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BIASES IN MONETARY POLICY EXPECTATIONS EXTRACTED FROM FED FUNDS FUTURES AND SURVEYS

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BIASES IN MONETARY POLICY EXPECTATIONS EXTRACTED FROM FED FUNDS FUTURES AND SURVEYS [#]

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Abstract

The literature estimates the risk premia in the federal funds futures rates to extract market expectations of monetary policy by assuming that the forecast errors of the market expectations are zero on average, or that survey forecasts are good proxies for market expectations. These assumptions, however, may fail due to an unanticipated downtrend of the federal funds rate over the available sample or strategic behavior of survey respondents. Consequently, the two estimated premia under these assumptions may be biased upward and downward, respectively. We propose an alternative measure of premium, which has been negative on average since 2004.

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1. Introduction

The federal funds futures rate is the most popular market-based measure of monetary policy expectations in the United States. Figure 1 shows the futures rate curve on October 4th, 2006, when the federal funds target rate was 5.25 percent, to help understand how the futures rate is used by market participants. According to this figure, the futures rate curve reached 5.00 percent between April and May in 2007. Thus the futures curve was interpreted that the financial market expected the Fed to lower the target rate by 25bps, the typical unit of a target change, in around a half year. The market-based measure is monitored by the Fed as well, and is used to extract market views. For instance, on this same day (October 4th, 2006), Kohn (2006), Vice Chairman of the Federal Reserve Board, expressed his concern about the gap between the Fed's view and the market views reflected in the market-based measure.[1]

The literature, such as Krueger and Kuttner (1996), Kuttner (2001), Sack (2004), and Gürkaynack, Sack and Swanson (2007), shows that the federal funds futures rates are very useful in predicting the future federal funds rate. The literature also finds that the futures rate is positively biased relative to the *ex post* realized federal funds rate, or the average excess return of the futures rate is significantly positive. The literature attributes the bias to a risk premium, and reports that the estimated premium for 6-month-ahead futures contracts is around 25bps. If this premium is taken into account, the futures curve

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[1] Kohn said, in his speech, "I must admit I am surprised at how little market participants seem to share my sense that the uncertainties around these paths and their implications for the stance of policy are fairly sizable at this point, judging by the very low level of implied volatilities in the interest rate markets." He also said, in response to questions after the address, "You think it will take some decline in interest rates to make this forecast come true. I'm saying I don't know where interest rates need to go." These comments were interpreted as evidence for the gap between the Fed and the market participants. See *Bloomberg* (2006), for instance.

in Figure 1 implies that the Fed will lower the target rate by around 50bps in a half year, suggesting a larger gap between the Fed and market participants. Piazzesi and Swanson (2006) advance the literature and succeed in extracting the time-variation of risk premium by using regressions of the excess return of the futures rate, while the mean of their premium is basically identical to the estimated time-invariant premium in the previous studies. Thus, in this paper, the estimated premium using the excess return is called Piazzesi and Swanson's premium for convenience.

Piazzesi and Swanson's premium is estimated based on an assumption of rational expectations, according to which the forecast error of market expectation should be zero on average. This assumption, however, may not hold due to a declining trend of the federal funds rate over the available sample beginning in the late 1980s, when the federal funds futures market launched, as shown in Figure 2. This declining trend probably reflects a similar trend in inflation, and may not have been fully anticipated. We use survey forecasts to examine whether the declining trend was anticipated. Although surveys are observed less frequently and are less useful in obtaining timely information than are market-based measures such as the federal funds futures rates, surveys are not influenced by risk premia and thus investigation on the relationship between surveys and the futures rates helps in understanding market expectations and risk premia. We find that not only the futures rate but also the survey forecast are positively biased against the *ex post* realized funds rate. We presume that the bias of survey forecast is at least partially caused by the unanticipated decline in the funds rate. Under this presumption, Piazzesi and Swanson's premium, which is estimated assuming that the sample size is large enough for the average forecast errors of the market expectations to converge to zero, is biased upward.

This paper also investigates two other methods to estimate risk premium. The premia estimated using these methods are called original, and modified survey-based premia, respectively. The original survey-based risk premium, which is defined as the futures rate minus the corresponding survey forecast, is based on the assumption that the surveys are good proxies for market expectations. Such a premium is examined and used in Durham (2003), Peacock (2004), and Gameiro (2006). Durham finds that the average of the original survey-based risk premium is much smaller than the average Piazzesi and Swanson's premium. We attribute this large difference mainly to the upward bias of Piazzesi and Swanson's premium.

The difference may be attributable to the downward bias of the original survey-based risk premium as well. Our empirical result shows that the survey forecast is inertial, which may reflect irrational market expectations and/or the slow adjustment to true market expectations possibly due to the respondents' strategic behavior to manipulate reputations about their ability, as discussed in the literature such as Ehrbeck and Waldmann (1996) and Lamont (2002). The inertia may cause the survey forecasts to be higher than the true market expectations on average under the unanticipated declining trend of the federal funds rate, which results in the downward bias of the original survey-based premium. To overcome this limitation of the previous studies, we propose an alternative measure of risk premium, the modified survey-based risk premium, which controls the inertia of surveys with a partial adjustment model.

The original and the modified survey-based premia are calculated by implicitly assuming that the inertia of survey forecasts is fully due to irrational market expectations and a deviation from the true market expectations, respectively. These assumptions, however, are not mutually exclusive, and hence both may be playing roles in the inertia of surveys. Consequently, the true premium may stand between these two kinds of estimated survey-based premia. Both the original and the modified survey-based premia have tended to be around zero or negative since 2004. These low risk premia in the federal funds futures rates are coherent with the decline in term premium of long-term interest rates, and may mitigate the recent gap between the Fed and market views.[2]

The rest of this paper is organized as follows. Section 2 uses the survey forecasts to show that the declining trend in the federal funds rate has not been fully anticipated, which have generated an upward bias in Piazzesi and Swanson's risk premium. Section 3 discusses the relevance of the original survey-based risk premium, and proposes a new measure, the modified survey-based premium. Section 4 then investigates the properties of the various types of estimated risk premia presented in this paper. Section 5 concludes.

2. An Unanticipated Declining Trend of Interest Rate and Upward Bias of Piazzesi and Swanson's Risk Premium

Most studies in the literature estimate the risk premium in the federal funds futures rate under the assumption that the available sample size is large enough for the average forecast error of the market expectations to converge to zero. This section examines the forecasting error of survey forecast to show that the typical assumption in

[2] The long-term interest rates have not risen since 2004 even though the Fed had raised the policy target on the federal funds rate from 1% to 5.25% during 2004-06. The literature, such as Rudebusch, Swanson, and Wu (2006), argues that this observation is probably due to the decline in term premium. Bernanke (2006) discusses possible explanations for the declined premium, such as rapid economic growth in high-saving countries on the Pacific Rim.

estimating risk premia does not hold, and results in an upper bias of estimated premia.

The forecast errors of the futures rate and the survey forecast are defined as

$$e^f_{t\to t+n} = f_{t\to t+n} - r_{t+n}, \qquad (1)$$

$$e^s_{t\to t+n} = s_{t\to t+n} - r_{t+n}, \qquad (2)$$

where r_{t+n} denotes the *ex post* realized value of federal funds rate in period $t+n$, $f_{t\to t+n}$ denotes the federal funds futures rate quoted in period t and settled in period $t+n$, and $s_{t\to t+n}$ denotes a survey forecast of the funds rate in period $t+n$ conducted in period t. We use the Blue Chip Financial Forecasts (BCFF) of the federal funds rate as the survey forecast. Since the forecasted values in the BCFF are on a quarterly basis, our analyses focus on the quarterly data. The sample period is 1989:1Q-2006:4Q, which begins at around the launch of the federal funds futures transactions and is in line with the sample used in the literature. Additional details of the data are provided in Appendix. Note that the forecast errors (1) and (2) are defined as the predictors minus the realized forecasted variables, and have opposite signs to the typical definitions. The opposite sign, however, is convenient when we discuss the relationship between the forecast errors and the risk premia. In fact, the forecast error of the futures rate (1) is equivalent to the excess return for the buyer of the futures contract, as noted in Piazzesi and Swanson (2006).

We'll now examine the biases of the futures rate and the survey forecast. The bias of futures rate, in fact, is closely related to the risk premium, as seen below. The risk premium of the futures rate is defined as the futures rate minus the expected funds rate:

$$\theta_{t\to t+n} = f_{t\to t+n} - E_t r_{t+n} . \quad (3)$$

The forecast error of the futures rate, using (1) and (3), can be written as

$$e^f_{t\to t+n} = \theta_{t\to t+n} - \eta_{t\to t+n} , \quad (4)$$

where $\eta_{t\to t+n} = r_{t+n} - E_t r_{t+n}$ is the forecast error of the market expectations, which is not predictable from information known in period t under rational expectations. It follows, by taking unconditional means in (4), that

$$E[e^f_{t\to t+n}] = E[\theta_{t\to t+n}] - E[\eta_{t\to t+n}] . \quad (5)$$

Since $E[\eta_{t\to t+n}] = 0$ by definition, the mean premium $E[\theta_{t\to t+n}]$ is equal to the mean forecast error or the bias of the futures rate $E[e^f_{t\to t+n}]$, and can be estimated as the sample average of the forecast error $e^f_{t\to t+n}$, if we have sufficient samples.

We estimate the biases of not only the futures rate but also the survey forecast by regressing of the forecast errors on a constant,

$$e^i_{t\to t+n} = \alpha^i_n + \varepsilon^i_{t\to t+n} \quad (6)$$

for different time horizons of forecast, $n = 1$, 2, and 3 quarters. Here i stands for the predictor, f or s. The results of the regressions are reported in Table 1.

The futures rates are biased at 5 percent significance, and this result is consistent with the literature. For instance, our estimates of biases for 1 and 2 quarter futures rates, which are 13.1bps and 35.8bps, are close to Piazzesi and Swanson's (2006) estimates for 3 and 6 month rates, 10.5bps and 30.7bps, respectively.[3] Most of the literature attributes these biases solely to the risk premia.

However, Table 1 also shows that the survey forecasts are also biased at 10 percent significance with p-values of 5 to 8 percent, although the sizes of biases are smaller than those of the futures rates. The significant biases in the survey forecasts may be surprising since surveys should not be affected by risk premia. We attribute at least a part of the estimated biases of surveys to sample biases caused by the declining trend in the federal funds rate, following Kim and Orphanides (2005), who argue that the decline in a short-term interest rate throughout the 1990s is unlikely to have been fully anticipated.[4]

The unanticipated trend violates a typical assumption in estimating risk premium in the literature. That is, the available sample period beginning at the late 1980s, which is typically the case in the literature, is not long enough for the average forecast error of the market expectations to converge to zero. Consequently, the average forecast error of the federal funds futures rate is influenced not only by the risk premium but also by the

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[3] As another notable feature of Table 1, the bias and the root mean squared error of the futures rate sharply increase with the forecasting horizon. This result may reflect lower liquidity of the longer-term futures.

[4] Kim and Orphanides (2005) use the BCFF of 3-month T-bill yield to find that the survey is biased even at 1 percent significance level. They also refer to the inflation forecasts of FOMC members and business forecasters, and to the accounts by former FOMC members, and argue that a significant part of the disinflation experienced during the 1990s may have been unanticipated. That, in turn, suggests that a significant part of the decline in the short-term interest rate may have been unanticipated as well. These discussions support our conclusion that the survey of the federal funds rate is also biased, although the statistical tests show that the bias is significantly different from zero only at 10 percent.

sample bias. This means that the risk premium estimated to be equal to the average forecast error is biased upward.

3. Inefficiency of Survey Forecasts, Biases in Original Survey-based Risk Premia, and Modifications

The preceding section shows that not only the federal funds futures rate but also the survey forecast are biased upward against the *ex post* realized federal funds rate. This result implies that the declining trend of the funds rate has not been fully unanticipated and that the literature—which directly uses the average excess return as the risk premium of the futures—overestimates the true value. A natural way to remove the upward bias is to take the difference between the futures rate and the survey forecast. Assuming that the survey equals the market expectations, the difference no longer includes the bias in *ex post* forecast errors of market expectations. Durham (2003), Peacock (2004), and Gamerio (2006) calculate this type of premium which we call the original survey-based risk premium. To derive this premium, we calculate the futures rate minus the corresponding survey forecast as

$$\hat{\theta}_{t\to t+n} = f_{t\to t+n} - s_{t\to t+n} \,. \qquad (7)$$

This is obtained from the definition of risk premium (3) by assuming the market expectation equals the survey forecast, i.e. $E_t r_{t+n} = s_{t\to t+n}$.

To test the above assumption, we examine whether the survey forecasts are efficient. The rejection of efficiency of the surveys suggests the failure of the assumption under rational expectations. In other words, this test can be interpreted as a joint test of rational expectation and the equality between the market expectation and the survey forecast. To conduct this test, we use the following two methods.

First, we test the efficiency by using an OLS regression of the forecast error on a constant and a predetermined business cycle indicator known in period t,

$$e^{s}_{t\to t+n} = \alpha_n + \beta_n X_t + \varepsilon^{s}_{t\to t+n} . \qquad (8)$$

If the coefficient of the business cycle indicator β_n is significantly different from zero, the forecast error is predictable and the survey is deemed inefficient. We use a year-on-year or a quarter-on-quarter annualized employment growth rate as the predetermined variable X_t for each regression.[5] Table 2 reports the slope coefficients, and shows that all of them are significantly negative and thus we conclude that the survey forecasts are inefficient.

Second, we use a partial adjustment model of the survey forecast as

$$s_{t\to t+n} = \rho_n s_{t-1\to t+n} + (1-\rho_n) E_t r_{t+n} , \qquad (9)$$

[5] Piazzesi and Swanson (2006) test the efficiency of the federal funds futures rate with a similar regression. They mainly use the year-on-year change in logarithm of U.S. nonfarm payroll employment as the predetermined variable, although many other variables are used to check the robustness. Since the nonfarm payroll numbers for a given month are not released until the first Friday of the following month, and revised after their initial release, Piazzesi and Swanson collect the real-time data and calculate the growth rate up to the previous month. Hamilton (2007) follows their method for his analysis on daily data. We also follow the method, although we use not only the year-on-year growth rate but also the quarter-on-quarter one, which is found to have a stronger correlation with estimated risk premia, as will be shown later.

where $0 \le \rho_n < 1$ denotes the measures of the degree of the inertia. According to (9), the current survey forecast $s_{t \to t+n}$ is expressed as a weighted average of the previous survey $s_{t-1 \to t+n}$ and the market expectation $E_t r_{t+n}$. If $\rho_n = 0$, $s_{t \to t+n} = E_t r_{t+n}$ holds and the survey forecasts are not influenced by previous surveys. Equation (9), using $\eta_{t \to t+n} \equiv r_{t+n} - E_t r_{t+n}$, can be rewritten as

$$r_{t+n} - s_{t \to t+n} = \frac{\rho_n}{1-\rho_n}(s_{t \to t+n} - s_{t-1 \to t+n}) + \eta_{t \to t+n}. \tag{10}$$

Thus, under rational expectations, it is testable whether the degree of the inertia ρ_n is nonzero by using a regression,

$$r_{t+n} - s_{t \to t+n} = \beta_n (s_{t \to t+n} - s_{t-1 \to t+n}) + \eta_{t \to t+n}, \tag{11}$$

with a null hypothesis $\beta_n = \rho_n / (1-\rho_n) = 0$. Note that a constant term is not included in the regression, since the forecast error $\eta_{t \to t+n}$ should be unbiased at least *ex ante*. Thus if the estimated forecast error is biased, we interpret the bias as caused by the unanticipated declining trend of the federal funds rate. We conducted the regressions for $n = 1, 2$.

Table 3 shows that β_n, i.e. ρ_n, is significantly positive, which implies the slow adjustment of the survey forecast to the rational expectation.[6] We confirmed the stability

[6] Nordhaus (1987) uses a similar regression to find that one-step-ahead professional forecasts for

of ρ_n by several methods including CUSUM test.[7] Note that the implied value of ρ_2 is larger than that of ρ_1. This suggests that the survey forecasts are more inertial when the forecasting horizons are longer, which may imply that the respondents of the survey are less willing to revise their forecasts the longer the time is until the results of the forecasts are revealed.

Both tests show that the survey forecasts are inefficient and irrational. A possible interpretation for the rejection of efficiency is that the surveys are equal to market expectations, as assumed to calculate the original survey-based risk premium, but they are irrational. Another interpretation is that the market expectations are rational, but the survey forecasts deviate from the market expectations. These interpretations, in fact, are not mutually exclusive and hence, both may be contributing toward the inefficiency.

The deviation of the survey forecasts from the market expectations may be caused by the strategic behavior of survey respondents facing payoff structures that provide incentives to produce forecasts that do not minimize forecast errors. This strategic behavior is called rational cheating and is investigated in the literature. For instance, Ehrbeck and Waldmann (1996) develop a model in which less-able professional forecasters may rationally choose to change their forecasts by a smaller amount than the change in their beliefs, if able forecasters do not have to change their forecasts by large amount, since their forecasts are more accurate. This mimicking strategy by the less-able

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some macroeconomic variables are anchored to the previous month's two step ahead forecast.

[7] We also conducted a more general version of regression (11), allowing β_n to depend on an implied volatility of the Eurodollar futures option, to examine whether higher uncertainty causes faster or slower convergence of the survey forecasts to the rational expectation. The regression results showed that the influence of the implied volatility is not statistically significant, and support the stability of ρ_n.

forecasters contributes to concealing their inferior skill and to keeping the relationship with their clients, the users of forecasts. Lamont (2002) discusses several theories of rational cheating, and provides anecdotal examples of strategies such as always forecasting the same extreme event, which might contribute to drawing attention and to gaining credibility in the unlikely event that the forecast turns out to be accurate. Campbell and Sharpe (2007) examine the responses of interest rates to economic news and find that market participants anticipated inertial behavior in surveys, which may suggest that the market expectations are more efficient than the surveys.

If the inefficiency of the survey forecasts is fully attributable to irrational market expectations, and if the surveys are good proxies of the expectations, the original survey-based risk premium is a relevant measure. On the other hand, suppose that the inefficiency of the survey forecasts is fully caused by a deviation from rational market expectations; we can then modify the survey-based premium by taking into account the slow adjustment of surveys using the partial adjustment model. In the model, the market expectation can be written as

$$E_t r_{t+n} = s_{t\to t+n} + \frac{\rho_n}{1-\rho_n}(s_{t\to t+n} - s_{t-1\to t+n}), \qquad (12)$$

which is obtained by rearranging (9). The first term on the right-hand side of (12) is the survey forecast itself, and the second term corresponds to the inertia of surveys. That is, the observed revision in the survey $s_{t\to t+n} - s_{t-1\to t+n}$ should be interpreted as reflecting a larger change in the market expectation, because the survey replies can only be revised slowly. The modified survey-based risk premium can be calculated using the market expectation obtained by (12) instead of the survey itself as

$$\tilde{\theta}_{t \to t+n} = f_{t \to t+n} - \left[s_{t \to t+n} + \frac{\rho_n}{1-\rho_n}(s_{t \to t+n} - s_{t-1 \to t+n}) \right]. \tag{13}$$

As mentioned above, the original and the modified survey-based premia are calculated by implicitly assuming that the inefficiency of surveys is fully due to irrational market expectations or to deviation from the true market expectations, respectively. In fact, these two assumptions are not mutually exclusive; hence the inefficiency is probably caused by both reasons. In this case, the true premium may stand between the original and the modified survey-based premia.

4. Properties of the Three Types of Estimated Risk Premia

The preceding section examines the original and the modified survey-based risk premia, and suggests that the true premium probably stands between them. This section investigates their properties in comparison with those of Piazzesi and Swanson's (2006), which implicitly assume that market expectations are rational and the available sample is enough for the average forecast errors of the market expectations to converge to zero.

Piazzesi and Swanson (2006) find that the forecast error or the excess return of the federal funds futures rate is related to business cycle indicators such as employment growth rate using a regression. For instance:

$$e^{f}_{t\to t+n} = \alpha + \beta f_{t\to t+n} + \gamma l_t + \varepsilon_{t\to t+n} \qquad (14)$$

where l_t is the year-on-year change in logarithm of U.S. nonfarm payroll employment. They interpret the relations to be caused by the business-cycle-related risk premium. Based on the interpretation, they consider the fitted value of the regression (14) as the time-varying risk premium. Their method, however, is subject to the following two limitations. First, since the regression (14) includes a constant term, their method implicitly assumes zero average *ex-post* forecast error of the market expectation, which is against the evidence shown in Section 3. Therefore their premium is biased upward on average, as already discussed. Second, the literature, such as Rudebusch, Swanson, and Wu (2006), finds that the decline in term premium has contributed to keeping long-term interest rates stable since 2004 despite the successive hikes of the policy rate; this decline in premium cannot be explained by macroeconomic factors, including employment. If this is the case, the relationship between the premium in federal funds futures rate and business cycle indicators may have weakened as well.

Table 4 reports the averages of the original and the modified survey-based premia, which are calculated using equations (7) and (13), in comparison with the average of Piazzesi and Swanson's premium, the fitted value of regression (14). Although all estimates are significantly positive, their magnitudes are totally different. The table shows that the original and the modified survey-based premia are smaller than Piazzesi and Swanson's premium on average. This result suggests that if the true risk premium stands between the original and the modified survey-based premia, the mean premium estimated—using the average excess return of the federal funds futures rate—is overestimated, since the unanticipated decline in the federal funds rate over the period is included in the realized excess return.

The unanticipated declining trend also may play a role in the downward bias of the original survey-based premium, because the delayed adjustment of the survey under such a situation may keep the survey forecast $s_{t\to t+n}$ higher than the true expectation $E_t r_{t+n}$ on average. As already discussed, the difference between the original and modified survey-based premia is the second term in the right-hand side of (12),

$$\hat{\theta}_{t\to t+n} - \tilde{\theta}_{t\to t+n} = \frac{\rho_n}{1-\rho_n}(s_{t\to t+n} - s_{t-1\to t+n}) . \tag{15}$$

Since the revision of the survey $s_{t\to t+n} - s_{t-1\to t+n}$ is negative on average with the unanticipated declining trend of the federal funds rate, the original survey-based premium $\hat{\theta}_{t\to t+n}$ tends to be lower than the modified one $\tilde{\theta}_{t\to t+n}$.

Figure 3 shows the time-variations of the original and the modified survey-based premia in comparison with that of Piazzesi and Swanson's premium. The modified survey-based premium is clearly countercyclical. The premium jumped during the two recessions in our sample, 1990-91 and 2001, and also rose in early 1995 and autumn of 1998, which were not recessions but periods with slower economic growth. Piazzesi and Swanson's premium is also countercyclical, which is natural since they estimate the premium using a business cycle indicator, namely employment growth rate. On the other hand, the original survey-based premium is smoother, and does not seem to have a cyclicality. To confirm these observations, we regress the estimated premia on a constant and an employment growth rate. Table 5 reports the estimates for slope coefficients with the standard errors, and supports our view that only the original survey-based premium is not countercyclical.

Figure 3 also shows that both survey-based risk premia have tended to be around zero or negative since 2004, while the corresponding Piazzesi and Swanson's premium has risen due mainly to consecutive rises in the federal funds rate. The low survey-based premia imply that the risk premium in the federal funds futures rate has declined as in long-term interest rates. Figure 4 reports the residuals of the regressions of the survey-based premia on a constant and an employment growth rate, whose slope coefficients are reported in Table 5. The figure shows that the residuals have declined in recent years, which supports our view that the risk premium has declined even though the macroeconomic condition has recovered. Thus the risk premia estimated—those that depend only on macroeconomic variables such as those estimated by Piazzesi and Swanson (2006)—may be biased upward.

5. Conclusion

The literature estimates and investigates the risk premia in the federal funds futures rates in order to extract the market expectations regarding monetary policy. In conducting this exercise, many papers assume that the available data are enough for the average forecast errors of the market expectations to converge to zero, while some others assume that the survey forecasts are good proxies of the market expectations. A representative study based on the former assumption is Piazzesi and Swanson (2006), while the estimated premium based on the latter assumption is the original survey-based risk premium. Our empirical analyses and discussion referring to the literature such as Kim and Orphanides (2005) and Campbell and Sharpe (2007) do not support these assumptions. We then propose an alternative, the modified survey-based premium, which does not depend on these assumptions, and argue that the true premium probably stands between the original and the modified survey-based premia. After comparing the three kinds of estimated premia, we conclude that the premia estimated in the literature have following limitations.

Piazzesi and Swanson's premium is biased upward on average, since the declining trend in the federal funds rate over the available sample has not been fully anticipated, which is against the assumption of the zero-average realized forecast error of the market expectation. In addition, since their premium is related only to observable macroeconomic variables and does not reflect the recent decline in the risk premium, the upward bias of their premium may have worsened recently.

The original survey-based premium may be biased downward on average, if some part of the inertia of the survey forecasts is influenced by a deviation from the true market expectations. The inertia of surveys may tend to cause the underestimation of premium under the declining trend of the funds rate, because the inertia may keep the surveys higher than the true expectation. As another property, the original survey-based premium is not related to the business cycle. This property may cause the estimated premium to be too high under good economic conditions, such as since 2004.

On the other hand, the modified survey-based premium is the most relevant measure of risk premium, if the survey forecasts deviate from the rational market expectation because of some reasons such as strategic behavior of survey respondents. The modified survey-based premium is lower than Piazzesi and Swanson's, but higher than the original survey-based premium. The modified premium is also clearly countercyclical as Piazzesi and Swanson's.

If the true risk premium stands between the original and the modified survey-based premia, the mean risk premium of the 2-quarter federal funds futures rate is between 12.8 and 22.8bps, which is around a half of Piazzesi and Swanson's premium, 35.7bps. The true risk premium may have been around zero or negative since 2004, which implies that the risk premium in the federal funds futures rate has declined recently. Thus, without taking this decline into account, the extracted expectation of monetary policy rate is probably biased to the lower side.

Appendix: Notes on the Data Used in This Paper

This appendix describes the detailed specification of the data set used for the three key variables: r_t, the federal funds rate in period t; $f_{t\to t+n}$, the federal funds futures rate quoted in period t and settled in period $t+n$; and $s_{t\to t+n}$, a survey forecast of the funds rate in period $t+n$ conducted in period t.

We use the Blue Chip Financial Forecasts (BCFF) of the federal funds rate as the survey forecast. Since the forecasted values in the BCFF are on a quarterly basis, our analyses focus on the quarterly data. The short-term rate r_t is calculated as the average of the daily funds rates for quarter t, while the futures rate $f_{t\to t+n}$ is calculated as the average of three federal funds futures rates settled at months within the quarter $t+n$. We use the futures rates and survey forecasts only in February, May, August, and November that predict the next three quarters, which are chosen so that the average forecasting horizons are around 1, 2, or 3 quarters. As noted in Kim and Orphanides (2005), the BCFF is published on the first day of next month and presents forecasts from a survey conducted during two consecutive days one to two weeks earlier, although the precise date of the survey varies and is not generally noted in the publication. We thus regard the surveys as if they are conducted on the date seven business days earlier than the date of publication, and sample the futures rates on the same date in order to analyze on a consistent basis.[8] For instance, $f_{t\to t+2}$ in 2006:Q1 is calculated as the average of three

[8] Kim and Orphanides (2005) use weekly yield data sampled on Wednesdays, and treat the surveys as if they are conducted on the Wednesdays closest to the date seven business days earlier than the date of the data release. Kim and Orphanides regard the survey for December as conducted on even earlier Wednesdays, since the survey is prepared before Christmas. We need not be annoyed by the

federal funds futures rates settled in July, August, and September, and contracted on February 20th. The forecasting performance is compared with that of the BCFF survey conducted in February and predicting the funds rate in 2006:Q3.

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exceptional data, since we do not use the data for December.

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Table 1: Forecasting Biases of the Futures and Surveys

	1Q		2Q		3Q	
	Futures	Survey	Futures	Survey	Futures	Survey
α_n^i	13.1**	9.7*	35.7**	22.6*	78.9**	38.7*
(s.e.)	(4.8)	(5.0)	(12.7)	(12.3)	(30.1)	(20.7)
RMSE	27.5	30.3	63.9	62.5	140.0	97.8

Note: This table reports the estimated coefficients and RMSEs (measured in basis points) for the regressions of the forecast errors of the futures rate or the survey forecast on a constant. The time horizons of forecasts are 1, 2, and 3 quarters, and the sample period is 1989:1Q-2006:4Q. Standard errors are calculated with the Newey-West estimator and reported in parentheses. The coefficients with * and ** denote significance at 10% and 5%, respectively.

Table 2: Test of the Efficiency of Surveys Using the Forecast Errors

	1Q	2Q	3Q
Employment (Y/Y)	-0.08**	-0.18**	-0.30**
(s.e.)	(0.03)	(0.07)	(0.10)
Employment (Q/Q)	-0.07**	-0.19**	-0.31**
(s.e.)	(0.02)	(0.04)	(0.07)

Note: This table reports the estimates of slope coefficients for regressions of the forecast errors of survey forecast on a constant and a business cycle indicator: year-on-year or quarter-on-quarter annualized growth rate of employment (% per annum), which is computed using real-time vintage data. The time horizons of forecasts are 1, 2, and 3 quarters, and the sample period is 1989:1Q-2006:4Q. Standard errors are calculated with the Newey-West estimator and reported in parentheses. The coefficients with * and ** denote significance at 10% and 5%, respectively.

Table 3: Estimation Result of the Partial Adjustment Model

	1Q	2Q
β_n	0.26**	0.66**
(s.e.)	(0.07)	(0.14)
$\rho_n = \beta_n/(1+\beta_n)$	0.20	0.40
RMSE	29.6	57.0

Note: This table reports the estimates and RMSEs (measured in basis points) for regressions of the forecast errors of surveys on the changes in the survey forecasts as shown in equation (8). The table also reports the implied values of the degrees of inertia of surveys ρ_n. The time horizons of forecasts are 1 and 2 quarters, and the sample period is 1989:1Q-2006:4Q. Standard errors are calculated with the Newey-West estimator and reported in parentheses. The coefficients with * and ** denote significance at 10% and 5%, respectively.

Table 4: Estimates of the Mean Risk Premia

	1Q	2Q
Piazzesi and Swanson's premium	13.1**	35.7**
(s.e.)	(3.1)	(9.6)
Original survey-based premium	3.4**	12.8**
(s.e.)	(1.4)	(3.9)
Modified survey-based premium	6.3**	22.8**
(s.e.)	(2.1)	(6.2)

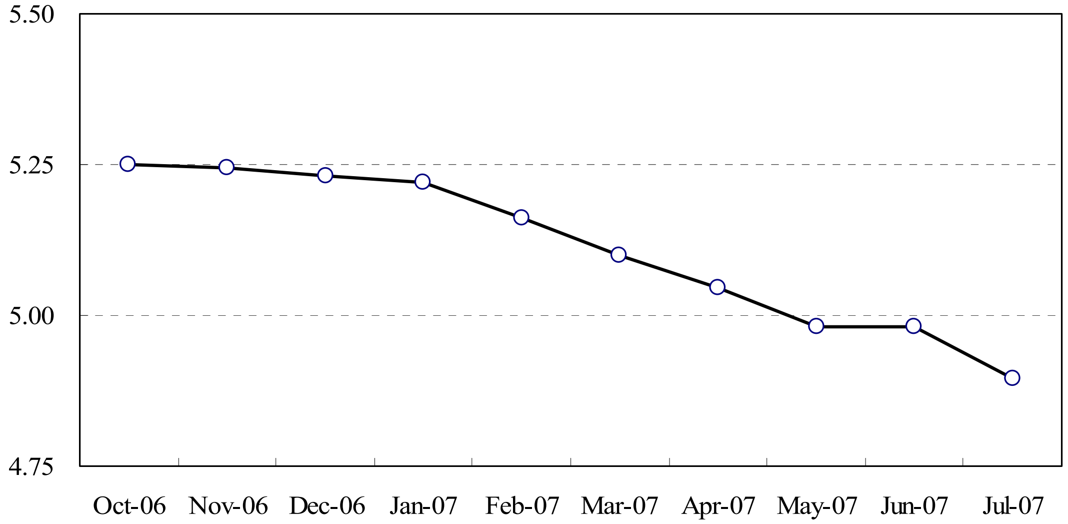
Note: This table reports the mean risk premia (measured in basis points) estimated by the method proposed by Piazzesi and Swanson (2006), which is basically identical to averaging the excess return of the federal funds futures rate, and the original and modified survey-based premia, which are calculated using equations (7) and (13). The time horizons of forecasts are 1 and 2 quarters, and the sample period is 1989:1Q-2006:4Q. Standard errors are calculated with the Newey-West estimator and reported in parentheses. The coefficients with * and ** denote significance at 10% and 5%, respectively.

Table 5: Relationship between the Estimated Premia and Business Cycle Indicators

	1Q			2Q		
	PS	Original	Modified	PS	Original	Modified
Employment (Y/Y)	-0.06**	0.01	-0.04**	-0.11	0.07**	-0.09**
(s.e.)	(0.03)	(0.01)	(0.02)	(0.09)	(0.02)	(0.04)
Employment (Q/Q)	-0.06**	0.01	-0.05**	-0.12*	0.03	-0.12**
(s.e.)	(0.02)	(0.01)	(0.01)	(0.06)	(0.03)	(0.03)

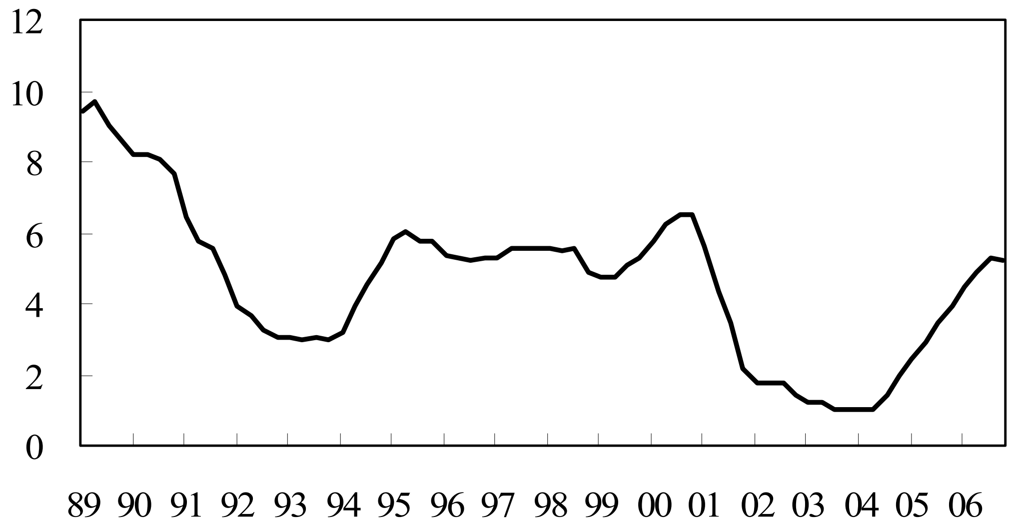
Note: This table reports the estimates of slope coefficients for regressions of three estimated risk premia on a constant and the year-on-year or quarter-on-quarter annualized growth rate of employment, which is computed using real-time vintage data. “PS”, “Original”, and “Modified” denote the premium estimated using the method proposed by Piazzesi and Swanson (2006) and calculated using regression (14), and the original and the modified survey-based risk premia which are calculated using equations (7) and (13). The time horizons of forecasts are 1 and 2 quarters, and the sample period is 1989:1Q-2006:4Q. Standard errors are calculated with the Newey-West estimator and reported in parentheses. The coefficients with * and ** denote significance at 10% and 5%, respectively.

Figure 1: Federal Funds Futures Rate on Oct. 4, 2006



Note: This figure reports the federal funds futures rates (percent per annum) contracted on October 4, 2006, and the horizontal axis represents settlement months.

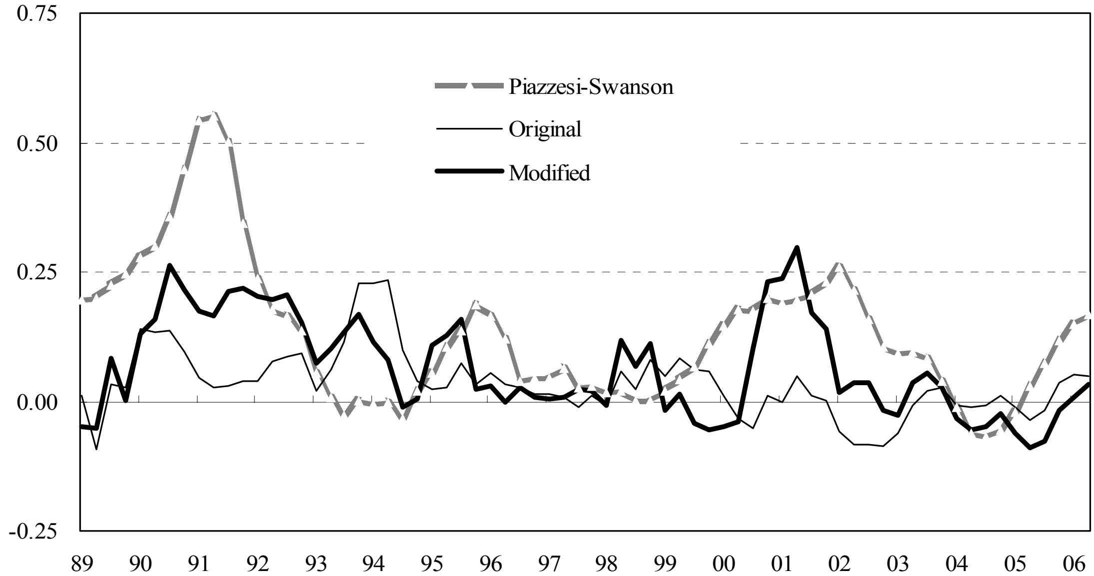
Figure 2: Federal Funds Rate



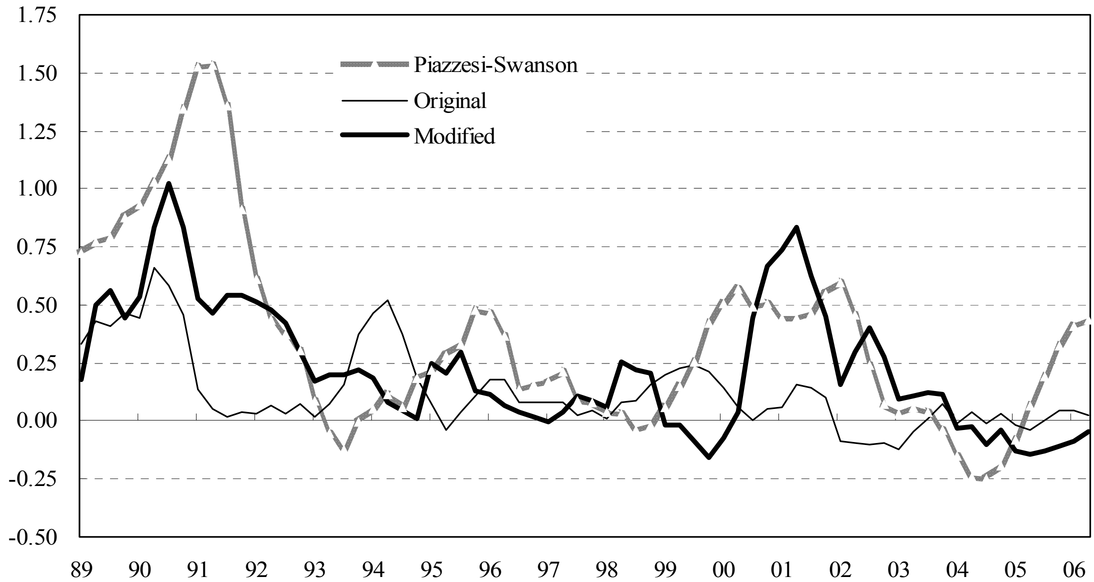
Note: This figure reports quarterly averages of effective federal funds rate (percent per annum).

Figure 3: Comparison of the Estimated Risk Premia

(a) Risk premia for the one-quarter rate



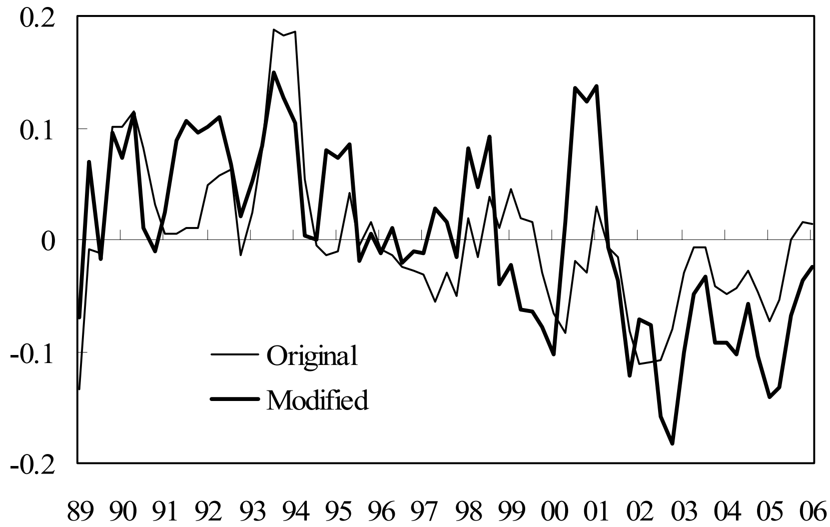
(b) Risk premia for the two-quarter rate



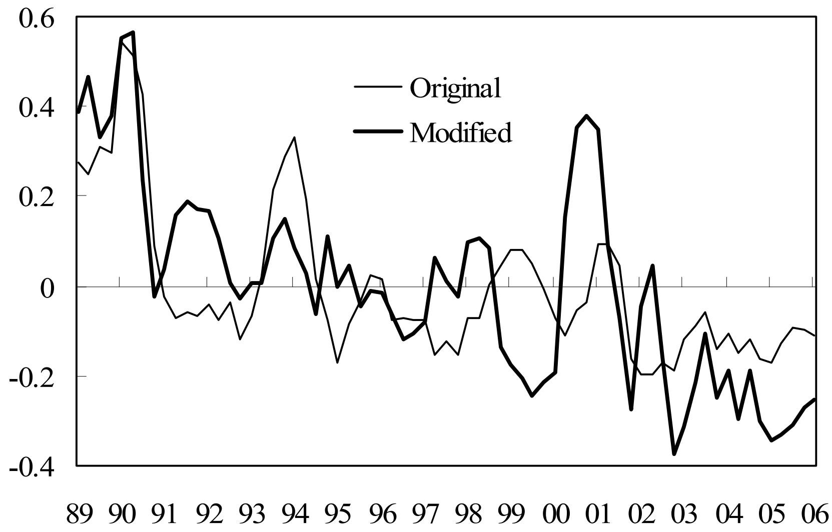
Note: Panel (a) and (b) report the three quarter moving averages of the three estimated premia (percent per annum) for the 1 and 2 quarter rates, respectively. The grey broken line corresponds to the fitted value for a regression of the excess return of futures rate on a constant, the futures rate, and an employment growth rate, which is computed using real-time vintage data, as proposed by Piazzesi and Swanson (2006). The thin line corresponds to the original survey-based risk premium, which is defined as the futures rate minus the survey forecast. The fat line corresponds to the modified survey-based risk premium, which modifies the original one by controlling the inertia of the survey forecast.

Figure 4: Non Business Related Components of the Survey-based Risk Premia

(a) One-quarter rate



(b) Two-quarter rate



Note: The figure reports three quarter moving averages for the residuals for regressions of the original and modified survey-based risk premia on a constant and the quarter-on-quarter growth rate of employment. Panels (a) and (b) report them for 1 and 2 quarter rates, respectively.