Estimating the Impact of Changes in the Federal Funds Target Rate on Market Interest Rates from the 1980s to the Present Day

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In this paper, Donal O'Cofaigh quantifies the influence the U.S. Federal Reserve possesses over market interest rates, through their tool of choice, the Federal Funds Rate. Through detailed econometric analysis, he finds that though the Fed still retains significant influence over market interest rates, this influence has weakened over time. In addition, he finds evidence that increases in the Federal Funds Rate have a greater impact on bonds, the longer the maturity.

Introduction

In 1988 Timothy Cook and Thomas Hahn (henceforth referred to as C&H) published a paper entitled "The Effect of Changes in the Federal Funds Rate Target on Market Interest Rates in the 1970s". The authors note that previous attempts to distinguish whether the Federal Reserve (Fed) can influence interest rates had found little support for the theory, which, C&H argued, conflicted with the views among financial markets. This premise is based on the following three principles.

Firstly, the Fed's policy instrument is the Federal Funds Rate (FFR). Secondly, the Fed uses the FFR in order to fit its policies. Thirdly, the expectations theory hypothesis stipulates that long run interest rates are what the markets expect short run interest rates to be at that point in time (removing the risk premium). C&H argue that these three principles imply that "the Fed influences market rates through its control of the current funds rate and its influence on expected future values of the funds rate". The authors then test this theory by regressing the changes in the FFR on changes in bond yields for a number of different maturities. It must be acknowledged that the authors stipulate that the time period over which the tests are conducted was somewhat unique. September 1974 to September 1979 was a period in which the Fed monitored rates particularly closely, so closely in fact, that market participants could identify most target changes on the day they were implemented. C&H found that changes in the FFR were followed by large movements in the same direction in short rates, moderate movements in intermediate rates, and small but significant movements in long-term rates.

I have attempted to reconstruct these tests from the period 1980 to present. My theory is fundamentally the same, in that prior to testing the data, I expect that changes in the FFR will result in corresponding changes in the same direction in bond yields. I expect this impact to have been somewhat diluted since the '70s as the Fed has sought to increase its transparency when conveying information to the markets in terms of its stance on monetary policy. This has culminated recently in the Fed announcing at the January Federal Open Market Committee meeting that it anticipates that rates will stay low into 2014. This was followed by a flattening of the yield curve as long rates decreased further.

Goodfriend (1990) noted that a particularly interesting aspect of C&H's findings was that T-Bill rates tended to move by only half of the change in the target rate, which would have suggested that the market has already built in the other 50 percent of the move into the market rates on the day of the change. What will become obvious from my findings below is that the markets have moved to price a significantly larger portion of anticipated rate changes prior to the announcement. If the FOMC announced at a March meeting that it was not raising rates at the present time, but was moving to an asymmetric bias towards raising the rate in the future, you would see a shift upwards in the yield curve today, despite the fact that rates are unchanged. What is evident is that, were the Fed to imply an increasingly hawkish stance, the market would anticipate future rate increases and would price that in to the market that day. Consequently when it comes to the day of the actual rate change, the market has fully anticipated this change, and yields do not change to the same extent that they might have done in the past. Forward curves are particularly indicative of the market's anticipation of the Fed's movements. For example, the 1y1y forward is the one-year rate in one year's time. If this is significantly above the current one year rate, then this would provide evidence that the market anticipates rate increases over the coming 12 months.

The paper continues as follows. In Section I, I review the expectations hypothesis for the term structure of interest rates, and then I introduce the initial regressions of changes in the FFR on bond yields. Section II reviews a number of potential scenarios where a change in the target rate could potentially have a greater impact on yields. Section III briefly focuses on the potential impact that changes in the target rate may have on inflation expectations.

Section I

Rational expectations implies that the interest rate on a longer-term security can be expressed as a weighted average of the current and expected future short-term interest rates over the life of the longer term security, plus a risk premium (Simon, 1990). C&H's findings, along with those held by market participants, constitute strong evidence that expectations of future level of the funds rate influence current market rates. Campbell and Shiller (1990) note that the expectations theory of the term structure implies that the spread is a constant risk premium, plus an optimal forecast of changes in future interest rates.

I have regressed changes in the FFR on changes in bond yields, beginning in October 1979, up to the most recent rate changes.[1] The Fed adjusted the target rate approximately one hundred and fifty nine times over the course of the sample.[2] The path of bond yields and the FFR from 1970 to now is best summarized in Figure 1.

Since the late 1970s, the yield on Treasuries has trended downwards, closely following the trend in the Fed's target rate. In order to see this more clearly, Figurea 2 and 3 depict the progressions of both the 3-Month T-bill yield and 30-Year Treasury from the late '70s up to the present day, with the target rate. The 30-Year Treasury has followed a similar trend, but quite notably does not follow quite as closely.

The results to the following regression are found in Table 1.

$$\Delta i = \beta_0 + \beta_1 \Delta FFR + u$$

Where Δi denotes the change in yield, and β_1 measures the market response to the unanticipated portion of the target change.

1 The data were sourced from Bloomberg. Close of day yields were extracted. It must be noted that 12-Month T-Bills were omitted because the data on Bloomberg for 12-Month yields were inconsistent.

2 A number of the sample changes were reported in the data as a change on a specific day when in reality they were spread out over the course of a number of days. In particular, Bloomberg has on record an increase of 8.5 percent in the FFR on the 01/04/1980, which I omitted from the sample.

Table 1

Coefficient	3month	6months	2yr	5yr	10yr	30yr
Intercept	0.0140	0.0274	0.0299**	0.0301**	0.0275**	0.0193*
	(0.0190)	(0.0177)	(0.015)	(0.0137)	(0.0115)	(0.0109)
β_1	0.0847**	0.0608*	0.0544***	0.0302**	0.0203**	0.0245**
	(0.0384)	(0.0313)	(0.017)	(0.013)	(0.0096)	(0.0118)
Adjusted R Squared	0.1114	0.0660	0.0734	0.0249	0.0137	0.0260
Standard Error	0.2372	0.2226	0.1889	0.1723	0.1454	0.1369
D-W Statistic	2.1635	2.1476	2.2616	2.1394	2.0951	2.1386

Figure 1: The Progression of the FFR and Treasury Yields since 1980

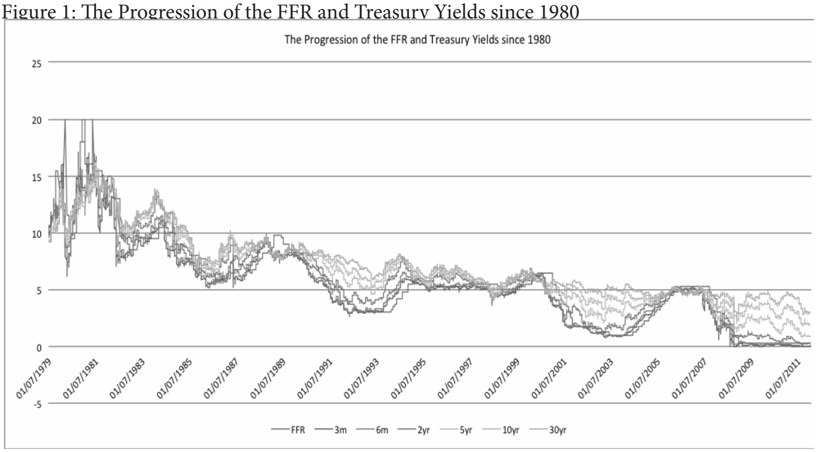


Figure 2: FFR vs 3-Month T-Bill

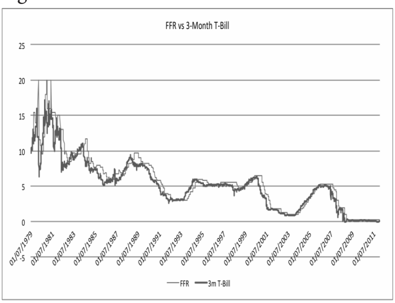
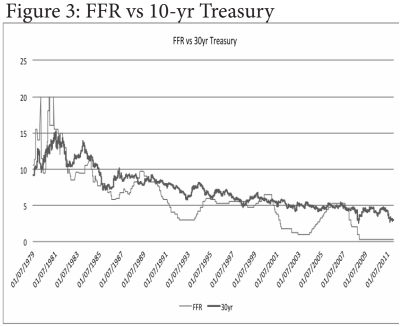


Figure 3: FFR vs 10-yr Treasury



Having failed to reject the null hypothesis of homoskedasticity it was not necessary that I included the robust standard errors, but I felt that it added weight to the findings. Durbin-Watson test results for each regression are included in the findings. In each case the result is in excess of 2.0, so serial correlation is not an issue3. Adjusted R-Squared values indicate that up to 11 percent of the variation in the yields can be accounted for by variation in the FFR.

As we can see from the results, in each case a change in the FFR has a statistically significant impact on the change in bond yields. The results are interpreted as follows: for a 1 percent increase in the FFR, we would expect the 3-Month T-bill yield to increase by 8.5 basis points. The reaction of longer-term rates to changes in the FFR diminishes as the maturity increases, but the impact remains statistically significant. An interesting point to highlight here is the contrast between the results observed by C&H, and what I have here. So while the results remain statistically significant, C&H found the corresponding changes in bond yields to be far greater than the impact I have found. The theory for this was briefly highlighted above. As a consequence of the attempted increase in transparency from the Fed, it would appear that changes in the FFR become almost entirely anticipated prior to the actual change, with in excess of 90 percent of the move priced into market yields.

The correlation coefficients of different maturities are presented in Table 3. The figures here highlight the tendency for long-term rates to move with the T-Bill rates. One of the methods of testing the expectations hypothesis is to regress the changes in T-Bill yields on changes in Treasuries of a longer maturity. I ran the following regression, with the results presented in Table 2.

$$\Delta i = \beta_0 + \beta_1 \Delta FFR + \beta_2 \Delta 3Month + u$$

Where β_2 denotes the relationship between changes in the 3-Month T-Bill and bonds of longer maturity, and β_1 the deviation as a consequence of changes in the FFR. The results now depict statistically insignificant responses of bond yields of longer maturity to changes in the FFR, coupled with a statistically significant impact from the change in 3-Month bills. Thornton (1998) notes that it might be unwise interpreting these results in terms of the expectations theory. Mankiw and Miron (1986 cited in Goodfriend, 1990), noted that in the presence of a time-varying premium, the coefficient in such a regression tends to be biased downwards. An alternative theory posed by Thornton (1998) is the segmented market hypothesis, which asserts that individuals have a preference to either borrow or lend in one end of the market,

3 I tested for Serial correlation in each case, and found the easiest way to represent it in the findings was with the Durbin Watson Statistic, the premise of which is if D.W.>2, then there is no issue with serial correlation.

and a consequence of this is that bond yields of different maturities are not necessarily related. The statistically significant impact of changes in 3-Month yield does not provide concrete evidence of the expectations theory. Durbin-Watson statistics once again indicate no issues with serial correlation. The adjusted R-Square results highlight that a much greater extent of the variation of our bond yields is now caused by the independent variables.

Table 2

Coefficient	2yr	5yr	10yr	30yr
Intercept	0.0214**	0.0231**	0.0221**	0.0147*
	(0.0099)	(0.0098)	(0.0088)	(0.0086)
β_1	0.0031	-0.0121	-0.0121	-0.0035
	(0.0183)	(0.0179)	(0.0156)	(0.0153)
β_2	0.6052***	0.5006***	0.3831***	0.3306**
	(0.1214)	(0.1368)	(0.1246)	(0.1309)
Adjusted R Squared	0.6057	0.4845	0.3952	0.3413
Standard Error	0.1232	0.1253	0.1138	0.1126
D-W Statistic	2.2580	2.1008	2.1295	2.1529

Table 3: Correlation Coefficients

	3month	6month	2yr	5yr	10yr	30yr
3month	1.000					
6month	0.940	1.000				
2yr	0.781	0.876	1.000			
5yr	0.698	0.822	0.951	1.000		
10yr	0.630	0.766	0.891	0.972	1.000	
30yr	0.591	0.718	0.834	0.899	0.933	1.000

Section II

In order to test whether the market's reaction to a change in the Federal Funds target rate was significantly different for a larger change I created a dummy variable that assigned 1 to every change in the FFR that was greater than 25 basis points. There were eighty occasions from my sample of changes where the change signaled by the Fed appeared to be greater than 25 basis points. The regression was as follows.

$$\Delta i = \beta_0 + \beta_1 \Delta FFR + \beta_2 Dummy + u$$

The results to this regression are presented in Table 4. The β_1 coefficient in each scenario remains statistically significant, and is almost identical to those findings in Table 1, but the β_2 coefficient accompanying the dummy variable is in no case statistically significant, and is inconsistent in sign across the maturities. What we can conclude from these findings is that large changes in the FFR do not have a statistically significantly greater impact than smaller changes. This could likely be attributed to the greater transparency the Fed has sought, and increasingly aggressive language and opinion towards changing rates would provide indicators to the market in advance of a rate change. Durbin-Watson statistics and Adjusted R-Squared values are similar to those found in Table 1.

Table 4

Coefficient	3month	6months	2yr	5yr	10yr	30yr
Intercept	0.0191**	0.0215**	0.0235**	0.0237**	0.0226***	0.0199***
	(0.0088)	(0.0103)	(0.0104)	(0.0103)	(0.0086)	(0.0069)
β_1	0.0848**	0.0606*	0.0542***	0.0301**	0.0202**	0.0245**
	(0.0384)	(0.0316)	(0.0171)	(0.0130)	(0.0097)	(0.0119)
Dummy	-0.0102	0.0118	0.0127	0.0126	0.0097	-0.0011
	(0.0381)	(0.0353)	(0.0299)	(0.0273)	(0.0230)	(0.0217)
Adjusted R Square	0.1061	0.0607	0.0686	0.0200	0.0085	0.0197
Standard Error	0.2379	0.2233	0.1894	0.1727	0.1457	0.1373
D.W. Stat	2.1689	2.1405	2.2554	2.1328	2.0885	2.1400

Dummy=1 if change in FFR was >25 basis points

Thornton (1998) argues that the Fed typically makes addition rate adjustments in the same direction, and that the market generally comes to anticipate this behaviour, so successive moves in the same direction are more likely to be priced into the market yields. This could also be argued to increase the effect that the Fed has on the market when it switches from a period of rate rises to the first decrease. The reversal could potentially be seen by the market as the first in a series, and so yields might move by a greater amount in anticipation of future changes. In order to assess the potential for this, I constructed another dummy variable that assigned 1 to each rate change that was not of the same sign as the one previous to it. There were 35 instances in my sample when the rate change did not follow previous changes in sign. The regression I ran was as follows, with the results depicted in Table 5.

$$\Delta i = \beta_0 + \beta_1 Dummy + \beta_2 \Delta FFR + u$$

Once again the β_2 shows little deviation from the findings in Table 1, with a similar case for D-W statistics and Adjusted R-Squared values. While the coefficients that accompany the dummy variable are consistent in sign across the board, they remain statistically insignificant. What the numbers indicate is if there is a rate change that is different in direction from the preceding change, the change tends to be larger, with the size of basis point move varying from 0 to 3.8. Unfortunately, the evidence is not concrete as the coefficients lack statistical significance.

Table 5

Coefficient	3month	6months	2yr	5yr	10yr	30yr
Intercept	0.0140	0.0213	0.0257	0.0216*	0.0204**	0.0139*
	(0.0192)	(0.0162)	(0.0136)	(0.0117)	(0.0096)	(0.0079)
Dummy	0.0000	0.0278	0.0193	0.0387	0.0324	0.0246
	(0.0543)	(0.0577)	(0.0504)	(0.0477)	(0.0409)	(0.0420)
β_2	0.0847**	0.0600*	0.0538***	0.0292**	0.0194**	0.0238*
	(0.0382)	(0.0314)	(0.0172)	(0.0131)	(0.0098)	(0.0124)
Adjusted R Square	0.1057	0.0626	0.0692	0.0272	0.0159	0.0252
Standard Error	0.2379	0.2230	0.1894	0.1721	0.1452	0.1369
D.W. Stat	2.1635	2.1243	2.2565	2.1336	2.0870	2.1279

Dummy=1 if Policy Changes Direction

Section III

The difference between the reaction of longer maturity bonds and that of shorter maturity bonds to changes in the FFR is seen as supportive of the interpretation that target changes affect the market's inflation outlook. The general assumption is that inflation can be reduced by increasing short-term interest rates. Alvarez et al (2001) note the evidence linking money growth, inflation and interest rates: "increases in average rates of money growth are associated with equal increases in average inflation rates and interest rates". The control of inflation is vitally important, and is one of the primary mandates for central banks around the world. Bernanke (2007) discusses the importance of the control of inflation, which is deemed to inject noise into the price system, to make long-term planning more complex, and to increase uncertainty. The same author also notes that experience suggests that high and persistent inflation undermines public confidence in the economy and in the management of economic policy generally.

The US Treasury began issuing 10-Year Treasury Inflation Protected Securities (TIPS) in January 1997 and 30-Year TIPS in April 1998[4]. I have compiled the yield data for bond break-even levels from 1998 up to the present day and have run a regression similar to that from Table 1. In this case, measures the changes in breakeven on the day of change in the FFR.

$$\Delta i = \beta_0 + \beta_1 \Delta FFR + u$$

Bond break-even level is essentially calculated from the Fisher Equation.

$$i = r + \pi$$

It is calculated as the difference between the yield on nominal bonds (i) and the yield on an inflation-linked bond of the same maturity (r). It can be interpreted as the expected inflation over the period up to the point of maturity of the bond. There were forty-nine instances, in which the Fed changed the target rate, that were applicable to TIPS. The results of the above regression are found in Table 6. Because changes in monetary policy are unlikely to have an immediate effect on market inflation expectations, we would anticipate that changes in inflation expectations would be muted in the short end of the curve and would have some impact in the long end. This is consistent with the findings in Table 6. While changes in the FFR have the expected impact on breakeven levels, the data are only significant at the 30-Year maturity. The signs of the β_1 coefficients are the opposite to those in Table 1. This is what we would expect: an increase in the FFR would decrease the market's anticipated rate of inflation and so reduce bond break-even levels. Both the Adjusted R-Squared value and the D-W statistics are similar to those found in previous results.

It must be highlighted that the measures of inflation used above (bond break-even level), are influenced by changes in inflation risk premi-

4 Consequently, break-even data do not exist for maturities less than 10 years for an extended period.

ums and liquidity premiums, and analyses are constrained by the fact that these markets have only been in operation in the US for a short period of time. However, these measures are market determined, with investors backing their views with real money. This is in contrast to forecasts determined by economic models and surveys.

Table 6: Impact on Break-Even

Coefficient	10yr BE	30yr BE
Intercept	0.0090	0.0070
	(0.0079)	(0.0058)
β_1	-0.0286	-0.0389**
	(0.0246)	(0.0179)
Adjusted R Square	0.0068	0.0740
Standard Error	0.0639	0.0455
D.W. Stat	2.0460	2.1739

Summary and Conclusions

The results highlighted in the tables above all indicate the strength that the US Federal Reserve has over market yields, and long-term inflation expectations. Although this impact has been diluted over time, the statistically significant results still emphasize the importance of the role the Fed has to play. An important assumption underlying all of the above results is that movements in the target federal funds rate cause movements in other market rates and not the reverse. For reverse causation to be a valid concern, changes in the federal funds rate would have to be triggered by contemporaneous daily changes in market rates, which seems unlikely, given the highly volatile nature of interest rates. Meyer (2004) made reference to the fact that the Federal Reserve does not like to be pushed into making changes by the market. Although the Fed will strive to avoid "shocking" the market, they are not likely to make changes if they do not see fit, even if the market has moved to price in an anticipated change.

The Fed began operations in 1914. Prior to the creation of the Fed, there were a number of measures of short-term interest rates, which were often subject to periods of extreme volatility, with changes of over 10 percent occurring on 8 occasions during the Civil War period. Since the creation of the Fed, such extreme temporary spikes have been absent. Evidence over time suggests that the Fed has had strong influence in smoothing rates.

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