Does the Fed Control Interest Rates?

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To what extent does *TF*, the target Federal funds rate set by the Fed, influence other rates? There is lots of variation in rates unrelated to *TF*, and any effects of *TF* on rates dissipate quickly for longer maturities. For short rates, all the tests have interpretations in terms of: (i) a Fed that has the power to control rates and uses it, and (ii) a Fed that has little power over rates or chooses not to exercise its power. In the end, there is no conclusive evidence (here or elsewhere) on the role of the Fed versus market forces in the long-term path of interest rates. (*JEL* E43, E58, G12)

The Federal funds rate, *FF*, is the interest rate on overnight loans of reserves among banks. The Fed can control *FF*, and arbitrage conditions link *FF* to the rate on other overnight loans of equivalent risk. The extent to which the Fed chooses to control overnight rates depends, however, on its willingness to vary the supply of reserves. Enforcing nontrivial changes in *FF* may require large changes in reserves that the Fed is not willing to accommodate. As a result, the Fed may passively let open market forces determine most of the variation in *FF* and limit itself to small changes at the margin.

Concretely, the Fed funds rate starts near 12% at the beginning of my September 1982 to June 2012 sample period, ends near zero, and takes wide swings in between. How much of this impressive variation is due to the will of the Fed and how much is due to market forces? I offer tests but no unassailable conclusions, and this seems to be the state of the literature on this issue. Acknowledging this ambiguity is important, however, since recent research in monetary economics typically just assumes the Fed is the dominant force in *FF* and interprets evidence that *FF* leads real activity as evidence of Fed influence on real activity (e.g., Christiano, Eichenbaum, and Evans 2005). But if much of the variation in *FF* is passive adjustment to market forces, causation likely goes the other way. Specifically, if asset pricing is rational, forecasts of real activity are prime determinants of current asset prices and interest rates. This potential interpretation of evidence that asset prices and

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interest rates lead real activity is prominent in the early literature (Fama 1981; Harvey 1989; Stock and Watson 1989), but it fades from view in recent work on how monetary policy, embodied in *FF*, affects real activity.

The Fed potentially controls the overnight interest rate, but open market rates for longer maturities are important in the decisions of agents that affect real activity. Thus, another important issue centers on how policy with respect to *FF* plays out across the term structure. I take *TF*, the Fed's target for *FF*, as the concrete expression of its interest rate policy. Section 1 uses autocorrelations and plots of the spreads of rates over *TF* to show that open market rates (specifically, one-month commercial paper and Treasury bill and bond rates) take long-lasting swings away from *TF*, and the swings are larger in amplitude for longer maturities. This is consistent with long-standing evidence that much of the variation in interest rates beyond the shortest maturities is due to time-varying expected term premiums in near-term returns rather than to forecasts of future short-term rates. (See, for example, Fama [1984], Fama and Bliss [1987], and the references therein.)

Section 2 uses autoregressions with error correction terms to document that the day-to-day variation in rates for maturities of a month or more has little or nothing to do with the Fed's target rate. This is consistent with a Fed that has little control of rates, but we shall see that it is also consistent with a powerful Fed whose predictable actions with respect to *TF* are built in advance into interest rates.

Open market rates take long swings away from *TF*, but *TF* does track the long-term path of open market rates, especially short-term rates. Put differently, when cumulated, changes in *TF* trace out the long-term path of open market interest rates. Thus, judging the power of the Fed over rates largely depends on determining the extent to which changes in *TF* are due to active attempts by the Fed to control rates versus passive adjustment to market forces. The regressions in Section 3 show that when the Fed changes *TF*, it moves toward existing short rates, especially the one-month commercial paper rate, *CP*. During the period after 1993, when the Fed announces changes in *TF*, the level of *CP* on the day before a change in *TF* captures 83% of the variance of changes in *TF*. This is consistent with a passive Fed that largely moves *TF* to align with existing market rates, but it is also consistent with an active Fed that controls rates but whose actions with respect to rates are predicted by the market.

The last test (Section 4) is an event study. It shows that especially after 1993, short-term open market rates respond to the unexpected part of a change in *TF*. This is the best evidence that the Fed exercises some control of rates, but the evidence is tempered by (i) the fact that the responses of rates to unexpected changes in *TF* deteriorate quickly for longer maturities, and (ii) unexpected changes in *TF* are a small part (17%) of the variance of total changes. Moreover, skeptics can argue that the Fed is an informed agent with private information about how market forces will shape future open market rates, and it uses this information to change *TF*. It is then rational that rates respond to unexpected changes in *TF* even if the changes are not active attempts by the Fed to move rates.

The general message of the paper is that there is no conclusive evidence (here or elsewhere) on the role of the Fed versus market forces in the long-term path of market interest rates. For the period that starts with the lingering recession of 2008, however, a stronger conclusion is possible. During this period the Fed purchases massive amounts of long-term bonds and finances its purchases by issuing reserves. The reserves pay interest at or slightly above short-term open market rates, which means reserves are now just another form of riskless interest-bearing short-term debt. I argue in Section 5 that the decline in short-term rates to near zero after 2008, despite massive injections of interest-bearing short-term debt by the Fed (and other central banks), is a cautionary tale about how market forces can limit the power of central banks even with respect to the short-term rates that are supposed to be their special preserve.

1. Summary Statistics

The tests focus on seven interest rates: *FF*, the Fed funds rate; *TF*, the target Fed funds rate set by the Fed; *CP*, the rate one-month high grade nonfinancial commercial paper; *B3* and *B6*, three-month and six-month U.S. Treasury bill rates; and *G5* and *G10*, five-year and ten-year U.S. Treasury bond rates. The data are from the FRED website of the Federal Reserve Bank of St. Louis. The sample period is September 27, 1982, to June 28, 2012 (henceforth 1982–2012). The start date is the first available for data on *TF*, which are from Thornton (2005) for the period prior to 1994. I take 1994, when the Fed starts announcing *TF*, as a natural break to define subperiods for the tests.

Rudebush (1995) and Romer and Romer (2004) argue that Fed funds rate targeting is the rule during almost all of my sample period. I interpret the target, *TF*, as the concrete expression of the Fed's interest rate policy.

For initial perspective, Panel A of Table 1 shows means and standard deviations of daily changes in the interest rates that change daily (all rates except *TF*) and the spread of each rate over *TF*. Results are shown for 1982–2012 and for the subperiods that split at the beginning of 1994 (henceforth 1982–1993 and 1994–2012). The spreads are measured on the day preceding the changes. Panel B of Table 1 shows autocorrelations for 20 daily lags (about a month of trading days). The subperiod autocorrelations are similar to those for the full sample, and only full-period results are shown.

Short-term interest rates are more variable before 1994 (Table 1, Panel A). The decline in volatility thereafter is especially noticeable for the Fed funds rate, *FF*, but *FF* is always about four times more variable than the other rates, probably because of special conditions in the market for reserves related to satisfying reserve requirements. Changes in *FF* are negatively autocorrelated

Table 1

Means, standard deviations (Std Dev), and autocorrelations for daily changes in the Federal funds rate (*dFF*), the one-month commercial paper rate (*dCP*), three-month and six-month Treasury bill rates (*dB3* and *dB6*), and five-year and ten-year U.S Treasury bond rates (*dG5* and *dG10*), measured on day *t*, and the lagged spread variables, *FF–TF*, *CP–TF*, *B3–TF*, *B6–TF*, *G5–TF*, and *G10–TF*, measured on day *t*−1, where *TF* is the target Fed funds rate

Panel A: Means and standard deviations

	dFF	*dCP*	*dB3*	*dB6*	*dG5*	*dG10*	*FF–TF*	*CP–TF*	*B3–TF*	*B6–TF*	*G5–TF*	*G10–TF*
Summary statistics for 9/27/1982–6/28/2012, 7382 observations												
Mean	−0.00	−0.00	−0.00	−0.00	−0.00	−0.00	0.04	0.04	−0.37	−0.25	1.13	1.61
Std Dev	0.28	0.06	0.06	0.06	0.07	0.07	0.29	0.21	0.39	0.42	1.05	1.30
Summary statistics for 9/27/1982–12/31/1993, 2812 observations												
Mean	−0.00	−0.00	−0.00	−0.00	−0.00	−0.00	0.09	0.04	−0.55	−0.42	1.38	1.78
Std Dev	0.40	0.08	0.07	0.07	0.08	0.07	0.42	0.30	0.43	0.43	1.02	1.20
Summary statistics for 1/3/1994–6/28/2012, 4570 observations												
Mean	−0.00	−0.00	−0.00	−0.00	−0.00	−0.00	0.01	0.04	−0.25	−0.14	0.98	1.51
Std Dev	0.18	0.05	0.05	0.04	0.07	0.06	0.17	0.14	0.32	0.36	1.04	1.36

Panel B: Autocorrelations for 9/27/1982–6/28/2012

Lag	*dFF*	*dCP*	*dB3*	*dB6*	*dG5*	*dG10*	*FF–TF*	*CP–TF*	*B3–TF*	*B6–TF*	*G5–TF*	*G10–TF*
1	−0.20	0.11	0.11	0.09	0.06	0.05	0.53	0.94	0.98	0.99	1.00	1.00
2	−0.20	0.06	−0.06	−0.01	−0.01	−0.01	0.26	0.88	0.96	0.97	0.99	1.00
3	−0.04	−0.04	−0.06	−0.04	0.00	−0.00	0.17	0.83	0.94	0.96	0.99	0.99
4	−0.02	−0.01	−0.01	0.01	−0.02	−0.03	0.12	0.77	0.93	0.95	0.99	0.99
5	−0.01	−0.00	−0.01	0.01	−0.02	−0.02	0.09	0.73	0.91	0.93	0.98	0.99
6	−0.04	−0.01	−0.03	−0.01	−0.00	−0.01	0.07	0.68	0.90	0.92	0.98	0.99
7	−0.04	−0.03	0.01	0.01	0.04	0.04	0.09	0.64	0.88	0.91	0.98	0.99
8	0.06	0.01	−0.02	−0.04	−0.00	−0.00	0.15	0.61	0.87	0.90	0.98	0.98
9	0.00	0.03	0.01	0.01	0.01	−0.00	0.15	0.58	0.86	0.89	0.97	0.98
10	0.06	−0.01	0.04	0.04	0.01	0.02	0.15	0.54	0.85	0.89	0.97	0.98
11	−0.02	0.00	0.00	0.01	0.00	0.01	0.10	0.52	0.84	0.88	0.97	0.98
12	−0.03	−0.01	−0.03	−0.01	0.02	0.02	0.06	0.49	0.83	0.87	0.96	0.98
13	0.01	0.02	−0.01	0.00	0.00	0.00	0.06	0.47	0.82	0.86	0.96	0.98
14	0.01	0.01	0.04	0.05	0.03	0.03	0.04	0.45	0.81	0.86	0.96	0.97
15	−0.04	0.02	0.03	0.03	0.00	0.00	0.02	0.43	0.80	0.85	0.96	0.97
16	−0.03	0.01	−0.01	−0.00	−0.00	−0.00	0.04	0.41	0.80	0.84	0.95	0.97
17	0.01	−0.02	−0.04	−0.01	0.02	0.01	0.09	0.38	0.79	0.84	0.95	0.97
18	0.01	0.02	0.04	0.02	0.02	0.02	0.12	0.37	0.78	0.83	0.95	0.97
19	0.07	−0.00	0.08	0.04	−0.01	−0.01	0.15	0.35	0.78	0.83	0.95	0.96
20	−0.02	0.00	0.02	0.03	0.01	0.01	0.11	0.34	0.77	0.82	0.94	0.96

The data are from the FRED website of the Federal Reserve Bank of St. Louis. *CP* is FRED series DCP30 until 1997 and DCPN30 thereafter. The standard error of the autocorrelations under a null of zero is 0.0116.

for the first few lags. The autocorrelations of changes in the other rates are positive for the first lag, and then random about zero thereafter. Because the sample size is huge (7,382 daily changes), many of the lower order autocorrelations are multiple standard errors from zero, but all seem minor in economic terms.

The spreads of interest rates over *TF* show how the rates for different maturities deviate from the Fed's target. The summary statistics for the spreads thus provide initial rough perspective on the Fed's control of rates. The standard deviations of the spreads are similar to or higher than those of changes in *FF*. The high volatility of the spreads largely reflects strong positive autocorrelation. The autocorrelations (Table 1, Panel B) tend to decay for longer lags, but the decay is slower for longer-term rates. For example, the autocorrelations of *FF–TF* start at 0.53 and decline to 0.11 at the 20^{th} lag. The autocorrelations of *CP–TF* start much higher, 0.94, and decay to 0.34 at the 20^{th} lag. The autocorrelations of *G5-TF* and *G10-TF* start at 1.00 and are still around 0.95 at the 20^{th} lag.

The slow decay of the autocorrelations of the spreads says that interest rates take long swings away from the Fed funds target rate and the swings are more persistent for longer-term rates. The plots of the spreads in Figure 1 provide perspective.

The means of the spreads for five-year and ten-year Treasury bonds are 1.13% and 1.61% respectively. If the Fed's target rate, *TF*, is the dominant force in the variation of *G5* and *G10*, *G5-TF* and *G10-TF* should fluctuate closely about their means. Figure 1c shows, however, that the spreads are commonly far above or far below their means for long periods. This is not surprising since the autocorrelations of *G5-TF* and *G10-TF* show little tendency to decay (Table 1), and we see later that Treasury bond rates do not respond much to *TF* and to unexpected changes in *TF*. In general, the results reported below suggest that the Fed's actions with respect to *TF* have little effect on longer-term rates.

We see later that the T-bill rates *B3* and *B6* respond to unexpected changes in *TF*, which is consistent with some Fed control of these rates. Figure 1b suggests, however, that the control is far from complete. The spreads *B3-TF* and *B6-TF* do not move as far from their means, −0.37% and −0.25%, as the Treasury bond spreads, but *B3-TF* and *B6-TF* are nevertheless rather far above or below their means for years at a time. In short, the Fed may have some control of *B3* and *B6*, but even T-bill rates take long swings away from the Fed's target rate, which suggests substantial variation beyond Fed control.

Finally, the autocorrelations of *CP–TF* decay more quickly than those of the spreads for T-bills and bonds, and we see later that the one-month commercial paper rate also shows a stronger response to unexpected changes in *TF*. These results suggest that *CP* is the open market rate most under Fed control. Figure 1a confirms that aside from occasional spikes, *CP–TF* is typically within 0.5% of its mean, 0.04%. Still, like other open market rates, *CP–TF* is often above or below its mean for years at a time, which again suggests sustained variation beyond the control of the Fed.

What market forces produce variation in rates beyond Fed control? One possibility is suggested by long-standing evidence that much of the variation in interest rates on T-bills and Treasury bonds is due to time-varying expected term premiums in near-term returns rather than to forecasts of future short-term rates. (See, for example, Fama [1984], Fama and Bliss [1987], and the references therein.) Whatever the explanation, Figure 1 and the autocorrelations of the spreads of rates over *TF* in Table 1, document sustained swings

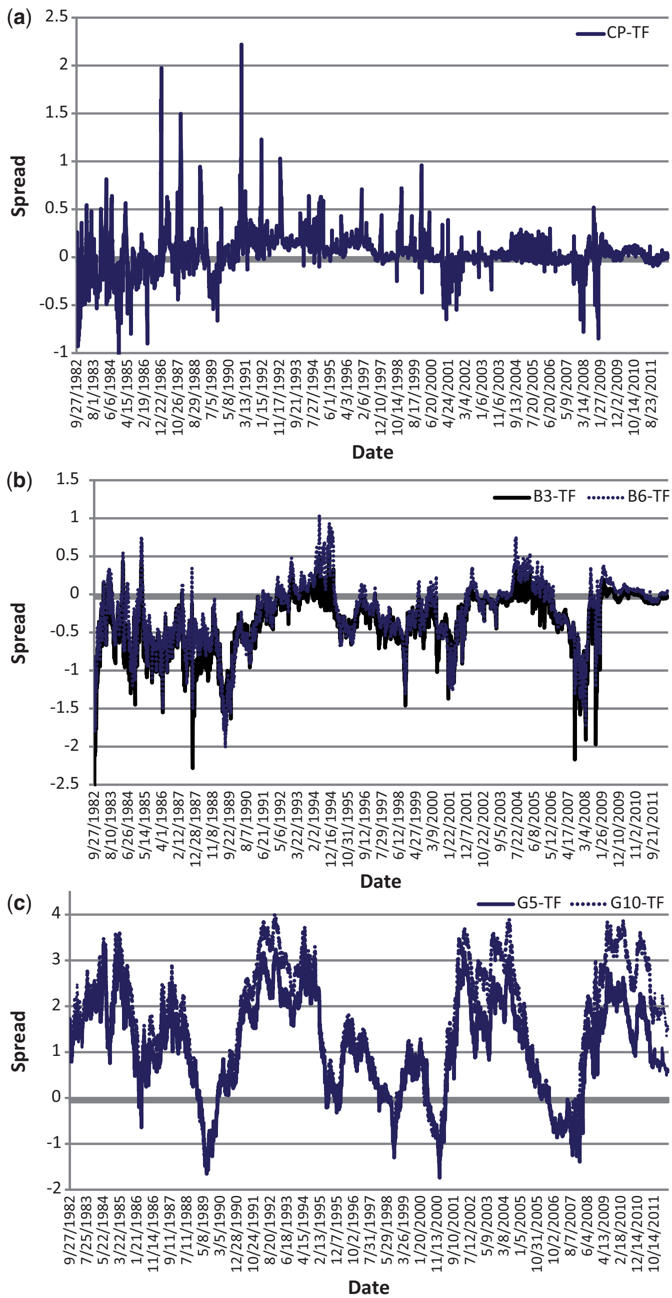

Figure 1
(a) Spread of Commercial Paper Rate, *CP*, over Fed funds Target Rate, *TF*. (b) Spreads of Three-Month and Six-Month Bill Rates, *B3* and *B6*, over the Fed Funds Target, *TF*. (c) Spreads of Five-Year and Ten-Year Government Bond Rates, *G5* and *G10*, over Fed Funds Target, *TF*.

of open market rates (*CP*, *B3*, *B6*, *G5*, and *G10*) away from the Fed's target rate.

2. Autoregressions with Error Correction

Table 2 shows regressions that measure the day-to day response of interest rates to *TF*. The regressions explain the change in an interest rate *R* from day $t-1$ to day t, dR_t, with the previous day's spread of the rate over the Fed funds target, $R_{t-1} - TF_{t-1}$, and ten lagged changes in the rate,

$$dR_t = a + b(R_{t-1} - TF_{t-1}) + c_1 dR_{t-1} + \ldots + c_{10} dR_{t-10} + e_t. \quad (1)$$

The lagged changes allow for predictability due to the time-series properties of changes in *R*, where *R* is one of the six rates in the sample. The variable that tests for movement of *R* toward the Fed's target is the error correction term, $R_{t-1} - TF_{t-1}$. If R_t moves toward TF_{t-1}, the slope b in (1) is negative; when R_{t-1} is above the target, the rate should fall. Table 2 also shows impulse response functions, given a 1% shock to R_t, with all explanatory variables in (1) set to zero before the shock. To save space, the table only shows results for the subperiods before and after the 1994 split.

The Fed funds rate moves strongly toward the target. The slope for $FF_{t-1} - TF_{t-1}$ in the dFF_t regression for 1982–1993 is −0.37 ($t = -12.12$), and the slope for 1994–2012 is similar, −0.44 ($t = -19.54$). Thus, today's change in *FF* tends to absorb about 40% of the deviation of yesterday's funds rate from the target rate. In contrast, other rates (which I call open market rates) show little tendency to move toward *TF* before or after the 1994 break. The slope for $CP_{t-1} - TF_{t-1}$ in the dCP_t regression for 1982–1993 is the most extreme, −0.04. This trivial slope is −6.27 standard errors from zero, but this just says the slope is estimated precisely with the large samples of daily data. For other rates, the slopes on lagged spreads over *TF* are even closer to zero, and for 1994–2012, the slopes are slightly positive (the wrong sign).

In the Table 2 regressions for dCP_t and other open market rates, the slopes on lagged changes in a rate are close to zero, like the autocorrelations in Table 1. Thus, autocorrelation does not produce a lot of forecast power. In the regressions for dFF_t, the slopes on lagged changes tend to be negative and stronger than those for open market rates, so autocorrelation produces more predictability.

The impulse response functions summarize how the error correction and lagged dependent slopes interact to produce a post shock path for *R*. A 1% shock to *FF* largely disappears, that is, *FF* has moved just about fully back to the target *TF* within about five trading days. In contrast, for *CP* and other open market rates, a 1% shock dissipates slowly at best. In the results for *CP* and *B3* for 1982–1993, near 90% of a shock remains in the level of the rate ten days later. In the 1982–1993 results for *B6*, *G5*, and *G10*, just about all of a shock is still in the level of the rate ten days later. In the 1994–2012 results,

Table 2

Estimates of regression (1) to explain the change in interest rate *R* on day *t*, dR_t

Panel A: 9/27/1982–12/31/1993, 2802 observations

	a	R_{t-1}–TF_{t-1}	dR_{t-1}	dR_{t-2}	dR_{t-3}	dR_{t-4}	dR_{t-5}	dR_{t-6}	dR_{t-7}	dR_{t-8}	dR_{t-9}	dR_{t-10}
dFF, $R^2=0.23$												
Coef	0.03	−0.37	−0.02	−0.15	−0.07	−0.07	−0.07	−0.07	−0.09	0.00	−0.01	0.05
t(*Coef*)	4.13	−12.12	−0.72	−4.94	−2.22	−2.48	−2.66	−2.72	−3.81	0.19	−0.49	2.55
dCP, $R^2=0.06$												
Coef	0.00	−0.04	0.21	0.02	−0.04	0.02	0.03	0.01	−0.04	0.05	0.04	−0.03
t(*Coef*)	0.09	−6.27	11.36	1.30	−2.26	1.18	1.43	0.49	−2.18	2.50	1.93	−1.39
dB3, $R^2=0.02$												
Coef	−0.01	−0.01	0.12	−0.01	−0.04	0.01	−0.00	−0.04	0.05	−0.02	−0.02	0.03
t(*Coef*)	−3.33	−3.27	6.41	−0.51	−2.29	0.38	−0.16	−2.38	2.46	−1.32	−0.96	1.45
dB6, $R^2=0.01$												
Coef	−0.00	−0.01	0.11	−0.00	−0.04	0.02	0.01	−0.04	0.02	−0.03	−0.02	0.02
t(*Coef*)	−2.23	−1.89	5.91	−0.13	−2.00	1.10	0.63	−2.40	1.28	−1.59	−1.18	1.03
dG5, $R^2=0.01$												
Coef	−0.00	−0.00	0.11	0.01	−0.01	−0.01	−0.01	−0.01	0.03	0.01	−0.01	0.01
t(*Coef*)	−0.02	−0.81	5.62	0.57	−0.30	−0.75	−0.34	−0.64	1.78	0.38	−0.57	0.47
dG10, $R^2=0.01$												
Coef	0.00	−0.00	0.09	0.01	0.00	−0.03	−0.00	−0.03	0.04	0.01	−0.01	0.01
t(*Coef*)	0.00	−0.75	4.60	0.26	0.26	−1.56	−0.11	−1.38	1.96	0.42	−0.46	0.45

Panel B: 1/3/1994–6/28/2012, 4560 observations

	a	R_{t-1}–TF_{t-1}	dR_{t-1}	dR_{t-2}	dR_{t-3}	dR_{t-4}	dR_{t-5}	dR_{t-6}	dR_{t-7}	dR_{t-8}	dR_{t-9}	dR_{t-10}
dFF, $R^2=0.27$												
Coef	0.00	−0.44	−0.13	−0.08	−0.06	−0.07	−0.04	−0.09	−0.07	−0.02	−0.04	0.05
t(*Coef*)	1.03	−19.54	−5.70	−3.47	−2.64	−3.31	−2.35	−4.98	−3.91	−1.05	−2.41	3.81
dCP, $R^2=0.02$												
Coef	0.00	−0.02	−0.06	0.10	−0.00	0.02	0.03	0.03	0.05	−0.02	0.04	0.03
t(*Coef*)	0.39	−3.44	−4.12	6.35	−0.17	1.54	2.03	1.72	3.63	−1.15	2.84	1.79
dB3, $R^2=0.04$												
Coef	0.00	0.01	0.12	−0.12	−0.06	−0.00	−0.01	−0.04	−0.00	−0.04	0.02	0.05
t(*Coef*)	1.48	3.11	7.79	−7.93	−3.96	−0.24	−0.44	−2.76	−0.14	−2.40	1.36	3.10
dB6, $R^2=0.03$												
Coef	0.00	0.01	0.03	−0.07	−0.03	0.01	0.02	−0.00	−0.01	−0.08	0.06	0.07
t(*Coef*)	1.45	5.63	2.24	−4.73	−2.17	0.41	1.04	−0.20	−0.45	−5.10	3.69	4.41
dG5, $R^2=0.00$												
Coef	−0.00	0.00	0.01	−0.05	0.00	−0.03	−0.03	−0.01	0.03	−0.01	0.01	0.01
t(*Coef*)	−1.34	0.87	0.70	−3.29	0.30	−2.29	−1.90	−0.44	2.06	−0.98	0.86	0.86
dG10, $R^2=0.00$												
Coef	−0.00	0.00	0.02	−0.03	−0.01	−0.03	−0.03	−0.01	0.03	−0.02	0.00	0.03
t(*Coef*)	−0.72	0.06	1.21	−2.25	−0.57	−2.30	−1.82	−0.45	2.35	−1.39	0.16	2.10

Panel C: Impulse response functions for a 1% shock to the interest rate *R* on day *t*

	t	$t+1$	$t+2$	$t+3$	$t+4$	$t+5$	$t+6$	$t+7$	$t+8$	$t+9$	$t+10$
9/27/1982–12/31/1993											
dFF	1.00	0.64	0.29	0.21	0.17	0.13	0.10	0.07	0.15	0.16	0.19
dCP	1.00	1.18	1.20	1.12	1.08	1.06	1.04	0.95	0.94	0.94	0.90
dB3	1.00	1.10	1.09	1.02	1.00	0.98	0.92	0.93	0.90	0.87	0.87
dB6	1.00	1.10	1.10	1.05	1.05	1.06	1.00	1.01	0.97	0.94	0.94
dG5	1.00	1.11	1.13	1.12	1.11	1.09	1.08	1.11	1.12	1.11	1.12
dG10	1.00	1.09	1.10	1.10	1.07	1.07	1.04	1.07	1.08	1.07	1.08
1/3/1994–6/28/2012											
dFF	1.00	0.44	0.25	0.15	0.08	0.07	−0.00	0.01	0.06	0.03	0.12
dCP	1.00	0.92	1.00	0.97	0.98	0.99	0.99	1.03	0.98	1.02	1.01
dB3	1.00	1.13	1.03	0.96	0.96	0.98	0.95	0.95	0.93	0.96	1.03
dB6	1.00	1.05	0.99	0.97	0.99	1.02	1.03	1.03	0.97	1.03	1.12
dG5	1.00	1.01	0.96	0.96	0.93	0.90	0.89	0.93	0.91	0.92	0.94
dG10	1.00	1.02	0.98	0.97	0.94	0.91	0.90	0.94	0.92	0.92	0.95

The interest rates are the Fed funds rate (*FF*), the one-month commercial paper rate (*CP*), the three-month or six-month Treasury bill rate (*B3* or *B6*), or the five-year or ten-year U.S. Treasury bond rate (*G5* or *G10*). The explanatory variables are the intercept, *a*, ten lags of dR_t and the lagged spread, $R_{t-1} - \text{TF}_{t-1}$, measured on day $t-1$, where TF_{t-1} is the Fed funds target rate. The table shows regression coefficients (*Coef*), *t*-statistics for the coefficients (*t*(*Coef*)) and regression R^2, adjusted for degrees of freedom. The impulse response functions in Panel C show the cumulative change in *R* after a 1% shock to *R* on day *t*.

reversion to *TF* after a shock is special to *FF*. For other rates, including *CP* and *B3*, all of a shock remains in the level of the rate ten days later. This continues to be true 20 days later (in the impulse response functions from unreported regressions that use 20 rather than ten lags of *dR*).

Evidence that *FF* moves quickly toward *TF* is commonly interpreted to imply that the Fed exercises substantial control of *FF*. This conclusion assumes that *TF* itself is determined actively by the Fed. Suppose instead that the Fed is passive and just sets *TF* to line up with open market rates. Daily changes in *FF* are about four times as variable as changes in other rates (Table 1). Much of this stronger variation in *FF* is probably due to transitory supply and demand conditions in the interbank market for reserves related to satisfying reserve requirements. Transitory variation in *FF* due to special conditions in the market for reserves can mean that *FF* moves strongly toward *TF* on a day-to-day basis, perhaps with a lot of help from the Fed via open market operations. If *TF* itself is set passively, however, the long-term path of *FF*, which closely tracks *TF*, is also determined by market conditions.

The fact that, unlike *FF*, open market rates show little tendency to move toward *TF* seems to say that the Fed has little or no control of open market rates. The results suggest instead that open market rates are driven by credit market conditions and the Fed is largely a powerless participant. There are, however, two reasons a powerful Fed may not show up in the results for open market rates in Table 2.

First, the estimates of regression (1) measure day-in-day-out effects; that is, they examine the behavior of open market rates on all days, not just days when the Fed actively tries to affect rates. It is reasonable that when the Fed judges that inflation and real activity require no action, it is passive and it lets rates move in response to market forces. It is thus possible that the Fed's power over rates is buried in the estimates of (1), which are dominated by days on which Fed policy is passive.

Second, suppose each open market rate, *R*, contains rational forecasts of the target Fed funds rate for the life of the rate. In this simple model, R_t does not respond to the spread $R_{t-1} - TF_{t-1}$ because R_{t-1} already embeds all the relevant information about Fed policy available at time $t-1$. And there is evidence (Gürkaynak, Sack, and Swanson 2007) that open market rates forecast *FF* (and thus *TF*).

This simple term structure model can explain why the slopes on the spread, $R_{t-1} - TF_{t-1}$, are close to zero in the estimates of (1) for open market rates, but it does not in itself imply that the Fed has much control of rates, for two reasons. First, the plots in Figure 1 and the autocorrelations of the spreads in Table 1 show that open market rates take protracted swings away from *TF*, and the regressions in Table 2 confirm that on a day-to-day basis open market rates do not respond to the spreads. Thus, even if negligible slopes on the spreads in Table 2 mean that interest rates already contain rational forecasts of future values of *TF*, this does not imply much Fed control of rates if lots of their variation has little to do with *TF*. Second, and perhaps more important, whether or not open market rates contain rational forecasts of *TF* implies nothing about whether the Fed controls rates since it does not tell us whether *TF* itself is actively or passively determined.

Finally, banks issue and purchase open market securities. This surely puts pressure on *FF* to move in the direction of open market rates, and perhaps vice versa. To test for such effects, Table 3 shows dFF_t and dCP_t regressions like those in Table 2 but with $FF_{t-1} - CP_{t-1}$ or $CP_{t-1} - FF_{t-1}$, the lagged spread between the Fed funds and commercial paper rates, as an additional explanatory variable. The estimates of these regressions say that the funds rate, *FF*, has two masters; it moves strongly toward the Fed's target, *TF*, but open market forces pull it toward *CP*. In contrast, the commercial paper rate, *CP*, does not move much toward either *FF* or *TF*.

Table 3 suggests that in setting *TF*, the Fed cannot ignore the pressure from open market rates. In other words, market forces constrain the Fed's actions in using the Fed funds rate to influence other rates.

3. What Moves *TF*?

Open market rates take long swings away from the target Fed funds rate *TF* (Figure 1), and on a day-to-day basis, open market rates move little if at all toward *TF* (Table 2). Figure 2 shows, however, that *TF* tracks the long-term swings in the six-month T-bill rate, *B6*, and the long-term variation in the levels of the two rates dwarfs the short-term swings of *B6* away from *TF*

Table 3

Autoregressions to explain changes in the Fed funds and one-month commercial paper rate, dFF_t and dCP_t, with error correction terms $FF_{t-1}-TF_{t-1}$ (labeled *FF–TF*) and $FF_{t-1}-CP_{t-1}$ (*FF–CP*) or $CP_{t-1}-TF_{t-1}$ (*CP–TF*) and $CP_{t-1}-FF_{t-1}$ (*CP–FF*), where TF_{t-1} is the Fed funds target rate and *a* is the regression intercept. The table shows regression coefficients (*Coef*), *t*-statistics for the coefficients (*t*(*Coef*)) and regression R^2, adjusted for degrees of freedom

Panel A: dFF_t

	a	*FF–TF*	*FF–CP*	dFF_{t-1}	dFF_{t-2}	dFF_{t-3}	dFF_{t-4}	dFF_{t-5}	dFF_{t-6}	dFF_{t-7}	dFF_{t-8}	dFF_{t-9}	dFF_{t-10}
9/27/1982–12/31/1993, 2802 observations, R2 = 0.24													
Coef	0.03	−0.28	−0.16	0.02	−0.12	−0.04	−0.05	−0.06	−0.06	−0.09	0.01	−0.01	0.05
t(*Coef*)	4.21	−8.46	−6.91	0.63	−3.96	−1.48	−1.92	−2.26	−2.46	−3.65	0.31	−0.36	2.58
1/3/1994–6/28/2012, obs = 4560, R2 = 0.28													
Coef	−0.00	−0.35	−0.14	−0.09	−0.05	−0.04	−0.05	−0.04	−0.09	−0.07	−0.02	−0.04	0.05
t(*Coef*)	−1.17	−14.19	−8.34	−4.02	−2.24	−1.72	−2.64	−1.89	−4.72	−3.86	−1.15	−2.57	3.62

Panel B: dCP_t

	a	*CP–TF*	*CP–FF*	dCP_{t-1}	dCP_{t-2}	dCP_{t-3}	dCP_{t-4}	dCP_{t-5}	dCP_{t-6}	dCP_{t-7}	dCP_{t-8}	dCP_{t-9}	dCP_{t-10}
9/27/1982–12/31/1993, 2802 observations, R2 = 0.07													
Coef	0.00	−0.05	0.02	0.23	0.03	−0.04	0.02	0.03	0.01	−0.04	0.05	0.04	−0.02
t(*Coef*)	1.13	−7.81	5.10	12.19	1.61	−2.18	1.13	1.49	0.79	−2.00	2.51	2.12	−1.21
1/3/1994–6/28/2012, 4560 observations, R2 = 0.03													
Coef	0.00	−0.00	−0.02	−0.07	0.09	−0.01	0.02	0.03	0.03	0.05	−0.02	0.04	0.03
t(*Coef*)	0.32	−0.12	−5.72	−4.69	5.78	−0.66	1.31	1.96	1.70	3.52	−1.24	2.81	1.74

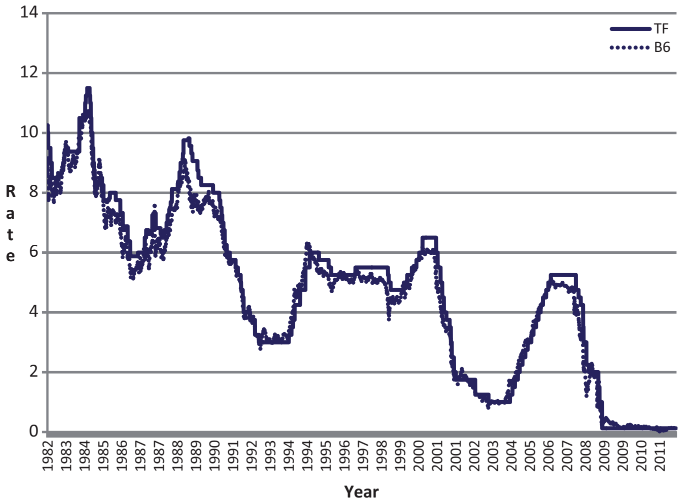

Figure 2
Plots of the target Fed funds rate, *TF*, and the six-month T-bill rate, *B6*.

(Figure 1b). Plots of *TF* that include other open market rates lead to similar conclusions. Thus, to judge how Fed power shows up in the history of open market rates, it is important to know how variation in *TF* splits between active attempts by the Fed to control the level of rates and passive responses to market conditions.

If the Fed sets *TF* passively, changes in *TF* move it toward existing rates. To examine the relation between a change in *TF* and credit market conditions before the change, I estimate the regression,

$$TF_t - TF_{t-1} = a + b(R_{t-1} - TF_{t-1}) + e_t. \qquad (2)$$

The sample of $TF_t - TF_{t-1}$ is changes in *TF* for the days when the target changes, and R_{t-1} is an interest rate on the day preceding the change in *TF* on day *t*. The regression tests whether the change in the target, when it changes, is related to the deviation of the pre-change target from the pre-change level of an interest rate. The estimates of (2) for each of the six interest rates in the sample are in Table 4.

Table 4 shows that interest rates predict changes in *TF*, and the one-month commercial paper rate, *CP*, is an especially strong predictor. The slopes in (2) taper off for longer maturity instruments, but all rates show some forecast power. Thus, when the Fed changes *TF*, it moves it in the direction of existing rates, especially *CP*.

In the Table 4 regression for the period beginning in 1994, the slope in the estimate of (2) for *CP* is near one (1.03, $t = 17.13$). Thus, during the period when the Fed announces *TF*, the change in *TF* on average responds just about

Table 4
Univariate regressions that predict changes in the target Fed funds rate, *TF*, with the difference between the level of *TF* and the level of an interest rate *R* on the day preceding the change

	FF–TF	*CP–TF*	*B3–TF*	*B6–TF*	*G5–TF*	*G10–TF*
Period is 9/27/1982–12/16/2008, 153 changes in the target						
b	0.24	0.66	0.40	0.41	0.13	0.09
t(*b*)	4.56	11.87	10.29	12.42	5.77	4.02
R Sq	0.11	0.48	0.41	0.50	0.18	0.09
Period is 9/27/1982–12/31/1993, 93 changes in the target						
b	0.17	0.46	0.27	0.34	0.08	0.06
t(*b*)	3.22	6.14	4.67	5.87	2.73	2.09
R Sq	0.09	0.29	0.18	0.27	0.07	0.04
Period is 1/3/1994–12/16/2008, 60 changes in the target						
b	0.56	1.03	0.59	0.52	0.21	0.13
t(*b*)	4.09	17.13	14.59	16.58	6.17	3.77
R Sq	0.21	0.83	0.78	0.82	0.39	0.18

The interest rates *R* are the Fed funds rate (*FF*), the one-month commercial paper rate (*CP*), the three-month or six-month Treasury bill rate (*B3* or *B6*), or the five-year or ten-year U.S. Treasury bond rate (*G5* or *G10*). The table shows the regression slopes, *b*, their *t*-statistics, *t*(*b*), and the regression R^2 (*R Sq*), adjusted for degrees of freedom. The regression intercepts are not shown. The sample period ends on 12/16/2008, the date of the last change in *TF*.

one-for-one to the deviation of the lagged *CP* rate from the lagged target rate. In the estimates of (2) for the preceding period, the slope in the regression for *CP* is lower, 0.46 ($t = 6.14$). Thus, during 1982–1993 changes in *TF* absorb less than half of the lagged spread of *CP* over *TF*. The weaker results for the earlier period may have something to do with the fact that *TF* and the dating of changes in *TF* are unknown and are inferred by Thornton (2005) from the behavior of *FF*.

The Table 4 evidence that short-term interest rates forecast changes in *TF* is not news (Hamilton and Jorda 2002). For those who believe in a powerful Fed, the driving force is *TF*, the concrete expression of Fed interest rate policy, and the forecast power of short rates simply implies that rates adjust in advance to predictable changes in *TF* (Taylor 2001). The evidence is, however, also quite consistent with a passive Fed that changes *TF* in response to open market interest rates. There are, of course, scenarios in which both forces are at work, possibly to different extents at different times. The Fed may go passive and let the market dictate changes in *TF* when inflation and real activity are satisfactory, but turn active when it is dissatisfied with the path of inflation or real activity. This mixed story is also consistent with the evidence in Table 3 that the Fed funds rate moves toward both the open market commercial paper rate and the Fed's target rate.

In short, we know that the target Fed funds rate tracks the long-term swings in the level of interest rates, especially short rates, but we do not know the extent to which this reflects a powerful Fed that sets *TF* to control rates or a passive Fed that adjusts *TF* to align with existing rates.

Acknowledging this uncertainty about the role of the Fed versus market forces in the path of *TF* is important since it casts a dark cloud over recent empirical work on the relation between monetary policy and real activity. The Fed's target rate, *TF*, is commonly interpreted as the concrete expression of monetary policy, and evidence that the Fed funds rate, *FF* (which closely tracks *TF*), leads real activity is interpreted as causation running from monetary policy to real activity (e.g., Christiano, Eichenbaum, and Evans 2005). This inference is based on the assumption that variation in *TF* and thus *FF* is closely controlled by the Fed. If much of the variation in *TF* and *TF* is instead passive adjustment to market forces, causation probably goes the other way; that is, with rational asset pricing, expectations of future real activity are a prime determinant of current asset prices and interest rates. This possibility is prominent in early work showing that stock returns and short-term interest rates lead real activity (Fama 1981; Harvey 1989; Stock and Watson 1989), but it fades from view in recent work on how monetary policy, embodied in the Fed funds rate, affects real activity.

4. Event Study

Like regression (1), regression (2) leaves a fundamental open question. Do open market rates forecast changes in the Fed's target rate because the Fed passively adjusts *TF* to align it with existing market rates or because the market predicts how a powerful Fed will set *TF* to control rates? The final tests attempt to bypass this problem by examining the responses of rates to unexpected changes in *TF*. If the Fed uses *TF* to control interest rates, unexpected changes in *TF* should move open market rates.

To test this hypothesis, I examine current and future changes in rates in response to a proxy for unexpected changes in *TF*. For each of the six interest rates *R*, and using a proxy, F_{t-1}, for the rational forecast of the new target rate TF_t to be set on day t, I estimate 11 univariate regressions,

$$dR_{t+lead} = a + b(TF_t - F_{t-1}) + e_{t+lead}, \quad lead = 0, 1, 2, \ldots, 10. \qquad (3)$$

Given a change in *TF* on day t, the 11 estimates of regression (3) measure the responses of the interest rate R on day t and the 10 subsequent days, using an error correction variable that is the difference between the new *TF* set on day t and a proxy for its expected value assessed on day $t-1$.

A simple proxy for F_{t-1} is the lagged target, TF_{t-1}, used, for example, by Cook and Hahn (1989) and Cochrane and Piazzesi (2002). The estimates of (2) say, however, that when *TF* changes, the change is in part predictable from past rates. This means the total change in *TF* is a noisy measure of the unexpected part of the change.

The estimates of (2) in Table 4 say that the lagged commercial paper rate, CP_{t-1}, is a better predictor of a new TF_t than any of the longer-maturity rates in the sample. This makes sense since, as predictors of TF_t, longer maturity rates are more contaminated by time-varying expected term premiums and longer-term forecasts of short rates. Table 4 also says that CP_{t-1} is a better predictor of a new TF_t than the lagged Fed funds rate, FF_{t-1}. This also makes sense since there is lots of transitory variation in *FF* due to special conditions in the market for reserves that is noise for predictions of a change in *TF*. I have confirmed that in the estimates of (3) to predict different open market rates, using CP_{t-1} as the proxy for F_{t-1} produces stronger slopes than the lagged values of any of the other rates. Thus, I use CP_{t-1} as the proxy for F_{t-1}. This can be viewed as data dredging to produce results in favor of Fed control of rates, but this seems appropriate, given my skepticism about a strong role for the Fed.

Kuttner (2001) uses predictions of *FF* from the Fed funds futures market as the proxy for the rational forecast of *TF*. This proxy requires complicated manipulation due to the fact that the futures contract covers the average daily effective Fed funds rate for a month. My simple approach produces results similar to his. (See also Gürkaynak, Sack, and Swanson [2007]. Hamilton [2008] reviews this literature and provides a refinement of Kuttner's approach.)

The estimates of (3) are in Table 5. To keep the table manageable, it shows results for 1982–1993 and 1994–2012, but not for the full sample period. Table 5 stops at lead 4 in regression (3), but nothing is lost since the (unreported) estimates of the slope b in (3) show that the responses of interest rates to the proxy for unexpected changes in the target funds rate are concentrated on the day of the change in *TF* and one or two days thereafter.

The Fed funds rate, *FF*, gets special treatment in Table 5. The purpose of the Fed funds target rate, *TF*, is to signal that the Fed will use open market operations to move *FF* toward *TF*. Table 2 confirms that *FF* moves strongly toward *TF* on a day-to-day basis. Part B of Table 5 shows regressions that use $TF_t - FF_{t-1}$, the spread of a new *TF* set on day t over the lagged funds rate, to predict changes in *FF*. The purpose of these regressions is to examine the response of *FF* to a new *TF*. The response is quick and complete. When *TF* changes, current and future changes in *FF* move it to the new *TF* in about three days. This is true during 1982–1993 as well as 1994–2012, which is not surprising since the Fed always knows its target rate. In short, all the evidence implies that *FF* moves quickly toward *TF*. It thus seems redundant to examine how *FF* responds to the unexpected part of changes in *TF*.

Table 2 says that unlike *FF*, open market rates show little or no tendency to move toward *TF* on a day-to-day basis. We are thus especially interested in whether a different picture of the response of open market rates emerges when the sample is limited to days when *TF* changes. Panel A of Table 5 shows that during 1994–2012, when the Fed announces changes in *TF*, open market rates respond to $TF_t - CP_{t-1}$, the proxy for the unexpected part of the change in *TF*. The responses decline with maturity. The commercial paper rate responds in full; that is, the sum of the slopes on $TF_t - CP_{t-1}$ in (3) for leads 0, 1, and 2 in the three dCP_{t+lead} regressions for 1994–2012 is close to 1.0. The cumulative

Table 5
Univariate regressions to predict contemporaneous and four future changes in interest rates

	9/27/1982–12/31/1993					1/3/1994–12/16/2008				
Lead	0	1	2	3	4	0	1	2	3	4
Panel A										
Predict dCP_{t+lead} with $TF_t - CP_{t-1}$										
b	0.17	0.11	0.01	−0.02	−0.06	0.26	0.66	0.16	0.05	0.02
t(*b*)	5.55	3.72	0.34	−0.88	−1.88	3.45	11.11	2.90	1.40	0.64
R Sq	0.24	0.12	−0.01	−0.00	0.03	0.16	0.67	0.11	0.02	−0.01
Predict $dB3_{t+lead}$ with $TF_t - CP_{t-1}$										
b	0.16	0.05	0.03	0.02	−0.02	0.33	0.18	0.14	−0.00	−0.06
t(*b*)	5.27	1.67	1.18	0.85	−0.66	4.53	2.27	2.04	−0.01	−1.64
R Sq	0.23	0.02	0.00	−0.00	−0.01	0.25	0.07	0.05	−0.02	0.03
Predict $dB6_{t+lead}$ with $TF_t - CP_{t-1}$										
b	0.19	0.05	0.04	0.00	−0.01	0.30	0.13	0.11	−0.00	0.03
t(*b*)	6.19	1.68	1.65	0.17	−0.30	4.75	2.24	1.91	−0.02	0.68
R Sq	0.29	0.02	0.02	−0.01	−0.01	0.27	0.06	0.04	−0.02	−0.01
Predict $dG5_{t+lead}$ with $TF_t - CP_{t-1}$										
b	0.12	0.08	0.03	−0.01	−0.03	0.11	0.05	0.05	0.03	0.04
t(*b*)	3.26	2.83	1.31	−0.46	−0.78	1.33	0.79	0.79	0.49	0.99
R Sq	0.09	0.07	0.01	−0.01	−0.00	0.01	−0.01	−0.01	−0.01	−0.00
Predict $dG10_{t+lead}$ with $TF_t - CP_{t-1}$										
b	0.07	0.08	0.04	−0.01	−0.03	0.02	0.03	0.02	0.01	0.04
t(*b*)	2.26	3.00	1.65	−0.28	−0.97	0.25	0.40	0.35	0.17	0.94
R Sq	0.04	0.08	0.02	−0.01	−0.00	−0.02	−0.01	−0.02	−0.02	−0.00
Panel B										
Predict dFF_{t+lead} with $TF_t - FF_{t-1}$										
b	0.67	0.14	0.16	0.06	−0.05	0.59	0.42	0.09	−0.01	−0.03
t(*b*)	9.92	2.49	3.23	1.15	−0.64	7.76	4.26	1.12	−0.13	−0.38
R Sq	0.51	0.05	0.09	0.00	−0.01	0.50	0.23	0.00	−0.02	−0.01

Panel A shows univariate regressions to predict contemporaneous and four future changes in dR_{t+lead} with $TF_t - CP_{t-1}$ for days *t* when TF_t changes. The interest rate *R* is the commercial paper rate (*CP*), the three-month or the six-month Treasury bill rate (*B3* or *B6*), or the five-year or ten-year U.S. Treasury bond rate (*G5* or *G10*). Panel B shows regressions to predict contemporaneous and four future changes in the Fed funds rate, dFF_{t+lead}, with $TF_t - FF_{t-1}$ for days *t* when TF_t changes. The table shows regression slope coefficients (*b*), *t*-statistics for the slopes (*t*(*b*)) and regression R^2 (*R Sq*), adjusted for degrees of freedom. The regression intercepts are not shown. The last change in *TF* is on 12/16/2008. There are 93 changes in TF_t in the regressions for 9/27/1982–12/31/1993, and there are 60 changes during 1/3/1994–12/16/2008.

three-day response drops to 65% for three-month T-bills, 54% for six-month T-bills, and 21% and 7% for five-year and ten-year Treasury bonds.

During the earlier 1982–1993 period, the three-day response of the commercial paper rate to the proxy for unexpected changes in the target rate is weaker, 29% versus 108% for 1994–2012. T-bill responses are also lower in the earlier period, 24% versus 65% for *B3* and 28% versus 54% for *B6*. Treasury bond responses are again weak during 1982–1993, but if anything, they are a bit stronger than during 1994–2012. The generally weaker responses of rates during 1982–1993 may in large part be a measurement error problem since *TF* and the dates of change in *TF* must be inferred from the behavior of *FF*, which is quite noisy prior to 1994.

The bottom line from the estimates of regression (3) is that the short-term open market rates, *CP*, *B3*, and *B6*, clearly respond to the estimates of the unexpected part of changes in the target Fed funds rate. The responses are stronger during 1994–2012, but the *t*-statistics for the 1982–1993 slopes say that the responses of the earlier period are also deep in the range of statistical reliability.

Table 5 is the best evidence for a Fed that exercises power at least over short rates. There is, however, a rejoinder. The response of short-term rates to unexpected changes in *TF* might just be a signaling effect. Rates adjust to unexpected changes in *TF* because the Fed is an informed agent with private information about the market forces that will determine future open market rates, and it uses this information passively to change *TF*. It is then rational that open market rates respond to unexpected changes in *TF* even if they do not represent active attempts by the Fed to move rates.

More important, viewed alone, the regression slopes in (3) for 1994–2012 in Table 5 give a misleading picture of Fed power. For example, the slopes say that during 1994–2012 the *CP* rate adjusts fully to the unexpected part of changes in *TF*. The regressions to explain changes in *TF* in Table 4 tell us, however, that unexpected changes are a small part of total changes in *TF*. During 1994–2012, expected changes, measured as $CP_{t-1} - TF_{t-1}$, observed on day $t-1$, capture 83% of the variance of changes in *TF* from $t-1$ to t, leaving only 17% for unexpected changes.

The quick decline with maturity in the responses of rates to unexpected changes in *TF* during 1994–2012 also illustrates the limitations of Fed power. Changes in *TF* are strongly correlated with past changes. The correlations of the changes for 1994–2012 start at 0.70 for the first lag and decline slowly to near zero at the sixth lag. The correlations for 1982–1993 are similar. During 1994–2012 changes in *TF* are on average almost four months apart. Given the positive correlation of successive changes in *TF*, an increase in *TF* means that *TF* is likely to increase further over the next year or so. Thus, if forecasts of *TF* are the sole force driving the responses of rates (i.e., if the expectations hypothesis rules rates), the three-month and six-month bill rates, *B3* and *B6*, should respond more to the unexpected part of changes in *TF* than the one-month commercial paper rate. In fact, they respond much less (Table 5). This suggests that changes in the expected term premiums in *B3* and *B6* tend to offset the implications of unexpected changes in *TF* for the expected future short rates in *B3* and *B6*.

5. New Game in Town

In response to the lingering recession of 2008, the Fed's game plan changes. Its credit market interventions expand far beyond anything previously observed. In changing its game plan, the Fed changes the game and the old arguments about how Fed actions affect rates no longer apply. In the new game, the massive reserves issued to purchase longer-term debt put upward rather than downward pressure on short-term rates. The fact that short-term rates decline to near zero is then a clear example of variation in rates due to market forces beyond Fed control.

The conventional story for how Fed control of the monetary base affects interest rates centers on the opportunity cost of excess reserves. Historically, the Fed paid no interest on reserves, which means reserves have an opportunity cost to banks. When the Fed does an open market operation that pushes reserves beyond the quantity banks judge to be optimal, the opportunity cost of the excess reserves leads banks to attempt to dispose of them by making loans and purchasing securities, which tends to push interest rates down.

In September 2008, the Fed's game plan changes. It starts issuing huge quantities of reserves to buy longer-term Treasury bonds and mortgage-backed securities, with the goal of lowering long-term interest rates to spur real activity (so-called quantitative easing). The effects of Fed actions on long-term rates are studied by Krishnamurthy and Vissing-Jorgensen (2011), but the point I wish to make is about how Fed actions affect short-term rates not long-term rates.

An important part of the Fed's new game plan is that in October 2008 it begins to pay interest on reserves at or slightly above the rate on open-market short-term riskless securities like Treasury bills. I infer that the Fed rightly judges that if massive new excess reserves have an opportunity cost, bank efforts to get rid of them are likely to produce high inflation. Whatever the reason, paying market interest on reserves means reserves no longer impose a cost on banks, and banks indeed largely respond to the reserves by holding them. At the end of 2012, excess reserves, which prior to September 2008 are almost always close to zero, are about \$1.5 trillion and rising, versus required reserves of \$112 billion. Other central banks adopt the same strategy, flooding the market with interest-bearing reserves.

Paying market interest rates on reserves changes the game facing the Fed. Reserves no longer have an opportunity cost (interest foregone). Instead, reserves are just another form of riskless interest-bearing short-term debt, and the Fed's actions with respect to reserves are subject to normal supply/demand effects. Specifically, when the Fed and other central banks increase the supply of short-term debt by issuing interest-bearing reserves to buy longer-term bonds, the interest rate on short-term debt should rise rather than fall.

In fact, short-term rates fall after the Fed executes its new game plan. The Fed funds rate and the one-month commercial paper rate fall from about 2% in September 2008 to near zero at the end of 2008 and thereafter. If my analysis is correct, this fall in riskless short-term rates (in the U.S. and around the world) occurs despite the actions of the Fed and other central banks in 2008 and thereafter, not because of them. Apparently, strong demand for short-term riskless debt, due to the uncertainty associated with a steep and lingering recession, more than suffices to absorb the massive amounts of such debt issued by the Fed and other central banks. Whatever the explanation, the fact that short-term rates fall despite multiple trillions of new short-term interest-bearing central bank debt is an example of the limitations imposed by markets on the control of interest rates by central banks.

6. Conclusions

Does the Fed control interest rates? On the negative side of the ledger, the persistent strong positive autocorrelation of the spreads of open market rates over the Fed funds target rate in Table 1 and the plots of the spreads in Figure 1 show that open market short-term rates (*CP*, *B3*, and *B6*) and long-term rates (*G5* and *G10*) take large sustained swings away from *TF*. This suggests that there is lots of variation in open market rates beyond Fed control.

The estimates of regression (1) in Table 2 show that open market rates have little or no tendency to move toward *TF* on a day-to-day basis. This is clear evidence that the day-to-day variation in open market rates has little to do with the Fed's target rate. This result is also consistent with the stronger hypothesis that the Fed has little control of open market rates.

The Fed funds rate converges quickly to *TF*, on a day-to-day basis (Table 2) and in response to changes in *TF* (Table 5). Pushing *FF* toward *TF* does not in itself imply, however, that the Fed exercises much control of *TF*. A passive Fed might let market rates drive *TF* and use daily open market operations to ensure that *FF*, the rate it can control, does not get out of line. This passive Fed story is consistent with the evidence in Table 4 that when the Fed changes *TF*, it moves toward existing short-term open market rates, and it is consistent with the evidence in Table 3 that on a day-to-day basis *FF* moves toward *CP* as well as toward *TF*.

There is, however, a different interpretation of Tables 2, 3, and 4 that is consistent with an active Fed with lots of control of open market rates. Suppose the Fed's intentions with respect to *TF* are predictable. If the Fed controls interest rates, rates should adjust in advance to expected changes in *TF*. This logic can explain the Table 4 evidence that when the Fed changes *TF*, it moves toward existing short-term rates, the Table 3 evidence that the Fed funds rate moves toward the commercial paper rate as well as toward *TF*, and the Table 2 evidence that on a day-to-day basis open market rates show little or no tendency to move toward *TF*. It cannot, however, explain the evidence in Table 2 that there is lots of day-to-day variation in open market rates that is unrelated to the Fed's target rate and the evidence in Table 1 and Figure 1 that open market rates take large long-lived swings away from *TF*.

A good way to test for Fed effects on open market interest rates is to examine the responses of rates to unexpected changes in *TF*. Table 5 confirms that short-term rates (the one-month commercial paper rate and three-month and six-month Treasury bill rates), respond to the unexpected part of changes in *TF*. Table 5 is the best evidence of Fed influence on rates, and event studies of this sort are center stage in the active Fed literature. But skeptics have a rejoinder. The response of short rates to unexpected changes in *TF* might be a signaling effect. Rates adjust to unexpected changes in *TF* because the Fed is viewed as an informed agent that sets *TF* to align with its forecasts of how market forces will shape open market rates. In this scenario, unexpected changes in *TF* move open market rates even when the Fed does not attempt to control open market rates.

Even if the event study results in Table 5 are accepted as evidence of Fed power, they do not imply that the Fed has much control of rates, for three reasons. First, the responses of rates to unexpected changes in *TF* fall off quickly for bond maturities beyond a few months. Second, unexpected changes in *TF* account for a small fraction of the variance of changes in *TF*, and there is no unambiguous evidence on how much of the predictable part of changes in *TF* is active or passive. Third, there is lots of evidence in the term structure literature that much of the variation in interest rates is due to time-varying expected term premiums rather than to forecasts of future spot rates. This result is observed even for relatively short-term rates (e.g., Fama 1984), and it is consistent with the large and protracted swings of short-term and long-term rates away from *TF* in Figure 1.

In sum, the evidence says that Fed actions with respect to its target rate have little effect on long-term interest rates, and there is substantial uncertainty about the extent of Fed control of short-term rates. I think this conclusion is also implied by earlier work, but the problem typically goes unstated in the relevant studies, which generally interpret the evidence with a strong bias toward a powerful Fed.

Finally, for the period that starts with the lingering recession of 2008, a less ambiguous conclusion is possible. The decline in short-term rates after 2008, despite massive injections of interest bearing short-term debt (reserves) by the Fed and other central banks, is a cautionary tale about how market forces can limit the power of central banks even with respect to the short-term rates that are commonly taken to be their special preserve.

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