Interpreting the Term Structure of Interest Rates Using Weekly Money Announcements

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1. Introduction

In empirical work based on the use of weekly data, the joint hypothesis consisting of rational expectations and the expectations model of the term structure has been subject to an increasing amount of inquiry. The use of weekly data offers the advantage of larger sample sizes at the expense of working with overlapping data sets. As noted by *Hansen* and *Hodrick* (1980), overlapping data sets introduce persistent expectational errors, which are often represented by a nth-order moving average process. *Jones* and *Roley* (1983) employ *Hansen's* (1982) serial correlation correction to examine the 3-month Treasury market without having to discard 12/13 of the available data. *Froot* (1987) implements the positive definite, heteroskedasticity and autocorrelation consistent covariance correction by *Newey* and *West* (1985) to test the joint hypothesis using weekly survey data.[1] A drawback of these studies is that the covariance corrections do not provide efficient test statistics and the necessary stationarity assumptions made in *Hansen* (1982) and *Newey* and *West* (1985) are not tested.

Alternatively, *Gavin* and *Karamouzis* (1984), *Hardouvelis* (1984), and *Shiller, Campbell*, and *Schoenholtz* (1983) test the joint hypothesis by observing the reaction of forward interest rates to weekly money supply announcements. The announcement studies offer the advantage that the data set is not overlapping. Since the announcement studies stress the significant reaction of the forward rate to weekly money innovations, they cannot be regarded as direct tests of the term structure hypothesis.

A volatility test stemming from *Mankiw, Romer* and *Shapiro* (1985) is devised which puts limits on the variability of long-term interest rates and on the short-term interest rate reaction to weekly money announcements. With the empirical relationship that short-term interest rates react to weekly money announcements, a present-value equation is constructed which imposes the term structure hypothesis.[2] The volatility test, which evades the overlapping expectations problem, rejects the joint hypothesis of rational expectations of

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[1] *Hsieh's* (1984) results with non-overlapping data suggest that tests assuming conditional homoskedasticity when the assumption is not justified often underestimates the standard errors of the OLS coefficients.

[2] The extensive documented empirical evidence of the announcement effect for the U.S. are referenced in the two survey articles by *Cornell* (1983) and *Sheehan* (1985).

the term structure and the reaction of short-term interest rates to money announcements.

Section 2 derives the present value model which imposes the joint assumptions of rational expectations of the term structure and that short-term interest rates react to money announcements. In section 3 a volatility test is presented which tests the joint assumptions. The results are given in section 4. Section 5 concludes with suggestions for applied practice involving weekly data.

2. Term Structure Theory of Interest Rates and Weekly Money Announcements

A common feature in the announcement models by *Engel* and *Frankel* (1984), *Nichols, Small* and *Webster* (1983), *Roley* (1987), *Roley* and *Walsh* (1985) and *Urich* (1982) is that short-term interest rate changes are positively correlated with money supply innovations,

$$(i_t^a \mid I_t^a) - (i_t^b \mid I_t^b) = \theta m_t^u, \qquad 0 < \theta < 1, \tag{1}$$

where i_t^b and i_t^a denote short-term interest rates before and after the announcement has been made, and m_t^u is the unanticipated component of money.[3] Likewise, I_t^b and I_t^a denote the information sets before and after the announcement is released. In the models of *Nichols, Small* and *Webster* (1983), *Roley* (1987), and *Roley* and *Walsh* (1985), θ stems from the assumption of serial correlation of the money demand function. In the models by *Engel* and *Frankel* (1984) and *Urich* (1982) instead, θ is a function of interest rate elasticity. Empirically *Cornell* (1983), *Fischer* (1988 a), *Gavin* and *Karamouzis* (1984) and *Hardouvelis* (1984) show that θ, the response of interest rates to a one percent unanticipated rise in money is positive and less than one.

In order to derive the response for longer-term interest rates to weekly money announcements, *Nichols, Small* and *Webster* (1983), *Roley* and *Walsh* (1985) and *Roley* (1987) assume the existence of the term structure theory for interest rates.[4] Under the linearized model of *Shiller, Campbell* and *Schoenholtz* (1983), the current long-term rate for a k period bill issued at time t, $i_t^{(k)}$ is a weighted average of expected future short rates, $i_t^{(j)}$

$$i_t^{(k)} = D_k^{-1} \sum_{p=0}^{(k/j)-1} y^{jp} E_t(i_{t+jp}^{(j)}), \qquad k > j, \tag{2}$$

[3] In the announcement literature, the anticipated component is derived by using Money Market Services survey data. Each week two days before the weekly *M1* announcement is released Money Market Services asks 50 to 60 government securities dealers what the change in weekly *M1* will be.

[4] Various explanations for the announcement effect are given in *Cornell* (1983). Virtually all the announcement hypotheses assume the term structure hypothesis in order to account for the long-term interest rate reaction to weekly money announcements.

where $y = (1+i^*)^{-1}$ is the discount factor, and D_k is *Macauley's* (1938) definition of duration for the k period bond when priced at par,

$$D_k = \frac{1-(1+i^*)^{-k}}{1-(1+i^*)^{-1}}, \tag{3}$$

where i^* is the coupon rate.

As in *Roley* and *Walsh* (1985) equation (2) is differenced before and after the *M1* announcement.

$$i_t^{a(k)} - i_t^{b(k)} = D_k^{-1} \sum_{p=0}^{(k/j)-1} y^{jp} \left(E_t i_{t+jp}^{a(j)} \mid I_t^a - E_t i_{t+jp}^{b(j)} \mid I_t^b \right), \tag{4}$$

where, $i_t^{b(k)}$ and $i_t^{a(k)}$ denote long-term interest rates before and after the announcement is made. By simple substitution of equation (1) into equation (4), and setting $k = \infty$, the above authors derive the long-term interest rate response to future money innovations.

$$i_t^{a(k)} - i_t^{b(k)} = \theta D_k^{-1} \sum_{p=0}^{\infty} y^{jp} (E_t m_{t+jp}^u). \tag{5}$$

The long-term interest rate response model of equation (5) has a similar structure to *Shiller's* (1981) present value model for prices and future dividends. Equation (5) imposes the joint hypothesis that short-term interest rates respond to money announcements and the assumption of rational expectations of the term structure. The validity of equation (5) may be examined with a volatility test.

A volatility test for equation (5) offers several improvements on previous empirical methodologies which use weekly data. In the case for weekly data *Fischer* (1988 b) shows that interest rates are stationary after having been differenced. *Fischer* (1988 b) also shows that Money Market Services, (MMS) survey data for the anticipated component is rational and cointegrated with the weekly *M1* (H.6 release) data. Hence, m_t^u is stationary. Equation (5) does not encounter potential problems arising from variables with unit roots.[5] Secondly, no overlapping expectations are present in (5). Unlike in *Jones* and *Roley* (1983), *Froot* (1987) and *Mishkin* (1987), *Hansen's* (1982) variance correction is not needed.[6]

[5] Previous studies (*Jones* and *Roley*, 1983, *Froot*, 1983, and *Shiller, Campbell*, and *Schoenholtz*, 1983) which examine the term structure hypothesis for weekly data fail to consider the stationarity issue (i.e. short and long-term interest rates are cointegrated, see *Campbell* and *Shiller*, 1987).

[6] With weekly data errors in equation (2) for a 3-month T-Bill can be depicted by a 12th-order moving-average process. As discussed in *Hansen* (1982) estimation with moving average processes results in consistent coefficient estimates, however the usual estimate of the variance-covariance matrix of the estimated coefficients is not consistent.

3. The Announcement-Volatility Test

The derived volatility test stems from the framework of *Mankiw, Romer* and *Shapiro* (1985).[7] The test places limits on the variability of long-term interest rates and on the short-term interest rate reaction to weekly money innovations. In addition it is a direct test against the theoretical announcement models by *Nichols, Small* and *Webster* (1983), *Roley* (1987), *Roley* and *Walsh* (1985) and *Urich* (1982), which assume the existence of an announcement effect and rational expectations of the term structure.

For ease of notation the long-term interest rate change before and after the announcement, $i_t^{a(k)} - i_t^{b(k)}$ is denoted as r_t. Let r_t^* denote the present value of interest rate changes generated by actual future money innovations, (i.e. perfect foresight for r_t)

$$r_t^* = \theta D_k^{-1} \sum_{p=0}^{\infty} y^{jp} m_{t+jp}^u . \tag{6}$$

r_t^* defines the underlying data generating process for (5). The relationship between r_t and r_t^* may be defined as,

$$r_t^* = r_t + v_t , \qquad v_t \sim NI(0, \delta_v^2) , \tag{7}$$

$$E_t(r_t^*) = r_t . \tag{8}$$

In (7), v_t is the error in forecasting r_t^*. Since v_t is a rational forecast error, it is uncorrelated with information available at time t. In particular, v_t must be uncorrelated with r_t.

Before the *M1* announcement at time t, $F_t(m_{t+jp}^u)$ denotes the "naive forecast" of m_{t+jp}^u. The naive forecast for r_t, r_t^0 is derived by replacing $F_t(m_{t+jp}^u)$ for m_{t+jp}^u in (6),

$$r_t^0 = \theta D_k^{-1} \sum_{p=0}^{\infty} y^{jp} F_t(m_{t+jp}^u) . \tag{9}$$

The naive forecast does not have to be rational. The only necessary requirement is that rational agents have access to this naive forecast at time t.

In the identity,

$$r_t^* - r_t^0 = (r_t^* - r_t) + (r_t - r_t^0) , \tag{10}$$

[7] The *Shiller* (1979) test has been criticized on the grounds of small properties (see *Flavin*, 1983). The sample variances are downward-biased estimates of the population variances because sample means are used instead of population means. In small samples the *Mankiw, Romer*, and *Shapiro* (1985) test is unbiased.

$(r_t^* - r_t)$ equals v_t and is uncorrelated with information available at time t. Also,

$$E_t[(r_t^* - r_t)(r_t - r_t^0)] = 0, \tag{11}$$

since r_t and r_t^0 are known at time t (after the announcement is made). Squaring both sides of equation (10) and taking the expectation implies

$$E_t(r_t^* - r_t^0)^2 = E_t(r_t^* - r_t)^2 + E_t(r_t - r_t^0)^2. \tag{12}$$

From (12) the following inequalities are derived,

$$E_t(r_t^* - r_t^0)^2 \geq E_t(r_t^* - r_t)^2, \tag{13}$$

and

$$E_t(r_t^* - r_t^0)^2 \geq E_t(r_t - r_t^0)^2. \tag{14}$$

As noted in *Mankiw, Romer* and *Shapiro* (1985), the law of iterated projections allows the replacement of expectations conditional on information available at time t with expectations conditional on information available prior to the beginning of the sample period. Letting E denote the expectation conditional on the initial conditions, equations 12–14 become,

$$E(r_t^* - r_t^0)^2 = E(r_t^* - r_t)^2 + E(r_t - r_t^0)^2, \tag{12'}$$
$$E(r_t^* - r_t^0)^2 \geq E(r_t^* - r_t)^2, \tag{13'}$$
$$E(r_t^* - r_t^0)^2 \geq E(r_t - r_t^0)^2. \tag{14'}$$

Equation (14′) tests whether the ex-post rational interest rate change, r_t^* has greater volatility around the naive forecast, r_t^0 than the current interest rate change, r_t^0. Equation (13′) is the required volatility relation. Under the criterion of mean squared error, if the naive forecast is better than the market forecast, then the inequality (13′) is violated and the present value model (5) is rejected.[8]

4. The Volatility Results Using the Naive Forecast

The naive forecast of future money innovations is defined to be constant,

$$F_t(m_{t+jp}^u) = 0. \tag{15}$$

Certainly such a forecast is possible at any point in time. Note, the naive forecast need not be efficient in any sense.

[8] It can be easily shown that the *Mankiw, Romer* and *Shapiro* (1985) test (equation (14′)) encompasses the *Shiller* (1981) volatility test.

Table 1 presents the results for various values of the announcement response coefficient, $0 < \theta < 1$. r_t denotes the change of a 20 year U.S. government bond (provided by DRI) before and after the announcement is given. The anticipated money component was provided by Money Market Services survey data. *Engel* and *Frankel* (1982), *Fischer* (1988 b), and *Grossman*, (1981) find the Money Market Services survey data to be rational. The sample period 1977 : 36 – 1985 : 24 includes several Federal Reserve regime changes. The announcement literature has often divided the sample along the regime shifts: federal funds rate (FFR) targeting (Oct. 1979), nonborrowed reserve (NBR) targeting (Oct. 1982), borrowed reserves (BR) targeting (Feb. 1984), and contemporaneous reserves (CRR). In the appendix the duration values used in calculating the volatility tests are given.

In Table 1, uniformly for every reaction coefficient, $0 < \theta < 1$, the naive forecast, r_t^0 is a better forecast of the perfect foresight model, r_t^* than the actual interest rate changes, r_t. Contrary to announcement theory, the inequality (13′) is violated, for the second column is greater than the first. The results in Table 1 suggest that a forecast of no interest rate changes (i.e. no announcement effect) has greater explicability for r_t^* than r_t. The assumptions of short-term interest rate reaction to unanticipated money within the term structure framework found in *Hardouvelis* (1984), *Nichols, Small* and *Webster* (1983), *Roley* (1987), and *Roley* and *Walsh* (1985) are rejected.

Since column 1 is greater than column 3 for most values, (14′) is not violated. By setting the naive forecast equal to zero (14′) becomes the *Shiller* (1981) test. At the time of the announcement long-term interest rates changes fluctuated less than the perfect foresight changes. The large disparity between the two columns may suggest that θ may be unrealistic for high values or simply there is too much noise coming from the Money Market Services survey data.

5. Conclusions

An alternative volatility test is proposed using the assumption that interest rates react to weekly money announcements. The test avoids the problem of overlapping expectations without having to discard observations from the sample. The volatility test also directly examines the validity of the joint assumptions made in the announcement literature; the existence of an announcement effect and rational expectations of the term structure.

Contrary to announcement theory the empirical results indicated that the joint hypothesis could be rejected over all regime periods. A variety of hypotheses could explain the results. Since a joint hypothesis was tested, the precise cause of the rejection cannot be established. Naturally, the statistical reliability may be questioned. A potential possibility is that the key assumption $cov(v_t, r_t - r_t^0) = 0$ is violated. Furthermore the present value model (5) uses several constancy assumptions. Although the empirical evidence remains mixed, it is possible that

Table 1

Unbiased Volatility Tests

	θ	$E_t(r^* - r^o)^2$	$= E_t(r^* - r)^2$	$+ E_t(r - r^o)^2$
Whole sample	0.9	1.116930	1.144950	0.018477
	0.8	0.478823	0.500765	0.018477
	0.7	0.235882	0.256216	0.018477
	0.6	0.127360	0.146847	0.018477
	0.5	0.071413	0.090557	0.018477
	0.4	0.059481	0.058433	0.018477
	0.3	0.020162	0.038960	0.018477
	0.2	0.008451	0.022110	0.018477
	0.1	0.002054	0.020602	0.018477
FFR	0.9	1.181770	1.183050	0.000683
	0.8	0.502957	0.503930	0.000683
	0.7	0.244682	0.245504	0.000683
	0.6	0.130184	0.130908	0.000683
	0.5	0.072089	0.072727	0.000683
	0.4	0.039440	0.040014	0.000683
	0.3	0.019944	0.020487	0.000683
	0.2	0.008267	0.008822	0.000683
	0.1	0.001982	0.025860	0.000683
NBR	0.9	1.178960	1.261290	0.034855
	0.8	0.526415	0.583561	0.034855
	0.7	0.272577	0.317986	0.034855
	0.6	0.152965	0.193151	0.034855
	0.5	0.088311	0.125493	0.034855
	0.4	0.049779	0.085538	0.034855
	0.3	0.025780	0.060784	0.034855
	0.2	0.010927	0.045593	0.034855
	0.1	0.002683	0.037320	0.034855
BR	0.9	0.791828	0.794496	0.013559
	0.8	0.343119	0.354236	0.013559
	0.7	0.171890	0.187472	0.013559
	0.6	0.095268	0.113184	0.013559
	0.5	0.053469	0.072517	0.013559
	0.4	0.029796	0.048989	0.013559
	0.3	0.015296	0.033865	0.013559
	0.2	0.006442	0.023774	0.013559
	0.1	0.001577	0.017190	0.013559
CRR	0.9	0.309261	0.333197	0.012131
	0.8	0.137779	0.157420	0.012131
	0.7	0.074248	0.089660	0.012131
	0.6	0.042333	0.057784	0.012131
	0.5	0.025816	0.040039	0.012131
	0.4	0.015489	0.028824	0.012131
	0.3	0.008512	0.021224	0.012131
	0.2	0.003792	0.016105	0.012131
	0.1	0.000966	0.013089	0.012131

the observed interest rate fluctuations are caused by continuous changes in real interest rates or the risk premium.

Appendix:

Duration Values

The duration values for the volatility test results in Table 1 are presented below. Duration D_i is calculated from the following formula:

$$D_i = \frac{1 - y^k}{1 - y}, \qquad 0 \leq k,$$

where

$$y = \frac{1}{1 + i^*}, \qquad \text{and} \qquad i^* = \text{mean } i_t.$$

i_t denotes the interest rate before the weekly M/announcement is released for each sub-sample period between September 1977 and July 1985. The values for i^*, y and D_i are given in Table A 1.

Table A 1

Assumed values for i^*, y and D_i

	Maturity	$i^* \cdot 100$	y	D_i
Sept 1977 – July 1985	20 year	11.251	0.898	8.711
Sept 1977 – Oct 1979	20 year	8.614	0.921	10.233
Oct 1979 – Oct 1982	20 year	12.598	0.888	8.096
Oct 1982 – Feb 1984	20 year	11.312	0.898	8.654
Feb 1984 – July 1985	20 year	12.071	0.892	8.311

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Summary

Interpreting the Term Structure of Interest Rates Using Weekly Money Announcements

A volatility test is devised which evades the overlapping expectations problem for weekly data without having to discard observations. With the empirical relationship that short-term interest rates react to weekly money announcements, a present value equation is constructed which imposes the term structure hypothesis. The volatility test examines the validity of the joint hypothesis of rational expectations of the term structure and the reaction of short-term interest rates to weekly money announcements. The test rejects the assumptions made in the announcement literature.

Zusammenfassung

Fristigkeitsstruktur der Zinssätze und wöchentliche Veröffentlichungen der Geldmengenzahlen

In diesem Aufsatz wird ein Volatilitäts-Test konstruiert, der das Problem der überlappenden Beobachtungen vermeidet, ohne Beobachtungen zu verlieren. Der Volatilitäts-Test untersucht die Gültigkeit der gemeinsamen Hypothese rationaler Erwartungen der Fristigkeitsstruktur und positive systematische Reaktion kurzfristiger Zinssätze auf Veröffentlichungen neuer Geldmengenzahlen. Der Test verwirft die beiden Hypothesen.

Résumé

Interprétation de la structure des taux d'intérêt à l'aide de la publication hebdomadaire des statistiques monétaires

Un test de volatilité est construit pour pouvoir utiliser des données hebdomadaires, sans supprimer d'obversations, lorsque les anticipations s'etendent sur plus d'une période. Sur la base de l'hypothèse que les taux d'intérêt sont sensibles à la publication hebdomadaire des statistiques monétaires, on forme une équation de valeur actuelle dont découle une structure des taux d'intérêt spécifique. Le test de volatilité vérifie la validité des hypothèses combinées de rationalité des anticipations dans la structure des taux d'intérêt et de la réaction des taux à court terme aux annonces hebdomadaires. Le test réfute les hypothèses faites dans la litérature concernée.