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Steven Strongin

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Excess Volatility and The Smoothing of Interest Rates: An Application Using Money Announcements

Steven Strongin*
Federal Reserve Bank of Chicago

This paper develops a new methodology for analyzing the behavior of interest rates along the yield curve. It finds that, at least within the Money Announcments literature, excess sensitivity of interest rates and forward interest rates can be explained by the assumption of interest rate smoothing behavior by the Federal Reserve. The paper also shows that the biases generated by Federal Reserve interest rate smoothing, addressed by the proposed methodolgy, are not addressed by the calculation of forward interest rates, the normal method of assessing the relative response of long-term interest rates. Specifically, the paper finds that one year interest rates respond with 1/3 the magnitude relative to money announcements than would be expected given the response of longer term interest rates. The descrepancy is constant for rates beyond a 3-year maturity, impling no further direct effects, while forward rate based estimates show direct effects 20 years into the term structure. These results can only be reconciled by interest rate smoothing or some other very similar distortion of short term interest rates. If these results can be extended beyond the Money Announcments literature it could explain much of the excess volatility puzzle.

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I. Introduction

A variety of studies analyzing asset returns have found anomalies in the behavior of long-term assets such as stocks and bonds (Shiller (1989) reviews this literature). Longer-term instruments typically exhibit excess volatility and excess sensitivity to transient impulses. One potential flaw in these studies is that all of their results are conditional on the assumption that the behavior of short-term interest rates accurately reflects movements in the short term discount factor. Recent work on liquidity models, such as Lucas (1990), Fuerst (1992), Christiano (1991) and Christiano and Eichenbaum (1992a,1992b), focus on models in which the observed one period interest rate differs from the marginal rate of time preference by a time-varying liquidity distortion subject to manipulation by the central bank. In Christiano and Eichenbaum(1992a and 1992b) this distortion can be generated by anticipated policy actions as well as surprises. The intuition is that the Federal Reserve can manipulate the value of cash equivilent or liquidity services provided by short term instruments causing the observed yield to differ from the true yield, creating what can be viewed either as a very specific type of measurement error or market distortion relative to the expectations model of interest rates. This type of distortion is analgolous to a time varying liquidity premium whose dominate effect is on short term interest rates.

This type of distortion, as will be shown, implies that standard term structure calculations in the manner of McCulloch (1971)[1] will not produce unbiased estimates of forward interest rates. Depending on the dynamic correlations of the liquidity distortion with other variables in the economy, these distortions can cause calculations based on short term interest rates to produce systematically misleading results. Specifically, if the central bank engages in the systematic smoothing of short term interest rates, it will generate the appearance of excess volatility in long term interest rates and in forward rates, as well as, the appearance of excess sensitivity to transient shocks, exactly the results that have produced substantial difficulty in the asset volatility and money announcements literatures (Cornell(1983), Shiller (1989)).

This paper presents a new methodology for analyzing the term structure

[1]The same problem also effects later refinements such as Shiller, Campbell and Schoenholtz (1983) and Campbell and Shiller (1984).

of interest rates. Rather than conditioning on short term interest rates, the proposed methodology simultaneously tests the relative response of interest rates across the entire yield curve. The proposed methodology exploits the fact that the interest rate response of a government bond to a change in the short term discount factor is a relatively simple non-linear function of term and the yield to maturity of the asset. Thus, given a common impulse the relative behavior of interest rates across the yield curve can be represented by a common response surface (CRS) with a precise shape. This, in turn, allows us to estimate and compare relative responses of government bonds across the entire maturity spectrum without having to condition on short term interest rates. So that instead of distorting subsequent analysis, any distortion in short term interest rates caused by central bank smoothing simply damps the estimated coefficients on short term interest rates, causing their estimated response to fall below the common response surface conditioned on long term interest rates. Thus, instead of rejecting the behavior of long term instruments as being consistent with economic theory, we can isolate which parts of the yield curve behave differently allowing a more precise delineation of any anomalies as well as allowing direct estimates of their size.

The empirical evidence presented in the paper, which is based on money announcements, suggests that smoothing of short term interest rates is a major source of the so called excess sensitivity of long term asset prices to transient impulses. Short term interest rates display only 1/3 the sensitivity to transient impulses that a common response surface conditioned on long term rates would imply. On the other hand, medium and long term interest rates lie along a single common response curve.[2] This could be consistent either with interest rate smoothing or with money announcements having direct effects (due to either anticipated inflation or real effects) on forward one year interest rates approximately 3 years into the future. However, these direct effect estimates can not be reconciled with the results in the literature based on forward rate calculations, such as Shiller, Campbell and Schoenholtz (1983), Hardouvelis(1984) and Loeys (1985), which show clear and significant direct effects from 5 year to more than 20 years into the term structure,

[2]If weekly money announcements had permanent or extended effects on the rate of inflation which is the most common explanation for the extended effects of money announcments on the yield curve there would be no common response surface until the inflation effects fully damped.

whereas the interest rates smoothing hypothesis is fully consistent with both sets of results. It is precisely this difference between CRS estimates and forward rate estimates that identifies interest rate smoothing since in the absence of interest rate smoothing or some other distortion of short term interest rates the two methodologies should produce identical results.

The assessment of the quality of the evidence on the interest rate smoothing hypothesis depends on prior beliefs about the nature of the persistence of the basic shock. Weekly money announcements, the common impulse studied, is especially useful in this context. Weekly money growth numbers were dominated by problems in weekly money seasonals and only had effects on the policy process because of peculiarities in the Federal Reserve's short run operating procedures.[3] Yet, we have well documented evidence of substantial responses to money announcement surprises have effects extending deep into the term structure (Cornell (1983). The magnitude of the results suggests that the interest rate smoothing hypothesis not only provides a plausible explanation of the observed excess sensitivity of long term bonds to money announcements, but if these results hold across more general classes of impulses, it would go a long way toward helping explain the general puzzle of excess asset volatility.

II. The problem with implied forward rates

The problem with tests based on implied forward rates is their dependence on short term interest rates. If these rates are distorted by Federal Reserve actions, then conditioning tests of longer term asset behavior on short term interest rates will be misleading. For simplicity, this section derives the biases generated by non-arbitraged smoothing of the one year rate on the behavior of the implied 1 year forward rate. The results are easily generalizable to longer term rates. Let i_1 be the undistorted and unobserved one year rate[4] and i_{f1} be the one year forward rate. In the market we would observe i_1^*,

[3]Federal Reserve studies (Pierce (1981)) at the time estimated that M1's growth rate had a standard deviation of 55% at annual rates just due to statistical noise.

[4]In the context of Christiano and Eichenbaum(1991a,1991b) this can be thought of as the one year rate plus liquidity services.

the distorted one year rate, and i_2 the two year rate.[5] If these rates are continuously compounded rates of return then their relationships can be summarized as follows. The distortion can be written

$$i - i^* = \Omega$$

where Ω is the Christiano-Eichenbaum (1992b) distortion[6]. The observed two year rate equals the simple average of unobserved and undistorted one year interest rate and one year forward one year interest rate. This is written

$$i_2 = \frac{i_1 + i_{f1}}{2}. \tag{1}$$

Using observed interest rates the standard "observable" implied one year forward rate would be calculated

$$i^*_{f1} = 2i_2 - i^*_1. \tag{2}$$

Substituting equation 1 into equation 2 yields the expression

$$i^*_{f1} = i_{f1} + (i_1 - i^*_1),$$

indicating that the bias in the implied one year forward rate equals the liquidity distortion in the one year rate. It follows that the covariance between i_1 and i^*_{f1} is

$$\sigma_{i_1, i^*_{f1}} = \sigma_{i_1, i_{f1}} + \sigma_{i_1, (i_1 - i^*_1)}.$$

From this formula it can be infered that if the central bank engages in interest rate smoothing, the observed forward rate would show a false positive correlation to transient shocks. This follows from the fact that the conditional covariance $\sigma_{i_1, i_{f1}} = 0$ by definition for a transient shock while $\sigma_{i_1, (i_1 - i^*_1)} \geq 0$

[5]Formally, this analysis should include expected future distortions. These are assumed to equal 0 to avoid notational clutter.

[6]Alternatively, this can be thought of as the value of being a cash equivalent. This is plausible since bonds of less than one year maturity can and are used by banks and other lenders as collateral for short term lending and are treated as cash by such lenders in the calculation of quick and other risk related loan criterion. Thus, as long as the Federal Reserve can effect the showdow value of cash it can generate distortions of the type discussed.

conditioning on a transient shock if the central bank smooths interest rates.[7] This, in turn, implies that if the central bank engages in short term interest rate smoothing, implied forward rates calculated in the normal way will show undue sensitivity to transient phenomena. Taken to the extreme, if the central bank eliminated all response in short term interest rates for the response horizon being analyzed, a situation could arise where short-term interest rates showed no response to transient shocks, but implied forward rates did.

Additionally, the "observed" forward rate will show undue volatility. This can be seen from equation 3, which is the formula for the variance of i^*_{f1}.

$$\sigma^2_{i^*_{f1}} = \sigma^2_{i_{f1}} + \sigma^2_{(i_1-i^*_1)} + 2\sigma_{i_{f1},(i_1-i^*_1)} \tag{3}$$

This shows that the volatility of observed forward rates is overstated by the variance of the liquidity distortion $(i_1 - i^*_1)$ plus the covariance of the distortion and the undistorted forward rate. If the central bank is successfully smoothing short-term interest rates, this covariance term is strictly non-negative. For transient shocks the covariance is 0, since, by assumption, i_{f1} is unaffected and thus has a 0 covariance. In the case of a persistent shocks, the covariance is strictly positive. For example, in response to a positive persistent shock, i_{f1} is higher and so is i_1, i^*_1 does not go up as much as i_1 because of the interest rate smoothing. Thus, a positive gap between i_1 and i^*_1 arises, implying a positive covariance between the forward rate and the distortion.[8]

It follows that analyzing the behavior of long term interest rates by taking observed short term interest rates as undistorted and correctly measured is potentially misleading. Misleading in precisely the way that could explain both the excess volatility and sensitivity results so common in the literature. Direct solution of this problem is daunting, requiring both accurate modeling of the policy process and of the arbitrage failure that leads to the systematic patterns in the liquidity premia that have been documented in the literature.

[7]Interest rate smoothing implies that i^*_1 will not, at least in the short run, fully reflect changes in i_1, implying a postive correlation between i_1 and $(i_1 - i^*_1)$.

[8]In the rather obscure case of shocks which twist the yield curve there is a possibility of understating the volatility of forward rates. Empirically this does not appear to be important, given the very high positive correlation between changes in short and long term interest rates.

In this paper an indirect method is exploited to investigate the potential size of these problems.

III. The Common Response Surface

Avoiding the use of implied forward rates is achieved by deriving what I will call the common response surface (CRS hereafter). The CRS is the implied relative response of interest rates across the term structure to an impulse of a given size and duration that follows from the standard expectations theory of interest rates (Shiller(1979) and Campbell(1986)). Deviations from the CRS can then be interpreted as deviations from predicted levels of response at each point of the term structure relative to other assets. The idea is that instead of calculating an implied forward rate, the implied relative response for each asset is calculated relative to a common impulse. Assets can then be classified as to their position relative to the CRS, assets which respond more vigorously to the impulse than the CRS predicts are "too" sensitive and rates below are insufficiently sensitive. As a matter of practice, the height of the CRS is a free parameter and thus some ambiguity will remain. Nevertheless, in this framework each asset is treated symmetrically rather than in a conditional hierarchy as is the case when short rates are used to calculate implied forward rates.

The CRS in general is a highly non-linear function which depends on the specific stochastic structure of the impulse and the specific debt instrument characteristics used to calculate the term structure; however, in a number of useful special cases the CRS can be approximated at a point in time by a reasonably tractable expression of the duration and yield to maturity for a set of debt instruments. The CRS can then be used to compare regressions relating an impulse to changes in the yield to maturity of assets across the term structure.

In the simplest case of zero coupon bonds the CRS is easy to derive. The yield to maturity is simply

$$i_T = \frac{1}{T}\sum_{t=0}^{T-1} i_{ft},$$

where i_{ft} is the one year rate t periods in the future. The change in i_T due to an impulse can be written

$$\frac{di_T}{d(impulse)} = \sum_{j=0}^{T-1} \frac{\partial i_T}{\partial i_{fj}} \frac{\partial i_{fj}}{\partial(impulse)} \tag{4}$$

For the special case of a transient shock, i.e., one which only affects the one year rate, this can be written

$$\frac{di_T}{d(impulse)} = \frac{\partial i_{f0}}{\partial(impulse)} \frac{1}{T}.$$

Thus, the response to a transient shock along the yield curve would die out as the inverse of maturity, implying that the estimated responses of zero coupon bonds of various maturities would trace out a curve proportional to $1/T$.

In general, zero coupon bond rates are not available. The CRS for more general cases is more complicated. The special case used in this paper is for government bonds priced at par[9] and for shocks which damp within one year. This CRS[10]is defined by:

$$\frac{di_T}{di_1} = \frac{1+i_T}{1+i_1} D^{-1}(T, i_T) \tag{5}$$

where i_1 is the one year interest rate and i_T is the yield to maturity on a T period bond priced at par and $D(T, i_T)$ is the Macaulay duration of a T period bond with rate i_T.

The intuition for this formula is quite simple, the Macaulay duration of a coupon bond approximates the term of a zero coupon bond whose price will behave in the same way.[11] Thus, this formula is conceptually identical to the preceding one. The one key difference is that this is a time varying formula since the duration of a bond with a given maturity varies with its yield. The

[9]This would include the government's constant maturity series, the data used in this paper, as well as most bond indexes.

[10]This formula is derived by calculating the effect of a change in the one year interest rate on the price of a bond priced at par and by calculating the effect of a change of the price of a bond on its calculated yield to maturity.

[11]It should be noted that in this application the Macaulay duration is not an approximation (as it is in most applications). Here, the Macaulay duration arises as a consequence of the fact that bond yields are calculated as internal rates of return which vary with the price of the bond according to the Macaulay duration regardless of the underlying pricing process.

formula implies that the response of a bond to a given transient impulse will vary as a function of its term to maturity, its stated yield and the one period rate. Thus in a regression of the form:

$$\triangle i_T = \alpha_T + \beta_T impulse + \epsilon_T$$

the CRS defines cross equation restrictions, such that the regression equations can be written

$$\triangle i_T = \alpha_T + \beta \frac{\partial i_T}{\partial i_1} impulse + \epsilon_T \tag{6}$$

where β is the same for all T. It is then possible to test whether specific assets deviate from a commonly estimated CRS. Alternately unconstrained β_T estimates can be compared on a relative basis to examine the relative sensitivity or volatility of instruments of different maturities. For instance, given a CRS estimated from one or some combination of long-term interest rates, any short fall in the magnitude of the short term interest rate's response relative to the CRS could be viewed as a point estimate of the impact of interest rate smoothing.

In cases where there is some question about whether the effects of the impulse completely die out in the first year an additional formula is helpful in interpreting the results. Specifically,

$$\frac{\partial i_T}{\partial i_j} = \frac{1 + i_T}{1 + i_j} D^{-1}(T, i_T)[1 - BPCT(j)]$$

where i_j is the expected one year rate in the jth period and $BPCT(j)$ is the percent of present value paid out in coupons before the jth period. This equation implies that if the effect of the common impulse extends beyond the first year, it will induce an "excess" response on longer rates that is somewhat less than proportional to the number of years the direct effects extend beyond the first year where the drop off is determined by how much of the present value of the bond is paid off before the direct effect at issue.

For bonds priced at par this does not seriously hamper the proposed methodology, since the percent of present value paid out each year by such bonds is roughly equal regardless of maturity, except of course for year in which the bond matures. The whole notion of pricing bonds at par is that their value is supposed to remain approximately constant during the life of the bond. Using this fact in conjunction with equation 4 leads to

$$\frac{di_T}{d(impulse)} \cong kD^{-1}(T, i_T) \sum_{j=1}^{L} [1 - BPCT(j)] \frac{\partial i_j}{\partial (impulse)}$$

for $L \leq T$ where L is the span of years over which the impulse has direct effects on one year interest rates and k covers terms which only vary slightly between bonds of different maturities. This suggests that the interest rate response along the yield curve to a common impulse will converge to a common CRS at the same maturity as the direct effects of the impulse die out. Further, the difference between successive responses at longer terms would provide a point estimate of the **direct** effects at that point in the term structure. Taken a step farther, this suggests a simple extension of the methodology, i.e. differencing the response profile to generate a time profile of an impulse's impact if interest rate smoothing is not deemed important. More importantly, this can also be used to discriminate between shocks which have extended direct effects and the interest smoothing hypothesis. Empirical work based on forward rate calculations should produce results which are consistent with results based on the CRS methodology, if direct effects dominate, while, as explained in Second II, *the two methods will produce inconsistent results if interest rate smoothing is important.*[12]

A. Implementing the tests

The CRS constraints can be imposed a number of ways, the most straight forward would be to directly estimate equation 6. A simpler method which provides results that are easier to interpret is to transform the regression equation by dividing it through by the CRS term-proportionality-factor, generating the equation

$$\triangle i_T \left(\frac{di_T}{di_1} \right)^{-1} = \alpha_T' + \beta' impulse + \epsilon_T'. \tag{7}$$

[12]Depending on how the forward rates are calculated the descrepancy between the two methodologies will either end when the conditioning rate is free of interest rate smoothing effects or will continue throughout the term structure if distorted rates are carried forward by recursive estimation of the entire term structure.

This form[13] of the regression has the advantage that the CRS is reduced to a simple horizontal line and that under most circumstances the system can be estimated by OLS. Other formulations require SUR or GMM estimation.[14]

This method raises some issues about heteroscedasticity as the error structure of the transformed regressions and the untransformed regressions cannot both be homoscedastic. In fact in the application used in the next section neither form generates homoscedastic residuals, implying the need to use White's (1981) correction or some other correction for heteroscedasticity.[15]

IV. An application to money announcements

The key to successfully applying the methodology outlined above is to find an application where the impulse is well defined and one that can be argued on a priori grounds is clearly transient. The money announcements literature provides such a case. In this literature the key regression is

$$\triangle i_T = \alpha_T + \beta_T M^u + \epsilon_T$$

where M^u is unanticipated money on a weekly basis. This literature is especially appropriate for the current methodology because the observed over sensitivity of long term interest rates has been discussed at length (see Hardouvelis (1984) and Cornell(1983) for surveys of the early literature and arguments). The problem has been that much of the variance of the weekly money announcements is due to poor seasonals[16] and its effects were due to quirks

[13]This specific form of the equation ignores the impact of the renormalization on the constant term. Various alternative treatments of the constant term were tried without effecting the quantitative or qualitative results. The lack of a clear reason for the constant term in this literature make it difficult to pick a treatment that is "best" on a priori grounds.

[14]These other formulations were estimated and produced virtually identical results.

[15]An additional note about power is worth making. In some applications the very high correlations between changes in interest rates of different maturities can generate a nearly singular joint covariance matrix, artificially inflating the power of some tests. Thus, very strong rejections should be viewed with caution until the covariance matrix is checked.

[16]According to the Federal Reserve Board staff studies (Pierce (1981), the standard deviation on weekly money growth rates due to noise was equivilent to a 55% rate of annual growth. This is larger than any plausable change in the Federal Reserve's long run target for M-1 growth.

of the Federal Reserves operating procedures during the 1979-1982 period that caused subsequent policy actions on the Federal Reserve to be linked to short run levels of money growth for periods of approximately 6 weeks and never more than twelve.[17] Nevertheless these highly transient shocks seem to have measurable effects even on thirty year rates. This oddity caused some investigators to argue that it had to be generating increased inflation expectations (Cornell (1983)). Strongin and Tarhan (1990) find evidence that this hypothesis is weak at best.

Work on implied forward rates[18] also found weekly unexpected money having direct impact extending deep into the term structure. Loeys also documented that the parameter were highly unstable over time potentially leading to serious miss-specification bias. Strongin and Tarhan (1990) showed that the instability could solved by explicitly adjusting for market perceptions about the current stance of monetary policy. Their methods effectively stabilized the parameters, but did not reduce the effect on long run interest rates. It is their specification transformed to match equation 7 that will be used[19], which is

$$\triangle i_T \left(\frac{1+i_T}{1+i_1} D^{-1}(T, i_T)\right)^{-1} = \alpha_T + \beta_T M^u + \gamma_T P^e M^u + \epsilon_T$$

where $\left(\frac{1+i_T}{1+i_1} D^{-1}(T, i_T)\right)$is taken from equation 5 and P^e is the expected level of policy response, which is measured by the Money Market Services' survey of expected Free Reserve levels. The market views free reserves as a measure of Federal Reserve tightness. The imbedded assumption in the specification is that the tighter Federal Reserve policy is, the more the Federal Reserve will respond to an unanticipated increase in money growth and thus the more interest rates will respond.

Using this specification, the CRS hypothesis is that both sets of coefficients will be the same across all Ts. If the Federal Reserve smooths short

[17]See Meulendye (1989) for a review of Federal Reserve procedures during the sample period and Pierce (1981) for the role of seasonals in generating money misses.

[18]Shiller, Campbell, and Scheonholtz (1983) found clear and significant effects 5-7 years into the term strucuture, while Hardouvelis (1984) and Loeys (1985) found strong effects on forward rates thoughout the term structure.

[19]In fact, except for transforming the dependent variables as suggested in equation 5, I follow Strongin and Tarhan (1990) exactly. The estimation period is from March 1980 to October 1984. The only period over which all the necessary data is available.

term interest rates then the parameters associated with short term interest rates should exhibit estimated coefficients below the CRS based on long term interest rates.

Graph 1 shows the estimated βs and their 2 sigma bounds by term for the each of the transformed regressions. Graph 2 shows the estimated γs and their 2 sigma bounds by term for the each of the transformed regressions.[20] The CRS line is drawn at the arithmetic average of the longest 5 maturities. Clearly, long rates are more sensitive relative to short rates. Only the one year rate is significantly different from the CRS line. The three year bond is the only other instrument that is more that one standard deviation away from the CRS. The strong consistency of estimated values of parameters beyond 3 years would seem to indicate that any violations of the normal assumptions occur in terms shorter than 5 years. The size of the differential between the longer-term rates and the one year rate, approximately a factor of $2\frac{1}{2}$, suggests that interest rate smoothing is a significant factor in determining relative interest rate movements.

The alternative hypothesis that money announcements have a significant impact on forward interest rates three years out into the term structure, while consistent with the current results, fails on two counts. First and most important, it cannot be reconciled with previous results in the literature based on forward rate calculations which show direct effects beyond 5 years and as much as 20 years into the future, whereas Section II showed interest rates smoothing on the part of the central bank would generate just such results. Second, on a priori grounds, the necessary direct effects are too large given the signal to noise ratios inherent in weekly money growth figures. Taking the point estimates as given the estimated coefficients would require that the direct effects on the 2nd and 3rd years sum to 40% more than the impact in the first year. Further, the very strong convergence to a single CRS is inconsistent with hypotheses that seek to reconcile these extended effects based on persistent increases in the inflation rates since such increases would generate an upward sloping CRS curve.

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[20]The system was actually estimated using GMM tedhniques. However, in this case equation by equation estimation by OLS with White corrected standard errors (White (1980)) would produce exactly the same results. In the tables results which do not correct for heteroscedasticity are refered to as uncorrected, results with the White correction are refered to as corrected estimates. In both cases, the estimated parameters are the same, only the standard errors differ.

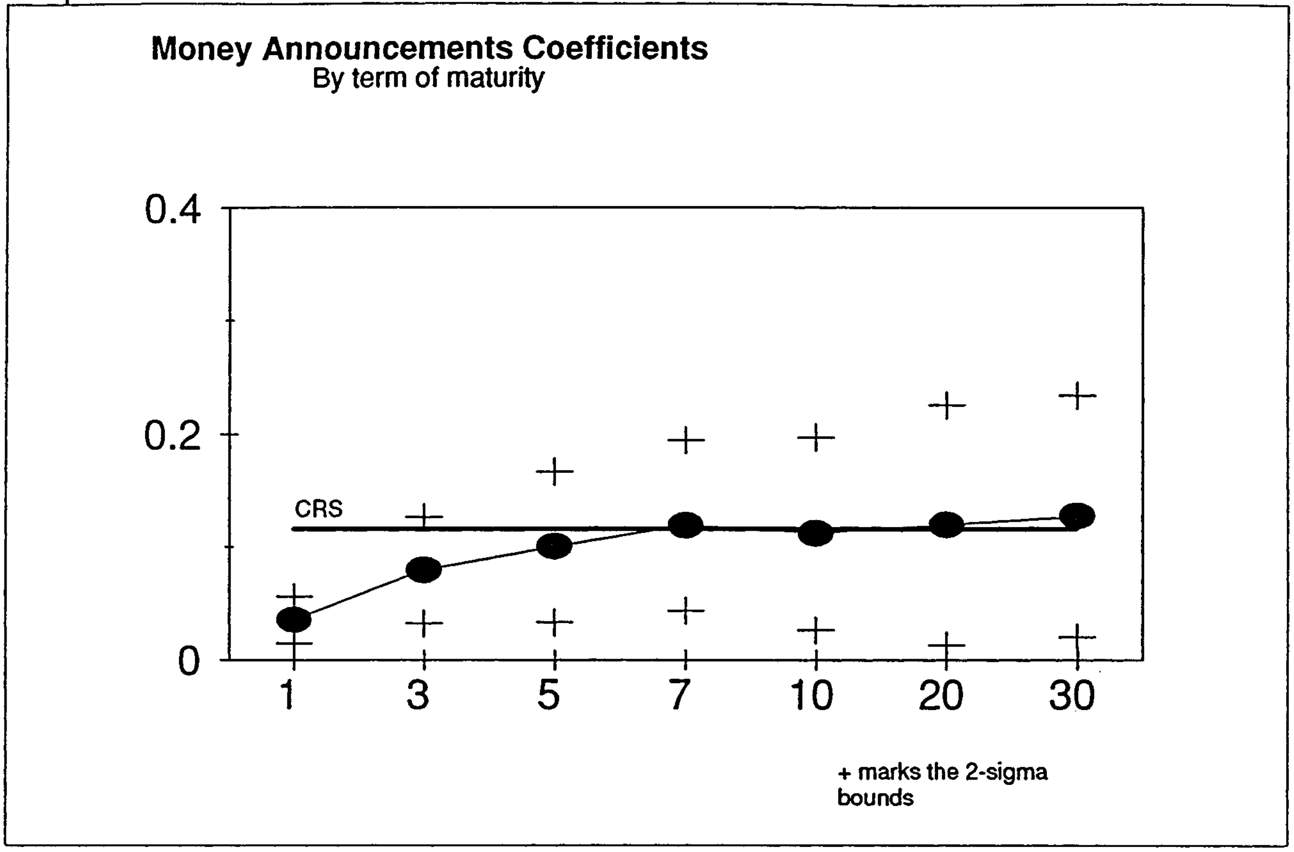
The general impression from the graphs is reinforced by Table 1 which shows the results of Wald tests for equality of β for all bonds with terms greater than T. There is strong evidence that 1 year bond rate is clearly different from all of the other interest rates. And again there is very mild evidence that the 3 year bond may be subject to some of the same smoothing effects. For terms greater than 3 years all assets seem to be responding to a common transient impulse according to expectations.

The results for γ, shown in Figure 2 and Table 2, strongly reinforce the analysis of β. The only difference is that in this case there is no evidence that the three year bond is any different than those of longer term. Only the one year rate behaves at all differently. Table 3 shows the unrestricted parameter estimates for all of the transformed regressions. The magnitudes suggested by these results are not small. They indicate that the one year bond rate may understate the sensitivity of the underlying discount rate by as much as a factor of $2\frac{1}{2}$. This would be sufficient to explain a great deal of the excess volatility that is observed when forward rates are calculated on the conditional assumption that the one year is an un-smoothed discount rate. How far this argument can be pushed depends on how typical this type of shock can be taken. It may well be that the Federal Reserve does not smooth all shocks equally. Also, actual Federal Reserve policy actions designed to move interest rates would not be smoothed by definition, though they might be serially correlated through time. It also suggests that the observed excess sensitivity in the money announcements literature is and artifact of the methodology and not an actual problem.

V. Conclusion

The results presented would appear to provide strong evidence that the Federal Reserve engages in a significant interest rate smoothing with respect to money announcement shocks, at least over the horizons studied. Further, these results indicate that the puzzle in the Money Announcements literature over the extended direct impacts of money surprises is an artifact of this smoothing behavior on the part of the Federal Reserve. The paper also shows that empirical results based on forward rate calculations or based on using observed short term interest rates as unbiased estimator (or with constant bias) of the true short term interest rate need to be viewed with caution, since short term interest rate yields may be distorted relative to the expectations model. The proposed methodology, which avoids this difficulty, suggests that the biases that such methods might generate are of sufficient potential magnitude to explain many of the excess volatility or sensitivity results in the literature. Specifically, the paper finds that one year rates respond with slightly more than 1/3 the magnitude of response to money announcements that would be expected given the response of longer term interest rates. These results also supply indirect evidence in favor of the new liquidity models such as Christiano and Eichenbaum (1992a and 1992b). The question of exactly why the market cannot not offset Federal Reserve actions aimed at smoothing interest rates remains open; nevertheless, it would appear that assuming away these effects is empirically problematic.

Graph 1



Graph 2

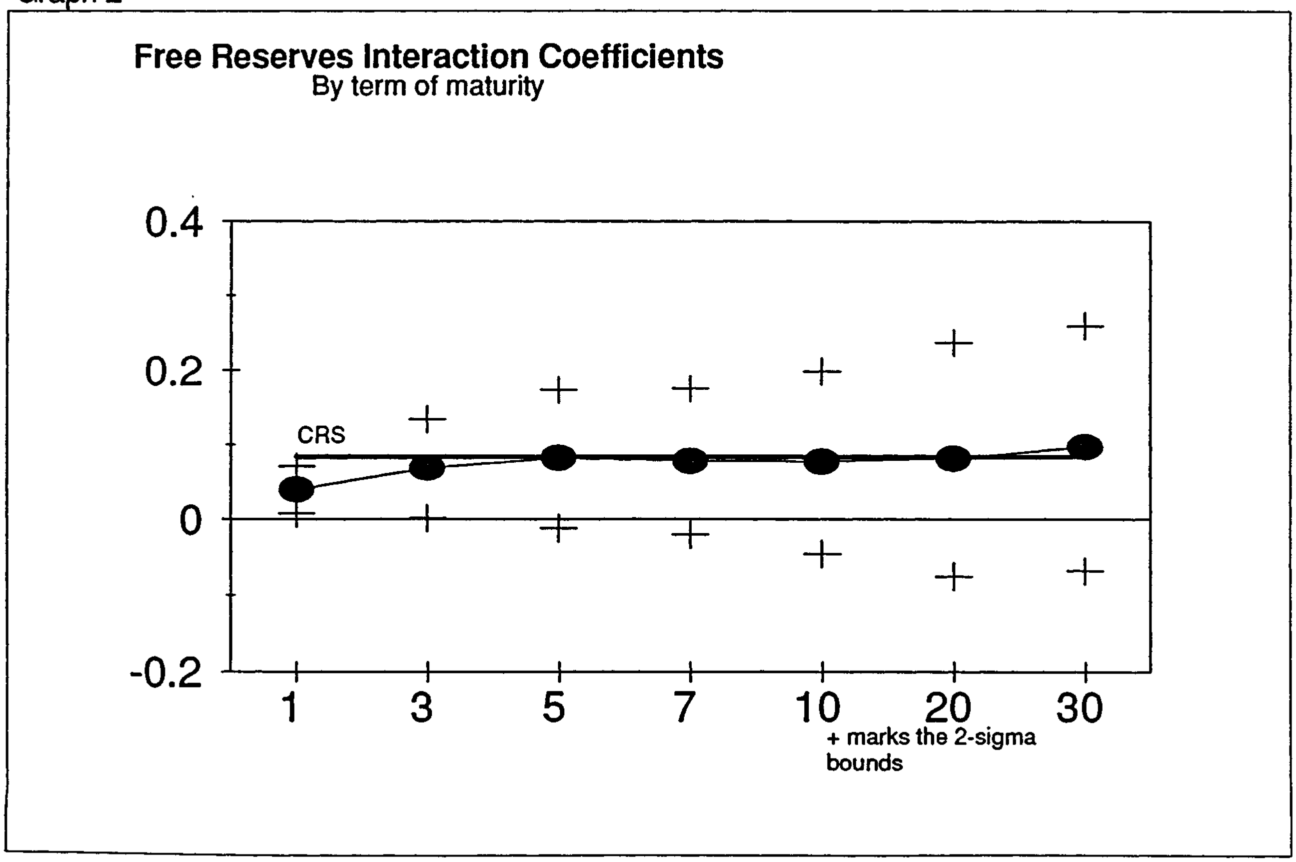


Table 1

Test of equality for Money coefficients

Uncorrected Standard Errors

Maturities held equal	Degrees of Freedom	Chi-Squared Statistic	P-Value
1-30	6	13.91	0.031
3-30	5	7.74	0.171
5-30	4	4.39	0.356
7-30	3	1.78	0.620
10-30	2	0.54	0.762
20-30	1	0.43	0.514

Corrected Standard Errors

Maturities held equal	Degrees of Freedom	Chi-Squared Statistic	P-Value
1-30	6	14.41	0.025
3-30	5	9.05	0.107
5-30	4	6.99	0.137
7-30	3	2.08	0.555
10-30	2	0.96	0.617
20-30	1	0.64	0.424

Table 2

Test of equality for Interaction coefficients

Uncorrected Standard Errors

Maturities held equal	Degrees of Freedom	Chi-Squared Statistic	P-Value
1-30	6	5.35	0.500
3-30	5	2.68	0.749
5-30	4	1.54	0.819
7-30	3	1.26	0.738
10-30	2	1.01	0.602
20-30	1	0.99	0.319

Corrected Standard Errors

Maturities held equal	Degrees of Freedom	Chi-Squared Statistic	P-Value
1-30	6	4.33	0.632
3-30	5	3.06	0.690
5-30	4	2.15	0.709
7-30	3	1.88	0.597
10-30	2	1.32	0.516
20-30	1	1.24	0.265

Table 3

Money Announcement Coefficients			
Term	β	std. error	T-ratio
1	0.035	0.010	3.38
3	0.079	0.023	3.39
5	0.100	0.033	3.00
7	0.119	0.038	3.15
10	0.112	0.043	2.62
20	0.119	0.053	2.24
30	0.127	0.053	2.38
Free Reserves Interaction Coefficients			
Term	γ	std. error	T-ratio
1	0.039	0.016	2.48
3	0.068	0.033	2.06
5	0.081	0.046	1.75
7	0.077	0.049	1.58
10	0.076	0.061	1.25
20	0.081	0.078	1.04
30	0.096	0.082	1.17

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