MONEY SUPPLY ANNOUNCEMENTS AND THE MARKET'S PERCEPTION OF FEDERAL RESERVE POLICY

Steven Strongin and Vefa Tarhan

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ABSTRACT

This paper investigates the reason why innovations in money supply announcements cause interest rates to change. The paper empirically discriminates between the liquidity premium and the expected inflation hypotheses by directly taking into account investor expectations regarding the Federal Reserve's monetary policy stance. The results support the liquidity premium hypothesis, and the model provides an explanation for the observed time variation in the response of interest rates to money announcement surprises.

Money Supply Announcements and the Market's Perception of Federal Reserve Policy

Steven Strongin
and
Vefa Tarhan*

*Steven Strongin is Senior Economist and Assistant Vice President, Federal Reserve Bank of Chicago. Vefa Tarhan is Associate Professor of Finance, J. L. Kellogg Graduate School of Management, Northwestern Univeristy, on leave from Loyola University of Chicago. Vefa Tarhan received partial financial support for this paper from the James S. Kemper foundation. We would like to thank David Aschauer, Paul Spindt, three anonymous referees of this Journal, and the participants of the quantitative methods workshop at the Board of Governors of the Federal Reserve System and the University of Michigan Economics Department seminar series. Eric Klusman and Don Wilson provided excellent research assistance.

I. Introduction

In this paper we examine the unsettled question of why interest rates rose in response to positive innovations in the money supply during the early and mid 1980s[1]. Two major hypotheses have been advanced in the literature[2]. The liquidity premium hypothesis holds that the market expects that the Federal Reserve will respond to a positive innovation in the money supply by raising reserve pressures and thereby raising interest rates. The alternative hypothesis, the expected inflation hypothesis, holds that the market expects that the Federal Reserve will accommodate the excess money growth and this in turn will raise the market's expectations of future inflation, again raising interest rates. The two hypotheses have opposite assumptions about Federal Reserve behavior, yet have identical implications for nominal interest rates.

Previous studies attempted to distinguish between the two hypotheses by examining the market's perceptions of how the Fed intends to respond to money surprises in indirect ways (e.g. by examining the reaction of exchange rates).[3] These techniques suffered from two major drawbacks. First, since the tests were indirect they could at best provide inferential evidence. Second and more important, they implicitly held both Federal Reserve policy and the market's perceptions of that policy constant, subjecting the models to potential parameter biases and instabilities of the sort outlined in Lucas's econometric critique [9]. Empirically, such parameter instability has been found to be large by Loeys [8]. We intend to show that we can both directly distinguish between the expected liquidity and expected inflation hypotheses and explain previously observed parameter instability, by developing a model which directly accounts for the market's current perceptions of Federal Reserve policy stances.

Using Irving Fisher's separation of nominal interest rates into two components, the real part and the inflation premium, we can gain some further understanding of the liquidity premium and expected inflation hypotheses. Liquidity premium hypothesis assumes that the Fed will attempt to offset unexpected money growth by restraining the availability of credit. Thus, if the Federal Reserve is attempting to constrain money growth to a predetermined path, then a positive innovation in the money supply will force the Federal Reserve to increase reserve pressures. The increase in reserve pressures reduces the current supply of credit and thus raises its real price.

The expected inflation hypothesis, on the other hand, works through the inflation part of the interest rate. If the Federal Reserve is unwilling to increase reserve pressures enough to return monetary growth to its original path then an increase, at some point in the future, in the rate of inflation is the inevitable result. This increase in the rate of inflation, while having no immediate effect on the supply of credit, raises the inflation premium that investors require. However, since the market does not distinguish which part of the interest rate becomes higher, in both cases all we observe is a higher nominal interest rate.

Most of the early attempts to distinguish directly between the two hypotheses did not yield clear-cut results because the hypotheses are not mutually exclusive. For example, it was argued that since the liquidity effect is immediate and temporary and the expected inflation effect should affect only the future, all that was necessary to determine which hypothesis was correct was to examine which parts of the term structure were affected. But, while the early part of the yield curve was affected the most, buttressing the case for the liquidity hypothesis, the effects lasted far too long into the yield curve to be explained solely by short-term liquidity considerations. This paradox can be easily explained if the Federal Reserve is allowed to <u>partially</u> offset innovations in the money supply, allowing both effects some play.

The key to quantifying the dual operation of these hypotheses is the observation that the liquidity effect should be greater the more the market is convinced that the Federal Reserve is attempting to constrain the growth of the money supply, while the inflation effect is reduced by such beliefs. Thus, by correlating the market's perception of the tightness of the Federal Reserve's policy stance with the size of the interest rate response to money supply innovations, we can determine which of the two hypotheses dominates and also examine if that dominance changes with the term of the asset.[4]

Intrinsic to this way of looking at the problem is the idea that money supply innovations affect interest rates by varying amounts over time. As mentioned earlier, parameter instability has been found empirically. If this instability is a natural part of the economic relationship much of the previous empirical work on this topic must be reconsidered. This need to formally consider changes in the posture of monetary policy is not surprising as both of the major hypotheses rely primarily on the effects of anticipated Federal Reserve policy. Unless the Federal Reserve's policy and consequently the market's perception of the Federal Reserve's short-run policy stance were nearly constant throughout the sample period, a model that ignores changes in policy may not be able to cope with the phenomenon. In light of Lucas (1976), models that are designed to explain market responses in the context of changing monetary policy actions, need to formally take into account shifts in expected monetary policy of those changes.

Section II describes a model that allows the magnitude of the interest rate response to innovations in the money supply to vary according to the market's perception of the contemporaneous Federal Reserve's policy stance. Section III discusses the data used in the estimation of the models. Section IV presents the empirical results. Finally, Section V summarizes our conclusions.

II. The model

The usual model in the literature is:

$$di_t = a + bM^u_t + e_t \qquad (1)$$

where di_t is the change in the interest rate and M^u_t is the innovation in the money supply. The estimates of (1) reported in the literature indicate that b is positive. It can be argued that, by viewing b as constant even though there were significant changes in the manner monetary policy was conducted, previous studies have suffered from a misspecification problem. In this study we argue that b must be viewed as a function of the market's perception of how tight the contemporaneous Federal Reserve short-run policy stance is. We write this:

$$b_t = c + dT_t \qquad (2)$$

where T_t is a measure of the market's perception of Federal Reserve policy tightness.[5] We claim that on the basis of the sign of the d coefficient in (2), it is possible to empirically differentiate between the two hypotheses. To see this, assume announced money exceeds expectations. It has been established that this triggers an increase in interest rates. If the liquidity premium hypothesis is correct (i.e., if it is true that interest rates rise because the Fed is expected to offset the innovation), it should be the case that the tighter is the perception of monetary policy (high values for T_t), the stronger should be the reaction of investors (the larger the magnitude of the interest rate increase). This means that a positive sign for d supports the liquidity premium hypothesis. A negative sign for d, on the other hand, will be consistent with the expected inflation hypothesis. Assume again that announced money exceeds expected money. If interest rate increases that accompany this event are driven by inflationary considerations, it should be the case that when the Fed policy is perceived to be accomodative (low values for T_t), the market's reaction should be stronger, than when the monetary policy is considered to be tight. Such an inverse relationship between the degree of market's reaction (size of b_t) and perceived tightness (size of T_t) implies that a negative estimate for the d coefficient will support the expected inflation hypothesis.

Substitution of equation 2 into 1 yields:

$$di_t = a + cM_t^u + dT_tM_t^u + e_t \qquad (3)$$

The primary problem in estimating equation (3) is finding a good proxy for T_t. Ideally the measure used should be available on a weekly basis and reflect the market's perception of how the Fed will respond to a given innovation in money. For our sample period, there is strong evidence indicating that the market participants used net borrowed reserves as measure of monetary policy tightness. For example, one Fed watcher notes:

"[U]nder the operating procedures in effect, with modifications, since late 1979, the key link between the Fed and the federal funds rate is the amount of reserves that the banks must borrow from the Fed's discount window. Consequently, the best single indicator of the degree of pressure the Fed is putting on the reserves market is the amount of borrowed reserves. . . [The net borrowed reserves] is simply borrowed reserves minus excess reserves. Since the level of excess reserves is typically relatively modest, looking at one is often just as good as looking at the other. . . Nevertheless, (net) borrowed reserves is usually the best indicator of the degree of pressure that the Fed is putting on the reserves market."[6]

Investors' reliance on net borrowed reserves as an indicator of monetary policy appears to be justified. During the sample period lagged reserve accounting (LRA) was in effect. LRA has the interesting property that it cleanly separates supply and demand shocks in the reserve market. The demand for reserves is set two weeks before the reserves are actually held. Thus, changes in the borrowed-non-borrowed reserve mix (i.e. reserve pressures) that occur can be attributed almost in their entirety to Federal Reserve actions.[7] The only exception to this is excess reserve demand. However, since this is both small and usually fully accommodated by the Federal Reserve, it can be subtracted from borrowings. Net borrowed reserves obtained in this manner performs well as a tightness measure since the level of net borrowed reserves is simply the arithmetic difference between the amount of reserves banks need to have to satisfy their reserve requirements and the amount which the Fed is willing to supply.

While it appears that the actual level of net borrowed reserves is a good proxy for the degree of tightness in monetary policy and was used as such by investors, what is needed for our model is the market's <u>perception</u> of tightness. For this we used a survey of expected net borrowed reserves that money market services conducted on a weekly basis. Thus, the model we estimate becomes:[8]

$$di_t = a + cM^u_t + dB^e_t M^u_t + e_t \qquad (4)$$

where B^e_t is expected net borrowed reserves, and u_t is the estimation error.

III. The Data

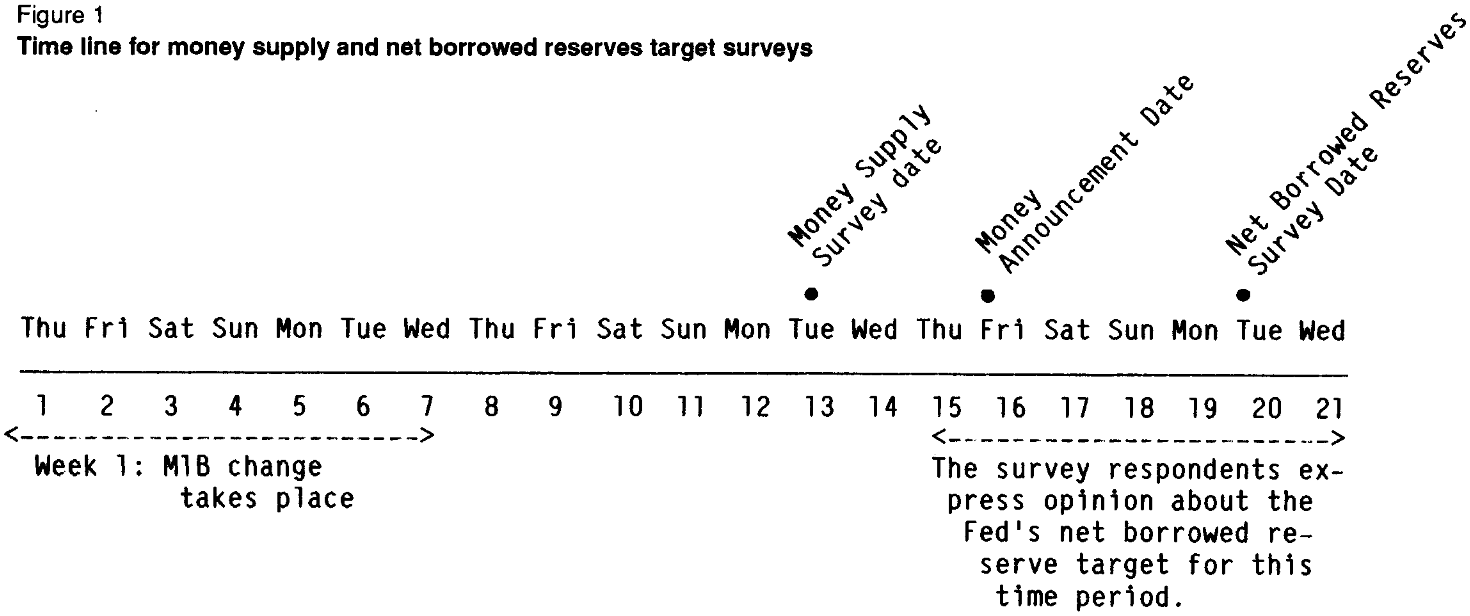
The sample period for this study is May 2, 1980 to January 6, 1984. The eleven interest rates used are the Federal funds rate, the rates on Treasury bills of 3,6, and 12 months maturities, and constant maturity security rates (1,3,5,7,10,20 and 30 years). Summary statistics on the variables used in this study are provided in Table 1.

Surveys of money supply and net borrowed reserves expectations are obtained from the Money Market Services.[9] Both were conducted on Tuesdays and measured fifty to sixty market participants' responses. The "money supply survey" solicited participants' estimates of the change in M1 from one week to the following week to be announced on the coming Friday.[10]

Note that the actual M1 change took place during the statement week that ended nine days prior to an announcement (see Figure 1). Also, market participants already had information about the actual level of the reserves for the statement week in question. The major source of the uncertainty about the money figure to be announced was that the market did not know how the Fed's actions (supply of reserves) and the activities of the public (currency and the type of deposits the public chose to hold) interacted to create the equilibrium level of M1.

In the "net borrowed reserves survey" the survey participants were asked each Tuesday to estimate what the Fed's net borrowed reserves target for the current statement week, ending the next day (Wednesday), was going to be. (See Figure 1). Net borrowed reserves is defined as adjusted borrowings minus excess reserves (where adjusted borrowing is defined as total borrowings minus extended credit). Thus, net borrowed reserves is the negative of free reserves. As discussed above, higher values for this variable indicate monetary tightness.

Figure 1
Time line for money supply and net borrowed reserves target surveys



As shown in Figure 1, survey participants reveal their expectations on Tuesday, Day 13, about the money supply for the statement week that ended six days before, i.e., days 1-7[11,12]. On Friday, Day 16, the actual money supply for the week that ended on the 7th is announced. The market's policy expectations regarding the Fed's net borrowed reserves target for the statement week covering days 15-21 are expressed on the Tuesday following the announcement (Day 20). The announcement surprise is discovered on Friday (Day 16). In this study the market's response is measured on the following Monday.[13] On Tuesday, Day 20, the market participants are asked to express their views on the Fed's target net borrowed reserves figure for days 15-21. They already know the extent of money deviation, and have responded to it on Monday on the basis of what they think the Fed will do (they have watched the Fed on Thursday, Friday, and Monday). Thus, on that Tuesday they reveal their beliefs about how the Fed decided to respond to the money shock.[14]

The net borrowed reserves survey data were examined for unbiasedness, efficiency, and forecast performance.[15] The results of these tests are summarized in Table 2.[16]

To test for unbiasedness, the following equation is estimated.

$$B_t^A = a_0 + a_1 B_t^E + e_t \tag{5}$$

where B_t^A is the actual net borrowed reserves.

The survey data is considered to be unbiased if $a_0 = 0$ and $a_1 = 1$. The test results indicate that unbiasedness cannot be rejected at the 10% level of significance.

The efficiency test considered is based on the premise that if the actual data on net borrowed reserves are generated by an autoregressive process, the market's expectation should conform with the same process. This implies that the lagged values of the actual data should turn out to be insignificant as explanatory variables in an equation where the dependent variable measures the forecast errors. The results in Table 2 show that efficiency cannot be rejected at the 10% significance level.

The third test is concerned with the forecast performance of the survey data. In this test the forecast performance of the survey data is compared with that of a simple autoregressive model. As can be seen from Table 2, the root mean square error associated with the survey is lower than that of the simple autoregressive model.

IV Empirical results

Equation (4) was estimated for the eleven interest rates by the ordinary least squares procedure. The OLS estimates are reported in Table 3.[17] Additionally the equations were estimated using an autoregressive procedure and checked for heteroscedasticity. The results indicated that no corrections were necessary and therefore we do not report those regressions.

It appears that interest rates of all maturities respond significantly to money announcement surprises. In all cases the c coefficient has the expected positive sign. In general, the size of the response declines as maturity increases. This result is along the same lines as those reported in the literature.[18]

As can be seen from Table 3, the sign of the d coefficient is positive across the maturity spectrum, supporting the liquidity premium hypothesis. What is more, ignoring the Fed funds equation for the moment, the coefficient in question declines both in magnitude and in statistical significance as maturity increases.[19] This implies that the expected liquidity effect is the dominant factor in the response of the short-term rates (up to three years). Its influence declines beyond three years. The fact that the estimates of this coefficient are statistically significant only in the equations for short-term interest rates is additional evidence in favor of the liquidity premium hypothesis. If interest rates are responding to money surprises because of expected liquidity considerations (and not due to changes in inflationary expectations) the response should by and large be confined to the shorter end of the maturity spectrum.

While the empirical evidence presented in Table 3 shows the existence of strong expected liquidity effects for maturities up to three years, it also appears that changes in inflationary expectations play at least a minor role in the response of longer-term interest rates. Since the expected sign for d is negative for the expected inflation, but positive for the liquidity premium hypothesis, the positive sign of the estimated d coefficient is consistent with a scenario where both effects are present, but the liquidity effect dominates inflation considerations. It is conceivable that, as the term to maturity increases, the importance of liquidity effects decline relative to expected inflation effects, with neither dominating.

There are a number of possible explanations of this. If a classical view of monetary policy is assumed, then the liquidity effects would decline through time and the inflationary effects grow. This is because, while the Federal Reserve may be able to raise real rates temporarily by reducing the rate of monetary growth, such effects dissipate as time passes. If the reduction in the rate of monetary growth is not all the way back to previous money growth expectations, inflation will rise. In this case, liquidity effects predominate in the early part of the term structure, but, depending on the extent to which money growth is allowed to stay above previous expectations, inflation effects will be relatively stronger on the longer end of the term structure.

An equivalent explanation of the behavior of the coefficient across the maturity spectrum follows from a belief that the Federal Reserve will tighten for some period of time, but will ease policy at some point in the future. This is also a mixed hypothesis, but the mix occurs across time, rather than at a point in time.

One puzzle that needs to be addressed is that the estimate for the d coefficient in the Federal funds rate equation is insignificant. It might be argued that the expected liquidity effect should be largest in this equation because the underlying instrument has the shortest maturity. Urich and Wachtel, [20] for instance, claim that the strong reaction of the funds rate to the money innovations is evidence supporting the expected liquidity hypothesis.[20] However, this is not necessarily the case. The increase in the funds rate, triggered by a positive innovation in money, does not necessarily mean the Fed intends to offset the innovation. The reason for this is related to the lagged reserve accounting. Under this regime, which was in effect during the sample period, the reserve requirements of banks are set two weeks before reserves are actually held. The money figure is announced with a nine-day lag, which means banks are already 2 days into the reserve settlement period when the announcement is made. Prior to the money announcement, the banks' assessment of the banking system's reserve demand is determined on the basis of expected money. When actual money exceeds expectations, the banks' estimate of the system's demand for reserves must be revised upwards, since the demand for reserves will be higher than expected. This could cause the Fed funds rate to go up regardless of expected Federal Reserve policy. Further, since the Federal Reserve does not allow intertemporal arbitrages in the reserve market, future actions on the part of the Federal Reserve should not have any affect.[21]

To see that even under conditions of inflationary expectations, the Federal funds rate may go up, consider a positive innovation in money. Assume

also that the Fed intends to accomodate this shock, and the market expects the Fed to behave in this manner. Even under these conditions, the funds rate will go up unless the injection of reserves by the Fed is both immediate and is of such a magnitude that it completely offsets the excess demand for reserves. The funds rate may increase in spite of an accomodative policy environment since the banks operate under a constraint in which the reserve requirements need to be met in the current reserve week.
Thus, the fact that the funds rate rises in reaction to positive innovations in money should not be considered evidence that the market expects the Fed to offset the innovations in money.

Based on our empirical results, in the fed funds market the reserve demand implications of money shocks under lagged reserve accounting apparently dominate any expected liquidity or inflation premium considerations. This appears to be the primary reason for a positive and significant c and a small and insignificant d in the Fed funds rate equation.

Table 3 also includes the average response of interest rates to money announcements, calculated in the following manner:

$$\bar{b}_{it} = \hat{c}_i + \hat{d}_i \bar{B}^e \qquad (6)$$

where $\hat{c}_i$ and $\hat{d}_i$ for each interest rate is obtained from the estimation of (3) and $\bar{B}^e$ is the average value of the expected net borrowed reserves for the sample period.

Figures 2 and 3 show the estimated response of each interest rate to money surprises over time. This response is calculated by

$$\hat{b}_{it} = \hat{c}_j + \hat{d}_j B^e_t \qquad (7)$$

where, as before, the slope and intercept coefficients are obtained from estimating (4) and B^e_t is the value of the market's weekly forecast of net borrowed reserves. The response of interest rates over time appears to be similar to those reported by Loeys [8], who estimated the reaction of interest rates to money by 'moving' regressions. The sample length in his regressions is fixed at one year, but each subsample moves over the 6-year master sample at 2-month intervals.

To better see the extent of the similarity, we duplicated his results for our sample period, using the rolling regression methodology he employed. We used 48 week subsample periods in the rolling regression. Then, we constructed the time path of interest rate response coefficients from our model by

$$\hat{b}_{it} = \hat{c}_j + \hat{d}_j \bar{B}_t^e \qquad (8)$$

where $\bar{B}_t^e$ is the expected net borrowed reserves averaged for each rolling regression subsample period. The time paths for the 90-day Treasury bill rate response coefficients obtained from his model and our model are graphed together in Figure 4. The similarity between the two time paths, especially over the period when there is complete information on $\bar{B}_t^e$ is striking. Estimating (4) by use of a rolling regression methodology, and testing if the estimate for the parameter c (and d) is relatively constant throughout the sample period would show the extent our model explains the time variation found by Loeys.[22] To test whether or not c varies over the sample period, we estimated the following equation

$$d_{it} = a + cM_t^u + c'M_t^u I(s_i) + dM_t^u \bar{B}_t^e + d'M_t^u \bar{B}_t^e I(s_i) + e_t \qquad (9)$$

where $I(s_i)$ is an indicator function which takes on a value of 1 for each subsample period, and zero otherwise. The level of significance on $\hat{c}_i$ tests whether or not the coefficient in each subsample period differs compared with the rest of the sample period. Figure 5 plots the values associated with $\hat{c}_i$. In our sample period there are 22 subsample periods. As can be seen from Figure 5, we are unable to reject the null hypothesis of constancy in any of the cases.

The t values associated with d_i are plotted in Figure 6, and again constancy cannot be rejected in any of the cases. Thus $\hat{c}$ and $\hat{d}$ individually do not have time-varying character that Loeys found.

As an additional point of interest, while our sample period does not include the October 1979 period, it does cover fall 1982 when the Fed made a major policy change by deemphasizing M1. Both Figures 2 and 3 show that this was a critical period, in that the reaction of interest rates shows a marked difference after fall 1982. However, when the parameter stability tests are done by splitting the sample period at October 1982, we find no evidence of structural instability in our model, unlike the standard models such as Loeys' which show substantial instability. This can be seen in the F statistics reported in Table 3.

V. Summary and Conclusions

This paper attempts to distinguish between alternative hypotheses regarding the positive correlation between money announcement surprises and interest rates. The issue was examined directly by taking into account investor expectations about the Fed's net borrowed reserves target immediately following an announcement surprise. The ability of the estimates obtained from our model to mimic the results of a rolling regression methodology used by Loeys indicate that reduced-form models that allow for policy changes can be useful across different policy regimes.

Based on our empirical results the conclusions of this paper can be summarized: 1) Interest rates respond to unanticipated money. 2) The magnitude of this response declines with the maturity of the instrument. 3) The expected liquidity hypothesis explains the reactions at the shorter end of the maturity spectrum. 4) While the liquidity effects still outweigh the inflation premium effects, the reaction of the long rates appears to be caused by the combination of both factors. 5) The response of the Fed funds rate cannot be explained by either effect, but instead by the peculiar way money shocks are transmitted to the reserves market under lagged reserve accounting. 6) While the reaction of interest rates change after October 1982, there is no evidence of structural instability. 7) The inclusion of a policy variable explains previously documented instabilities in parameter estimates.

Footnotes

[1]In recent years, the effect of money supply announcements on interest rates has been studied extensively (Cornell [1, 3], Urich and Wachtel [19, 20], Roley [15], Grossman [6]). The impact of unanticipated movements in money on stock returns (Pearce and Roley [13, 14] and Lynge [10], and on foreign exchange rates has also been investigated (Hardouvelis [7], Cornell [2], Engel and Frankel [5]). Generally, these studies find that the anticipated component of money supply announcements has no effect on capital market prices. On the other hand, unanticipated changes in money generate an interest-rate response in the same direction that is both significant and prompt. Both short- and long-term interest rates are affected. These studies also find that the impact of announcement shocks on market rates became more pronounced following the Federal Reserve's decision in October 1979 to switch to an operating procedure that targeted nonborrowed reserves, and then declined again following the policy to deemphasize-M1 in October 1982.

[2]Additionally, signalling models have been advanced in the literature to explain the reaction of interest rates to money announcement surprises. For example, see Cornell [4], Siegel [16] and Nicholas, Small and Webster [12]. In Cornell's case, money surprises are a signal about future real activity. In Siegel's model, the announced money supply reveals information both about the current and future state of real economic activity. The response of interest rates depends upon the variance-covariance matrix of real output, interest rates, and money. Nicholas, Small, and Webster [12], argue that when announced money exceeds expectations, this is a signal that future money demand will be higher. This being the case, they argue that interest rates will rise in response, if investors believe that the shock to money demand will dissipate more slowly than the equally large shock to money supply.

Cornell [4], proposes another channel through which money surprises may cause interest rates to change. He argues that innovations in money announcements may influence nominal interest rates by affecting the aggregate level of risk aversion.

The goal of this paper is to empirically discriminate between the liquidity premium and expected inflation hypotheses. Our model in its present form does not enable us to assess the empirical content of the signalling and risk premium hypotheses.

[3]Attempts have been made in the literature to discriminate between these two hypotheses on empirical and theoretical grounds. Engel and Frankel [5], for example, study the response of exchange rates to money announcements. They suggest that the spot value of the dollar (vis-a-vis the German mark in their study) would increase when money exceeds expectations if the expected liquidity hypothesis is correct, and decline if the inflation premium hypothesis holds. The empirical results presented in their study support the expected liquidity hypothesis. Cornell [2] also comes to the same conclusion on the basis of examination of the exchange rates between the dollar and five other currencies. However, Cornell in another paper [3] argues that the strong reaction of long term bond rates to money announcements is compatible with the inflation premium hypothesis.

Cornell [4] carefully lays out and tests the implications of the expected liquidity and the inflation premium hypothesis, as well as the risk premium and signalling models. While he does find that money supply announcements have an impact on the real rate, he concludes that no single hypothesis fully explains the data.

Hardouvelis [7], extends the previous empirical work by using forward exchange rates and also by examining the response of expected future exchange rates and foreign interest rates. Like Cornell, he concludes that, taken in isolation, neither of the two hypotheses is consistent with the data. He instead offers an alternative hypothesis which combines the two hypotheses in question. He argues that his results are compatible with a scenario where both the expected liquidity and inflation premium effects are present.

[4] It is conceivable that both effects are present simultaneously. Some plausable scenarios where both factors may be present simultaneously are discussed below. Since the two hypotheses imply opposite signs for the d coefficient, in our model, the term "dominance" is used simply to refer to the fact that, if both effects are present, the sign of the estimated d coefficient can be interpreted to mean that one effect outweighs the other.

[5] The market's perception of "tightness" refers to how the market participants view the current short-run Federal Reserve monetary stance conditional on their current information set-in other words, given the prevailing conditions in the economy (GNP growth, the unemployment level, the inflation rate etc.), the degree of monetary restraint they think the Fed intends to follow.

[6] See Melton, William C. Inside the Fed, pp. 129-30. Spindt and Tarhan [17] develop an algorithm for the manner in which operating procedures were conducted in the post 1979 period.

[7] Note that monetary policy that relied on free reserves was criticized in the 1960s for its indeterminancy. However, during this period contemporaneous reserves accounting was in effect. Under this reserve accounting regime, it is difficult to sort out the demand and supply shocks in the reserves market.

[8] Tests were performed to determine if a nonlinear specification might have been more appropriate. However, polynomial and other standard transforms did not provide any additional explanatory power. Additionally, the expected Fed funds rates was used as a proxy variable for monetary policy tightness. Our results indicated that the funds rate was not a good indicator of degree of tightness in monetary policy. We estimate our model for a sample period that starts on May 2, 1980 because our data on net borrowed reserves survey start on this date.

[9] We would like to thank Raul Nicho and Kim Rupert of the Money Market services for making the data available to us.

[10] Money announcements were made on Thursdays prior to February 8, 1980. Since February 16, 1984 the announcement day has been switched back to Thursdays. During the sample period, the announcement days did not always fall on a Friday due to holidays. To measure the response of interest rates over a consistent length of time. all non Friday announcement dates were deleted from the sample, a loss of 17 observations.

[11] On the same day, they also express their opinions regarding the expected net borrowed reserves for the statement week covering days 8-14. This, however, is not marked on the diagram so as not to cause confusion. The relevant net borrowed reserves survey for our purposes is the one that takes place on Tuesday the 20th.

[12]Only the median value of the survey is made public. The subscribers get information on the distribution of responses.

[13]In some studies the market response is measured from 3:30 to 5:00 p.m. on the day of the announcement. Other studies measure the response over close of business on announcement day and the opening rates the following day. In this study we measure the responses over closing rates on announcement dates and the closing rates the following business day.

[14]A referee pointed out the possibility that Tuesday's survey responses may be affected by Monday's interest rates. This has the potential to generate an inconsistent estimator problem. We believe that relying on a survey that is conducted on the Tuesday following the money supply innovation enables us to use the most up-to-date market assessment of expected Fed behavior. However, reestimating the model with previous Tuesday's survey data produced essentially identical results. This indicates that information biases introduced by the timing of the survey are small.

[15]Pearce and Roley [13] conduct these tests for the survey data on expected money. Their results show that the money survey data passes the tests of unbiasedness and efficiency and has lower RMSE compared with an autoregressive model of actual money.

[16]Note that the survey data reveal the investors' perception of the expected Fed policy. Thus all tests conducted are joint tests of unbiasedness, efficiency, etc., and also the hypothesis that the Fed is able to achieve its net borrowed reserves objectives.

[17]The survey on money is conducted on Tuesdays but the money is announced on Fridays. Since expectations can change between Tuesday and Friday, the difference between the announced and expected money may not truly represent the "surprise". To overcome this potential problem, Roley [15] suggests that changes in the fed funds rate from Tuesday to Friday can be used as a proxy for the change in expectations. We estimated [4] with this correction. The variable in question turned out to be insignificant. Additionally, it did not affect the relative sizes and significance of the estimates for the other variables.

[18]For example, Cornell [3] finds that the magnitude of the fed funds rate response is the largest and is about three times the response shown by the 30-year bond rate.

[19]The decline in the size of the coefficients is not monotonic. In fact the estimated coefficient for the 1-year bond exceeds that of the 12-month bills. This however is not unexpected since bonds pay coupons and have lower effective maturities relative to bills, and also bills are quoted on a discount basis.

[20]Hardouvelis [7] makes a point in a footnote which is similar to Urich and Wachtel's argument. He claims that the strong reaction of the Fed funds rate under lagged reserve accounting regime supports the expected liquidity hypothesis.

[21]Under the Lagged Reserve Accounting regime, a bank could carry forward a surplus or deficit up to two percent of its required reserves provided it does not carry forward deficits two weeks in a row. However, this in all likelihood did not change the intertemporally segmented nature of the market, since the size of the carryover provision is rather insignificant. See Spindt and Tarhan [18] for the implications of the carryover provision in an intertemporal reserve arbitrage framework.

[22]We are indebted to an anonymous referee for his suggestion that we pursue just how much of the time variation documented by Loeys is captured by our model.

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Table 1
Summary Statistics on Selected Variables

	Mean	Stnd. Dev.	Min. Value	Max Value	Stnd. Error of Mean
B^A	466.14	578.04	-456	2276	43.82
B^E	504.98	527.79	-300	2000	40.012
M^A	0.71	2.88	-5.9	11.4	0.21
M^E	0.34	1.57	-4.2	6.8	0.11
FF	0.037	0.047	-1.86	1.48	0.036
TB3	0.049	0.31	-0.94	1.34	0.023
TB6	0.057	0.29	-0.78	1.17	0.022
TB12	0.029	0.23	-0.61	0.88	0.018
CM1	0.036	0.29	-0.77	1.1	0.022
CM3	0.026	0.22	-0.77	0.83	0.017
CM5	0.029	0.20	-0.68	0.72	0.015
CM7	0.030	0.18	-0.58	0.58	0.014
CM10	0.027	0.16	-0.55	0.50	0.013
CM20	0.023	0.16	-0.45	0.49	0.012
CM30	-0.024	0.15	-0.47	-0.47	0.012
$(M^{\underline{A}}M^E)(B^E)$	-17.99	1790.9	-6480	7800	135.77

B^A = Actual net borrowed reserves
B^E = Expected net borrowed reserves
M^A = Actual (announced) money
M^E = Expected money
CM1, CM3, CM5, CM7, CM10, CM20, CM30 = constant maturity bond rates of 1, 3, 5, 7, 10, 20 30 years. (All Friday to Monday closings)
TB3, TB6, TB12 = Returns on T-bill rates of 3 mos, 6 mos and 12 mos.
FF = Fed funds rate (Friday close to Monday close).

Table 2: Tests on Net Borrowed Reserves Target Survey Data

Unbiasedness: $B_t^A = a_0 + a_1 B_t^E + U_t$

Coefficient estimates a_0	a_1	Summary Statistics R^2	D-W	Ho: $a_0 = 0$, $a_1 = 1$ F(2,172)	Prob>F
-12.35 (-0.4)	0.94 (22.6)	0.75	2.14	2.33	0.09

Efficiency: $B_t^A - B_t^E = b_0 + b_1 B_{t-1}^A + b_{2t}B_{2}^A{}_{t-2} + b_{3t}B_{3}^A{}_{t-3} + b_{4t}B_{4}^A{}_{t-4} + U_t$

b_0	b_1	b_2	b_3	b_4	Summary Statistics R^2	D.W	Ho: $b_0 = b_1 = b_2 = b_3 = b_4 = 0$ F(4.165)	Prob>F
6.4	-0.1	-0.05	0.06	-0.0				
(0.2)	(-1.7)	(-0.97)	(1.09)	(0.1)	0.05	1.91	2.10	0.08

Survey Forecast Performance: $B_t^A = c_0 + c_1 B_{t-1}^A + c_{2t}B_{2}^A{}_{t-2} + c_{3t}B_{3}^A{}_{t-3} + c_{4t}B_{4}^A{}_{t-4}$

c_0	c_1	c_2	c_3	c_4	Summary Statistics R^2	D.W	Forecast RMSE Auto	Survey
63.2	0.33	0.21	0.19	0.09				
(1.5)	(4.4)	(2.71)	(2.49)	(1.17)	0.53	1.97	391.46	291.19

Notes: t - statistics are reported in parentheses.
B_t^A = actual net borrowed reserves.
B_t^E = Market's perception of the Fed's net borrowed reserves target as indicated by the survey data.
R^2 = multiple correlation coefficient.
D-W = Durban Watson statistic.
Auto = the autoregressive model

Table 3
Market Response to Money Supply Announcements

$$di_t = a + c\,M^u_t + d_1\,M^u_t * B^E_t, + e_t \qquad \bar{b}_t = c + d_1\,\bar{B}^E_t$$

Dependent Variable	a X10^2	c X10^2	d X10^5	$\bar{b}_t$ X10^2	D-W	R^2	F-Test[1] for stability
FF	2.38 (0.7)[2]	4.37 (1.9)[2]	-.25 (-.08)[2]	4.1	2.7	0.041	1.48 (0.32)[3]
TB3	4.15 (1.9)	2.37 (1.7)	5.90 (3.3)	22.0	1.7	0.221	0.57 (.64)
TB6	4.7 (2.3)	3.17 (2.4)	4.43 (2.6)	22.2	2.0	0.222	0.92 (.43)
TB12	2.03 (1.2)	2.87 (2.8)	3.27 (2.4)	23.1	2.0	0.221	0.80 (.49)
CM1	2.49 (1.3)	3.49 (2.7)	4.19 (2.5)	23.8	2.0	0.238	0.69 (.56)
CM3	1.73 (1.2)	2.91 (3.0)	2.74 (2.2)	23.5	2.0	0.235	0.63 (.60)
CM5	2.14 (1.6)	2.57 (2.9)	2.03 (1.7)	20.0	2.1	0.201	0.85 (.46)
CM7	2.30 (1.8)	2.4 (3.0)	1.55 (1.5)	18.3	2.1	0.183	0.75 (.53)
CM10	2.15 (1.8)	1.75 (2.3)	1.43 (1.4)	13.6	2.0	0.136	0.37 (.46)
CM20	1.88 (1.6)	1.39 (1.8)	1.24 (1.24)	9.5	2.0	0.096	0.98 (.40)
CM30	2.01 (1.7)	1.34 (1.7)	1.36 (1.39)	10.2	2.0	0.102	1.19 (0.3)

B^E_t = expected net borrowed reserves. M^u_t = unanticipated money

FF = fed funds rate. TB3 = 3 month T-bill rate, TB6 = 6 month T-bill rate., TB12 = 1 year T-bill rate, CM1 to CM30 are one-year constant maturity rate to 30-year constant maturity Treasury bond rates.

[1]F-test is a chow test for stability of parameters with Oct 1982 as the sample split date.

[2]T ratios.

[3]P-values.

Figure 2

The value of b_t through time: the bills

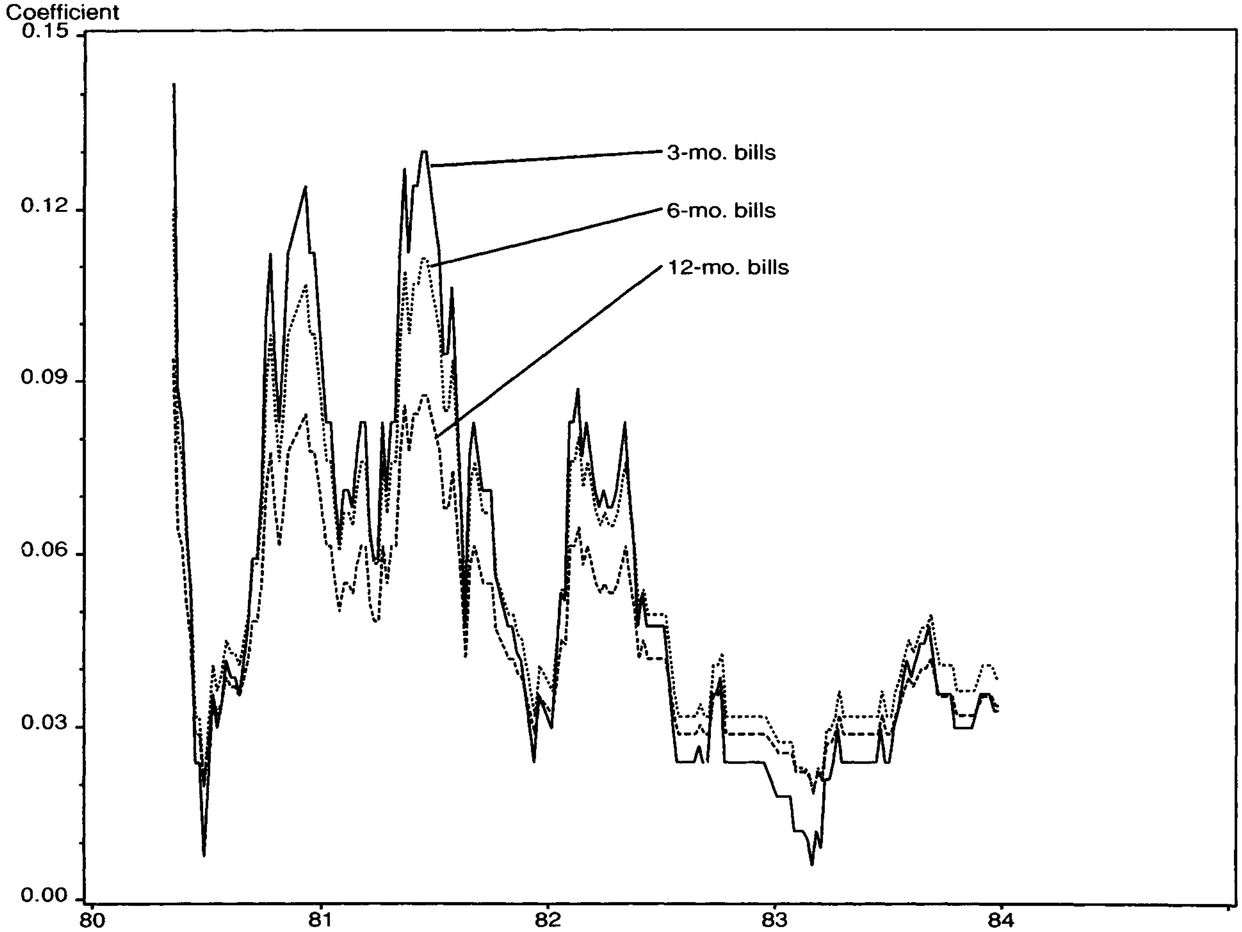


Figure 3
The value of b_t through time: the bonds

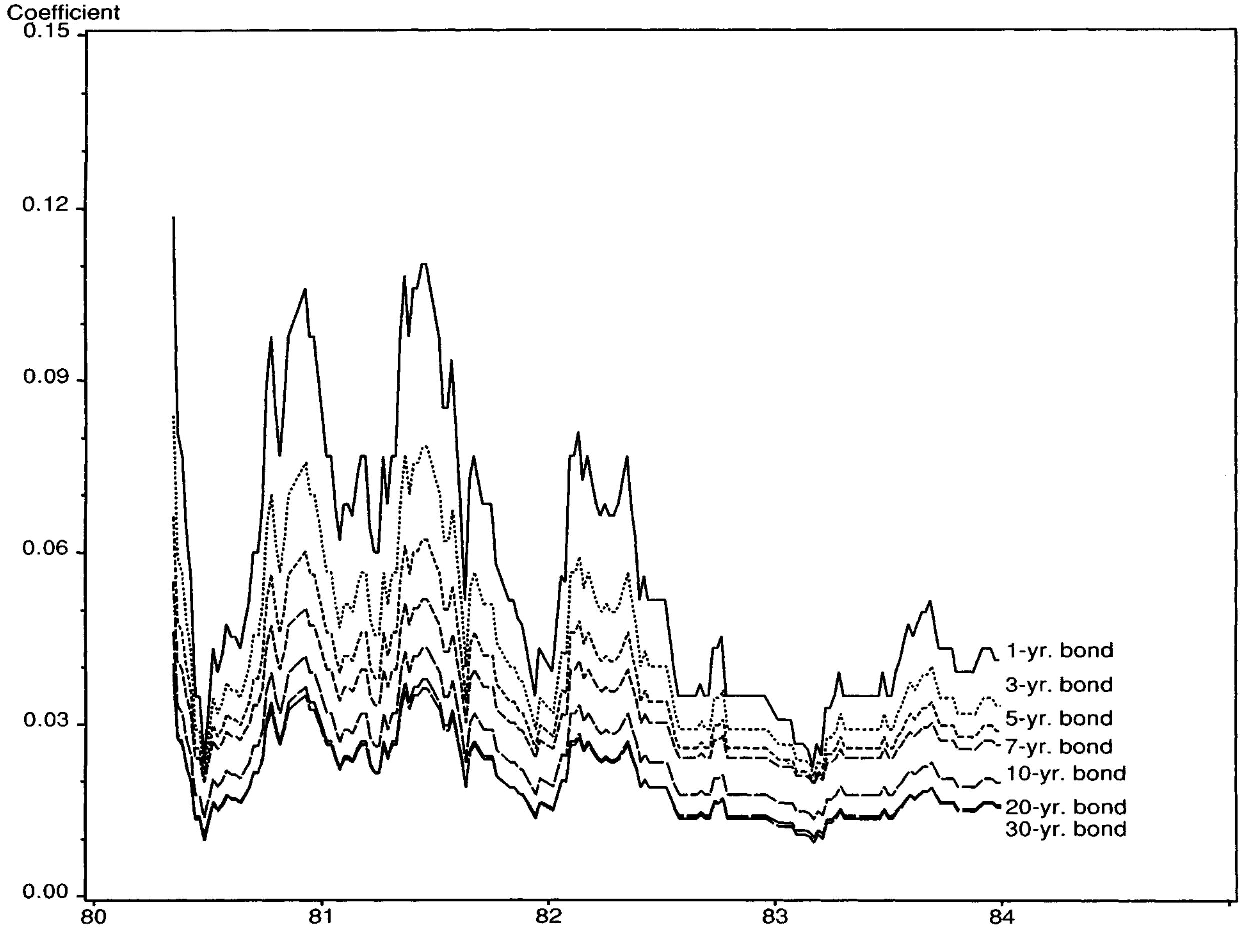


Figure 4

Time path of interest rate response coefficients (90-day treasury bill rate)

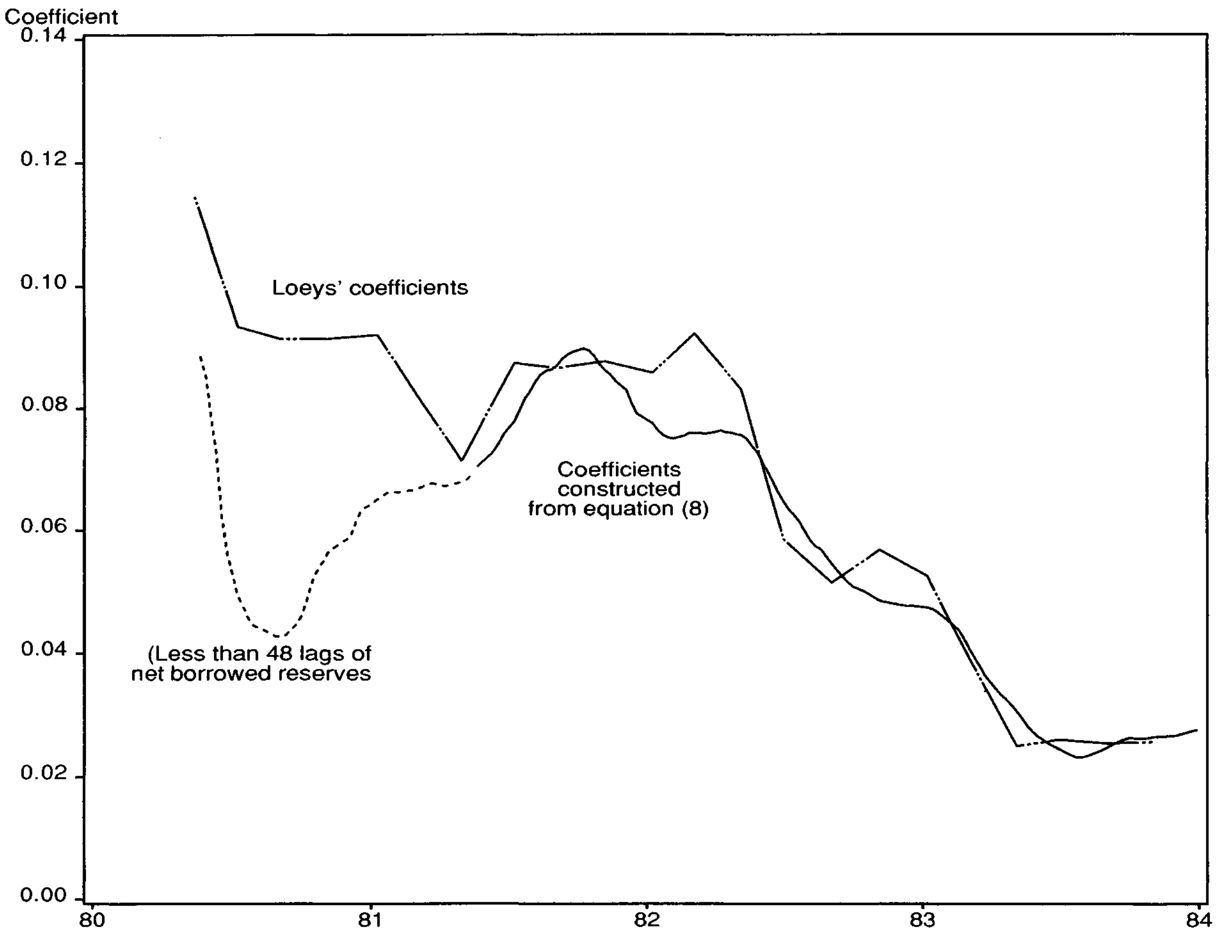


Figure 5
***t*-statistics for estimates of *c* across rolling regression subsample periods (90-day treasury bill rate)**

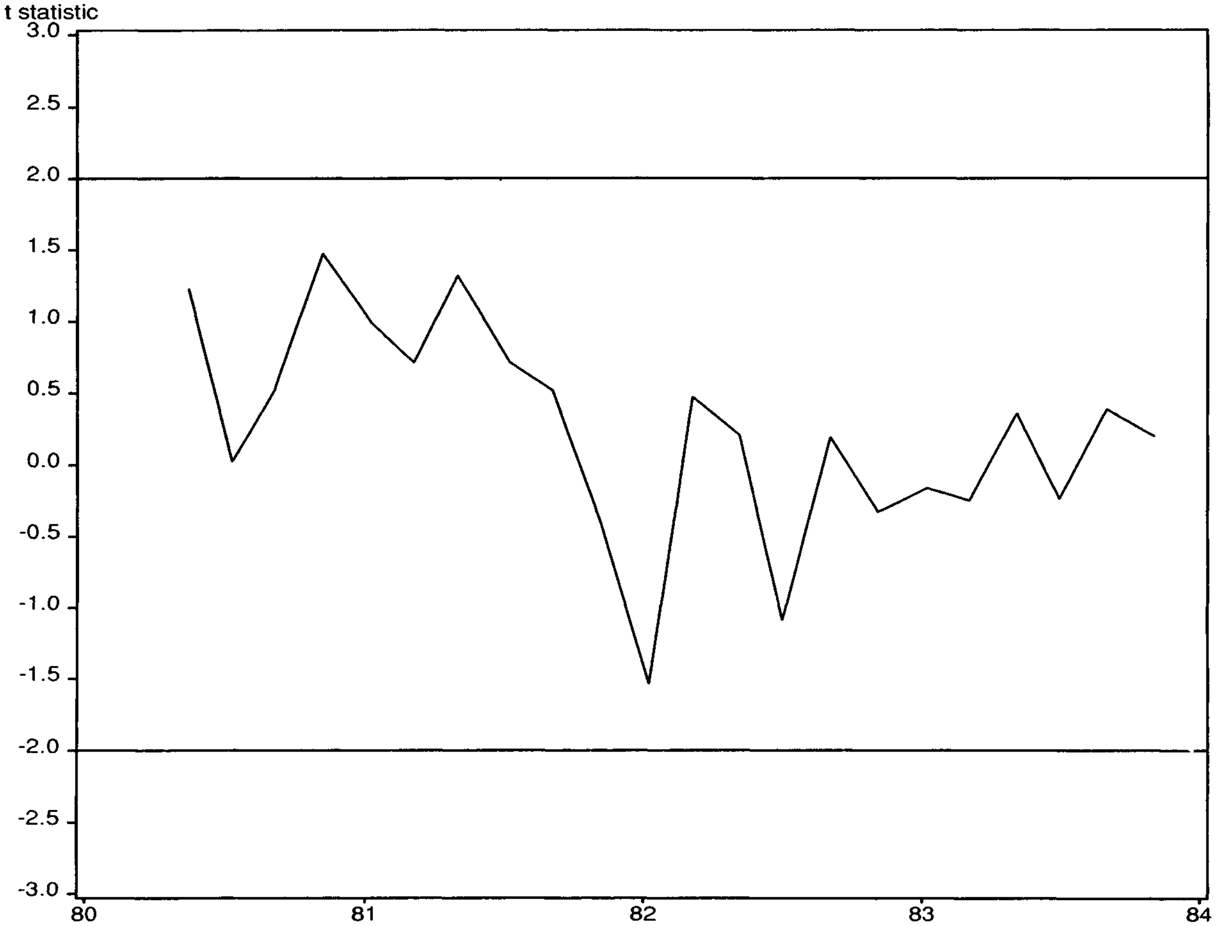
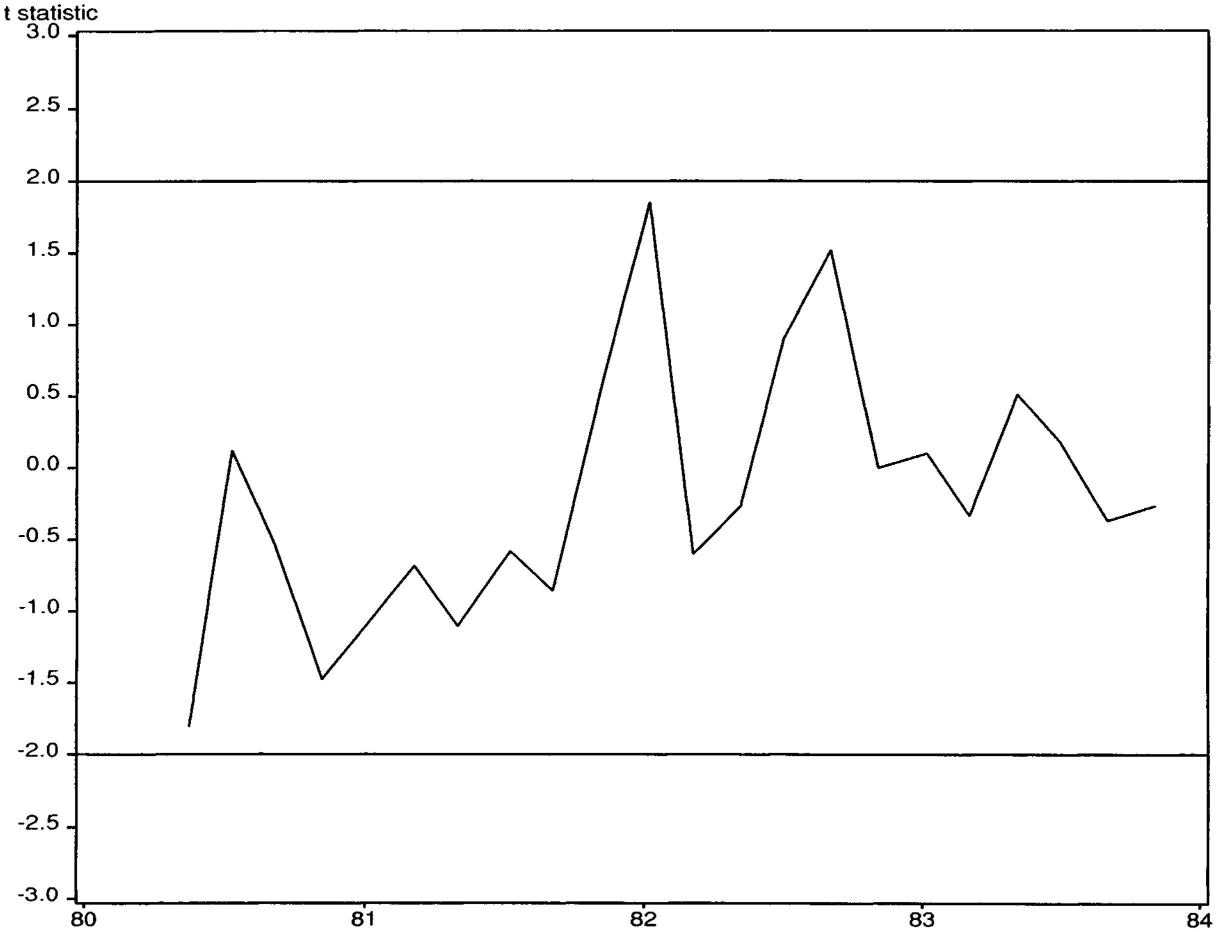


Figure 6

t-statistics for estimates of d across rolling regression subsample periods (90-day treasury bill rate)



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