Predicting monetary policy using federal funds futures prices*

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Abstract

In theory, prices of current-month federal funds futures contracts should reflect market expectations of near-term movements in the Federal Reserve's target level for the federal funds rate. However, empirical results show that such measures of market expectations are too noisy to predict day-to-day changes in the funds rate target; partly due to time aggregation problems, partly because they are affected by funds rate movements not directly related to monetary policy considerations. In particular, the futures market shows a large amount of systematic variation across months and trading days, variation that needs to be taken into account when predicting policy moves or extracting policy expectations. For the period from January 1994 to February 1998, the extracted expectations perform fairly well in predicting the target level that will prevail after the next meeting of the Federal Open Market Committee, especially when adjusting for market regularities.

Keywords: Market expectations of monetary policy, The Federal Reserve, The Federal Open Market Committee.

JEL Classification: E58, G13, G14.

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1 Introduction

Since their introduction in October 1988, prices of federal funds futures contracts have become very popular as a simple way of measuring market expectations about the future path of monetary policy and trying to predict future policy moves. Since these contracts are based on the monthly average of the federal funds rate, which is the main policy instrument of the Federal Reserve, efficient futures markets should set prices to reflect the expected path of Fed policy. The usefulness of federal funds futures contracts in predicting monetary policy moves one to three months ahead has been demonstrated by, for example, Carlson et al. (1995), Krueger and Kuttner (1996), Robertson and Thornton (1997), and Rudebusch (1998).

Existing studies have concentrated on using monthly averages or end-of-the-month observations on futures contracts of one to three months' maturity to predict policy moves on that horizon. However, in contrast to many other futures contracts, federal funds futures are also traded during the contract month, when past observations of the funds rate are known. Therefore it should be possible to extract even more precise market expectations about the average funds rate for the rest of the current contract month. Since the federal funds rate on average follows the target set by the Federal Reserve, such measures could be interpreted as the expected average of the federal funds rate target for the remaining days of the month, and, in particular on the day before a meeting of the Federal Open Market Committee from 1994 onwards, as the level of the funds rate target expected to prevail after the meeting, since policy moves after 1994 have been made almost exclusively at FOMC meetings.[1]

The purpose of this paper is to examine the use of current-month futures prices to measure monetary policy expectations in the very short run (over the period from the next day to the end of the month, when the contract matures). This is done for the period from the introduction of the futures contracts in October 1988 until March 1998. The main question to examine is whether the expected funds rate series calculated from the futures prices is a good predictor of near-term movements in the target level for the federal funds rate.

It turns out that the extracted expectations perform very poorly when predicting day-to-day changes in the federal funds rate target; partly because the market may have been expecting a policy move later in the month, partly because of noise coming from the federal funds cash market and other regularities. Nevertheless,

[1]See Pakko and Wheelock (1996) for such an exercise over the period from 1994 to 1996.

expectations from the day before meetings of the Federal Open Market Committee in the period from 1994 to 1998 are quite successful in predicting the target level which will prevail after the meeting. Even on those occasions, however, the funds rate expectations display some systematic variation across trading days and calendar months. The first of these regularities can be ascribed to the behavior of the actual federal funds rate, which tends to increase on the last days of each month, possibly due to banks engaging in balance sheet 'window dressing.' The second regularity is more puzzling, since no corresponding movement in the federal funds cash market can be observed, although it could be due to increases in the perceived riskiness of futures contracts in these months.

Adjusting for the monthly variation of the expected funds rate series, its predictive value improves dramatically. In an out-of-sample test, the extracted expectations are shown to have predicted the target change in September 1998 very well, and they also improve on expectations taken from the financial press.

As a final exercise, using average monthly futures data to predict the average funds rate and funds rate target one to three months ahead (following, e.g., Carlson et al., 1995, and Krueger and Kuttner, 1996), the monthly variation in futures prices remains. Consequently, these regularities of the futures market are an important factor to take into account when extracting market expectations or predicting policy moves.

The paper proceeds as follows. In Section 2, the federal funds futures market and the extraction of funds rate expectations from futures prices is described, and the relation between the federal funds futures and cash markets is discussed. Section 3 presents the empirical results from predicting the funds rate target using the expected funds rate series obtained in the previous section, and Section 4 presents some alternative tests of the estimates, by using a case study of the policy move of September 1998, and by comparing the estimates with market expectations from the financial press. Finally, after briefly considering average monthly data in Section 5, Section 6 concludes.

2 The federal funds futures market

2.1 The futures contract

The 30-day federal funds futures contract, traded on the Chicago Board of Trade since October 3, 1988, calls for delivery of the interest paid on a principal amount of $5 million in overnight federal funds held for the contract month. The settlement price is calculated as 100 minus the average effective federal funds rate for the contract month, and at maturity, the contract is cash-settled against the monthly average of daily effective federal funds rates, including weekends and holidays, as calculated and reported each business day by the Federal Reserve Bank of New York.[2]

Thus a buyer of a federal funds futures contract will pay (or receive from) the seller an amount corresponding to the interest on $5 million held for the contract month, with the interest rate determined by the difference between the average funds rate for the month and the futures rate negotiated at the trade. Instead of paying the entire sum at maturity, the contract is marked-to-market daily, so payments are made each day as the futures price changes, using a constant tick size of $41.67 (one hundredth of a percent of $5 million over one month). If during a trading day the futures price falls by two basis points (e.g., from 94.53 to 94.51, so that the implied funds rate increases from 5.47% to 5.49%), the buyer pays the seller $2 \times \$41.67 = \$83.34$ per contract. In total, a buyer of a futures contract at a price of 95.50 will, if the futures price settles at 95.00, have paid the seller $50 \times 41.67 = \$2,083.50$ at maturity, equal to the difference between a 5% and a 4.50% interest on $5 million held for 30 days.[3]

As with most futures markets, the federal funds futures market is mainly used by two groups of traders: hedgers and speculators. To see how the futures market can be used for hedging purposes, consider the following example, adapted from the Chicago Board of Trade (1997b). A bank consistently buying $75 million per month in federal funds is worried that the funds rate will increase from the current rate of 5.25%. By selling 15 futures contracts ($15 \times \$5$ million $= \$75$ million), any losses incurred from increases in the funds rate will be offset by gains from the futures position. If the price of the futures contracts is 94.75, implying an expected funds rate of 5.25%, and the average funds rate for the contract month subsequently increases to 5.45%, the monthly interest expense on $75 million is $5.45\% \times 30/360 \times \$75$ million $= \$340,625$. At the same time, however, if the futures price has converged to 94.55 at maturity,[4] the bank gains $15 \times 20 \times \$41.67 = \$12,501$, so the net cost is $328,124, implying an effective cost of funds of 5.25%.

In contrast to the federal funds cash market, which is open only to those depos-

[2] The effective federal funds rate is a weighted average of the rates on those overnight federal funds transactions arranged through New York brokers.

[3] See the Chicago Board of Trade (1997a) for details.

[4] Carlson et al. (1995) show that the futures price does converge to the average funds rate at maturity.

itory institutions required to hold reserves with Federal Reserve Banks (Goodfriend and Whelpley, 1993), the federal funds futures market is open to anyone who can satisfy margin requirements (Carlson et al., 1995). Thus, traders and 'Fed watchers' can use futures contracts to speculate on the future path of the federal funds rate. In the example above, a Fed watcher expecting the funds rate to increase from 5.25% to 5.45% when the futures contract sells for 94.75, could, by selling a number of contracts, make a profit of $20 \times \$41.67 = \$833.40$ per contract as the futures price falls to 94.55.

Such speculation should drive the futures price to the level consistent with market participants' expectations of the average federal funds rate, plus a hedging premium as speculators must be compensated for bearing the risk of hedgers. Since the federal funds rate is closely monitored by the Federal Reserve, and used as their primary policy tool, expected shifts in the monetary policy stance should therefore be priced into the futures market. Consequently, the prices of futures contracts can be used to estimate the expected path of monetary policy over the near future.

An important feature of federal funds futures contracts is that they are traded also during the contract month, to offer more flexible management of interest rate exposure (Chicago Board of Trade, 1997a). During this month, past observations of the funds rate are publicly known, so efficient futures markets should adjust prices to reflect the observed path of the funds rate. Thus, the price of the current-month futures contract contains information about the expected path of the funds rate for the rest of the month, information that should get more precise as the contract gets closer to maturity. Therefore, while most existing studies have used average monthly futures prices to predict coming policy moves, using current-month contracts is a promising way of predicting policy moves in the very near-term future.

2.2 Extracting market expectations from futures prices

Since the futures settlement price is calculated as 100 minus the average effective federal funds rate for the contract month, the implied futures rate at day t for the mth month ahead, $i^f_{m,t}$, is given by

$$i^f_{m,t} = 100 - p^f_{m,t}, \tag{1}$$

where $p^f_{m,t}$ is the price at day t of a futures contract maturing m months from now. For coming months, the implied futures rate is simply equal to the expected average effective funds rate for the contract month, so

$$i^f_{m,t} = \sum_{\tau=1}^{n_m} \frac{1}{n_m} E_t i^{ff}_{m,\tau}, \tag{2}$$

where $i^{ff}_{m,\tau}$ is the effective funds rate on day τ in the mth month from now, and n_m is the number of days in the mth month, including weekends and holidays.

For the current month, market participants have observed the effective funds rate up to the previous trading day (the effective funds rate for a trading day is calculated by the Federal Reserve Bank of New York and published on the following morning), so the expected average funds rate for the entire contract month can be divided into two parts: the observed rates so far in the month and the expected rates for the remaining days. Thus,

$$i^f_t = \frac{1}{n}\left[\sum_{\tau=1}^{t-1} i^{ff}_\tau + \sum_{\tau=t}^{n} E_t i^{ff}_\tau\right], \tag{3}$$

where the month subscript m has been skipped for the current month. Defining i^a_{t-1} as the average funds rate up to day $t-1$ in the month,

$$i^a_{t-1} = \frac{1}{t-1}\sum_{\tau=1}^{t-1} i^{ff}_\tau \tag{4}$$

and i^e_t as the average expected funds rate for the rest of the month, including day t,

$$i^e_t = \frac{1}{n-t+1}\sum_{\tau=t}^{n} E_t i^{ff}_\tau, \tag{5}$$

we can express the current-month futures rate as

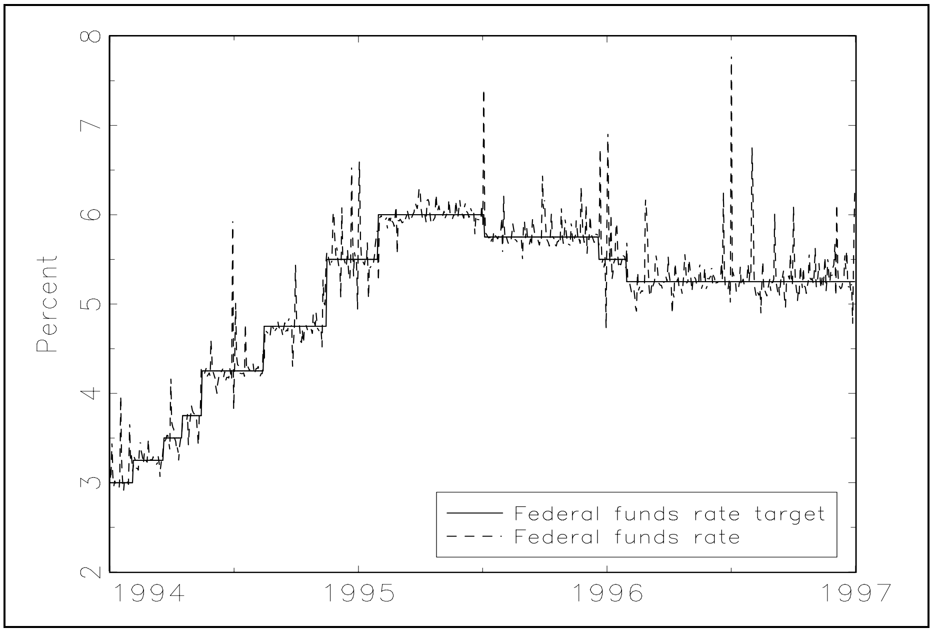
$$i^f_t = \frac{1}{n}\left[(t-1)i^a_{t-1} + (n-t+1)i^e_t\right]. \tag{6}$$

Then it is straightforward to solve for the expected average funds rate for the rest of the month as

$$i^e_t = \frac{n i^f_t - (t-1)i^a_{t-1}}{n-t+1}. \tag{7}$$

Strictly interpreted, the calculated i^e_t is the expected average effective federal funds rate from day t until the end of the current month. Since the Federal Reserve uses the federal funds rate as its primary policy instrument by setting a target for the funds rate and performing open market operations to steer is towards the target level, the average funds rate could be interpreted as a measure of the current monetary policy stance. The expected average funds rate is then a measure of the expected path of monetary policy for the rest of the month. Since 1994 the Federal Reserve has adjusted its policy stance almost exclusively directly after a meeting of its main policy body, the Federal Open Market Committee (FOMC), and the funds

Figure 1: Federal funds rate and funds rate target, 1994–96



rate target has never been changed twice during the same month. Consequently, during this period, on the day preceding an FOMC meeting, the expected average funds rate for the rest of the month can be interpreted as a measure of the funds rate target expected to prevail after the meeting.[5]

2.3 Relation to the federal funds cash market

Although the federal funds rate in the long run is largely determined by movements in the Federal Reserve's funds rate target, in the short run there may be significant deviations between the funds rate and the target, seen as temporary by the Fed and therefore not offset through open market operations. Figure 1 shows the funds rate target and the daily effective funds rate for the period from 1994 to 1996. As can be seen, the funds rate tends to fluctuate around the target, occasionally with large deviations, but in the long run it always returns to the target level. Some of these movements in the funds rate are due to Federal Reserve regulations of depository institutions, and as such are predictable, while other movements are more difficult to predict in advance.

The method used by the Fed to compute and maintain the reserves kept by

[5]Interpreting the extracted series as the expected funds rate (target) from the next day on also relieves the identification problem inherent in the series. Given a measure of the average funds rate expected to prevail over a certain period of time, one cannot separately identify the expected magnitude and the expected timing of a monetary policy move. See Robertson and Thornton (1997) for details.

depository institutions has been demonstrated to lead to predictable movements in the funds rate (see, e.g., Griffiths and Winters, 1995; Hamilton, 1996; Ho and Saunders, 1985; Saunders and Urich, 1988; and Spindt and Hoffmeister, 1988). Under the current system of reserve accounting, required reserves are computed as fractions of daily average deposit levels, which are computed over a two-week period beginning every other Tuesday (Meulendyke, 1998, p. 71ff). Daily average reserves must then be close to computed required reserves over a two-week period (the reserve maintenance period) beginning two days after the start of the reserve computation period. Thus not until the last two days of the reserve maintenance period do banks know the exact level of reserves they need to satisfy, so there is much volatility on the reserves (or federal funds) market on the last days of the period, especially on the very last day, the so-called settlement Wednesday. Since the Federal Reserve has a hard time trying to predict the demand for reserves in the market around the end of the reserve maintenance period, large movements in the federal funds rate are common on these days.

Another phenomenon affecting the fed funds market is the so-called balance sheet 'window dressing.' At the end of each quarter and year, banks (and other corporations) have their balance sheets evaluated by regulators and investors. Therefore, bank managers may have incentives to 'window dress' their balance sheets before reporting the data, that is, to undertake temporary asset and liability transactions to manipulate the accounting values around the report date. Allen and Saunders (1992) find strong evidence of systematic upward window dressing adjustment on the last day of each quarter over the period from 1978 to 1986. Such window dressing is often conducted using federal funds, both on the asset and on the liability side, since these provide low transaction cost financing. Therefore, if window dressing is important among federal funds market participants, and if such behavior is difficult to predict by the Federal Reserve, the federal funds rate should be expected to exhibit more volatility around the end of each quarter.

Movements in the federal funds rate such as these, if they affect the average monthly funds rate, will tend to introduce noise into the estimates of the expected funds rate target acquired from the futures market, since they affect futures prices but are not related to actual policy adjustments of the Federal Reserve. After examining how well the expectations derived from the futures market predict movements in the funds rate target, the following section will try to evaluate the importance of such noise.

3 Empirical results

Given the daily estimates of the expected average federal funds rate for the rest of the month, it is time to see how well these predict movements in the Federal Reserve's target level for the funds rate. The Fed conducts monetary policy by affecting the cost of federal funds via open market operations, and although the specific targeting procedure has changed somewhat over the sample period, the actual procedure of the Fed for the entire sample has been one of effective funds rate targeting (Meulendyke, 1998).

Daily data on federal funds futures prices, volumes, and open interest (the number of outstanding contracts) were obtained from the Chicago Board of Trade; data on the effective federal funds rate were downloaded from the FRED database of the Federal Reserve Bank of St. Louis;[6] and data on the federal funds rate target are from Rudebusch (1995) for 1988–92 and the Federal Reserve Bank of New York for 1993–98. The sample period used is from the introduction of federal funds futures on October 3, 1988, to March 6, 1998.

3.1 Predicting the funds rate target

To see how well the deviation of the calculated expected funds rate from target predicts the actual target change on the next day, the following regression is estimated:

$$\Delta i_{t+1}^{T} = \alpha + \beta \left(i_t^e - i_t^T \right) + \varepsilon_{t+1}, \tag{8}$$

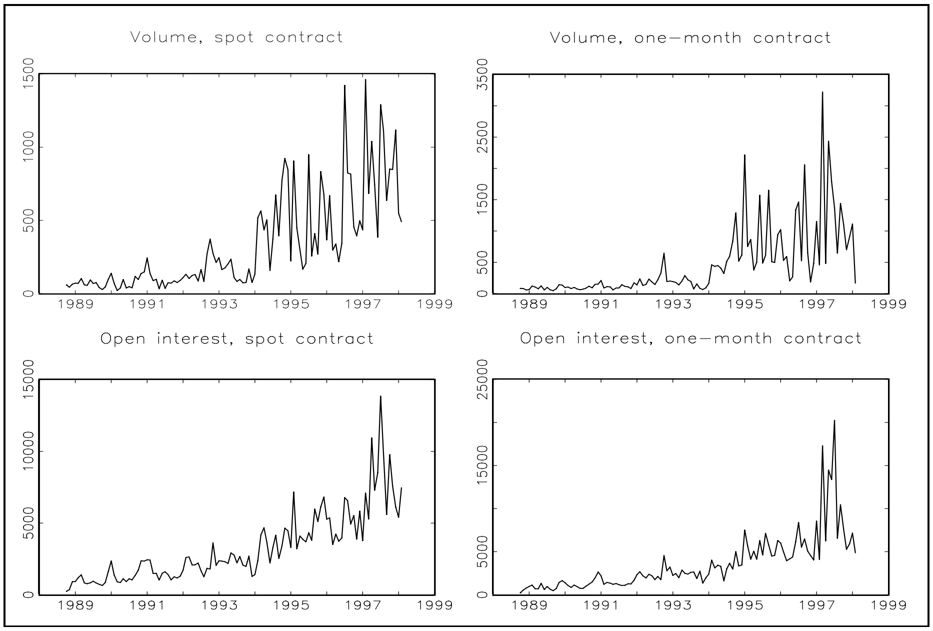
where $\Delta i_{t+1}^{T} = i_{t+1}^{T} - i_t^T$ is the change in the funds rate target from day t to day $t+1$, and i_t^e is the expected funds rate for the rest of the month, as given by equation (7) above.[7] In the case where expected funds rate deviations predict target changes well, we would expect the intercept α to be zero and the slope coefficient β to be close to unity.[8]

[6] *http://www.stls.frb.org/fred/*.

[7] On the last day of each month, the futures rate for the next month's contract is used as a measure of the expected funds rate. Also, I choose to subtract the current level of the target from both sides of equation (8) to control for the general level of the funds rate. An alternative would be to predict the level of the target using the level of the expected funds rate, which would tend to capture long-run movements in the target level. Since the focus here is on short-run movements, I choose to concentrate on the specification of equation (8).

[8] An estimate of β below unity could be interpreted as market participants not being perfectly informed about the Federal Reserve's policy motivations, but assigning a positive probability (although less than unity) to the possibility of a change. If market participants are completely ignorant about future policy moves, β should be close to zero, whereas $\beta = 1$ implies that markets

Figure 2: Volume and open interest on futures market, monthly averages of daily data



The estimation of equation (8) is done for the entire sample, and for two subsamples: 1988–93 and 1994–98. The separation into subsamples is done for several reasons. First, trading volumes in the futures market were rather small during the first years of the sample, but have since grown substantially. The upper graphs in Figure 2 show monthly averages of trading volume and the lower graphs show average open interest for the current-month (spot) contract and the one-month contract. From 1988 until 1993, both volume and open interest were fairly low, although steadily growing. From 1994 on, market activity increases significantly, but also becomes more volatile between months. Thus, there is reason to believe that the estimates from the late part of the sample are more reliable measures of market expectations than those from the early part of the sample.

Second, after being secretive about its policy decisions during the early part of the sample, when policy changes were more or less unpredictable, the Federal Reserve began announcing changes in the funds rate target at the February 1994 meeting of the FOMC, a procedure that was formalized in February 1995 (Thornton, 1996). Also, since 1994, it has been a deliberate policy of the FOMC to change

are perfectly informed (or always guess correctly) about future moves. Alternatively, if there are movements over time in the perceived risk of the futures contracts, we would expect the estimated coefficient for β to be biased downwards (see, e.g., Söderlind and Svensson, 1997).

the target almost exclusively at policy meetings.[9] As a consequence, 10 out of 11 target changes in the sample since 1994 have occurred on days of an FOMC meeting.[10] Furthermore, along with the move towards less secrecy in monetary policymaking, financial market participants have become better informed about the Fed's motivations, and nowadays eagerly await the next meeting of the FOMC amid vivid speculation about the probability of a change in the policy stance.

A related third reason to concentrate on the 1994–98 period is the lack of consensus about the number or exact dates of target changes in the early part of the sample. Although the series of target changes compiled by Rudebusch (1995) is often used for similar purposes, some authors (e.g., Roley and Sellon, 1996) argue that some of the target changes reported by Rudebusch do not correspond to actual decisions to change policy. However, Ellingsen and Söderström (1998) show, from reading newspaper reports in the *Wall Street Journal*, that market participants did notice some of these alleged non-changes in policy. On the other hand, Ellingsen and Söderström also show that on two occasions (January 8 and October 30, 1991) market participants noticed the policy change on the day preceding that reported by Rudebusch. Also, in the early part of the sample (from 1988 to 1990), ten of the policy changes were not noticed by market participants.

The results from estimating equation (8) with ordinary least squares[11] on the 2,376 daily observations from October 3, 1988, to March 6, 1998, are presented in panel (a) of Table 1. Since the expected funds rate series measures the expected funds rate for the rest of the month, and the sample interval is daily, we are likely to have serial correlation in the error term. Therefore, standard errors are adjusted following Newey and West (1987), using 20 lags (the maximum number of overlapping observations). Apparently, the expected funds rate performs very poorly in predicting changes in the funds rate target on a daily basis; both adjusted R^2 and the slope coefficient are virtually zero. The results for the two subsamples are not much different, although the fit is slightly better for the period from 1994 to 1998. That daily prediction of policy moves is not successful should not come as a surprise, since the actual funds rate target was changed only 47 times during the sample pe-

[9] This procedure was adopted after committee members complained to Chairman Greenspan that they were not fully part of the policy decisions (Beckner, 1996, p. 348). That this policy is still very much in effect can be seen from the financial market turmoil following the unexpected policy move in between meetings on October 15, 1998.

[10] The exception is April 18, 1994.

[11] Attempts to capture the probability of target changes through probit modeling were not very successful, since the futures expectations are very noisy, see below.

Table 1: Predicting target changes using the expected funds rate

Sample	Intercept	Slope	$\bar{R}^2$	Observations
(*a*) *All trading days*				
1988–98	−0.004**	0.038**	0.019	2,376
	(0.001)	(0.013)		
1988–93	−0.006**	0.025*	0.011	1,326
	(0.001)	(0.010)		
1994–98	−0.004*	0.090*	0.054	1,050
	(0.002)	(0.036)		
(*b*) *Target changes*				
1988–98	−0.132**	0.607**†	0.331	47
	(0.031)	(0.204)		
1988–93	−0.176**	0.379**	0.246	36
	(0.031)	(0.119)		
1994–98	−0.119	1.433**	0.734	11
	(0.073)	(0.144)		
(*c*) *FOMC meetings*				
1988–98	−0.025*	0.478**	0.287	75
	(0.012)	(0.173)		
1988–93	−0.012	0.081	0.095	42
	(0.010)	(0.076)		
1994–98	−0.069**	0.869**‡	0.460	33
	(0.026)	(0.238)		

OLS estimation of equation (8) on various samples of daily data from October 3, 1988, to March 6, 1998. Newey-West (1987) standard errors with (*a*) 20, (*b*) 3, and (*c*) 0 lags in parentheses. **/* denote coefficient significantly different from zero at the 1%-/5%-level, ‡/† denote coefficient *not* significantly different from 1 at the 10%-/5%-level.

riod of 2,376 observations, and the expected funds rate series is affected by other things than the funds rate target, and thus moves around day by day. Also, if the market expects a policy adjustment later in the month, these expectations will be priced into the futures market, but not captured by the estimation of equation (8).

Instead, a more interesting test is to see how well the funds rate deviation predicts target changes on certain occasions, when the noise from other funds rate movements is dominated by monetary policy expectations. In panels (*b*) and (*c*) of Table 1, equation (8) is estimated for two groups of observations, when the market might have been able to foresee target changes: all actual target changes, and meetings of the FOMC.[12]

[12] In the regressions of panels (*b*) and (*c*), standard errors are adjusted using 3 and 0 lags, respectively.

Panel (b) shows the results for all days of actual target changes. Now the expected funds rate deviation from target performs fairly well in predicting policy moves. Adjusted R^2 is 0.331 for the entire sample, 0.246 for the first part, and 0.734 for the second subsample, which is surprisingly high, although slope coefficients are not very close to unity (only the coefficient for the entire sample is *not* significantly different from unity).

Predicting actual target changes may seem rather *ad hoc*, however, since these dates are not known to market participants *ex ante*, especially during the early subsample. Instead panel (c) shows the results from predicting the target after each FOMC meeting. This is especially interesting for the late subsample from 1994 to 1998, since, as mentioned above, during this period, the focus when predicting target changes has shifted almost entirely towards these meetings. For the whole sample, adjusted R^2 is 0.287, and the slope coefficient is 0.478, which is well below unity. This result is completely dominated by the late subsample, however. For the early period, the expected funds rate deviation contains virtually no information about future target changes: adjusted R^2 is 0.095, and the slope coefficient is not even significantly different from zero. For the late subsample, on the other hand, $\bar{R}^2$ is 0.460, and the slope coefficient is 0.869, which is not significantly different from unity at the 10%-level (the marginal significance level of the χ^2-statistic is 0.581).

That the period 1994–98 performs so well is encouraging, and the results for the period 1988–93 are not very surprising. During this period, the target was changed 36 times, but only once (on June 6, 1989) at an FOMC meeting. Thus, the meetings did not attract much attention from people predicting immediate target changes; in fact, they were not very different from any other day. Since the beginning of 1994, the focus is completely concentrated on the policy meetings, so that the market is more successful in predicting the direction of policy moves around these days.

3.2 Other movements in the expected funds rate series

As is obvious from the first regression reported in Table 1, there is a lot of movement in the expected funds rate series that is not related to changes in the funds rate target, and presumably reflects something other than expectations of target changes. From the discussion of Section 2.3 and from Figure 1, it is clear that the funds rate does not follow the target very closely in the short run, and deviations of the funds rate from target could possibly be ascribed to predictable factors such as reserve accounting and balance sheet window dressing. Insofar as these movements in the funds rate affect the average funds rate for the rest of the month, they should also

Table 2: Mean deviation of actual and expected funds rate from target

Sample	Actual funds rate		Expected funds rate	
	Mean deviation	Mean absolute deviation	Mean deviation	Mean absolute deviation
All days				
1988–98	0.0573	0.1361	0.0729	0.0949
1988–93	0.0708	0.1473	0.0783	0.1101
1994–98	0.0404	0.1220	0.0660	0.0757
FOMC meetings				
1988–98	0.0465	0.1383	0.0816	0.1179
1988–93	0.0712	0.1218	0.0751	0.1082
1994–98	0.0152	0.1594	0.0899	0.1303

Means and means of absolute values of $(i_t^{ff} - i_t^T)$ and $(i_t^e - i_{t+1}^T)$ over subsamples of daily data from October 3, 1988, to March 6, 1998.

have an effect on the expected funds rate estimates.

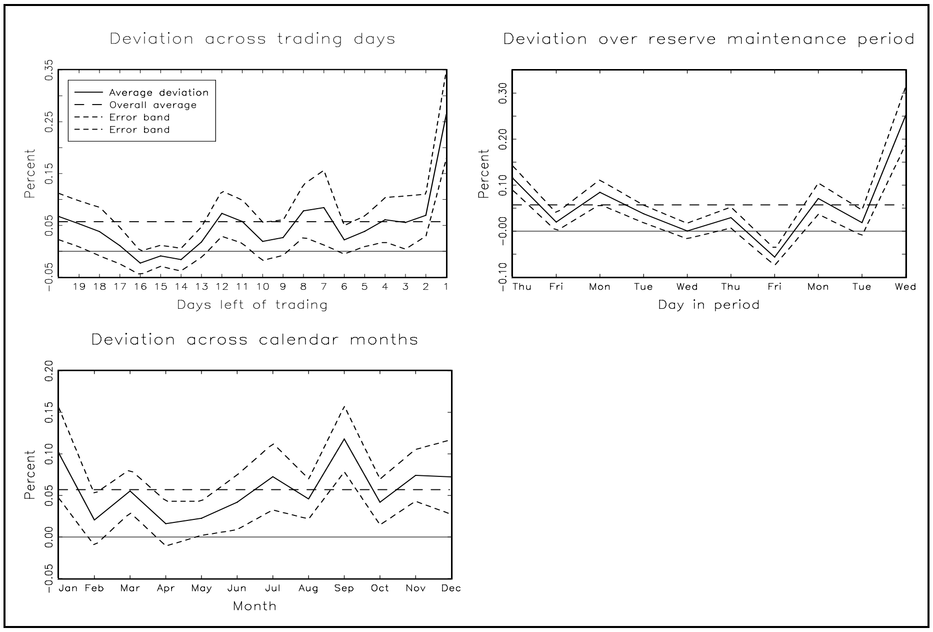
Table 2 shows the mean deviation and the mean absolute deviation of the actual and the expected funds rate from the funds rate target. As can be seen, both the actual and the expected funds rate are above target on average; on all days the actual funds rate is on average 4–7 basis points above target and the expected funds rate is 6–8 basis points above, depending on the sample period. The expected funds rate deviation is smaller for the second part of the sample, indicating that the measures of market expectations are more reliable for this period, and/or that market participants were better informed about the Fed's policy motivations. On days with FOMC meetings, the mean deviation is not very different from that on regular trading days.

To get an idea of the relative importance of the different regularities for the deviation of the actual and the expected funds rate from target, I calculate the mean deviation and its standard error across groups by estimating a simple dummy regression for each potential regularity. For example, to analyze the actual funds rate deviation from target across trading days, I estimate

$$i_t^{ff} - i_t^T = \sum_{j=1}^{20} \alpha_j d_j^D + \varepsilon_t, \tag{9}$$

where d_j^D is a dummy for the trading day j days before maturity. Similar regressions are estimated across the days of the reserve maintenance period and across calendar months, both for the deviation of the actual funds rate from target and for the deviation of the expected funds rate from next day's target.

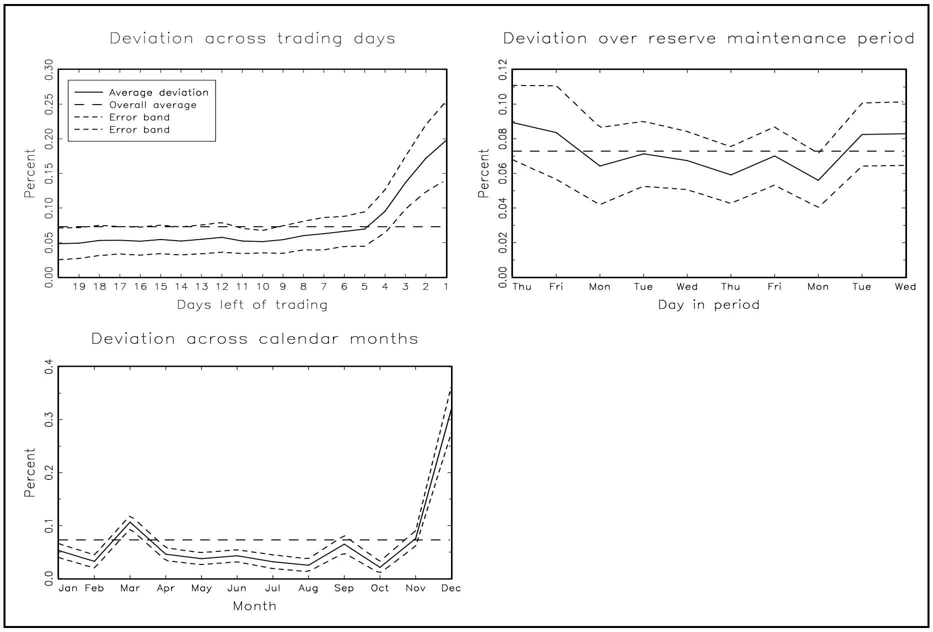
Figure 3: Average deviation of federal funds rate from target



Figures 3 and 4 show the estimated means with 5% confidence intervals (±1.96 standard errors) for the actual and the expected deviation from target, along with the overall mean for the entire sample. As is clear from Figure 3, the actual funds rate deviation from target varies substantially across trading days and over the reserve maintenance period. On the last day of trading, the funds rate is on average 26 basis points above target, whereas the overall average deviation is only 6 basis points. This behavior is probably due to balance sheet window dressing, as described by Allen and Saunders (1992). Likewise, on settlement Wednesdays, the funds rate deviation is on average considerably larger than on other days (25 basis points), confirming the results of, for example, Griffiths and Winters (1995) and Hamilton (1996). Also across months there is some variation, for example, in September the deviation is typically larger than in other months, but this variation is less significant statistically, judging from the wide confidence intervals.

To the extent that these regularities on the federal funds cash market affect the average funds rate for the rest of the month, they should also, if they are predictable, affect the expected funds rate series. As can be seen from Figure 4, there is a lot of variation in the expected funds rate's deviation from target, especially across trading days and calendar months. The average deviation of the expected funds rate from target increases steadily as the month passes, and reaches 20 basis points on the last trading day of the month, since the increase of the actual funds rate on the last days of the month becomes increasingly important for the average as

Figure 4: Average deviation of expected funds rate from next day's target



the number of trading days left falls. Across the reserve maintenance period, there is less variation, and confidence intervals are very wide, which is not surprising, since the funds rate variation across the reserve maintenance period is unlikely to systematically affect the monthly average funds rate. Most surprising is the variation of the expected funds rate deviation across calendar months, since there seems to be no corresponding variation in the actual funds rate. The expected funds rate is on average 32 basis points above target in December, as compared to 7.3 basis points overall.

To get an idea of the reasons behind the monthly regularities, Table 3 shows the average daily change and the squared change (as a measure of volatility) in the effective funds rate across months. Here we see that there is considerably more volatility in the funds rate in January, July, and December than in other months, indicating that the monthly regularities in the futures market are likely to be derived from movements in the risk premium of futures contracts.

3.3 Extended predictions

Can the regularities documented in the previous section be used to improve on the policy predictions? As suggested by Figure 4, the important regularities to take into account when using the expected funds rate series to predict monetary policy moves are across calendar months and trading days. Therefore, these are included in the

Table 3: Average daily change and volatility of federal funds rate

Month	Change	Volatility	Month	Change	Volatility
January	0.0247	0.2241	July	−0.0220	0.1728
February	0.0004	0.0766	August	−0.0082	0.0414
March	0.0084	0.0530	September	0.0233	0.1116
April	−0.0060	0.0600	October	−0.0133	0.0551
May	0.0058	0.0306	November	−0.0063	0.0923
June	0.0205	0.0671	December	−0.0233	0.1505

Monthly averages of $(i_t^{ff} - i_{t-1}^{ff})$ and $(i_t^{ff} - i_{t-1}^{ff})^2$ over 2,393 daily observations from October 3, 1988, to March 31, 1998.

prediction regression (8), so I estimate[13]

$$\Delta i_{t+1}^T = \beta \left(i_t^e - i_t^T \right) + \sum_{j=1}^{12} \gamma_j d_j^M + \sum_{j=1}^{3} \delta_j d_j^D + \nu_{t+1}, \tag{10}$$

where d_j^M is the intercept dummy for calendar month j and d_j^D is the dummy for the trading day j days from maturity. Thus intercepts are allowed to vary across months and across the last three days of trading in each month.

The results from estimating equation (10), first on all trading days and then on the dates of FOMC meetings from 1994 to 1998, are presented in Table 4. Columns (*i*)–(*iii*) show the results for all trading days in the sample, and columns (*iv*) and (*v*) those for FOMC meetings in the late subsample. The first column in each group—(*i*) and (*iv*)—repeats the results from Table 1, where the systematic variation over months and trading days is not taken into account. The second column—(*ii*) and (*v*)—shows the results when including only monthly dummies, and the third column for the daily observations (*iii*) shows the results when also including trading day dummies.[14]

For the regressions including all 2,376 observations in columns (*i*)–(*iii*), intercepts vary considerably across months, from around 0.3 basis points in February to around −2.5 in December, regardless of whether or not we also adjust for trading days. The intercepts are smallest (and significantly negative) in June, July, September, and December, where consequently the expected funds rate deviation from target is unusually large relative to the actual target change. On the last three

[13]Several different configurations of interaction dummies were tested, but never proved significant.

[14]Since only two FOMC meetings (January 31, 1996, and September 30, 1997) were held on the last day of the month, and none on the second or third to last day, trading day dummies are not included when predicting the target level after policy meetings. Also, since only one FOMC meeting was held in January, it is excluded from the sample of the regression in column (*v*).

Table 4: Predicting target changes, including intercept dummies

	All days			FOMC meetings	
	(*i*)	(*ii*)	(*iii*)	(*iv*)	(*v*)
Slope	0.0384**	0.0583**	0.0661**	0.8686**‡	0.9820**‡
	(0.0129)	(0.0148)	(0.0161)	(0.2380)	(0.1508)
Intercept	−0.0039**			−0.0691**	
	(0.0009)			(0.0264)	
January		−0.0042*	−0.0033		
		(0.0020)	(0.0019)		
February		0.0030	0.0042		0.0357
		(0.0046)	(0.0047)		(0.0326)
March		−0.0051	−0.0046		−0.1026
		(0.0027)	(0.0028)		(0.0540)
April		−0.0039	−0.0029		
		(0.0024)	(0.0023)		
May		0.0006	0.0016		−0.0014
		(0.0019)	(0.0019)		(0.0463)
June		−0.0037**	−0.0027*		
		(0.0013)	(0.0012)		
July		−0.0093**	−0.0081**		−0.1107**
		(0.0028)	(0.0029)		(0.0384)
August		−0.0006	0.0005		0.0308
		(0.0024)	(0.0025)		(0.0394)
September		−0.0064**	−0.0055*		−0.2473**
		(0.0022)	(0.0021)		(0.0859)
October		−0.0040*	−0.0028		
		(0.0017)	(0.0016)		
November		−0.0038	−0.0030		0.0174
		(0.0033)	(0.0034)		(0.0475)
December		−0.0248**	−0.0259**		−0.2295**
		(0.0057)	(0.0058)		(0.0461)
Last			−0.0127**		
			(0.0040)		
2nd last			−0.0084**		
			(0.0030)		
3rd last			−0.0072		
			(0.0037)		
$\bar{R}^2$	0.0194	0.0359	0.0408	0.4600	0.7062
Observations	2,376	2,376	2,376	33	32

OLS estimation of equation (10) on 2,376 daily observations from October 3, 1988, to March 6, 1998, and 33 FOMC meeting dates from January 1994 to February 1998, respectively (meeting of January 31, 1996, excluded in regression (*v*)). Newey-West (1987) standard errors with 20 and 0 lags, respectively, in parentheses. **/* denote coefficient significantly different from 0 at the 1%-/5%-level, ‡/† denote coefficient *not* significantly different from 1 at the 10%-/5%-level.

days of trading in column (*iii*), the intercepts fall further, by 0.7, 0.8, and 1.3 basis points, respectively, where the latter two effects are significant.

Predicting target changes after the next day's meeting of the FOMC in the late part of the sample is also more successful when taking market regularities into account, as seen in column (*v*). The intercept again varies across months, and considerably more than for the whole sample, with July, September, and December being strongly negative, and significantly different from zero. In September and December the intercept is around -25 basis points, which is considerably more than the average intercept of -7 points in column (*iv*). Introducing the monthly dummies increases the slope coefficient from 0.87 to 0.98, neither of which can be statistically separated from unity at the 10%-level, and adjusted R^2 increases from 0.46 to 0.71.

Consequently, variation across months and trading days is important on the futures market, and taking the regularities into account substantially improves the predictions of the target to prevail after the next FOMC meeting.

4 Additional tests

Although the expected funds rate series has been demonstrated to give a good prediction of the target level that will prevail after FOMC meetings from 1994 to 1998, especially when taking the systematic monthly variation into account, it is less clear how useful the estimates are for specific occasions. The results from Table 4 indicate that there is a large amount of time variation in the predictions, so the uncertainty is still large. Therefore this section presents two alternative tests of the estimates of market expectations extracted from futures prices. First, the policy move of September 29, 1998, is examined to see how the model performs out-of-sample. Second, the estimates are compared to market expectations of policy moves taken from the *Financial Times* on the day preceding each FOMC meeting from January 1994 to February 1998.

4.1 September 29, 1998

On September 29, 1998, the Federal Open Market Committee announced that it had decided to "ease the stance of monetary policy slightly, expecting the federal funds rate to decline 1/4 percentage point to around 5-1/4 percent" (Federal Reserve Board, 1998). This change in the target level for the federal funds rate had been widely expected by market participants, after several hints by Chairman Alan Greenspan and by William McDonough, President of the Federal Reserve Bank of

New York and Vice Chairman of the FOMC. Discussion in the financial press and among Fed watchers circled around whether the cut would be 25 or 50 basis points, rather than whether there would be a cut at all.

On September 28, the September futures contract closed at 94.505 and the October contract at 94.820. The average level of the effective funds rate from September 1 to September 27 had been 5.49%, so the spot futures rate of 5.495% implies that the expected average funds rate for the rest of the month was

$$
\begin{aligned}
i_t^e &= \frac{n i_t^f - (t-1) i_{t-1}^a}{n-t+1} \\
&= \frac{30 \times 5.495 - 27 \times 5.49}{30 - 28 + 1} \\
&= 5.54\%,
\end{aligned} \tag{11}
$$

and the expected average funds rate for October was $100 - 94.820 = 5.18\%$.

Since the level of the funds rate target on September 28 was 5.50%, a quick look at the expected funds rate for the rest of the month would suggest that the market did not expect the target to be changed on September 29. On the other hand, since there was no FOMC meeting scheduled for October, looking at the one-month October contract would lead to the conclusion that the market expected a large rate cut of between 25 and 50 basis points at the September 29 meeting, or possibly a 25 point cut on September 29, followed by a second cut in October, in between meetings.[15]

To explain why the estimates from the spot contract and the one-month contract seem to contradict each other, we need to recall that futures prices tend to fall on the last trading days of each month, so the futures rate tends to increase, and that there are large variations across months.[16] Because of the small number of observations, we have no estimates of the effects on futures prices on the last days of the month, but we can adjust the estimate for the month of September. Using the results in column (v) of Table 4, a gap of 0.04% between the expected funds rate and the target level on the day before the September meeting implies an average expected target change of $-0.2473 + 0.9820 \times 0.04 = -0.2080\%$, which is close to the actual change of -0.25%, without adjusting for the end-of-month/-quarter effect, which

[15]Note that this last scenario is what actually happened: the FOMC decided to cut the funds rate target by 25 basis points on September 29, and then surprised markets with a second cut of 25 points on October 15.

[16]Note also that September is also the last month of the third quarter, so the results of Allen and Saunders (1992) lead us to predict large movements in the funds rate due to end-of-quarter window dressing by banks.

would probably have moved the estimate even closer to or beyond the actual target change.

Consequently, the example of the target change on September 29, 1998, illustrates very well how funds rate expectations extracted from the current month futures contract can be used to predict target changes. Taking the expectation directly does not capture the 'true' market expectation, but adjusting the estimate for the variation of futures pricing over calendar months we get very close to the actual target change, which was very well anticipated by market participants.[17]

4.2 Estimates from the financial press

As a second test of the market expectations extracted from futures prices, these are compared to expectations taken from the *Financial Times* on the day preceding each meeting of the Federal Open Market Committee from January 1994 to February 1998. On the day preceding an FOMC meeting, the financial press typically interviews a number of traders and analysts to see what outcome the market expects from the meeting. These reports have been collected from the *Financial Times* and processed to yield a measure of the expected target change for the 33 dates of FOMC meetings.

Table 5 reports the federal funds rate target before and after each meeting, the predicted target change from the futures data (both the simple measure and the measure adjusted for monthly variation in Table 4), and the data collected from the *Financial Times*. When collecting these data, a problem of calculating the average expectations from the newspaper reports arises. Typically the *Financial Times* reports a number of possible outcomes suggested by market participants, so a probability distribution must be assigned to these outcomes to calculate the average market expectation. Sometimes, such a distribution is given by poll results, but often it is necessary to assign a probability distribution by studying the newspaper report carefully. (The resulting probability distribution is reported in Table 5 as 'weights.') Consequently, an element of arbitrariness in the measurement of market expectations from the newspaper reports is inevitable.

[17] Although there was some 'hope' in the financial press for a 50 point cut in the funds rate target on September 29, and some talk afterwards of financial markets being disappointed with the small magnitude of the cut, many serious Fed watchers did not find such a large move likely. For example, Steven Beckner of *Market News International* wrote on September 28 that "the rate cut is likely to take the form of a 25 basis point reduction in the key funds rate... Some are calling for a larger rate cut of 50 basis points, but while not out of the question, it would be unusual for the Fed to make a change of this magnitude as its first move in a different direction..." (available at *http://www.economeister.com*).

Table 5: Actual and predicted target changes around FOMC meetings

Date	Old target	New target	Target change	Futures predictions		*Financial Times*		
				Simple	Adjusted	Range	Weights†	Average
940204	3.00	3.25	0.25	0.162	0.194	+0.25	100	+0.25
940322	3.25	3.50	0.25	0.295	0.188	+0.25/+0.50	75/25	+0.3125
940517	3.75*	4.25	0.50	0.361	0.353	+0.25	100	+0.25
940706	4.25	4.25	0.00	0.247	0.132	0	100	0.00
940816	4.25	4.75	0.50	0.345	0.370	+0.25/+0.50	50/50	+0.375
940927	4.75	4.75	0.00	0.246	−0.006	0/+0.25	50/50	+0.125
941115	4.75	5.50	0.75	0.588	0.594	+0.50	100	+0.50
941220	5.50	5.50	0.00	0.364	0.128	0/+0.25	75/25	+0.0625
950201	5.50	6.00	0.50	0.460	0.487	+0.50	100	+0.50
950328	6.00	6.00	0.00	0.112	0.007	0	100‡	0.00
950523	6.00	6.00	0.00	0.031	0.029	0	100	0.00
950706	6.00	5.75	−0.25	−0.161	−0.269	0/-0.25	50/50	−0.125
950822	5.75	5.75	0.00	−0.015	0.017	0	100	0.00
950926	5.75	5.75	0.00	0.040	−0.208	0/-0.25	75/25	−0.0625
951115	5.75	5.75	0.00	−0.034	−0.016	0	100	0.00
951219	5.75	5.50	−0.25	0.001	−0.228	0	100	0.00
960131	5.50	5.25	−0.25	0.198	NA	0/-0.25/-0.50	25/50/25	−0.25
960326	5.25	5.25	0.00	0.242	0.135	0	100	0.00
960521	5.25	5.25	0.00	0.011	0.010	0	100	0.00
960703	5.25	5.25	0.00	0.060	−0.052	0/+0.25	75/25	+0.0625
960820	5.25	5.25	0.00	0.052	0.082	0	100‡	0.00
960924	5.25	5.25	0.00	0.186	−0.064	0/+0.25/+0.50	44/48/8‡	+0.16
961113	5.25	5.25	0.00	0.066	0.083	0/-0.25	90/10	−0.025
961217	5.25	5.25	0.00	0.148	−0.084	0	100	0.00
970205	5.25	5.25	0.00	0.031	0.066	0	100	0.00
970325	5.25	5.50	0.25	0.278	0.170	0/+0.25/+0.50	10/80/10	+0.25
970520	5.50	5.50	0.00	0.111	0.108	0/+0.25	54/46‡	+0.115
970702	5.50	5.50	0.00	0.050	−0.062	0	100	0.00
970819	5.50	5.50	0.00	0.001	0.032	0	100	0.00
970930	5.50	5.50	0.00	0.535	0.278	0	100	0.00
971112	5.50	5.50	0.00	0.072	0.088	0	100	0.00
971216	5.50	5.50	0.00	0.167	−0.065	0	100	0.00
980204	5.50	5.50	0.00	−0.034	0.002	0	100	0.00

*Target changed 940418 from 3.50 to 3.75. †Author's subjective estimate, unless marked by ‡, when based on poll results reported in the *Financial Times*. Observation of 960131 excluded from calculation of adjusted expected funds rate, see Table 4. Sources: Rudebusch (1995), Federal Reserve Bank of New York, Federal Reserve Bank of St. Louis, *Financial Times*, own calculations.

Also, market participants in the poll are well aware that the Fed typically changes its target for the funds rate in steps of 25 or 50 basis points, if at all, and they take this discrete character of monetary policy changes into account. The resulting expectations are often of no change in the target, and on only one occasion (December 19, 1995) was a zero expectation followed by a change in the target, so that market participants were completely caught off guard. The sign of target changes is always correctly predicted, and only twice (May 17 and November 15, 1994) did the actual target change fall outside the range of market predictions, these changes being unusually large (50 and 75 basis points, respectively).

The question is whether the expectations from the financial press perform better than those extracted from the futures market when predicting monetary policy moves at FOMC meetings. And additionally, do the futures estimates improve on the expectations from the newspaper reports?

The first of these questions is answered by estimating the same simple regression as before (equation (8)), using the expected target change from the *Financial Times*, $i_t^{FT} - i_t^T$, as the independent variable;

$$\Delta i_{t+1}^T = \alpha + \beta \left(i_t^{FT} - i_t^T \right) + \varepsilon_{t+1}. \tag{12}$$

The results are presented in Table 6, column (*ii*). For reference, column (*i*) repeats the results when using the expected target change from the futures market as the independent variable in equation (8). The *Financial Times* estimates clearly outperform the estimates from the futures market: adjusted R^2 is 0.832 compared with 0.460, when not adjusting for the monthly variation (including monthly dummies, the futures expectations reached an $\bar{R}^2$ of 0.706, see Table 4, column (*v*)). Thus the expectations from the financial press seem to be a better source of information if one is to predict the target level after the next day's FOMC meeting.

To see if the information in the financial press is completely superior to that on futures markets, I estimate the regressions

$$\Delta i_{t+1}^T = \alpha + \beta \left(i_t^{FT} - i_t^T \right) + \gamma \left(i_t^e - i_t^T \right) + \nu_{t+1} \tag{13}$$

and

$$\Delta i_{t+1}^T = \alpha + \beta \left(i_t^{FT} - i_t^T \right) + \gamma \left(\hat{i}_t^e - i_t^T \right) + \eta_{t+1}, \tag{14}$$

where $\hat{i}_t^e$ is the fitted value from the regression including monthly dummies. The results from estimating these regressions are presented in columns (*iii*) and (*iv*) of Table 6. Interestingly, both the simple expectations in column (*iii*) and the adjusted

Table 6: Expectations from the *Financial Times* versus futures estimates

	(*i*)	(*ii*)	(*iii*)	(*iv*)
Intercept	-0.069^{**}	-0.023	-0.042^{*}	-0.026^{*}
	(0.026)	(0.014)	(0.018)	(0.013)
Expectations				
Financial Times		$1.207^{**\dagger}$	$1.080^{**\ddagger}$	$0.771^{**\ddagger}$
		(0.117)	(0.095)	(0.142)
Simple futures	$0.869^{**\ddagger}$		0.182	
	(0.238)		(0.093)	
Adjusted futures				0.481^{**}
				(0.147)
$\bar{R}^2$	0.460	0.832	0.839	0.884
Observations	33	33	33	32

OLS estimation of equations (8), (12), (13), and (14), respectively, on 33 FOMC meeting dates from January 1994 to February 1998. White (1980) standard errors in parentheses. $^{**}/^{*}$ denote coefficient significantly different from 0 at the 1%-/5%-level, $^{\ddagger}/^{\dagger}$ denote coefficient *not* significantly different from 1 at the 10%-/5%-level.

expectations in column (*iv*) improve on the newspaper reports when predicting the funds rate target: adjusted R^2 increases to 0.839 and 0.884, respectively, although only the coefficient on $\left(\hat{i}_t^e - i_t^T\right)$ is significantly different from zero at the 5%-level.[18]

Consequently, although the expectations of target changes reported in the *Financial Times* outperform the expectations from the futures market, the two types of measures do not contain the same information. Adding information from the futures market improves on the predictions from the newspaper reports.

5 Using monthly data

Most previous studies have concentrated on monthly averages of futures data, predicting policy moves one to three months ahead. Although there are significant problems with time aggregation using monthly data (see Evans and Kuttner, 1998), such data are still a convenient way of measuring policy expectations, since the daily noise in the futures market tends to cancel out. Also, because of the futures prices' simple conversion into the expected funds rate, monthly data are often used by market analysts when predicting future policy moves.

Carlson et al. (1995) show that monthly averages of futures rate of up to five

[18] The coefficient on $\left(i_t^e - i_t^T\right)$ is significantly different from zero at the 10%-level, however.

Table 7: Predicting monthly changes in the funds rate and target

	Funds rate target			Funds rate		
	1-month contract	2-month contract	3-month contract	1-month contract	2-month contract	3-month contract
Intercept	−0.069**	−0.118**	−0.172*	−0.045*	−0.089*	−0.145*
	(0.018)	(0.040)	(0.067)	(0.018)	(0.039)	(0.065)
Slope	0.809**	0.970**‡	0.976**‡	0.847**‡	0.989**‡	1.002**‡
	(0.083)	(0.133)	(0.169)	(0.111)	(0.145)	(0.173)
$\bar{R}^2$	0.462	0.501	0.446	0.459	0.505	0.459
Observations	113	112	111	113	112	111

OLS estimation of equation (15) on 114 monthly observations from October 1988 to March 1998. Newey-West (1987) standard errors with 1, 2, and 3 lags, respectively, in parentheses. **/* denote coefficient significantly different from 0 at the 1%-/5%-level, ‡/† denote coefficient *not* significantly different from 1 at the 10%-/5%-level.

months' maturity yield better predictions of the average effective federal funds rate for the contract month in terms of mean squared errors than do a naive random walk model and an estimated univariate model. Krueger and Kuttner (1996) perform out-of-sample forecasts of future monetary policy based on one- and two-month futures prices, and conclude that predictable changes in the funds rate are rationally forecast by the futures market, and that the inclusion of other information only marginally improves on the futures-based forecasts. However, none of these studies take into account the monthly variation of futures prices. Therefore, it is natural to ask whether these variations are still important when using monthly data.

To analyze the predictive power of monthly futures data, I estimate regressions similar to equations (8) and (10), but using the monthly averages of the federal funds rate, the funds rate target, and the one- to three-month futures rates. Here I choose to predict changes not only in the average funds rate target, but also in the average funds rate, since the futures contracts are based on the average funds rate for the contract month.

Consequently, I estimate

$$\Delta\bar{\imath}_{t+m} = \alpha + \beta\left(\bar{\imath}^f_{m,t} - \bar{\imath}_t\right) + \varepsilon_{t+1}, \tag{15}$$

and

$$\Delta\bar{\imath}_{t+m} = \sum_{j=1}^{12}\gamma_j d^M_{m,j} + \delta\left(\bar{\imath}^f_{m,t} - \bar{\imath}_t\right) + \nu_{t+1}, \tag{16}$$

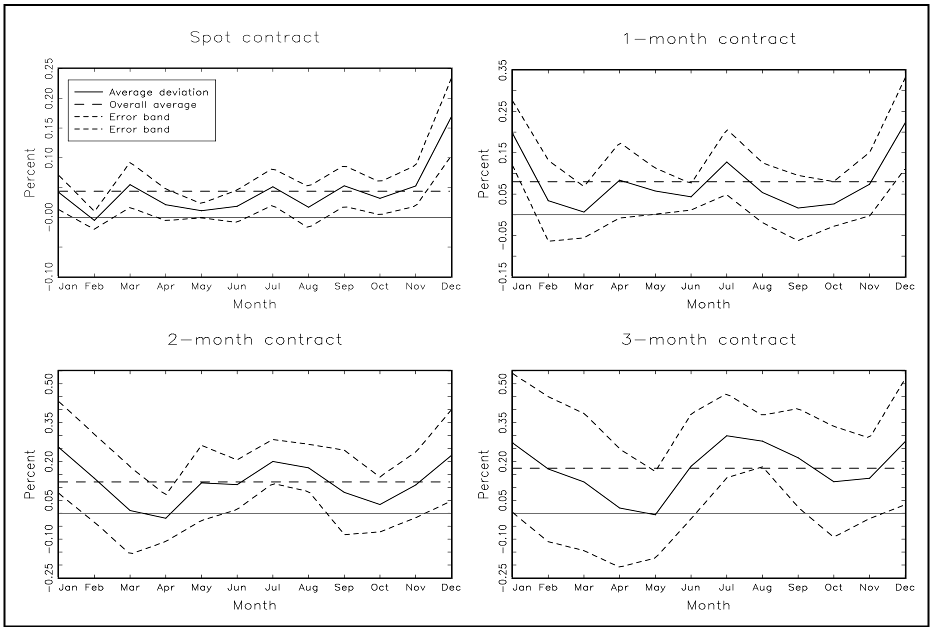
where $\Delta\bar{\imath}_{t+m} = \bar{\imath}_{t+m} - \bar{\imath}_t$ is the change in the average funds rate or funds rate target from month t to $t+m$, and $\bar{\imath}^f_{m,t}$ is the average m-month futures rate in month t.

Table 8: Predicting monthly changes, including monthly intercept dummies

	Funds rate target			Funds rate		
	1-month contract	2-month contract	3-month contract	1-month contract	2-month contract	3-month contract
January	−0.185**	−0.255**	−0.271	−0.141**	−0.207*	−0.223
	(0.046)	(0.098)	(0.141)	(0.041)	(0.094)	(0.143)
February	−0.029	−0.135	−0.170	−0.031	−0.135	−0.169
	(0.053)	(0.091)	(0.148)	(0.057)	(0.095)	(0.146)
March	−0.002	−0.011	−0.119	0.032	0.025	−0.087
	(0.035)	(0.088)	(0.140)	(0.039)	(0.089)	(0.144)
April	−0.074	0.019	−0.018	−0.095*	0.002	−0.037
	(0.044)	(0.047)	(0.117)	(0.044)	(0.054)	(0.124)
May	−0.051	−0.118	0.007	−0.047	−0.115	0.010
	(0.029)	(0.077)	(0.086)	(0.031)	(0.074)	(0.082)
June	−0.039*	−0.110*	−0.178	−0.015	−0.088	−0.158
	(0.016)	(0.048)	(0.106)	(0.030)	(0.057)	(0.109)
July	−0.127**	−0.200**	−0.296**	−0.093*	−0.167**	−0.267**
	(0.040)	(0.045)	(0.078)	(0.047)	(0.060)	(0.096)
August	−0.053	−0.175**	−0.277**	−0.024	−0.143**	−0.249**
	(0.034)	(0.046)	(0.051)	(0.029)	(0.040)	(0.050)
September	−0.017	−0.081	−0.214*	0.062	0.000	−0.134
	(0.039)	(0.084)	(0.097)	(0.037)	(0.081)	(0.086)
October	−0.027	−0.034	−0.121	−0.013	−0.015	−0.104
	(0.025)	(0.053)	(0.109)	(0.036)	(0.059)	(0.112)
November	−0.073	−0.109	−0.135	−0.009	−0.039	−0.066
	(0.042)	(0.065)	(0.080)	(0.044)	(0.072)	(0.086)
December	−0.207**	−0.224*	−0.276*	−0.186**	−0.195*	−0.266*
	(0.063)	(0.096)	(0.128)	(0.052)	(0.085)	(0.106)
Slope	0.910**‡	1.002**‡	0.987**‡	0.947**‡	1.031**‡	1.017**‡
	(0.095)	(0.147)	(0.177)	(0.111)	(0.154)	(0.179)
$\bar{R}^2$	0.527	0.513	0.430	0.530	0.509	0.436
Observations	113	112	111	113	112	111

OLS estimation of equation (16) on 114 monthly observations from October 1988 to March 1998. Newey-West (1987) standard errors with 1, 2, and 3 lags, respectively, in parentheses. **/* denote coefficient significantly different from 0 at the 1%-/5%-level, ‡/† denote coefficient *not* significantly different from 1 at the 10%-/5%-level.

Figure 5: Average futures deviation from funds rate target across months, monthly data

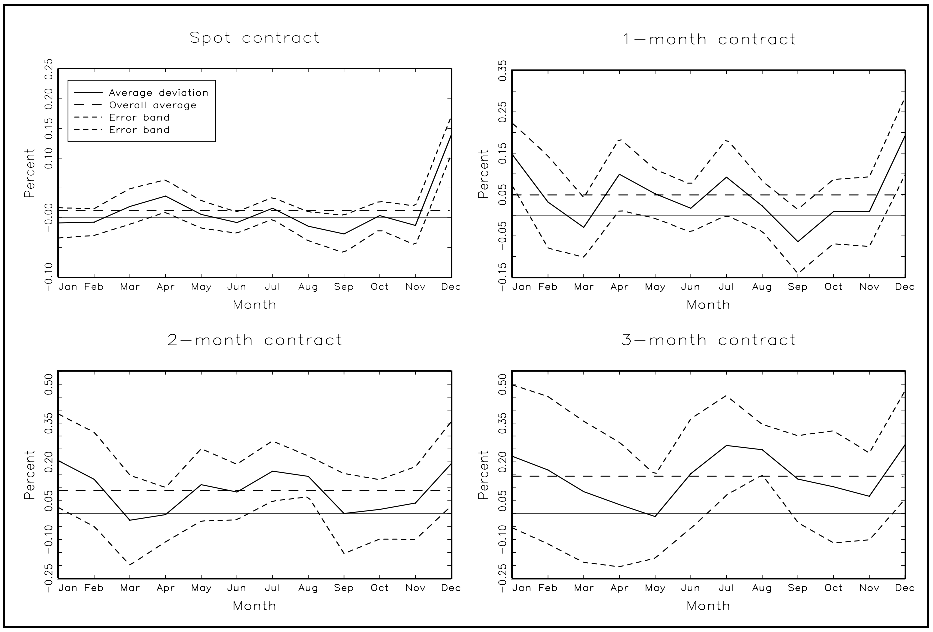


The results using monthly data from October 1988 to March 1998 are presented in Tables 7 and 8.

From Table 7 it is clear that the average monthly futures prices have considerable predictive power for changes in the average funds rate target until the contract matures. The results when predicting changes in the average funds rate are very similar, since the average funds rate in a given month follows the average funds rate target very closely. When allowing the intercepts to vary across trading months in Table 8, we see that futures prices do vary considerably across months. Although in most months the intercept is not significantly different from zero, and quite close to the overall intercept, the months of January, July, August, and December have significantly negative intercepts (up to −30 basis points), indicating that the futures rates are unusually large relative to the expected funds rate in these months. Figures 5 and 6 show the average deviation of the futures rate from the contract month funds rate and target across calendar months. For the spot contract, December clearly stands out, and for the one- to three-month contracts, January, July, and August also have unusually large deviations. As indicated by Table 3, these variations are probably due to increases in the perceived riskiness of futures contracts in these months.

These results clearly show that there are strong monthly variations in prices on the federal funds futures market, which definitely need to be taken into account if

Figure 6: Average futures deviation from funds rate across months, monthly data



one is to use futures prices to extract market expectations or predict policy moves, also when using monthly futures data.

6 Conclusions

Because of their simple interpretation, prices of federal funds futures contracts one to three months into the future are often used to extract market expectations of the path of monetary policy. In the current month, futures prices should contain even more precise information about the near-term path of monetary policy, since market participants have already observed part of the federal funds rate path that determines the price of the futures contract at maturity. Thus one should in theory be able to extract fairly exact measures of the expected federal funds rate—and consequently of its target—from the current month's contract, especially as the contract gets close to maturity.

This study has shown that things are not that straightforward in reality. Even though the extracted expected funds rate from the day before meetings of the Federal Open Market Committee from January 1994 to February 1998 performs fairly well in predicting the target level that will prevail after the meeting, there are large systematic variations in the funds rate expectations, especially across calendar months, and possibly across trading days in the contract month (although the number of FOMC meetings is too small to verify this last claim). The monthly variation is probably due to increased volatility in the underlying federal funds cash market in the relevant months, leading to increased risk premia on the futures market.

Adjusting the funds rate expectation for monthly variation substantially improves the prediction of target changes. Additional tests have shown that the extracted expectations were successful in predicting the (widely anticipated) policy move in September 1998, and that they improve on market expectations taken from newspaper reports on the days preceding the FOMC meetings.

Consequently, the expectations of near-term changes in the federal funds rate target extracted from the federal funds futures market seem to be useful as measures of market expectations, although a simple adjustment for systematic monthly variations is recommended.

References

Allen, Linda and Anthony Saunders, "Bank window dressing: Theory and evidence," *Journal of Banking and Finance* 16 (3), June 1992, 585–623.

Beckner, Steven K., *Back from the brink: The Greenspan years*, John Wiley and Sons, New York, 1996.

Carlson, John B., Jean M. McIntire, and James B. Thomson, "Federal funds futures as an indicator of future monetary policy: A primer," Federal Reserve Bank of Cleveland *Economic Review* 31 (1), 1st quarter 1995, 20–30.

Chicago Board of Trade, "Insights into pricing the CBOT fed funds futures contract," Chicago, 1997(a).

———, "Practical applications using CBOT fed funds futures," Chicago, 1997(b).

Ellingsen, Tore and Ulf Söderström, "Monetary policy and market interest rates," Working Paper No. 56, Sveriges Riksbank, August 1998.

Evans, Charles L. and Kenneth N. Kuttner, "Can VARs describe monetary policy?," Research Paper No. 9812, Federal Reserve Bank of New York, April 1998.

Federal Reserve Board, Press release, September 29, 1998.

Goodfriend, Marvin and William Whelpley, "Federal funds," in Cook, Timothy Q. and Robert K. LaRoche (eds.), *Instruments of the money market,* Seventh edition, Federal Reserve Bank of Richmond, 1993.

Griffiths, Mark D. and Drew B. Winters, "Day-of-the-week effects in federal funds rates: Further empirical findings," *Journal of Banking and Finance* 19 (7), October 1995, 1265–1284.

Hamilton, James D., "The daily market for federal funds," *Journal of Political Economy* 104 (1), February 1996, 26–56.

Ho, Thomas S. and Anthony Saunders, "A micro model of the federal funds market," *The Journal of Finance* 40 (3), July 1985, 977–988.

Krueger, Joel T. and Kenneth N. Kuttner, "The fed funds futures rate as a predictor of Federal Reserve policy," *Journal of Futures Markets* 16 (8), December 1996, 865–879.

Meulendyke, Ann-Marie, *U.S. monetary policy and financial markets*, Federal Reserve Bank of New York, 1998.

Newey, Whitney K. and Kenneth D. West, “A simple, positive semi-definite, heteroskedasticity and autocorrelation consistent covariance matrix,” *Econometrica* 55 (3), May 1987, 703–708.

Pakko, Michael R. and David C. Wheelock, “Monetary policy and financial market expectations: What did they know and when did they know it?,” Federal Reserve Bank of St. Louis *Review* 78 (4), July/August 1996, 19–31.

Robertson, John C. and Daniel L. Thornton, “Using federal funds futures rates to predict Federal Reserve actions,” Federal Reserve Bank of St. Louis *Review* 79 (6), November/December 1997, 45–53.

Roley, V. Vance and Gordon H. Sellon, Jr., “The response of the term structure of interest rates to federal funds rate target changes,” Research Working Paper No. 96-08, Federal Reserve Bank of Kansas City, November 1996.

Rudebusch, Glenn D., “Federal Reserve interest rate targeting, rational expectations, and the term structure,” *Journal of Monetary Economics* 35 (2), April 1995, 245–274.

———, “Do measures of monetary policy in a VAR make sense?,” *International Economic Review* 39 (4), November 1998, 907–931.

Saunders, Anthony and Thomas Urich, “The effects of shifts in monetary policy and reserve accounting regimes on bank reserve management behavior in the federal funds market,” *Journal of Banking and Finance* 12 (4), December 1988, 523–535.

Söderlind, Paul and Lars E. O. Svensson, “New techniques to extract market expectations from financial instruments,” *Journal of Monetary Economics* 40 (2), November 1997, 383–430.

Spindt, Paul A. and J. Ronald Hoffmeister, “The micromechanics of the federal funds market: Implications for day-of-the-week effects in funds rate variability,” *Journal of Financial and Quantitative Analysis* 23 (4), December 1988, 401–416.

Thornton, Daniel L., "Does the Fed's new policy of immediate disclosure affect the market?," Federal Reserve Bank of St Louis *Review* 78 (6), November/December 1996, 77–88.

White, Halbert, "A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity," *Econometrica* 48 (4), May 1980, 817–838.