Examining The Behavior Of Treasury Yields Using A Dynamic Taylor-Type Rule

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ABSTRACT

A dynamic version of Taylor's rule is applied to the analysis of the behavior of short-term and long-term treasury securities. Support for the Fisher effect is found for both maturities while there is evidence that long-term rates are less responsive to the output gap than short-term rates. In addition, long-term rates display a higher speed of adjustment but less persistence than short-term rates.

Keywords: interest rate, Taylor's Rule

INTRODUCTION

A monetary rule proposed by John Taylor (1993) recommends that the central bank set the federal funds rate (or its equivalent) as a function of the output gap, current inflation, and the difference between current inflation and its inflation target. This simple rule, now known as Taylor's rule, includes variables that capture information that a central bank would normally consider in setting monetary policy. If inflation is above its target, the federal funds rate should be raised, and monetary policy should be tightened in an effort to bring inflation down. If actual GDP exceeds potential GDP, implying the corresponding output gap is positive, inflationary pressures are building and the central bank should increase the funds rate in a preemptive strike against inflation. Judd and Rudebusch (1998) proposed a modified version of Taylor's rule that accounts for a dynamic adjustment mechanism since the interest rate is unlikely to adjust immediately to its theoretically optimal rate.

Many of the same principles employed by the Fed in setting a target for the federal funds rate are used by bond traders in deriving the appropriate value for market interest rates. Investors respond to concerns about increases in expected inflation by selling bonds thus reducing bond prices and increasing yields. Similarly, signs of economic strength lead to higher yields either due to fears of higher inflation or increasing demand for credit. As with the federal funds rate, one would expect interest rates to take some time to adjust to their appropriate levels since it may take investors time to process the available information. Thus, a dynamic version of Taylor's rule can prove useful in examining the behavior of Treasury yields. We find empirical evidence that bond investors do indeed respond to changes in expected inflation and indicators of economic strength. In addition, bond markets tend to display some persistence in the movement of interest rates accompanied by differing speeds of adjustment depending on the maturity considered.

DESCRIPTIVE STATISTICS

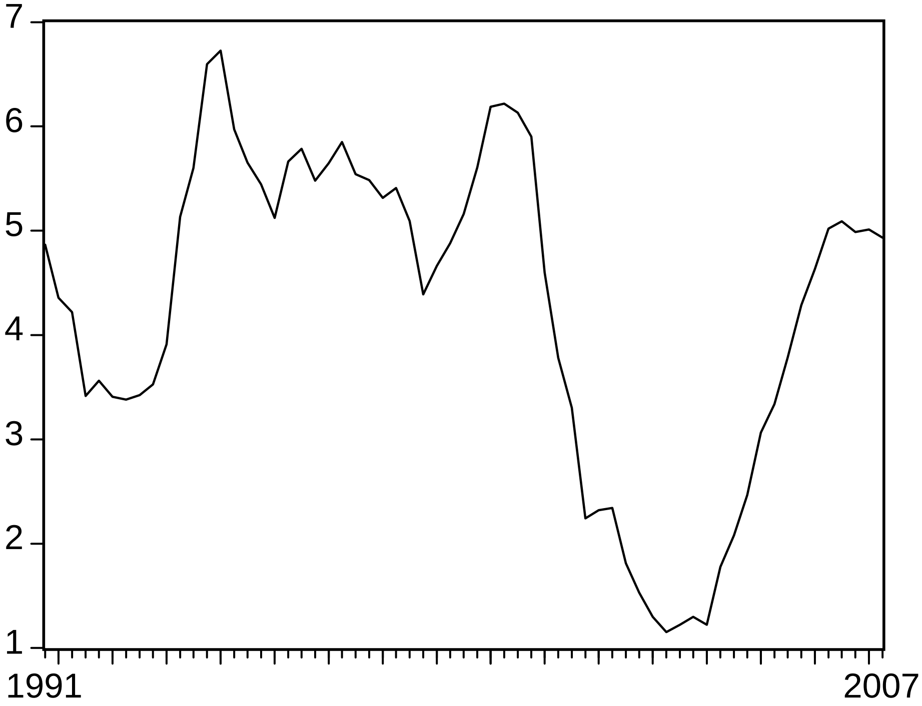
Quarterly data for the respective variables from 1991 to 2007 were obtained. The output gap was estimated using data from the Congressional Budget Office. Both one-year and ten-year Treasury bond rates using constant maturity were obtained from the Federal Reserve. Expected inflation was proxied using the Philadelphia Federal Reserve survey of professional economists. Expected inflation over the next year was used in the model for one-year treasuries while for ten-year Treasury bond yields, the expected annual inflation rate for the next ten years was employed.

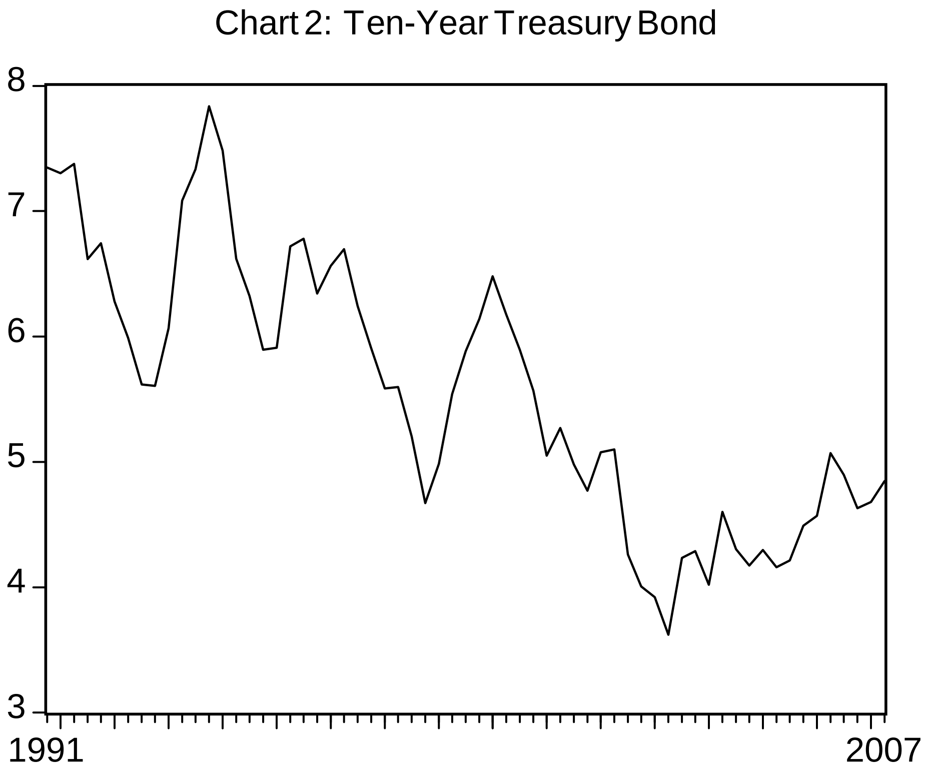
Table 1 presents the basic descriptive statistics for each variable. Long-term interest rates, as expected, tended to be higher than short-term interest rates, on average. In addition, the ten-year bond rate exhibited less volatility than the one-year treasury. Charts 1 and 2 illustrate the movement of both interest rates over the entire period. The ten-year rate shows a downward trend during the period considered while the one-year seems to fluctuate around its mean (other than a significant decline in the early 2000s).

Table 1: Descriptive Statistics

	Mean	Median	Standard Deviation
Interest Rate on 1-year Treasury	4.24%	4.66%	1.56
Interest Rate on 10-year Treasury	5.55%	5.59%	1.07
Expected Inflation (1 year)	2.67%	2.52%	0.48
Expected Inflation (10 year)	2.82%	2.50%	0.47
Output Gap	-0.67%	-1.27%	1.57

Chart 1: One-Year Treasury





DYNAMIC VERSION OF TAYLOR'S RULE

An extensive amount of literature has been devoted to using Taylor-type rules to examine monetary policy (for example, see Gerlach and Schnabel, 1999; Orphanides, 2007, Smets, 1998; Taylor, 1999). In its original form, Taylor's rule simply relates the federal funds rate to both the output and inflation gaps (see 1). If inflation rises above its desired level, the Fed should raise the federal funds rate. If GDP exceeds its potential, inflationary pressures exist and the Fed should raise the federal funds rate to contain these pressures.

$$f_t^* = \pi_t + r_t + ½(\pi_t - \pi_t^*) + ½y_t \quad (1)$$

where f is the federal funds rate; π is the inflation rate; r is the equilibrium real federal funds rate; and y is the output gap. The coefficients on the original model were chosen by Taylor. Subsequent researchers sought instead to estimate the relationship using a model similar to (2).

$$f_t^* = \pi_t + r^* + B_1(\pi_t - \pi^*) + B_2y_t \quad (2)$$

Further modifications were made including introducing a dynamic adjustment process to account for the speed and persistence of interest rate movements (Judd and Rudebusch, 1998).

$$\Delta f_t = \gamma(f_t^* - f_{t-1}) + \rho\Delta f_{t-1} \quad (3)$$

Gamma provides an estimate of how quickly the federal funds rate adjusts to its optimal value (f^*) while rho is a measure of the persistence of changes in the federal funds (with higher values implying more persistence). That is, if the federal funds rate has been increasing recently, there's a greater likelihood that it will continue to increase. When one combines (2) and (3), a dynamic version of Taylor's rule can be estimated:

$$\Delta f_t = \gamma\alpha - \gamma\ f_{t-1} + \rho\Delta f_{t-1} + \gamma(1+B_1)\ \pi_t + \gamma B_2 y_t \qquad (4)$$

where $\alpha = r^* - B_1\pi^*$.

Some have suggested that the Fed focuses on expected inflation instead of inflation since it seeks to keep inflation from rising instead of reacting to it once it already has risen. Thus, one could view □ as inflation or expected inflation.

Many of the same forces and concerns that influence decisions regarding monetary policy also affect the bond market. Bond investors are very sensitive to changes in expected inflation as it would reduce the value of their bond holdings. Also, economic strength significantly affects interest rates. A stronger economy may increase the demand for credit thus pushing up real interest rates. Also, a positive output gap may provide further signals of inflationary pressures. Thus, Taylor's rule can be modified as follows:

$$\Delta i_t = \gamma\alpha - \gamma\ i_{t-1} + \rho\Delta \imath_{t-1} + \gamma(1+B_1)\ \pi_t + \gamma B_2 y_t \qquad (5)$$

where i is the interest rate on a Treasury security.

REVIEW OF THE LITERATURE

Though there is an extensive literature examining the application of Taylor's rule to setting the interest rate targeted by central banks (see above), there has been little application to interest rates determined by financial markets. William Poole (2003), president of the Saint Louis Federal Reserve, has discussed how one expects a one-for-one relationship between expected inflation and nominal interest rates and also that a robust economy increases real interest rates as businesses drive up the demand for credit by seeking new funds with which to invest. Diebold, et. al. (2006) makes use of inflation versus its average as well as the output gap to examine the behavior of interest rates. Similarly, Rudebusch et. al. (2006) analyze the movement of short-term interest rates by using the output gap and an inflation gap.

Thus, though Taylor's rule has not been employed to examine market-based interest rates, many of the principles embodied in Taylor's rule have been put to use in previous studies. This paper proceeds to the next step in modeling the behavior of interest rates on treasuries by using a dynamic version of Taylor's rule. Additional insight can be obtained by considering bonds of different maturities thus distinguishing the behavior of short-term and long-term interest rates.

EMPIRICAL MODEL AND RESULTS

Quarterly data from 1991 to 2007 were used to estimate the model described above (see equation 5). One would expect B_1 to be equal to one if the Fisher effect holds true. That is, a one percent increase in expected inflation leads to a corresponding one percent increase in the nominal interest rate on Treasury securities. B_2 is expected to be positive since relative economic strength puts upward pressure on real interest rates. The magnitude of the coefficient would indicate how sensitive the interest rate is to economic strength (or weakness). The speed of adjustment is estimated by γ – a higher value for γ would reveal a higher speed of adjustment to the appropriate value based on macroeconomic conditions. The degree of persistence is estimated by ρ – a high value for ρ indicates that once interest rates start moving in a certain direction, they continue moving that way for an extended period of time.

Standard econometric tests for the validity of the model revealed no econometric issues for either maturity. The empirical results can be seen in Tables 2 and 3. To test for the statistical significance of expected inflation and the output gap, one needs to employ indirect least squares since the estimation of (5) yields γB_2 and $\gamma(1+B_1)$ as the respective coefficients. Estimated values for B_1 and B_2 can be obtained by modifying both terms using the estimated coefficient on the lagged interest rate (γ).

Table 2: Dynamic Model of Interest Rate on Ten-Year Treasury Bonds

	Estimated Coefficient	t-stat or X^2
Speed of adjustment	0.44^{**}	5.13
Degree of persistence	0.26^{*}	2.34
Expected inflation	1.03^{**}	20.14
Output gap	0.37^{**}	31.21

Note: t-statistic used for speed of adjustment and degree of persistence; X^2 used for expected inflation and output gap. ** indicates 1% level of significance, * indicates 5% level of significance

Table 3: Dynamic Model of Interest Rate on One-Year Treasuries

	Estimated Coefficient	t-stat or X^2
Speed of adjustment	0.20^{**}	3.66
Degree of persistence	0.47^{**}	4.41
Expected inflation	0.89^{*}	2.88
Output gap	0.67^{**}	18.90

Note: t-statistic used for speed of adjustment and degree of persistence; X^2 used for expected inflation and output gap. ** indicates 1% level of significance, * indicates 5% level of significance

All of the coefficients were tested to see whether they differed from zero and were found to be statistically significant (most at the 1% level). In addition, the coefficients on expected inflation were tested to see whether they were statistically different from one (a test of the Fisher effect). For the model of the ten-year Treasury bond, the estimated coefficient was 1.03 while the resulting X^2 was 0.14 indicating that it was not significantly different from one, thus providing support for the Fisher effect. Similarly, for the model of the one-year Treasury, the estimated coefficient was 0.89 with a X^2 of 0.05, also indicating that it was not statistically different from one. Thus, support for the Fisher effect was found for both short-term and long-term interest rates.

Differences were detected for the coefficient of the output gap, depending on the maturity considered. In both cases, a positive output gap put upward pressure on interest rates, as expected. However, the model for the ten-year bond suggests that for each 1 percent that GDP exceeds its potential, the interest rate rises by 37 basis points (other factors held constant) while for the one-year Treasury, each 1 percent that GDP exceeds its potential results in the interest rate rising by 67 basis points. The results suggest that both short-term and long-term interest rates rise one-for-one with expected inflation while short-term interest rates are more responsive to current economic conditions as measured by the output gap.

When considering the market for the ten-year Treasury bond, the estimated speed of adjustment was moderate to high (a little less than 0.5) while the degree of persistence was low (0.26). However, for the one-year Treasury, the speed of adjustment was estimated to be relatively low, 0.20, while the degree of persistence was relatively high, 0.47. Together, this suggests that short-term interest rates tend to move in one direction longer than long-term rates whereas long-term rates adjust more quickly to their "appropriate" value as determined by macroeconomic conditions.

CONCLUSION

The dynamic Taylor-type rule presented in this paper provides insight into the behavior of the yield on one-year and ten-year Treasury securities. Support is found for the Fisher effect in that a one percent increase in expected inflation leads to a corresponding one percent increase in the nominal interest rate regardless of the maturity considered. Economic strength, as measured by the output gap, significantly affects real interest rates as a one percent increase in the output gap leads to a 0.37% increase in the long-term interest rate and a 0.67% increase in the short-term rate. This difference is likely due to long-term interest rates not being as sensitive to short-term fluctuations in economic activity while short-term rates are more responsive to current economic conditions.

Evidence was also found indicating that short-term rates display a higher degree of persistence while long-term rates show a higher speed of adjustment. This may be due to short-term interest rates being more closely correlated with the federal funds rate, which the Fed manipulates as part of its conduct of monetary policy. Since the Fed tends to display persistence in its setting of its target for the federal funds rate, other short-term interest rates are likely to follow a similar pattern. Long-term interest rates are not as correlated to the federal funds rate and thus display less persistence. Taylor's rule appears to prove useful in providing insight into the behavior of interest rate on Treasuries.

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