasts of this variable by using data on core inflation. Based on a series of results for forecasting inflation at the 6,12,24 and 36 month forecasting horizons, they state that:

> "Every specification in the table points to the same conclusion: that recent core inflation is a better predictor of future *headline* inflation than is recent headline inflation…. Indeed, once you take core inflation into account, adding headline inflation has at best no effect on forecasting performance, and at most horizons makes forecasts even worse."

[12] Note that the SPF forecasters' practice of placing a zero weight on food and energy price data in recent years cannot be justified even if changes in noncore inflation are temporary. First, this practice ignores the dynamics of the known temporary component, which is unlikely to be white noise. More problematic is the assumption of independence between the core and non-core components. Specifically, the non-core component will affect the core component (given the range of historical responses of monetary policy to oil shocks); e.g., oil shocks are likely to affect other prices in the economy and so should be taken into account.

So, one could argue that the forecasters' switch to relying on core inflation data was a reflection of prevailing opinion.[13] But, as discussed above, that does not mean that the forecasters' response was appropriate.

Table 3 provides a comparison of different ways of forecasting CPI inflation since the beginning of 2003, which is just after the ABW (2007) sample ends and close to the time that the inflation process appears to have changed. When forecasting inflation using survey data, ABW find that using the actual survey values as the forecast of inflation does better than forecasts obtained by regressing inflation on a constant and the survey data. This is not true for our sample, so we do not use the actual survey values as forecasts. This means that all forecasts in Table 3 are obtained by regressing inflation on a constant and the explanatory variable (which can be survey data or lagged inflation data) up to the period prior to the forecast. The estimated equation is then used to forecast next period's inflation. This specification and procedure is the same as that in Blinder and Reis (2005).

The results are very different from either of these studies, though. Using core inflation to predict headline inflation turns out to be worse than using headline inflation, as a comparison of the root mean square errors in the second and third columns of Table 3 indicates. The SPF forecasts are worse still. Somewhat surprisingly, it is the Michigan survey that does the best. Using the Diebold-Mariano (1995) MSE test, the forecast based on the Michigan survey is better than the SPF forecast at the 5 percent level. The last three columns of data show that adding lagged headline inflation to the surveys or to lagged core inflation does not matter.

For comparison, the lower panel of Table 3 presents results from the previous five years. Here we replicate the results found by ABW and Blinder-Reis: lagged core inflation does better at predicting headline inflation than lagged headline inflation does, while the SPF survey does best of all.

The forecasting performance of the SPF panel has clearly deteriorated in recent years; in terms of the RMSE, they have moved from being the best to being the worst of all the alternatives we have considered (with the exception of the random walk alternative, which does the worst in both sample periods). In view of this evidence, it is hard to argue that the SPF forecasters' apparent decision to pay little or no attention to the non-core inflation data in recent

[13] It is worth noting that such an opinion was not universally held. For an alternative, see Smith (2005).

years and to continue to place a large weight on the core inflation data was motivated by a desire to predict headline inflation more accurately.

Perhaps there is more than one realizes to the Blinder and Reiss argument that Chairman Greenspan turned public attention towards the core inflation data. Could it be that the SPF forecasters have followed the Fed and switched their attention to forecasting the core CPI, even though they are being asked to forecast headline CPI?

Table 4 presents some evidence that is consistent with this hypothesis. It shows what happens (over the period since the beginning of 2003) when the SPF forecast of headline CPI inflation is treated as a forecast of core CPI inflation.[14] For comparison, we also include forecasts based on lagged core inflation (the Blinder-Reis specification), a random walk and the Michigan survey. As can be seen, the SPF forecast of *headline* inflation is the best predictor of *core* inflation, whether one looks at the mean error or the RMSE. Note that the SPF forecast is better than the next best alternative at the 5 percent level (Diebold-Mariano MSE test). Forecasts using lagged core inflation, whether the random walk specification or the AR(1) specification, lie in the middle. The Michigan survey does the worst by a wide (and statistically significant) margin, which is not really surprising since the respondents are not being asked to forecast core inflation.

Section 4: Conclusions

The evidence suggests that the inflation process has changed since the beginning of this decade. The autoregressive representation of CPI inflation shows a noticeable decline in the sum of the coefficients on lagged inflation over time and by the end of the sample lagged inflation data have no predictive power for future inflation at all. If, instead, Stock and Watson's unobserved-component-stochastic-volatility specification is imposed on the data, the change shows up as a noticeable increase in the variance of the high frequency component. While it is hard to determine the correct representation of the data, either kind of change should lead survey respondents to place less weight on recent inflation data when predicting future inflation.

Households do not appear to have learned about this change in the inflation process, as they do not appear to have changed the way in which they form expectations of inflation.

[14] Here we follow ABW and treat the survey value as the forecast of inflation. Because the change in the behavior of the SPF forecasters appears to be recent, the sample is not large enough to estimate regressions like those in Table 3.

Historically, households have placed a large weight on recent inflation data when forming inflation expectations, and they continue to do so now. The recent accuracy of the Michigan expectations data when used as inflation forecasts is puzzling, but may reflect the fact that the economy has been hit by a sequence of one-sided shocks (that is, a long series of increases in the price of food and oil) towards the end of our sample period.

Professional forecasters appear to have changed the way they forecast CPI inflation and at first glance this change appears consistent with the change in the inflation process. Specifically, the headline inflation process appears to have become more noisy than the core inflation process and professional forecasters appear to be reacting less to non-core inflation. But while households are placing too much emphasis on headline inflation data, professionals appear to be placing too much emphasis on recent core inflation data. In other words, the data suggest that professional forecasts of headline inflation should not be as sensitive to recent core inflation data as they turn out to be.

The deterioration in professionals' ability to forecast headline CPI inflation (both in relative and absolute terms) in recent years suggests that the change in forecasting strategy has not been made only in pursuit of lower forecast errors. The finding that the recent SPF forecasts of headline CPI are actually very good forecasts of core CPI is especially suggestive in this context. Together, these findings suggest that professionals have switched to forecasting core CPI in recent years, a development which may have been encouraged by then-Chairman Greenspan's advocacy of the core inflation rate. If true, this hypothesis suggests that analyses which use these data to determine how agents learn about the economy need to account for a wide variety of influences on agents.

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Table 1. Projections of 1-year-ahead Realized and Expected CPI Inflation on Realized Inflation
Sample: 1978Q1-2008Q2

	Realized Inflation	**Expected Inflation – Michigan Survey**
Constant	1.13[1] (0.42)	0.99[1] (0.17)
D93	1.43[1] (0.59)	0.61[1] (0.24)
Pi_t	0.62[1] (0.17)	0.31[1] (0.05)
Pi_{t-1}	0.07 (0.06)	0.17[1] (0.04)
Pi_{t-2}	0.27[1] (0.09)	0.10[1] (0.02)
Pi_{t-3}	-0.20 (0.13)	0.06[5] (0.03)
DPi_t	-0.56[1] (0.18)	-0.12[10] (0.07)
DPi_{t-1}	-0.10 (0.08)	-0.01 (0.04)
DPi_{t-2}	-0.27[1] (0.10)	-0.01 (0.04)
DPi_{t-3}	0.21[10] (0.12)	-0.02 (0.04)
$\overline{R}^2$	0.71	0.94
F(4,118)*	4.1 (0.01)	1.92 (0.10)

Pi_t is realized CPI inflation in quarter *t*, DPi_t is realized inflation multiplied by a dummy which equals 0 until the end of 1992 and 1 after that. HAC standard errors are reported in parentheses.

[1] denotes significant at 1 percent; [5] denotes significant at 5 percent

* Null for the F statistic is that all four DPi terms can be excluded from the equation.

Table 2. Projections of 1-year-ahead SPF Inflation Forecast
Sample: 1981Q3-2008Q2

	On Headline Inflation	On Core Inflation
Constant	2.51[1]	1.97[1]
	(0.25)	(0.31)
D93	-0.26	-1.13[1]
	(0.31)	(0.39)
Pi_t	0.12[1]	0.12[1]
	(0.04)	(0.05)
Pi_{t-1}	0.15[1]	0.22[1]
	(0.03)	(0.02)
Pi_{t-2}	0.09[1]	0.09[1]
	(0.02)	(0.03)
Pi_{t-3}	0.12[1]	0.09[5]
	(0.04)	(0.04)
DPi_t	-0.13[1]	0.10
	(0.04)	(0.08)
DPi_{t-1}	-0.09[5]	0.04
	(0.04)	(0.04)
DPi_{t-2}	-0.06[5]	0.04
	(0.03)	(0.04)
DPi_{t-3}	-0.06	0.03
	(0.04)	(0.04)
$\overline{R}^2$	0.85	0.90
F(4,118)*	5.2(0.01)	0.75 (0.55)

Pi_t is realized (headline or core) CPI inflation in quarter *t*, DPi_t is realized inflation multiplied by a dummy which equals 0 until the end of 1992 and 1 after that. HAC standard errors are reported in parentheses.

[1] denotes significant at 1 percent; [5] denotes significant at 5 percent

* Null for the F statistic is that all four DPi terms can be excluded from the equation.

Table 3. Predicting 1-year-ahead headline CPI Inflation

A. Sample: 2003:Q1 – 2008:Q2

Using:	Random walk	Lagged headline inflation only	Lagged core inflation only	SPF only	Michigan only	Lagged core + headline inflation	SPF + lagged headline inflation	Michigan + lagged headline inflation
Mean Error	0.31	0.19	0.55	0.67	0.12	0.36	0.71	0.14
Root Mean Square Error	1.21	0.90	0.96	0.99**	0.82*	0.90	1.01	0.83

*Better than SPF forecast at 5% and better than lagged inflation forecast at 10% (Diebold-Mariano MSE test).

**Worse than lagged inflation forecast at 17%.

B. Sample: 1998:Q1 – 2002:Q4

Using:	Random walk	Lagged headline inflation only	Lagged core inflation only	SPF only	Michigan only	Lagged core + headline inflation	SPF + lagged headline inflation	Michigan + lagged headline inflation
Mean Error	0.15	-0.36	-0.13	-0.01	-0.33	-0.25	0.03	-0.31
Root Mean Square Error	1.12	0.88	0.80	0.76*	0.84**	0.83	0.77	0.84

*Better than lagged inflation forecast at 13%.

**Better than lagged inflation forecast at 18%.

Table 4. Predicting 1-year-ahead core CPI Inflation
Sample: 2003:Q1 – 2008:Q2

Using:	Random walk	Lagged core inflation only	SPF only	Michigan only
Mean Error	0.18	-0.22	-0.06	-0.81
Root Mean Square Error	0.50	0.42	0.32*	0.86**

*Better than forecast based on core inflation at 5% (Diebold-Mariano MSE test)
**Worse than forecast based on core inflation at 1%.

Figure 1: 1-year-ahead expected inflation

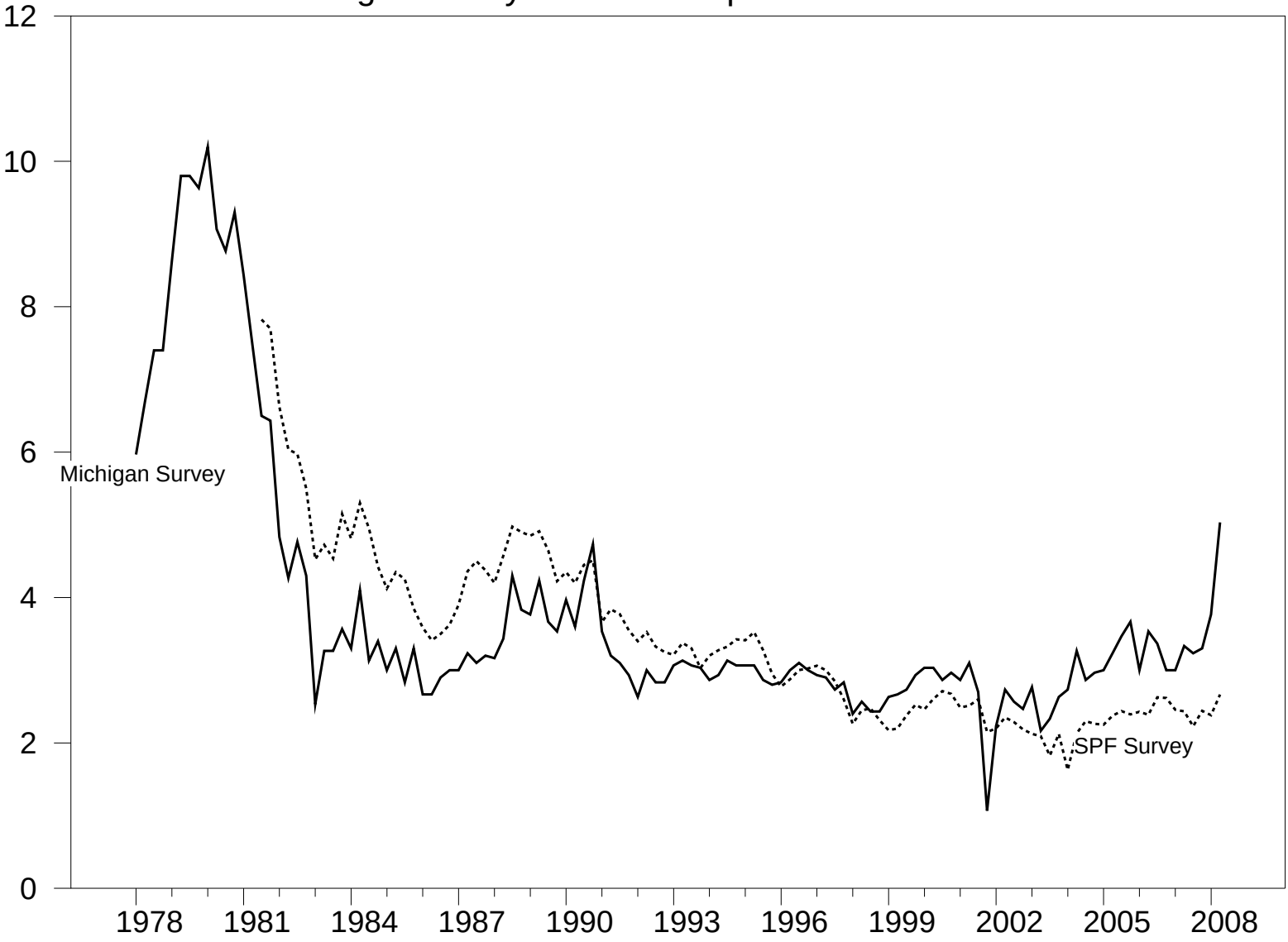
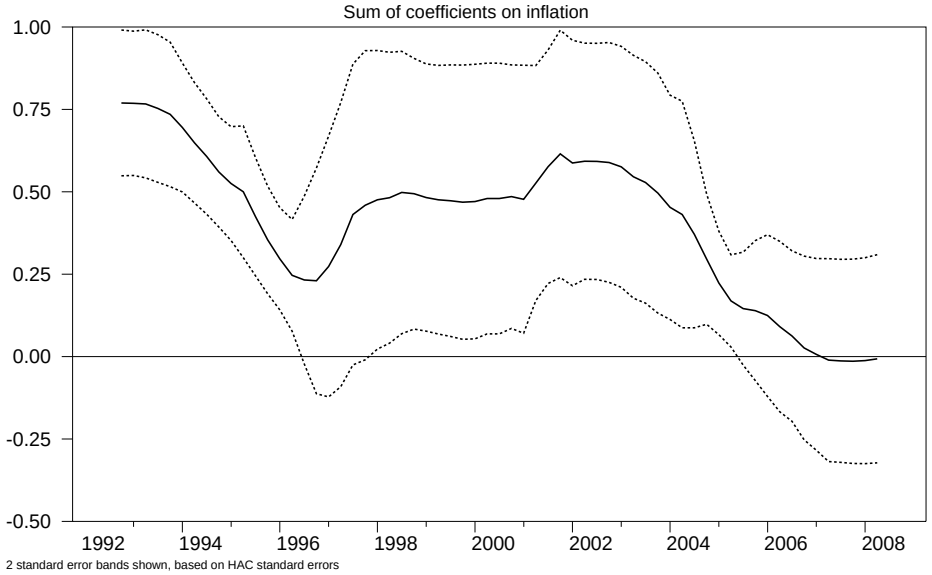


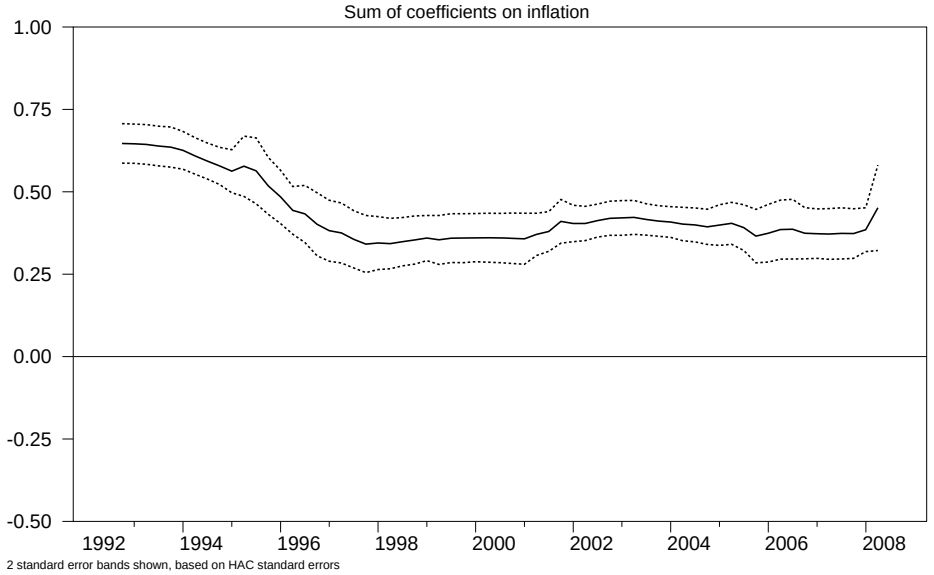
Figure 2: Projections on quarterly CPI inflation

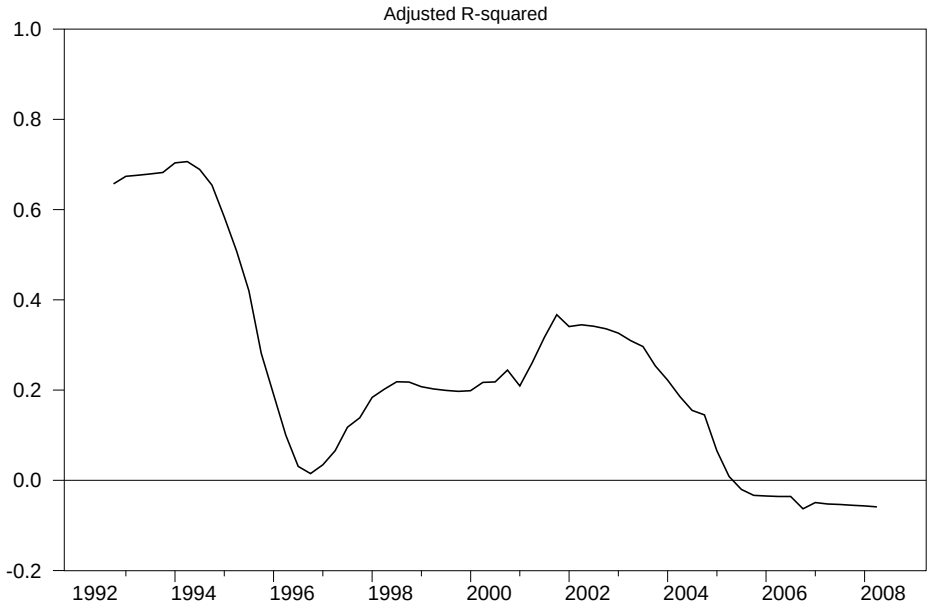
15 year rolling samples

A. Dependent variable: 1-year-ahead realized CPI inflation



B. Dependent variable: 1-year-ahead expected inflation from Michigan Survey





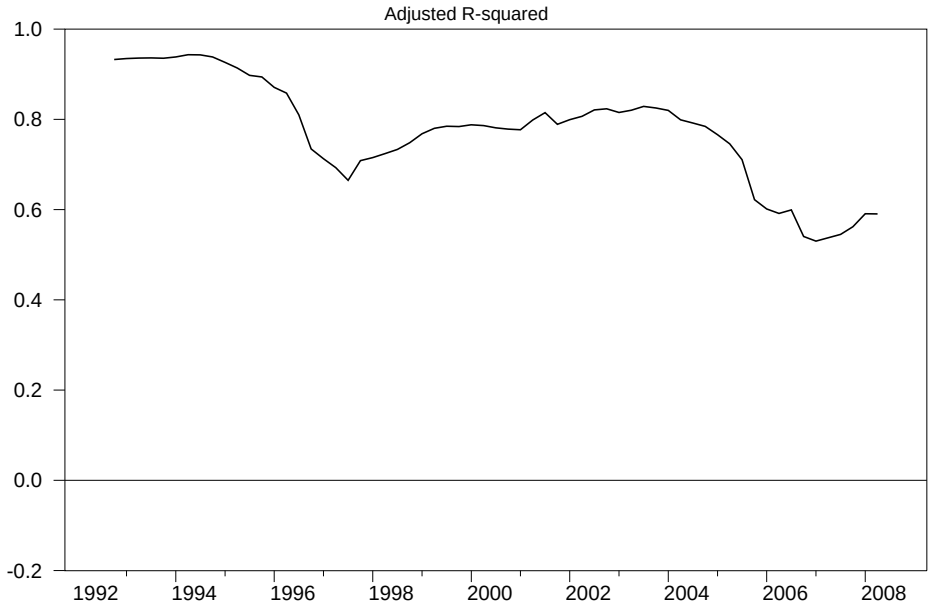


Figure 3: Estimates from unobserved component stochastic volatility model for CPI inflation

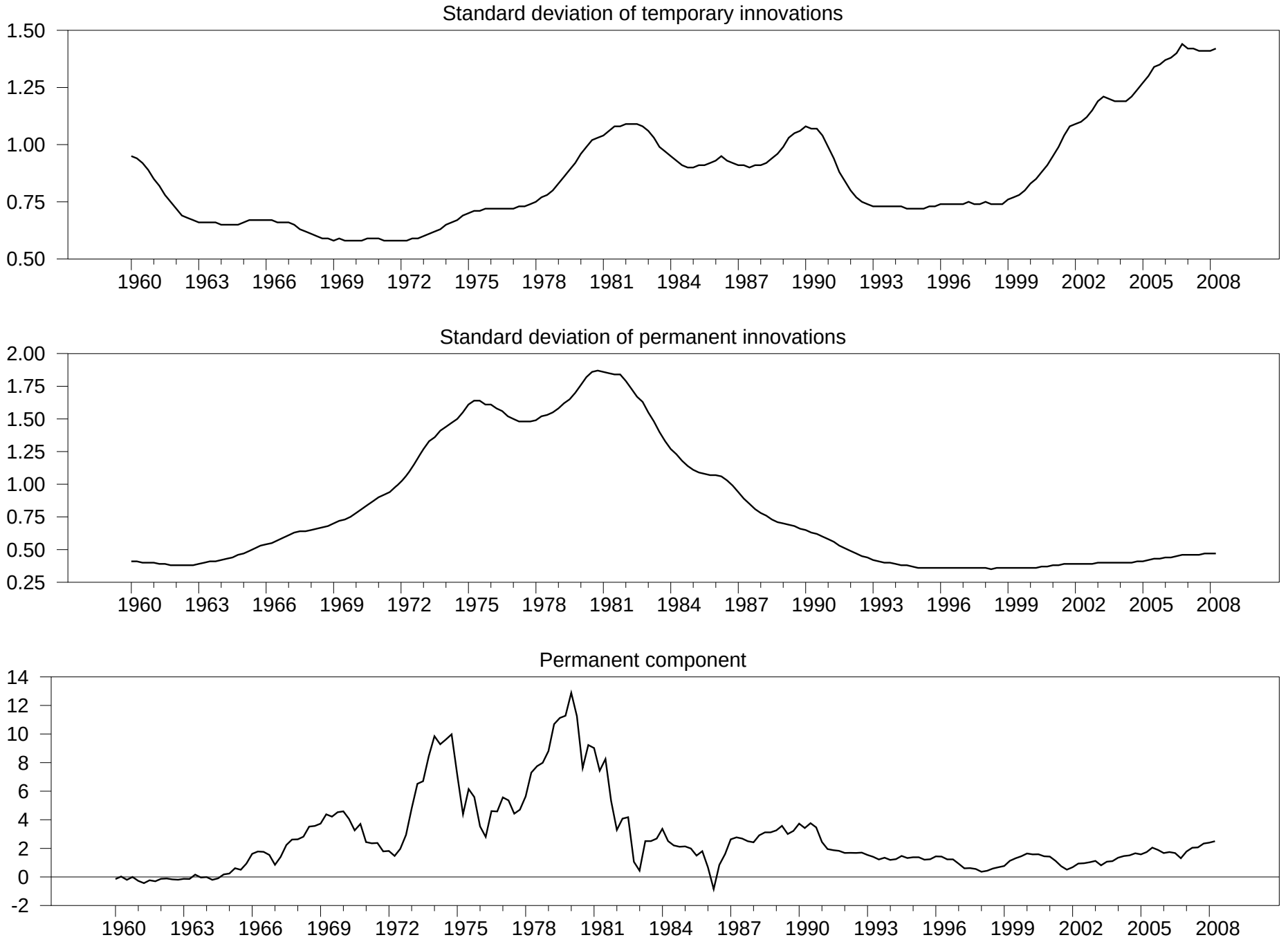
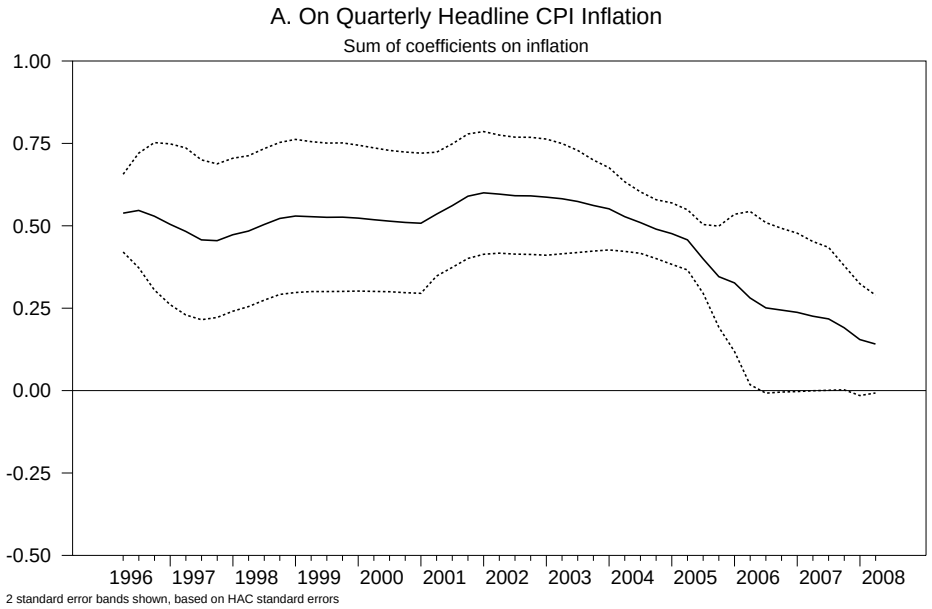
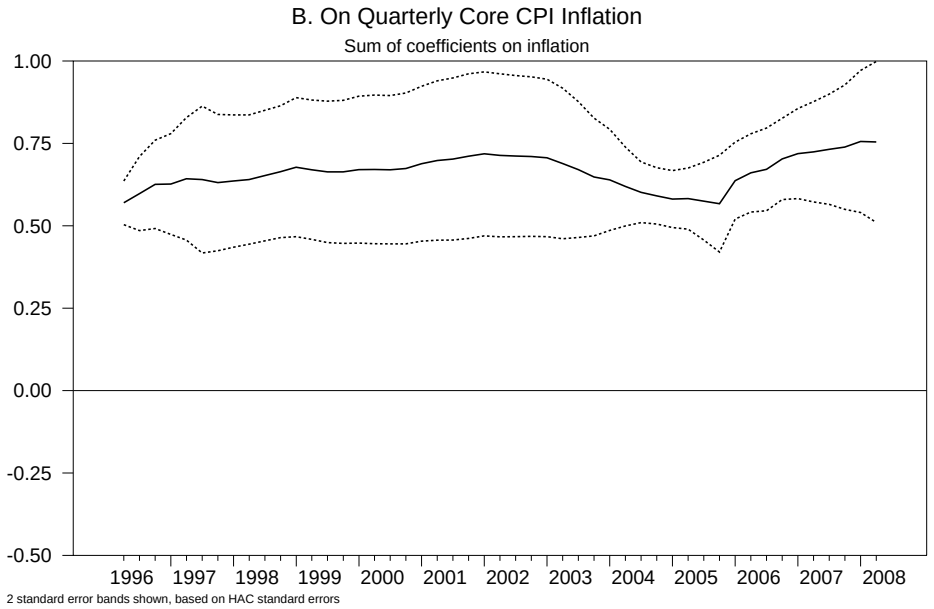
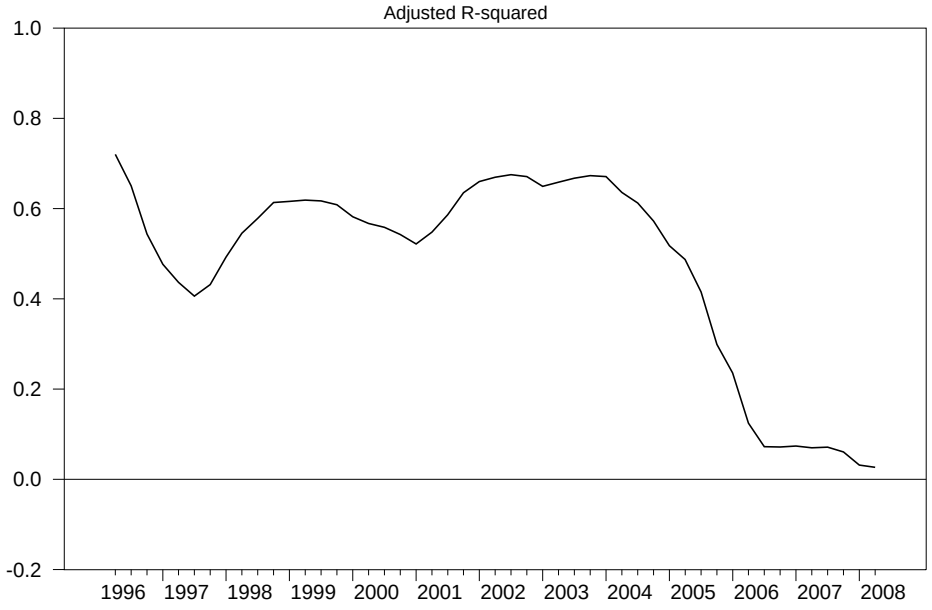


Figure 4: Projections of the 1-year-ahead SPF Inflation Forecast

15 year rolling samples







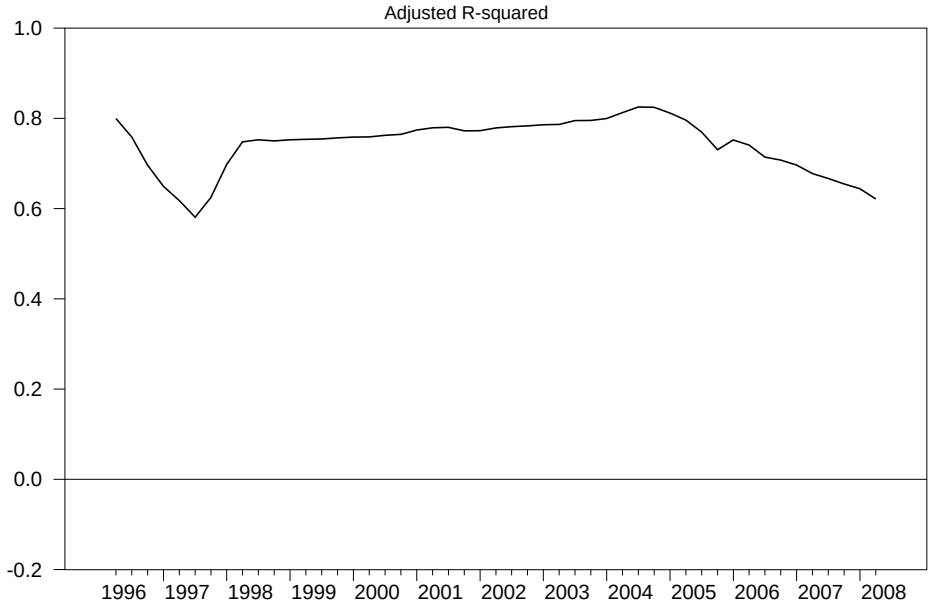


Figure 5: Estimates from unobserved component stochastic volatility model for core CPI inflation

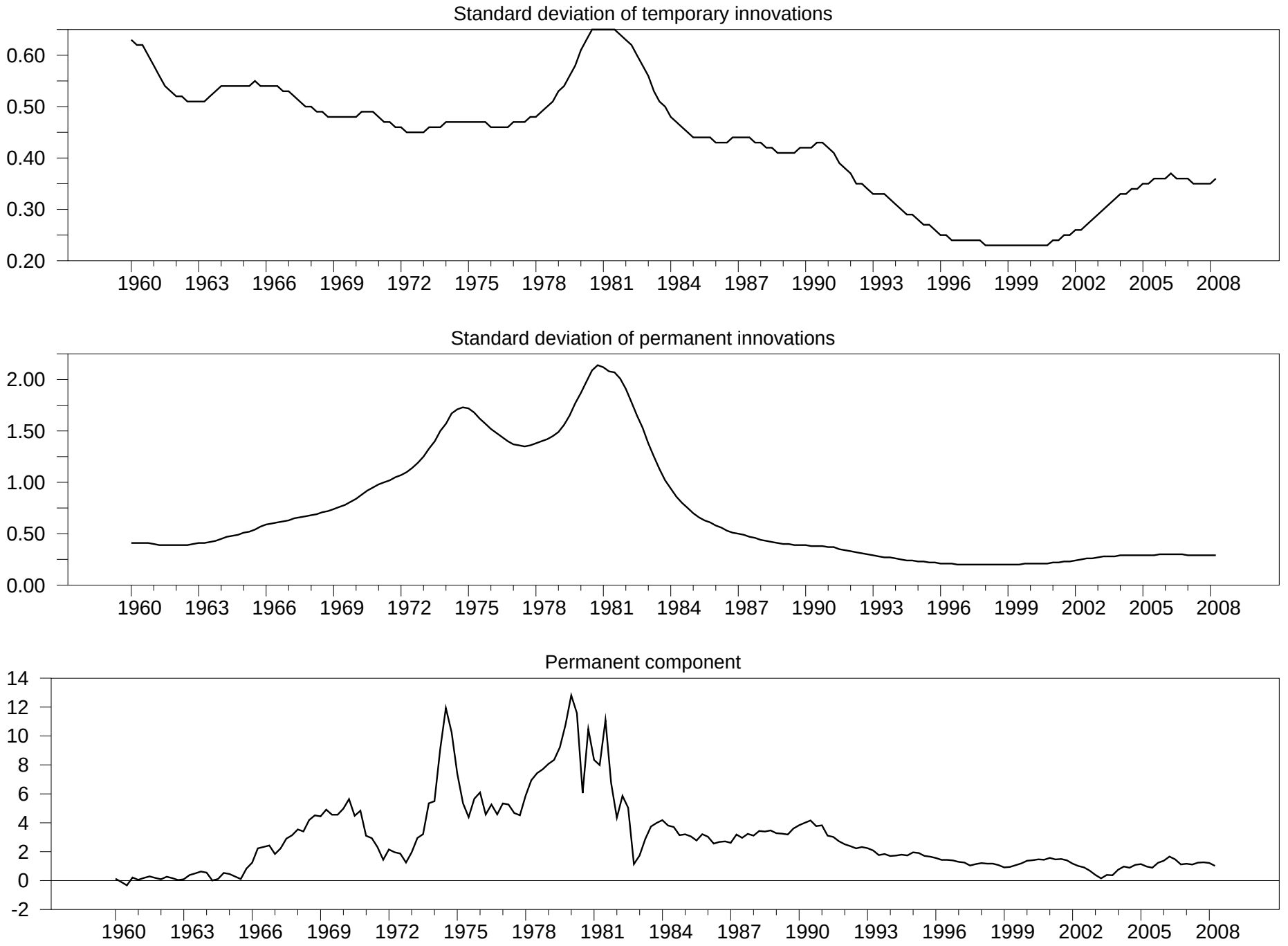
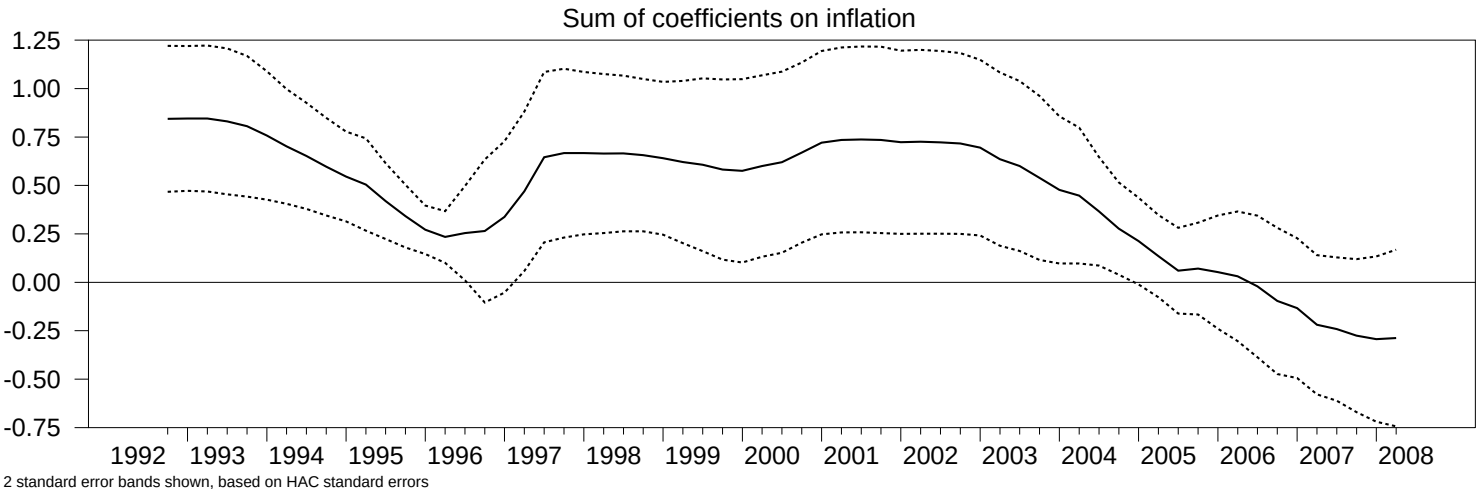


Figure 6: Year-ahead CPI inflation regressed on quarterly core CPI inflation

15 year rolling



2 standard error bands shown, based on HAC standard errors