The Information Content of Surprise Changes in the Fed Funds Futures Rate

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Abstract

This paper attempts to explain a price puzzle associated with surprise changes in the Fed funds futures rate due to the Fed’s policy announcements, a popular monetary shock measure. I show that these monetary shocks exhibit the price puzzle: a tightening shock significantly raises the price level. To explain the puzzle, I decompose futures rate surprises to show that these surprises are not clean monetary shocks, but contaminated by (1) information shocks due to the information gap between the Fed and the market, and (2) revisions in risk premia due to the revelation of the information gap. A simple measure of the information gap as forecast differences between the Fed and the market on the current state of the economy accounts for about 20% variations in futures rate surprises. Controlling for information differences between the Fed and the market solves the price puzzle.

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1 Introduction

Surprise changes in the federal funds futures rate in response to the Fed’s announcements of the target funds rate (henceforth, futures rate surprises) have been widely used in the literature to measure monetary shocks. These surprises are usually constructed as changes in current-month or one-month-ahead federal funds futures rate in a short time window around FOMC announcements of the target funds rate. Kuttner (2001) uses futures rate surprises to identify responses of market interest rates to monetary policy. Faust, Swanson and Wright (2004) use futures rate surprises to help identify monetary VAR models; Bernanke and Kuttner (2005) study the impact of monetary policy on equity returns using futures rate surprises to measure monetary shocks. It seems that these surprises have become a standard “market-based” measure of monetary policy shocks.¹ Though many papers use futures rate surprises, few study their properties as a measure of monetary shocks.²

This paper studies the information content of futures rate surprises. It begins by documenting that inflation responses to a positive surprise are substantial and significantly positive: A positive, 25-basis-point surprise raises CPI by 14.0% in four years. The anomaly is robust across a variety of specifications. The positive response contradicts typical monetary economic models, which predict that a tightening monetary policy lowers inflation. Futures rate surprises thus exhibit the “price puzzle” usually found in monetary VAR models. For this reason, it may be that futures rate surprises are not a clean measure of monetary shocks, just like monetary shocks identified by VAR models.

¹Futures rate surprises are also employed to measure monetary shocks in the following researches. Faust, Rogers, Swanson and Wright (2003) use futures rate surprises to identity effects of monetary shocks on exchange rates; Gürkaynak, Sack and Swanson (2005b) study responses of long-term interest rates to monetary shocks. Barakhian and Crowe (2013) estimate the impact of monetary shocks on output; Gorodnichenko and Weber (2013) study responses of return volatilities to monetary shocks of firms with different levels of price stickiness.

²There are a few exceptions. Faust, Swanson and Wright (2004) document that futures rate surprises do not contain the Fed’s private information on macroeconomic indicators of the last month (or quarter) that are released after the futures rate surprises. Piazzesi and Swanson (2008) argue that, as a measure of monetary shocks, futures rate surprises are free of contamination of risk premia.
So, what are contained in futures rate surprises? To answer this question, I follow Kuttner (2001) to express the Fed funds futures rate in terms of the expected target funds rate and risk premia. Different from Kuttner (2001), however, I show that futures rate surprises are not pure monetary shocks. They are contaminated by (1) “information shocks”, which are market’s unanticipated policy changes due to the information gap between the market and the Fed, and (2) revisions in risk premia due to the revelation of the Fed’s private information upon policy announcements. The intuition is that due to the information gap, the market and the Fed have different economic outlook, and therefore expect different target rates. The different expectations on the target rate cause information shocks. Moreover, as the Fed’s actions partially reveal the information gap, the market infers the Fed’s information and adjusts risk premia associated with Fed funds futures upon the observation of the Fed’s actions.

To quantify the contamination, I construct a simple measure of the information gap using forecast differences between the Fed and the market on the current state of the economy. The Fed’s information set is proxied by Greenbook forecasts for current-quarter and one-quarter-ahead GDP growth rate and inflation. And the market’s information set is proxied by forecasts from the Blue Chip survey for the same variables. The information gap is constructed as forecast differences between the Greenbook and the Blue Chip. I show that futures rate surprises are not orthogonal to the Fed’s information set. About 20% of variations in the surprises can be accounted for as the Fed’s reaction to the state of the economy. Moreover, futures rate surprises are not orthogonal to the information gap. The simple information gap measure accounts for up to 30% of variations in futures rate surprises. Similar results are found when the market’s information set is measured by forecasts from the Survey of Professional Forecasters.

This paper further identifies the sources of contamination. To empirically disentangle information shocks and revisions in risk premia, I measure the former from survey data on the target funds rate. Specifically, I use median forecasts on the target funds rate from the Money Market Services Survey and Bloomberg survey to measure the market’s expected
target funds rate that is not adjusted for risk premia. The differences between the announced
target rate and the the median survey forecast contain information shocks but not revisions
in risk premia. Accordingly, revisions in risk premia are measured as the differences between
futures rate surprises and survey forecast errors in the target funds rate. I find evidence
for the existence of both information shocks and revisions in risk premia. Specifically, the
simple information gap measure predicts survey forecast errors in the target funds rate,
which indicates the existence of information shocks. Revisions in risk premia are found to
be the main fluctuations in futures rate surprises. I do not find, however, my measure of
information gap explains revisions in risk premia.

Having shown that futures rate surprises are contaminated monetary shocks, it is thus
natural to ask whether the contamination is responsible for the price puzzle? To answer
this question, I clean futures rate surprises by removing the component contributable to the
information gap. This simple cleaning largely solves the price puzzle. Responses of CPI
inflation to the cleaned futures rate surprises become negative: A positive, 25-basis-point
surprise decreases CPI by 5.8% in four years, though the decrease is not significantly different
from zero. The contamination is, therefore, indeed partly responsible for the abnormal
inflation responses to futures rate surprises.

The remainder of the paper is organized as follows. Section 2 documents abnormal
inflation responses to futures rate surprises. Section 3 decomposes futures rate surprises using
the expectations hypothesis and shows that futures rate surprises are not clean monetary
shocks, but rather contaminated by information shocks and risk premium revisions. Section
4 assess the magnitude of the contamination using a simple measure of the information gap.
Section 5 empirically investigates information shocks and risk premium revisions. Inflation
responses to “cleaned” monetary shocks are shown in Section 6. Section 7 concludes the
paper.
2 Abnormal Inflation Responses to Futures Rate Surprises

To be a measure of monetary shocks, futures rate surprises need to behave like monetary shocks. In particular, one would expect a positive (contractionary) surprise to have negative effects on inflation. In this section, I investigate inflation responses to futures rate surprises.

2.1 Inflation Responses to Futures Rate Surprises

I study the impact of futures rate surprises on inflation by estimating a single-equation model as in Romer and Romer (2004),

\[ \pi_t = \alpha_0 + \sum_{i=1}^{K} b_i \pi_{t-i} + \sum_{j=1}^{J} c_j \Delta f_{t-j} + \varepsilon_t, \]  

(1)

where \( \pi_t \) is CPI inflation, \( \Delta f_t \) is the futures rate surprise. Lags of \( \pi_t \) are included to capture the normal dynamics of inflation, and lags of \( \Delta f_t \) are included to capture the direct impact of futures rate surprises on inflation.\(^3\) Under the null hypothesis that futures rate surprises are monetary shocks, inflation responses estimated from this single-equation model are unbiased.\(^4\) Data are monthly, from January 1990 to December 2007. Twenty-four lags of \( \pi_t \) and \( \Delta f_t \) are included in the estimation. Futures rate surprises, \( \Delta f_t \), are changes in current-month or one-month-ahead Fed funds futures rate in a 30-minute window around FOMC announcements, as constructed by Gürkaynak, Sack and Swanson (2005a). For the months having no FOMC actions, futures rate surprises are set to zero. For months that have more than one surprises, I use the average of the surprises to measure futures rate

\(^3\)The contemporaneous futures rate surprise is not included by assuming that monetary shocks do not affect inflation within the quarter. Allowing for contemporaneous responses has little effect on inflation responses.

\(^4\)Under the null hypothesis that futures rate surprises are monetary shocks, these surprises are orthogonal to non-monetary shocks. Therefore, potentially omitted variables to the single equation do not bias the estimation of inflation responses. Incorporating futures rate surprises in a VAR model generates inflation responses similar to the single-equation estimates.
surprises in the months.5

I summarize inflation responses by reporting responses of the log CPI index to a one-time realization of futures rate surprise of 25 basis points.6 Figure 1 plots the median response together with the bootstrapped 68% confidence interval. The response of CPI to a positive surprise is positive, substantial and significantly different from zero. A positive, 25-basis-point surprise raises CPI by 14.0% in 4 years, a strikingly abnormal impact.

The abnormal inflation response to futures rate surprises is robust to different measures of inflation. Core CPI increases by 9.3% in 4 years in response to a 25-basis-point futures rate surprise. The GDP deflator and PCE index respond positively and significantly, increasing by 6.0% and 6.3% in 4 years, respectively, following a 25-basis-point shock.7 The abnormal inflation response is also robust to futures rate surprises excluding intermeeting actions. As shown in Figure 2, a 25-basis-point shock associated with scheduled FOMC meetings raises CPI by 8.0% in four years, though not significant. Core CPI increases by 7.7% in four years in response to a 25-basis-point, positive shock associated with scheduled FOMC meetings.

In summary, as a measure of monetary shocks, futures rate surprises generate abnormal inflation responses: A positive surprise tends to substantially raise inflation. The anomaly is robust across a variety of specifications.

5There are usually eight futures rate surprises associated with scheduled FOMC actions in each year, and occasionally some surprises associated with FOMC intermeeting actions. For example, January 2001 saw two surprises on January 3 and January 31, respectively. The first surprise is due to an intermeeting action, and the last one is associated with a scheduled FOMC meeting. I use the average of the two surprises to measure the futures rate surprise in January 2001.

6The inflation response one month after the impact is \( c_1 \), and the response two months after the impact is \( c_2 + b_1c_1 \). The response of log price level equals to the cumulative inflation response. Thus, the response of the log price index one month ahead is \( c_1 \), two months ahead \( c_1 + c_2 + b_1c_1 \), and so on.

7For quarterly data, I estimate (1) by including 8 lags of the inflation measure and futures rate surprises. Quarterly futures rate surprises are the sum all futures rate surprises occurring in one quarter.
2.2 The Price Puzzle in the Literature

The positive inflation response contradicts predictions of new-Keynesian models. In a typical new-Keynesian model, a contractionary monetary shock lowers inflation. If futures rate surprises, as argued in the literature, are not contaminated, inflation responses should be negative. Therefore, the positive response of inflation casts doubts on the monetary shock interpretation of futures rate surprises.

Admittedly, it is not uncommon to find positive responses of inflation to a contractionary monetary shock in empirical studies. For instance, VAR models usually encounter the “price puzzle,” a positive response of inflation to a positive monetary shock. However, the price puzzle is perhaps not an intrinsic property of monetary shocks, but rather an indication of contamination in the estimated monetary shocks. In a parsimonious VAR model, there are omitted variables to the interest rate equation due to limited information included to the VAR model. For example, inflation expectations that raise inflation are likely omitted variables (Sims, 1992; Romer and Romer, 2004). Monetary shocks, measured by residuals from the estimated interest rate equation, pick up information of the omitted variables. Since the omitted variables, such as inflation expectations, can positively drive inflation dynamics, it is thus possible to see a positive response of inflation to monetary shocks that are contaminated by omitted variables.

It is not really surprising either to find abnormal inflation responses to market-based measures of monetary shocks. Barakchian and Crowe (2013) measure monetary shocks as the first principal component of daily futures rate surprises, and find the “price puzzle” in a VAR model. Cochrane and Piazzesi (2002) have documented similar anomalies. Similar to the practice of measuring monetary shocks from futures rate surprises, Cochrane and Piazzesi

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8There are a few theoretical exceptions. First, if a new-Keynesian model is indeterminate, it is possible to generate a positive response of prices to a contractionary monetary policy (Lubik and Schorfheide, 2004; Castelnuovo and Surico, 2010). However, the literature tends to show that the US economy was in a determinant state for the sample period considered here (Lubik and Schorfheide, 2004; Mavroeidis, 2010). Second, if the cost channel of monetary policy transmission is sufficiently important, a tightening monetary policy may push up prices (Barth and Ramey, 2001; Chowdhury, Hoffmann and Schabert, 2006).
(2002) construct monetary shocks as changes in the one-month Eurodollar rate surrounding target changes. They argue that their monetary shocks are superior to conventional estimates of monetary shocks. Despite the advantages they argue, their monetary shocks find no evidence that a tightening shock reduces inflation or output. They comment the abnormal responses this way: “As often happens, the purer the shock, the more unusual the response.” Moreover, they doubt that the Fed’s information advantage is responsible to the unusual responses.

In contrast to existing literature, this paper argues that market-based monetary shocks are not necessarily “pure”, and furthermore the Fed’s information advantage on the near-term economic state accounts for a large part of the abnormal responses.

3 The Information Content of Futures Rate Surprises

The anomalies discussed in the previous section could mean that futures rate surprises are not a clean measure of monetary shocks. It is thus worthwhile to study their information content. This section first discusses properties of monetary shocks. It then demonstrates how futures rate surprises are related to monetary shocks, and why the monetary-shock interpretation of futures rate surprises is probably incorrect.

3.1 Monetary Shocks

I follow Christiano, Eichenbaum and Evans (1999) and Romer and Romer (2004) to define monetary shocks as the component of monetary policy unexplained by the central bank’s reaction to the state of the economy. Suppose the central bank’s policy stance is well gauged by its target interest rate. Monetary shocks are defined as residuals of a target rate equation,

$$\tilde{r}_t = f(\Omega_t) + s_t,$$

9Cochrane and Piazzesi (2002) argue that their monetary shocks are free of the omitted-variable problem, the time-varying parameter problem and the orthogonalization problem that usually affect policy-rule-based or VAR-based monetary shocks.
where \( \bar{r}_t \) is the Fed’s target funds rate; \( f(\Omega_t) \) is the systematic component of the target rate determined by a reaction function modeled implicitly on the Fed’s information set \( \Omega_t \); and \( s_t \) is the monetary shock that is orthogonal to \( \Omega_t \). The orthogonality condition is not an identification assumption, but rather directly implied by the definition that monetary shocks are unexplained by the Fed’s reaction to the economic conditions.\(^\text{10}\)

### 3.2 Futures Rate Surprises

Federal funds futures contracts settle on the average of the effective federal funds rate in the delivery month. For instance, the settlement price of the current-month federal funds futures is based on the average of current month’s federal funds effective rate.\(^\text{11}\)

Suppose the market expects the Fed to change the target rate on day \( t \) of month \( m \). Shortly prior to the announcement of the new target rate, the current-month futures rate \( f_{m,t}^- \) can be interpreted as the conditional expectation of the average funds rate in month \( m \), plus a risk premium term,

\[
f_{m,t}^- = \frac{1}{n} \sum_{i=1}^{t-1} r_i + \frac{1}{n} \sum_{j=t}^{n} E_t^- r_j + \omega_t^-,
\]

where \( r_i \) is the effective overnight funds rate on day \( i \) of month \( m \), \( n \) is the number of days in the month, \( E_t^- r_j \) is the expected funds rate on day \( j \) conditional on the information set prior to the announcement, and \( \omega_t^- \) is the risk premium prior to the announcement.

Writing the effective funds rate as the sum of the target rate and a targeting error, \( r_i = \bar{r}_i + \eta_i \), futures rate \( f_{m,t}^- \) can be expressed as,

\[
f_{m,t}^- = \frac{1}{n} \sum_{i=1}^{t-1} (\bar{r}_i + \eta_i) + \frac{1}{n} \sum_{j=t}^{n} E_t^- (\bar{r}_j + \eta_j) + \omega_t^-,
\]

where \( \bar{r}_i \) is the target funds rate of day \( i \), and \( \eta_i \) is the targeting error of that day.

\(^\text{10}\)The orthogonality condition is largely uncontroversial. In particular, a contemporaneous response of the information set, \( \Omega_t \) to the monetary shock, \( s_t \), is very unlikely, as the information used by the Fed for making policy decision is predetermined.\(^\text{11}\)The average is based on calendar days of the month with rates on nonbusiness days carried over from the last business day.
Different from Kuttner (2001), this paper allows risk premia to respond to the Fed’s announcements. The reason is that market participants may possess information on the state of the economy that is different from the Fed’s. When market participants observe $\bar{r}_t$, they may infer the Fed’s information from the policy action. Thus, the information set of the market and risk premia associated with futures contracts after the announcement can be different from that before the announcement.

The futures rate shortly after the announcement, denoted by $f_{m,t}^+$, is given by

$$f_{m,t}^+ = \frac{1}{n} \sum_{i=1}^{t-1} (\bar{r}_i + \eta_i) + \frac{1}{n} \sum_{j=t}^{n} E_t^+(\bar{r}_j + \eta_j) + \omega_t^+, \quad (4)$$

where $\omega_t^+$ is the risk premium after the announcement, and $E_t^+ \eta_j$ is the expected targeting error after observing the new target rate.

As in Kuttner (2001), I make two assumptions about the market’s expectations on the target rate and targeting errors. First, the market expects no further changes in the target rate in a month with an expected change.\(^{12}\) That is $E_t^- \bar{r}_j = E_t^- \bar{r}_t$ and $E_t^+ \bar{r}_j = \bar{r}_t$ for all $j \in [t + 1, n]$. Second, the target rate change does not affect the expected targeting errors. That is $E_t^+ \eta_j = E_t^- \eta_j$ for all $j \in [t, n]$.

Under these two assumptions, futures rate surprise, $\Delta f_t$, are defined as,

$$\Delta f_t = \frac{n}{n-t+1}(f_{m,t}^+ - f_{m,t}^-),$$

where the multiplier $\frac{n}{n-t+1}$ reflects the number of days affected by the target change. It follows from (3) and (4) that

$$\Delta f_t = \bar{r}_t - E_t^- \bar{r}_t + \frac{n}{n-t+1}(\omega_t^+ - \omega_t^-). \quad (5)$$

My interpretation of (5) differs from Kuttner’s (2001) in two ways. First, I do not treat $\frac{n}{n-t+1}(\omega_t^+ - \omega_t^-)$ as negligible, as I do not rule out the possibility that market participants

\(^{12}\)As pointed out by Kuttner (2001), this assumption is not entirely justified. There are four months in the period from June 1989 to December 2007 that experienced two target rate changes (July 1989, December 1990, December 1991 and January 2001). Before 1994, the ex ante probability of having two changes in one month is even higher, since unscheduled FOMC actions were common at the time.
update their information set by inferring the Fed’s economic views from its actions. Second, I do not interpret $\bar{r}_t - E_t^{\bar{r}_t}$ as pure monetary shocks as Kuttner (2001), Bernanke and Kuttner (2005) and Faust, Swanson and Wright (2004) do. In contrast, I argue that they are contaminated by information shocks.

To see how futures rate surprises are related to monetary shocks, information shocks and revisions in risk premia, suppose market participants form their expectations on the new target rate and calculate risk premia using the following functional forms,

$$E_t\bar{r}_t = h(\Theta_t)$$ and $$\omega_t = \omega(\Theta_t),$$

where $\Theta_t$ is the private sector’s information set. Substituting (2) and (6) into (5) yields,

$$\Delta f_t = s_t + f(\Omega_t) - h(\Theta_t^-) + \frac{n}{n-t+1}(\omega(\Theta_t^+) - \omega(\Theta_t^-)),$$

where $\Theta_t^-$ and $\Theta_t^+$ are market participants’ information set prior to and after the announcement, respectively. It indicates that a futures rate surprise is a sum of three components, among which $s_t$ is the monetary shock, $f(\Omega_t) - h(\Theta_t^-)$ is an “information shock” due to information differences between the market and the Fed, and finally $\frac{n}{n-t+1}(\omega(\Theta_t^+) - \omega(\Theta_t^-))$ is the revision in risk premia due to the revelation of the Fed’s private information upon the policy announcement.

The quality of futures rate surprises as a measure of monetary shocks depends on the magnitude of information shocks and revisions in risk premia relative to that of monetary shocks. The next section turns to investigate the empirical importance of information shocks and revisions in risk premia.
4 Contamination of Futures Rate Surprises

4.1 Futures Rate Surprises and the Fed’s Information

It follows from (2) that monetary shocks, $s_t$, are orthogonal to the Fed’s information set $\Omega_t$. Therefore, $\Delta f_t$ is orthogonal to $\Omega_t$ under the monetary-shock interpretation of futures rate surprises. The empirical strategy to test the orthogonality is as follows. I use Greenbook forecasts prepared by the Fed’s economists to proxy the Fed’s information set, $\Omega_t$.\(^{14}\) I assume the Fed’s policy rule is linear, for instance a Taylor rule.

Specifically, I regress futures rate surprises on four Taylor-rule variables,

$$\Delta f_t = \alpha_0 + \alpha_1 g_t + \alpha_2 g_{t+1} + \alpha_3 \pi_t + \alpha_4 \pi_{t+1} + \epsilon_t,$$

where $g_t$ and $\pi_{t+1}$ are Greenbook forecasts for the current-quarter real GDP growth rate and one-quarter-ahead GDP inflation, respectively.\(^{15}\) The sample is from January 1990 to December 2007. Since only scheduled FOMC meetings are accompanied with Greenbook forecasts, I consider in the regression only futures rate surprises associated with FOMC scheduled meetings.

One important timing issue of FOMC meetings is that there are usually two scheduled FOMC meetings in one quarter, one in the middle and another one toward the end of the quarter or in the beginning of the next quarter.\(^{16}\) The timing may imply that the FOMC puts different weights on forecasts at different horizons according to the timing of the meeting. For example, it is reasonable to think that the FOMC pays less attention to current-quarter forecasts than one-quarter-ahead forecasts for meetings at the end of a quarter. To account for the timing difference, I introduce to (8) a dummy variable $e_t$ and its interactions with $g_t$ and $\pi_{t+1}$.

\[^{14}\text{Greenbook forecasts are usually made about one week before the corresponding FOMC meeting, which takes the decision on the new target rate.}\]

\[^{15}\text{The measure of GDP price index varies over time. It is the GNP implicit deflator prior to 1992Q1, and GDP implicit deflator between 1992Q1 and 1996Q1. After 1996Q2, it is measured by chain-weight price index for GDP.}\]

\[^{16}\text{For example, there are two meetings in the first quarter of 2007, on January 24 and March 14, respectively.}\]
forecast variables. Specifically, $e_t$ takes value 0 if the FOMC action is in the middle of a quarter, and 1 otherwise.

Table 1 shows that orthogonality of futures rate surprises to the Fed’s growth and inflation forecasts is rejected at the 5% significance level. Together, the Fed’s forecasts for the real GDP growth rate and inflation account for 21% of variations in futures rate surprises.

As we expected, the timing of FOMC meetings matters. For FOMC actions occurring in the middle of a quarter, $g_t$ and $\pi_{t+1}$ have significant, substantial explanatory powers to futures rate surprises. A one-percent increase in $g_t$ leads to a surprise of 1.9 basis points. A one-percent increase in $\pi_{t+1}$ gives a futures rate surprise of 2.2 basis points. For FOMC meetings that do not occur in the middle of a quarter, the relationship between futures rate surprises and Greenbook forecasts are different. $g_t$ does not have explanatory power for futures rate surprises. A one-percent increase in $\pi_{t+1}$ seems to decrease futures rate surprises by 3.1 basis points.\(^{17}\) As I show later, this result is not driven by influential observations.

For the concern that some observations may have undue influence on the estimation of (8), I estimate it by excluding influential observations. I detect potential influential observations using Cook’s (1977) method. For each futures rate surprise $i$, a statistic $c_i$ is calculated as,

$$c_i = (\hat{\alpha}(i))' \hat{\Sigma}^{-1}(\hat{\alpha}(i))$$

where $\hat{\alpha}(i)$ is the change in the vector of estimates, $\hat{\alpha}$, resulting from dropping the $i$th observation, and $\hat{\Sigma}$ is the estimated covariance matrix for $\hat{\alpha}$. Observations with $c_i$ greater than 0.5 are treated as influential, as in Bernanke and Kuttner (2005).

To check the robustness of the results from the baseline regression, I remove all four identified influential observations. As shown in the right panel of Table 1, excluding influential observations does not change the main results. Greenbook forecasts for growth and inflation jointly explain 19% of variations in futures rate surprises. In addition, the timing pattern persists after excluding potential influential observations. Therefore, the explanatory power\(^{17}\) It seems to be a puzzling result, as we expect an optimistic economic forecast for $\pi_{t+1}$ from the Fed to give a positive futures rate surprise to the market. However, (8) is only a test of orthogonality. We do not impose a structural interpretation to (8) due to, for example, omitted variable biases.

\(^{17}\)
of the Fed’s information is not driven by outliers.

In summary, futures rate surprises are not exogenous to the Fed’s information set. They are not purely the irregular component of the Fed’s target rate, but related to the Fed’s views on the current state of the economy.

4.2 Futures Rate Surprises and the Information Gap

As suggested by (7), differences in information sets between the market and the Fed are the main reason for the contamination. To study how information differences contribute to the contamination, I proxy the Fed’s and the market’s information sets using their forecasts for macroeconomic variables. As in the test of orthogonality, I use Greenbook forecasts to proxy the Fed’s information set. The market’s information set prior to announcements, $\Theta_t^-$, is proxied by forecasts from the Blue Chip survey. The market’s updated information set, $\Theta_t^+$, is not directly measurable. As suggested by Romer and Romer (2001), private forecasters tend to update their forecasts toward the Fed’s following the Fed’s announcements. I therefore use the Fed’s information set, $\Omega_t$, to proxy $\Theta_t^+$.

To assess how much contamination is contributable to information differences, I make two simplifications to the functional forms of (7). First, the Fed’s and the market’s rules for the target rate are linear and identical. Second, risk premia are linear in the market’s information set. With these simplifications the magnitude of contamination due to information differences is estimated by regressing futures rate surprises on a measure of the information gap,

$$\Delta f_t = \gamma_0 + \gamma_1 \tilde{g}_t + \gamma_2 \tilde{g}_{t+1} + \gamma_3 \tilde{\pi}_t + \gamma_4 \tilde{\pi}_{t+1} + \epsilon_t,$$

where $\tilde{g}_t$ and $\tilde{\pi}_{t+1}$ are variables measuring the information gap, defined as differences between Greenbook and Blue Chip forecasts on the current-quarter real GDP growth rate and one-quarter-ahead GDP inflation, respectively.\(^{18}\)

\(^{18}\)In general Greenbook forecasts and Blue Chip forecasts are not made at the same time points. Blue Chip forecasts are prepared in the first several days of each month, whereas Greenbook forecasts are prepared about one week before FOMC meetings, which can take place at any time of a month. I match Greenbook forecasts and Blue Chip forecasts to make sure Blue Chip forecasts are made before FOMC announcements.
Table 2 shows that the simple information gap measure contributes to the contamination. Differences in forecasts for the real GDP growth rate and GDP inflation together account for 17% of variations in futures rate surprises. As discussed earlier, the explanatory power of forecast variables depends on the timing of FOMC meetings. For meetings taking place in the middle quarter, \( \hat{g}_t \) has a significantly positive effect on futures rate surprises. If the Fed’s forecast for the current-quarter growth rate is one percent higher than the market’s, the FOMC tends to give the market a positive surprise of 2.7 basis points. For FOMC meetings not in the middle quarter, \( \hat{g}_t \) does not seem to have explanatory power. Nevertheless, forecast differences in current-quarter inflation significantly explain futures rate surprises. A one-percent increase in \( \hat{\pi}_t \) leads to a surprise of 3.2 basis points.

To check the robustness of the results to potential influential observations, I remove five influential observations identified with Cook’s (1977) method. As shown in the right panel of Table 2, excluding influential observations actually increases the explanatory power of the information gap. About 22% variations in futures rate surprises are explained. The timing pattern persists, and \( \hat{g}_t \) and \( \hat{\pi}_t \) have slightly higher explanatory power after deleting influential observations.

The genuine relationship between futures rate surprises and information differences can also be seen in Figure 3, which plots futures rate surprises against forecast differences between the Greenbook and the Blue Chip. The left graph plot futures rate surprises occurring in the middle quarter against forecast differences in the current-quarter real GDP growth rate. The right panel plots futures rate surprises that do not occur in the middle-quarter against forecast differences in the current-quarter inflation. It is apparent that the explanatory power of information differences on futures rate surprises are not driven by outliers.

In summary, a simple measure of the information gap can explain a substantial part of futures rate surprises. The relationship between futures rate surprises and the information gap is not driven by outliers. Therefore, futures rate surprises are contaminated estimates of monetary shocks, and information differences between the Fed and the market seem to be

\[ \text{and match the timing of the announcements as close as possible.} \]
one reason for the contamination.

4.3 Robustness

A. Alternative Private Forecasts

I check the robustness of the explanatory power of information differences by using an alternative set of private forecasts. I replace Blue Chip forecasts by forecasts from the Survey of Professional Forecasts (SPF). The SPF makes four sets of forecasts each year. To match the frequency of the SPF, I use only four observations of futures rate surprises in one year (and four sets of the corresponding Greenbook forecasts). Futures rate surprises are selected to match the timing of SPF as close as possible. The timing mismatch between Greenbook and SPF forecasts is discussed in detail later. The sample covers the period from 1990Q1 to 2007Q4.

For the reason that we have only 72 sets of SPF forecasts, I estimate (9) in a more parsimonious way,

\[ \Delta f_t = \gamma_0 + \gamma_1 \tilde{g}_t + \gamma_2 \tilde{\pi}_t + \epsilon_t, \]

where, \( \tilde{g}_t \) and \( \tilde{\pi}_t \) are differences between Greenbook and SPF forecasts on the current-quarter real GDP growth rate and GDP inflation, respectively.

Figure 4 shows a scatter plot of futures rate surprises and forecast differences between the Greenbook and the SPF on the current-quarter GDP growth rate. Apparently, there is a positive relationship. Panel A of Table 3 reports least-square estimation results, which in general confirm the results using Blue Chip forecasts. Information differences in forecasts for the current-quarter real GDP growth rate and GDP inflation together account for 15% of variations in futures rate surprises. The effect of \( \tilde{g}_t \) on \( \Delta f_t \) is strong and significant at the 5% significance level. A one-percent difference in growth forecast causes a surprise of 3.8 basis points. The effect of \( \tilde{\pi}_t \) is negative, relatively small, and insignificant. Excluding influential observations makes the joint explanatory power stronger.

The timing of SPF forecasts does not match that of futures rate surprises exactly. To study the timing issue, I use the deadline for forecasters submitting their projections to
approximate the date of SPF forecasts, and compare it with the date of the futures rate surprise. For the sample from 1990Q3-2007Q4 (excluding 1996Q1), SPF forecasts in general were made several days after the futures rate surprises.\footnote{On average SPF forecasts fell behind futures rate surprises for 4 days. The lag varies from -10 day to 20 days. SPF deadlines for 1990Q1 and 1990Q2 are not known. The 1996Q1 survey deadline was delayed because of the shut down of federal government, and thus the deadline lags the corresponding Greenbook for 36 days. Note that none of these is identified as influential in the baseline regression.}

The fact that SPF deadlines fell behind the dates of futures rate surprises may cause endogeneity problems to the least-square estimation of (10). Two endogeneity issues can arise when SPF forecasts are made later than futures rate surprises. First, before submitting their projections SPF forecasters may have updated their forecasts by incorporating the impact of monetary shocks, $s_t$, on the economy. Second, SPF forecasters may try to update their forecasts by extracting information from $\Delta f_t$. In each case, least-square estimates for $\gamma$’s are biased. To overcome the endogeneity problem, I instrument $\tilde{g}_t$ and $\tilde{\pi}_t$ with Greenbook forecasts for $g_t$ and $\pi_t$.

Results from the instrumental variable estimation are presented in Panel B of Table 3. For the full sample, instrumental estimates indicate that a one-percent increase in forecast difference for the current-quarter growth rate gives the market a surprise of 6.5 basis points. The figure is significant at the 1% significance level, and higher than the least-square estimate. The effect of $\tilde{\pi}_t$ is positive, yet insignificant. Joint insignificance of $\tilde{g}_t$ and $\tilde{\pi}_t$ is rejected at the 10% significance level by the Wald test. The instrumental estimation is unlikely subject to the weak instrument problem. The Cragg-Donald statistic is 21.59, much higher than Stock and Yogo’s (2001) critical value of 7.03, at which all Wald tests based on 2SLS estimates at a 5% level have the maximal size of 10%.\footnote{Note that Stock and Yogo’s (2001) test for weak instruments based on Cragg-Donald statistics only applies to models with iid errors. Nevertheless, I still report the test for a check.}

For the sample excluding influential observations, the instrumental estimation yields similar results. The estimate for $\gamma_1$ is significant at the 5% significance level, and higher than the least-square estimate. The estimate for $\gamma_2$ is small, insignificant, yet positive.
The joint insignificance is rejected at the 10% significance level. Again, the instrumental estimation seems to be free of the weak instrument problem.

B. An Unrestricted Monetary Policy Rule

In the baseline regression, I assume that the market uses a linear monetary policy rule that is identical to the Fed’s rule. Therefore, $f(\Omega_t) - h(\Theta^-)$ reduces to a linear function of forecast differences between the Fed and the market on variables that enter the monetary policy rule. Here I relax the assumption on identical policy rules, though the assumption about linearity of the rules is maintained. That is to say, the monetary policy rule used by the market differs from the Fed not only in measures of variables that enter the rule, but also in parameters of the rule. As in the baseline model, I assume revisions in risk premia are linear functions of forecast differences between the Fed and the market.

Under the assumption of less restricted monetary policy rules, the magnitude of contamination can be assessed by regressing the futures rate surprises on Greenbook and Blue Chip forecasts in an unrestricted way,

$$
\Delta f_t = \beta_0 + \beta_1 g_t + \beta_2 \pi_t + \beta_3 g_{bc}^{t} + \beta_4 \pi_{bc}^{t} + \epsilon_t, \quad (11)
$$

where $g_t^{bc}$ and $\pi_t^{bc}$ are the current-quarter real GDP growth rate and GDP inflation forecasts from the Blue Chip, respectively. As in the baseline, a dummy variable $e_t$ and its interactions with forecasts variables are introduced to the model to account for the timing of FOMC meetings. To limit the number of explanatory variables, I include only current-quarter forecast variables.

Table 4 reports estimation results for (11). As expected, a larger share of variations in futures rate surprises are explained by the unrestricted model than the baseline model (9). The $R^2$ is 0.25, indicating that a substantial part of the surprises are explained by the four explanatory variables. The explanatory variables are jointly significant at the 1% significance level. The timing of FOMC meetings matters. For middle-quarter observations, $g_t$ and $g_{bc}^{t}$ have positive impacts on futures rate surprises. For meetings that do not take place in the middle quarter, $g_t$ does not seem to have explanatory power, while $\pi_t$ has positive and $g_{bc}^{t}$
has negative explanatory power on futures rate surprises. Excluding potential influential variables make the explanatory power even stronger. About 29% variations in futures rate surprises are explained by the simple measure of information differences between the Fed and the market.

4.4 Discussion

A. Reconciling the Findings with the Literature

The finding of substantial contamination contradicts with Faust, Swanson and Wright (2004), who argue that futures rate surprises do not contain the Fed’s private information. To support the argument, they investigate whether futures rate surprises add additional values to the private sector’s estimates for macroeconomic indicators of the last month (or quarter) that are released after the corresponding futures rate surprises. The idea is that if futures rate surprises indeed reveal the Fed’s private information, the private sector should improve its estimates for the macroeconomic indicators by incorporating information revealed by futures rate surprises.

Faust, Swanson and Wright (2004) find that incorporating futures rate surprises does not improve the private sector’s estimates, and thus conclude that futures rate surprises do not contain the Fed’s private information. However, a proposition as “futures rate surprises do not contain the Fed’s private information” can almost never be verified, as the Fed’s information set is not well defined. On the contrary, the proposition is falsified as long as a single piece of evidence is found against it. Faust, Swanson and Wright’s findings only verify that futures rate surprises do not reveal the Fed’s backward-looking information, namely, estimates on macroeconomic indicators of the last month (or quarter). However, the findings of this paper show that futures rate surprises reveal the Fed’s forward-looking information, namely, forecasts on current-quarter macroeconomic indicators.
B. Longer Forecast Horizons

Differences in the Fed’s and the market’s forecasts beyond the current quarter are found having no explanatory power for futures rate surprises. So, why only differences in current-quarter forecasts matter for the surprises? There are two interconnected reasons. First, the Fed’s forecasts for current-quarter inflation and growth rate are superior to the private sector’s. D’Agostino and Whelan (2008) shows that to make optimal current-quarter forecasts, a forecaster having access to both Greenbook and SPF forecasts should put a substantial weight on Greenbook forecasts but essentially no weight on SPF forecasts. The Fed’s superior performance in current-quarter forecasts is well founded. As pointed out by Bernanke (2007), to forecast near-term (current or one-quarter-ahead) inflation the Fed’s staff rely on a bottom-up approach that focuses on estimating and forecasting price behavior for individual components that make up the price index in question. The Fed’s forecast superiority for the current-quarter real GDP growth rate may come from the fact that the Fed collects data for compiling the industrial production index. The Fed’s private data on industrial production probably help to forecast the current-quarter GDP growth rate.

The second reason is that forecastability of inflation and real growth rates beyond current quarter is very low for the sample from 1990Q1 to 2007Q4. D’Agostino and Whelan (2008) show inflation and growth rates one- or more-quarter ahead become very difficult to forecast during the Great Moderation. They show that neither Greenbook nor SPF forecasts for inflation and real GDP growth rates beyond current quarter are useful to predict the actual data. If the market is aware of the the predictability limit, it should not try to infer from the futures rate surprises the Fed’s forecasts beyond the current quarter, which are not more precise than the market’s. Furthermore, if the Fed knows the predictability limit, it should not bases its policy actions on forecasts beyond current quarter. Thus, the difference between forecasts at horizons beyond current quarter is irrelevant to the futures rate surprises.
5 The Sources of Contamination

Having documented that the contamination is substantial, this section turns to study the sources of contamination: information shocks, revisions in risk premia or both?

The Fed’s private information is well documented in the literature. For instance, Romer and Romer (2001) show that the Fed has superior information compared to the market, and moreover, the market learns the Fed’s information from its actions. Therefore, it is reasonable to expect information difference between the Fed and the market causing information shocks, $f(\Omega_t) - h(\Theta_t^{-})$, as in (7).

Time-varying risk premia that respond to economic fundamentals and monetary policy are well documented in the literature. Alvarez, Atkeson and Kehoe (2009) show that a model featured with time-varying risk premia that respond to monetary policy can explain the forward premium anomaly. Empirically, Piazzesi and Swanson (2008) document that risk premia associated Fed funds futures are substantial and predictable by macroeconomic variables. Ludvigson and Ng (2012) show that macroeconomic fundamentals have important forecasting power for excess bond returns. Bansal and Shaliastovich (2013) show that bond risk premia are closely related to uncertainty about expected inflation and growth. It thus seems natural that risk premia which compensate investors holding a Fed funds futures contract, respond to monetary shocks and the Fed’s private information revealed by its policy actions. In other words, risk premia could change along with the Fed’s policy action. Therefore, the assumption that $\omega(\Theta_t^+) - \omega(\Theta_t^-) = 0$ is a difficult case to make.

5.1 Information Shocks

It follows from (2) that

$$\bar{r}_t - h(\Theta_t^-) = s_t + f(\Omega_t) - h(\Theta_t^-).$$

This equation indicates that the difference between the target rate and the market’s expected target rate measures the information shock up to a monetary shock, $s_t$. Since $s_t$ is orthogonal to the information gap, I test the existence of information shocks by testing whether
information differences between the Fed and the market explains the market’s forecast errors in the target federal funds rate.

I measure $h(\Theta^-_t)$ using median forecasts from the Bloomberg survey on the target federal funds rate. I use survey forecasts to measure $h(\Theta^-_t)$ for two reasons. First, it is usually found that few statistical models outperform median survey forecasts for macroeconomic variables. Second, compared to market expectations derived from asset prices, survey forecasts are physical expectations, not involving risk premia (see e.g., Cieslak and Povala, 2013 and references therein). The Bloomberg survey is conducted on the same days as FOMC scheduled announcements. The data are available since May 20, 1997. I complement the Bloomberg survey data with median forecasts from the Money Market Services Survey, which conducts a Friday telephone survey of about 40 money managers and collects forecasts of the target funds rate to be released during the next week.\footnote{In a study on the response of exchange rates to macroeconomic announcements, Andersen, Bollerslev, Diebold and Vega (2003) construct monetary policy surprises as the difference between announced target rates and median forecasts from the Money Market Services Survey.} The Money Market Services Survey data are available since 1993.

Figure 5 plots survey forecast errors from 1993 to 2007, together with futures rate surprises. In most cases, median survey forecasts get the target rate correctly. There are only eleven forecast errors, five of which are positive. More interestingly, all forecast errors have a magnitude of 25 basis points.\footnote{This is understandable since that it is well known to the market that the Fed changes the target funds rate with a 25-basis-point incremental.} To take care of the discreteness of the dependant variable, I estimate an ordered logit model using the Fed’s information or information differences to explain the $-25$, $0$, and 25-basis-point forecast errors in the target funds rate,

$$
\bar{r}_t - h(\Theta^-_t) = \begin{cases} 
-25, & -\infty < I_t < \tau_1, \\
0, & \tau_1 < I_t < \tau_2, \\
25, & \tau_2 < I_t < \infty.
\end{cases}
$$

where

$$
I_t = \lambda_1 g_t + \lambda_2 g_{t+1} + \lambda_3 \pi_t + \lambda_4 \pi_{t+1} + \varsigma_t
$$
or

\[ I_t = \lambda_1 \tilde{g}_t + \lambda_2 \tilde{g}_{t+1} + \lambda_3 \tilde{\pi}_t + \lambda_4 \tilde{\pi}_{t+1} + \varsigma_t \]

depending on the model specification. \( \varsigma_t \) has the logistic density, and \( \tau_1 \) and \( \tau_2 \) are two threshold values to be estimated. As explained earlier, I use a dummy \( e_t \) and its interactions with forecast variables to account for the timing difference of FOMC meetings.

Results are reported in Table 5. The left panel shows that the Fed’s information can explain market’s forecast errors in the target funds rate. The p-value associated with Wald test for the joint significance is 0.00. That is to say the Fed has its reasons to set a target rate that surprises the market. The right panel shows that information differences between the Fed and the market can explain market’s forecast errors in the target funds rate. Explanatory variables are jointly significant at the 1% level. The information gap between the Fed and the market is one reason why the market makes errors in forecasting the Fed’s target rate. The timing of FOMC meetings is again important.

In summary, the market’s forecast errors in the target funds rate is not only due to monetary shocks, but also information differences between the Fed and the market. Therefore, there is evidence for the existence of information shocks.

### 5.2 Revisions in Risk Premia

Since risk premia associated with the futures are not directly measurable, I estimate revisions in risk premia caused by Fed announcements in an indirect way. Specifically, I rewrite (7) as

\[
\Delta f_t - (\tilde{r}_t - h(\Theta_t^-)) = \phi(\omega(\Theta_t^+) - \omega(\Theta_t^-)).
\]

This equation shows that the difference between \( \Delta f_t \) and \( \tilde{r}_t - h(\Theta_t^-) \) are revisions in risk premia. I again use median forecasts from Bloomberg survey and the Money Market Services survey to measure \( h(\Theta_t^-) \).

Figure 5 clearly shows that revisions in risk premium (measured as differences between \( \Delta f_t \) and \( \tilde{r}_t - h(\Theta_t^-) \)) are non-zero. These are actually the main variations in futures rate surprises. In other words, the median market forecasts usually get the forthcoming target
rate correctly, and therefore the Fed’s announcements surprise the futures market only to the extent of revisions in risk premia.

I further investigate whether information differences between the Fed and the market caused risk premium revisions, as suggested by (7). The empirical strategy is as follows. I regress the measure of revisions in risk premia, \( \Delta f_t - (\bar{r}_t - h(\Theta_t^-)) \), on the Fed’s information or information differences between the Fed and the market,

\[
\Delta f_t - (\bar{r}_t - h(\Theta_t^-)) = \theta_0 + \theta_1 \tilde{g}_t + \theta_2 \tilde{g}_{t+1} + \theta_3 \tilde{\pi}_t + \theta_4 \tilde{\pi}_{t+1} + \mu_t. \tag{13}
\]

Results are reported in Table 6. Neither the Fed’s information nor information differences between the Fed and the market explain revisions in risk premia. In summary, we find that a substantial part of variations in futures rate surprises are due to revisions in risk premia. We do not find, however, that revisions in risk premia are explained by information differences between the Fed and the market.

6 Contamination and the Inflation Response

Having shown that information differences between the Fed and the market account for substantial variations in futures rate surprises, it is interesting to see whether the information differences are responsible for the abnormal inflation responses documented in Section 2. To this end, I clean the futures rate surprises by regressing them on information sets of the Fed and the market. Specifically, I take residuals from (11) as “clean” monetary shocks and denote them by \( \hat{s}_t \).

I estimate (1) replacing the original futures rate surprises, \( \Delta f_t \), by the clean monetary shocks, \( \hat{s}_t \). Figure 6 presents responses of CPI inflation to the clean monetary shocks. Cleaning the contamination helps to solve the anomalies: A positive, 25-basis-point surprise decreases CPI by 5.8% in four years, though the decrease is not significantly different from zero. Compared to responses to the original futures rate surprises, the simple cleaning largely solves the price puzzle. It seems that the contamination due to information differences between the Fed and the market indeed contributes to the abnormal inflation responses.
Conclusion

Futures rate surprises are widely used to gauge monetary shocks in the literature. But few papers study their properties as a measure of monetary shocks. This paper documents that the surprises exhibit the “price puzzle” as usually found in monetary VAR models. A positive surprise tends to raise inflation significantly and substantially. The abnormal inflation response calls for a study on the information content of futures rate surprises.

I decompose futures rate surprises using the expectations hypothesis to study its information content. I show that futures rate surprises are monetary shocks contaminated by (1) information shocks due to the information gap between the Fed and the market, and (2) revisions in risk premia due to the revelation of the Fed’s private information. I use a simple measure of the information gap to quantify the contamination. It shows that up to 30% of variations in futures rate surprises are predictable with the simple measure of information gap. Controlling for information differences largely solves the price puzzle.

As futures rate surprises are widely used to study the impact of monetary policy on macroeconomic and financial variables, an interesting work in the future is to study the consequence of the contamination in those applications.

References


Figure 1: Cumulative Responses of CPI Inflation to Futures Rate Surprises

*Notes:* This graph presents cumulative responses of CPI inflation to a 25-basis-point futures rate surprise. Dashed lines show the bootstrapped 68% confidence interval. Data are monthly from 1990 to 2007. When multiple surprises occur in one month, these surprises are summed to measure the surprise in the month.
Table 1: Exogeneity of Futures Rate Surprises to the Fed’s Information

<table>
<thead>
<tr>
<th></th>
<th>the full sample</th>
<th>excl. influential ob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>$g_t$</td>
<td>1.91*** (0.62)</td>
<td>1.91*** (0.63)</td>
</tr>
<tr>
<td>$g_{t+1}$</td>
<td>-0.03 (0.59)</td>
<td>-0.03 (0.59)</td>
</tr>
<tr>
<td>$\pi_t$</td>
<td>0.17 (0.71)</td>
<td>0.17 (0.71)</td>
</tr>
<tr>
<td>$\pi_{t+1}$</td>
<td>2.17* (1.13)</td>
<td>2.17* (1.13)</td>
</tr>
<tr>
<td>$e_t$</td>
<td>11.04** (4.93)</td>
<td>14.13*** (4.32)</td>
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<td>$e_t \times g_t$</td>
<td>-2.36*** (0.91)</td>
<td>-2.18*** (0.77)</td>
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<td>$\pi_{t+1}$</td>
<td>0.61 (0.96)</td>
<td>-0.50 (0.72)</td>
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<td>$\pi_t$</td>
<td>1.51 (1.15)</td>
<td>1.09 (0.88)</td>
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<td>$\pi_{t+1}$</td>
<td>-5.28*** (1.86)</td>
<td>-4.68*** (1.49)</td>
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</tbody>
</table>

Ob. 144 140
$R^2$ 0.21 0.19
$F$-sta. 1.98 (0.05) 2.49 (0.00)

Notes: This table reports estimation results for regressing futures rate surprises on Greenbook forecasts. $g_t$ denotes Greenbook forecasts for the current-quarter real GDP growth rate, and $\pi_{t+1}$ denotes forecasts for one-quarter-ahead GDP inflation. $e_t$ takes value 0 for futures rate surprises associated with middle-quarter FOMC meetings, and 1 otherwise. A constant is included, but not reported. Heteroskedasticity-consistent standard errors are reported in parentheses. $F$-statistics for testing the joint significance of regressors are reported together with associated $p$-values (in parentheses). The left panel reports results for the full sample from the first FOMC meeting in 1990 to the last meeting in 2007. The right panel reports results for the sample excluding four influential observations identified using Cook’s (1977) method. ***, ** and * indicate significance at the 1%, 5% and 10%, respectively.
<table>
<thead>
<tr>
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<td>$\tilde{g}_t$</td>
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<td>$\tilde{g}_{t+1}$</td>
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<tr>
<td></td>
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<td>(0.79)</td>
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<tr>
<td>$\tilde{\pi}_t$</td>
<td>-1.85</td>
<td>-2.32**</td>
</tr>
<tr>
<td></td>
<td>(1.18)</td>
<td>(1.14)</td>
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<tr>
<td>$\tilde{\pi}_{t+1}$</td>
<td>-2.11</td>
<td>-1.89</td>
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<td></td>
<td>(1.40)</td>
<td>(1.39)</td>
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<td>$e_t$</td>
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<td>(0.95)</td>
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<tr>
<td>$e_t \times \tilde{g}_t$</td>
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<td>-3.59***</td>
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<tr>
<td></td>
<td>(1.92)</td>
<td>(1.41)</td>
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<td>$\tilde{g}_{t+1}$</td>
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<td></td>
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<td>$\tilde{\pi}_t$</td>
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<td>5.52***</td>
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<td>$\tilde{\pi}_{t+1}$</td>
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<td></td>
<td>(2.35)</td>
<td>(2.21)</td>
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</table>

**Notes:** This table reports estimation results for regressing futures rate surprises on forecast differences between the Greenbook and the Blue Chip survey. $\tilde{g}_t$ and $\tilde{\pi}_{t+1}$ are differences between Greenbook and Blue Chip forecasts for the current-quarter real GDP growth rate and one-quarter-ahead GDP inflation, respectively. Heteroskedasticity-consistent standard errors are reported in parentheses. $F$-statistics for testing the joint significance of regressors are reported together with associated $p$-values (in parentheses). See also notes for Table 1.
Table 3: Exogeneity of Futures Rate Surprises to Information Differences between the Fed and the Market: the Survey of Professional Forecasters

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<th></th>
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<th>excluding influential Ob.</th>
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<tr>
<td></td>
<td>γ₁</td>
<td>γ₂</td>
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<td>A. Least-Square Estimation</td>
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<tr>
<td></td>
<td>3.79</td>
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<td>(1.19)</td>
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<td>B. Instrumental Estimation</td>
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<tr>
<td></td>
<td>6.45</td>
<td>2.48</td>
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<tr>
<td></td>
<td>(2.86)</td>
<td>(1.72)</td>
</tr>
</tbody>
</table>

Notes: Panel A reports least-square results for regressing futures rate surprises on forecast differences between the Greenbook and the SPF. A constant is included, but not reported. Panel B reports instrumental estimation results using Greenbook forecasts to instrument the forecast differences. Heteroskedasticity-consistent standard errors are reported in parentheses. F-statistics or Wald statistics for testing the joint significance of regressors are reported together with associated p-values (in parentheses). Cragg-Donald are statistics for testing weak instruments. Stock-Yogo (2002) critical values for Cragg-Donald statistics are parentheses below. At the critical values all Wald tests based on 2SLS estimates at a 5% level have the maximal size of 10%. The left part of the table reports results for the full sample covering the period from 1990Q1 to 2007Q4. The right part reports results for the sample excluding six influential observations.
Table 4: Exogeneity of Futures Rate Surprises to Information Differences between the Fed and the Market: An Unrestricted Model

<table>
<thead>
<tr>
<th></th>
<th>the full sample</th>
<th>excl. influential ob.</th>
</tr>
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<tbody>
<tr>
<td>$g_t$</td>
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<td>3.56***</td>
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<td>$\pi_t$</td>
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<td>$g_{tbc}$</td>
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<td>$\pi_{tbc}$</td>
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<td>$e_t$</td>
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<td>16.03***</td>
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<td>$\pi_t$</td>
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<td>5.03***</td>
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<tr>
<td>$g_{tbc}$</td>
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<td>$\pi_{tbc}$</td>
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<td>1.02</td>
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Ob. 144 140
$R^2$ 0.25 0.29
$F$-sta 3.25 (0.00) 4.41 (0.00)

Notes: This table reports estimation results for regressing futures rate surprises on Greenbook and Blue Chip forecasts. $g_{tbc}$ and $\pi_{tbc}$ are Blue Chip forecasts for the current-quarter real GDP growth rate and GDP inflation, respectively. Heteroskedasticity-consistent standard errors are reported in parentheses. $F$-statistics for testing the joint significance of regressors are reported together with associated p-values (in parentheses). See also notes for Table 1.
Table 5: Ordered Logit Models for Survey Forecast Errors on the Target Funds Rate

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<tr>
<td>$g_t$</td>
<td>1.31*** (0.39)</td>
<td>$\tilde{g}_t$</td>
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<td>$g_{t+1}$</td>
<td>-1.14** (0.54)</td>
<td>$\tilde{g}_{t+1}$</td>
</tr>
<tr>
<td>$\pi_t$</td>
<td>-0.35 (0.52)</td>
<td>$\tilde{\pi}_t$</td>
</tr>
<tr>
<td>$\pi_{t+1}$</td>
<td>1.49** (0.66)</td>
<td>$\tilde{\pi}_{t+1}$</td>
</tr>
<tr>
<td>$e_t$</td>
<td>1.53 (2.58)</td>
<td>$\epsilon_t$</td>
</tr>
<tr>
<td>$e_t \times g_t$</td>
<td>-1.30** (0.62)</td>
<td>$\epsilon_t \times \tilde{g}_t$</td>
</tr>
<tr>
<td>$g_{t+1}$</td>
<td>1.47* (0.76)</td>
<td>$\tilde{g}_{t+1}$</td>
</tr>
<tr>
<td>$\pi_t$</td>
<td>1.43* (0.73)</td>
<td>$\tilde{\pi}_t$</td>
</tr>
<tr>
<td>$\pi_{t+1}$</td>
<td>-3.12*** (0.92)</td>
<td>$\tilde{\pi}_{t+1}$</td>
</tr>
</tbody>
</table>

Ob.     120 | Ob.     120
Wald    33.37 (0.00) | Wald    32.53 (0.00)

Notes: This table reports estimation results for ordered logit models for survey forecast errors for the target funds rate. The left panel uses Greenbook forecasts for the real GDP growth rate and GDP inflation as explanatory variables. The right panel explains survey forecast errors in the target rate using Greenbook and Blue Chip forecast differences. Heteroskedasticity-consistent standard errors are reported in parentheses. $p$-values are reported in parentheses beside the associated Wald statistics. See also notes for Table 1 and 2.
Table 6: Risk Premium Revisions and Information Differences between the Fed and the Market

<table>
<thead>
<tr>
<th></th>
<th>Greenbook</th>
<th>Greenbook-Blue Chip Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$g_t$</td>
<td>($0.29$)</td>
</tr>
<tr>
<td></td>
<td>$g_{t+1}$</td>
<td>($0.81$)</td>
</tr>
<tr>
<td></td>
<td>$\pi_t$</td>
<td>($0.89$)</td>
</tr>
<tr>
<td></td>
<td>$\pi_{t+1}$</td>
<td>($-1.48$)</td>
</tr>
<tr>
<td></td>
<td>$e_t$</td>
<td>($4.80$)</td>
</tr>
<tr>
<td></td>
<td>$e_t \times g_t$</td>
<td>($-2.20$)</td>
</tr>
<tr>
<td></td>
<td>$g_{t+1}$</td>
<td>($0.46$)</td>
</tr>
<tr>
<td></td>
<td>$\pi_t$</td>
<td>($-1.31$)</td>
</tr>
<tr>
<td></td>
<td>$\pi_{t+1}$</td>
<td>($1.86$)</td>
</tr>
<tr>
<td></td>
<td>$\tilde{g}_t$</td>
<td>($0.29$)</td>
</tr>
<tr>
<td></td>
<td>$\tilde{g}_{t+1}$</td>
<td>($1.29$)</td>
</tr>
<tr>
<td></td>
<td>$\tilde{\pi}_t$</td>
<td>($2.01$)</td>
</tr>
<tr>
<td></td>
<td>$\tilde{\pi}_{t+1}$</td>
<td>($0.64$)</td>
</tr>
<tr>
<td></td>
<td>$e_t$</td>
<td>($0.94$)</td>
</tr>
<tr>
<td></td>
<td>$e_t \times \tilde{g}_t$</td>
<td>($-3.05$)</td>
</tr>
<tr>
<td></td>
<td>$\tilde{g}_{t+1}$</td>
<td>($0.94$)</td>
</tr>
<tr>
<td></td>
<td>$\tilde{\pi}_t$</td>
<td>($-2.40$)</td>
</tr>
<tr>
<td></td>
<td>$\tilde{\pi}_{t+1}$</td>
<td>($0.91$)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ob.</th>
<th>120</th>
<th>Ob.</th>
<th>120</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R^2$</td>
<td>0.11</td>
<td>$R^2$</td>
<td>0.10</td>
</tr>
<tr>
<td>$F$-sta</td>
<td>1.27 (0.26)</td>
<td>$F$-sta</td>
<td>0.97 (0.47)</td>
</tr>
</tbody>
</table>

Notes: This table shows results for regressing a measure for revisions in risk premia on Greenbook and Blue Chip forecasts on real GDP growth rates and GDP inflation. The left panel reports explanatory power of Greenbook forecasts for risk premium revisions. The right panel regresses risk premium revisions on forecast differences between the Greenbook and the Blue Chip. Heteroskedasticity-consistent standard errors are reported in parentheses. $F$-statistics for testing the joint significance of regressors are reported together with the associated $p$-values (in parentheses). See also notes for Table 1 and 2.
Figure 2: Cumulative Responses of CPI Inflation to Futures Rate Surprises: Excluding Intermeeting Surprises

Notes: This graph presents cumulative responses of CPI inflation to a 25-basis-point futures rate surprise. Dashed lines show the bootstrapped 68% confidence interval. Data are monthly from 1990 to 2007. Surprises due to FOMC intermeeting actions are excluded.
Figure 3: Futures Rate Surprises and Information Differences between the Fed and the Market

Notes: The left graph plots futures rate surprises (in basis points) occurring in the middle quarter against forecast differences in the current-quarter real GDP growth rate between the Greenbook and the Bluechip. The right graph plots futures rate surprises that do not occur in the middle quarter against forecast differences in the current-quarter inflation. Least-square fits are shown in red lines.
Figure 4: Futures Rate Surprises and Forecast Differences in the Growth Rate

Notes: This scatter plot shows the relationship between futures rate surprises and differences in Greenbook and SPF forecasts for the current-quarter real GDP growth rate. Labeled observations are identified as influential. The red line is the least-square fitted line.
Figure 5: Futures Rate Surprises and Survey Forecast Errors

Notes: The bars present forecast errors on the target Fed funds rate from the Money Market Services survey (from the first FOMC scheduled meeting in 1993 to the second meeting in 1997) and Bloomberg survey (from the third FOMC scheduled meeting in 1997 to the last scheduled meeting in 2007). The superimposed line shows futures rate surprises.
Figure 6: Cumulative Responses of CPI Inflation to Purified Futures Rate Surprises

Notes: This graph presents responses of CPI inflation to futures rate surprises cleaned by removing the Fed’s and the market’s information according to (11). The solid line shows median responses to a 25-basis-point shock. The 68% confidence interval is shown by the dashed lines.