What Do You Expect? Imperfect Policy Credibility and Tests of the Expectations Hypothesis

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Abstract

The expectations hypothesis is a theory of the term structure of interest rates that describes a conventional view of the transmission mechanism of monetary policy. According to the expectations hypothesis, bond rates are related to current and expected movements in the policy-controlled rate. However, empirical rejections of the expectations hypothesis are commonplace and lead many to question this description of policy transmission. This paper argues that failure to account for imperfect policy credibility may explain empirical rejections. Empirical rejections may occur even when changing anticipations of future short rates are the primary source of variation in bond rates and the standard term structure transmission channel remains valid.

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1 Introduction

The expectations hypothesis is a theory of the term structure of interest rates that lays out a conventional view of the transmission channel of monetary policy. In particular, economic activity depends on market rates on securities of various maturities and the expectations hypothesis provides a link between such rates and the policy-controlled rate. Unfortunately, the literature is rife with empirical evidence against the expectations hypothesis. Such evidence is troubling as the conventional description of monetary policy transmission rests on the hypothesis that variation in current bond rates is driven by variation in current and expected movements of the policy-controlled short-term rate.

A commonly offered explanation for empirical rejections of the expectations hypothesis is that the term premium on multi-period yields is time-varying.[1] As Shiller, Campbell, and Schoenholtz (1983) concluded: "Variations in risk premiums are so large as to destroy any information in the term structure about future interest rates." This paper offers an alternative explanation of the empirical rejections: Failure to adequately model expectations and to account for imperfect policy credibility may explain empirical rejections of the expectations hypothesis.[2] An interesting feature of the explanation is that empirical rejections may occur even when variation in bond rates is being driven primarily by changing anticipations of future short rates—in other words, even though the term structure transmission channel remains valid.

The explanation of empirical rejections of the expectations hypothesis presented in this paper centers on expectations and imperfect information. Carefully accounting for expectations formation

[1]Tests of the expectations hypothesis are based on an assumption that the term premium on multi-period yields does not vary over time.

[2]Other explanations have been offered for empirical rejections of the expectations hypothesis. See the discussion in Bekaert and Hodrick (2000). First, as noted earlier, term premiums may be time-varying, not constant as assumed by the expectations hypothesis. Second, the expectations hypothesis may be correct, but tests may lead to false rejections owing to their poor small small sample properties (due to highly persistent variables as in McCallum (1994) or "peso problems" as in Bekaert, Hodrick, and Marshall (1997b)). Third, whereas the expectations hypothesis assumes rational expectations, investors may be irrational in that they may make systematic forecast errors. Expectations may be irrational if, for example, all or a fraction of the market is characterized by adaptive expectations. Fourth, agents may be subject to bounded rationality. Under bounded rationality agents are rational optimizers but do not have full information and must learn about their environment. Market participants may be subject to asymmetric information or may be acting in a complex system where linear approximations are used. The explanation offered in this paper fits into the fourth grouping. Imperfect policy credibility as modeled in this paper implies systematic forecast errors. However, these errors obtain with rational expectations conditioned on a perceived inflation target that differs from the true inflation target—in other words, because agents learn about the true inflation target only gradually.

in a world of imperfect information is important within the context of the term structure of interest rates. This is because theories of the term structure relate yields on multi-period securities to *expectations of future* shorter-term interest rates. In particular, the continuous-time yield to maturity on an n-period bond can be expressed as:

$$R_{n,t} = \frac{1}{n} \sum_{i=0}^{n-1} E_t R_{t+i} + \theta_{n,t} \tag{1}$$

where R_t is the one-period yield in t and $\theta_{n,t}$ is the term premium on an n-period bond in t.[3] Under the assumption that the term premium is constant over time, i.e., $\theta_{n,t} = \theta_n$, (1) corresponds to the log expectations hypothesis.[4]

Issues related to policy credibility are important for the term structure of interest rates. Yields contain implicit information on expectations of policy goals. Long-horizon yields are related to long-horizon expectations of the policy-controlled rate.[5] The policy rate, as a nominal variable, embeds inflationary expectations. Consequently, although short-horizon expectations of the policy rate may predominantly reflect transitory cyclical factors, long-horizons expectations of the policy rate reflect conditional views of long-horizon expectations of inflation, and these long-horizon expectations are anchored by market perceptions of the price and/or inflation goal of monetary policy.

The explanation offered in this paper draws on the U.S. monetary policy experience. Several other policy-based explanations of the empirical rejections have been provided, but none focus on issues related to monetary policy credibility. Mankiw and Miron (1986) suggest that the failure of the expectations hypothesis may be due to the Federal Reserve's commitment to stabilizing interest rates. Using a small model, McCallum (1994) shows that interest rate smoothing, combined with policy responses to long rate movements may explain some empirical rejections. Rudebusch (1995) argues that Federal Reserve targeting behavior, including discrete target changes with transitory deviations of the funds rate from the target, short-term interest rate smoothing, and medium-term target persistence account for emirical results. Dotsey and Otrok (1995) suggest Federal Reserve behavior that smooths interest rates and moves discretely, in combination with time-varying term

[3] See, for instance, the derivation in Kozicki and Tinsley (2001b).

[4] See the discussion in Campbell, Lo, and MacKinlay (1997) on pages 413-418. For simplicity, we generally use the terminology "expectations hypothesis" and drop the reference to "log" in the text.

[5] For simplicity in this paper the terms one-period rate, short rate, and policy rate are used interchangeably.

premiums may explain empirical regularities. While these four articles focus on Federal Reserve interest rate targeting behavior, Fuhrer (1996) explores the implications of shifts in monetary policy regimes. This article has some features in common with Fuhrer, but the differences are fundamental. In particular, while Fuhrer considers the possibility of time-varying inflation targets, his analysis gives agents full contemporaneous knowledge of the policy regime.

This paper diverges from most empirical studies by relaxing the standard assumptions of full information and policy credibility.[6] A standard assumption, either explicit or implicit, in macroeconomic policy modeling is that private agents know the central bank's inflation target.[7] This paper relaxes this full information assumption. The central bank is assumed to have private information derived from knowledge about its inflation target. Private agents must infer the central bank's target from policy actions. This informational asymmetry gives rise to imperfect policy credibility and private agent perceptions about the central bank's target for inflation may deviate from the central bank's true target at any point in time.

Evidence from survey data suggests that private agents are slow to adjust their beliefs. Long-horizon survey expectations of inflation declined only gradually in the 1980s although actual inflation retreated quite quickly under Volcker. Actions taken by the Federal Reserve in October 1979 may be taken as a signal that the implicit target for inflation was being adjusted down forcefully. Refering to the decisions taken by the Federal Reserve on October 6, 1979, then-chairman of the Federal Reserve Board, Paul Volcker, noted on November 13, 1979:

> The clear and present danger was that failure to deal with inflation and inflationary expectations would in time produce more–not less–economic instability, ultimately with higher prices and greater unemployment. In that setting, the priority for policy was decisive action to deal with inflationary pressures and to defuse the dangerous

[6]The treatment of credibility in this paper deals with the issue of transition to a new unknown policy regime. As noted by Clarida, Gali, and Gertler (1999), virtually all of the literature ignores this issue. One notable exception is the Federal Reserve Board's model of the U.S. economy, FRB/US. Brayton, Levin, Tryon, and Williams (1997) use the FRB/US model to illustrate the implications of different assumptions about information and learning in simulations of a change in the inflation target. Most of the existing literature deals with credibility issues as part of the discretion versus commitment debate. Sargent (1999) may provide impetus to increase research into private sector learning about transition to a new unknown regime.

[7]Taylor (1999) presents a collection of papers that address important monetary policy issues. Although, as Taylor puts it, "the papers in the volume share an important common methodology that defines the state of the art in monetary policy evaluation research," all of the models assume that private agents know the central bank's inflation target. A recent exception is Huh and Lansing (2000).

> expecational forces that were jeopardizing the orderly functioning of financial and commodity markets.

However, after several years of elevated inflation, private agents did not initially believe that a new regime of lower inflation would last. The difficulties were voiced by then-Chairman Volcker himself in a statement before the Joint Economic Committee on October 17, 1979:

> An entire generation of young adults has grown up since the mid-1960s knowing only inflation, indeed an inflation that has seemed to accelerate inexorably. In the circumstances, it is hardly surprising that many citizens have begun to wonder whether it is realistic to anticipate a return to general price staibility, and have begun to change their behavior accordingly. Inflation feeds in part on itself, so part of the job of returning to a more stable and more productive economy must be to break the grip of inflationary expectations.

Meulendyke (1998) concurs that when the Federal Reserve changed FOMC policy in October 1979 after accelerating inflation over the preceding decade, the central banks's credibility with the public had been low after previous efforts to slow inflation had been followed by further price acceleration. Kozicki and Tinsley (2001a) use survey evidence to argue that during the Volcker disinflation in the early 1980s, private agents only gradually adjusted down their views of the rate of inflation implicitly being targeted by the Federal Reserve and credibility was slow to improve. Thus, it seems reasonable to conclude that the early 1980s provide an example of imperfect policy credibility.[8]

In addition to the focus on monetary policy credibility, another important feature of this paper that distinguishes it from the other papers with policy-based explanations is the scope of the analysis. Previous studies have tended to focus on empirical regularities from one test of the expectations hypothesis. Mankiw and Miron (1986), McCallum (1994), Rudebusch (1995), and Dotsey and Otrok examine spread predictions for short-rate changes, while Fuhrer (1986) compares actual and theoretical spreads. Also, Fuhrer's analysis, like that of Kozicki and Tinsley (2001a), emphasizes fits of yields estimated based on the expectations hypothesis rather than tests of the

[8]The slow adjustment of market expectations to the change in Federal Reserve policy during the early stages of the Volcker disinflation has also been noted by Blanchard (1984) and Huh and Lansing (2000). Goodfriend(1995) suggests that even in the 1990s there was a lingering lack of Federal Reserve credibility. He points out that the long rate was in roughly the same range of 8 percent in November 1994 as in the late 1970s, despite an inflation rate that was 4 to 5 percentage points lower.

expectations hypothesis. By contrast, this paper investigates whether imperfect monetary policy credibility can explain empirical regularities obtained from several different empirical approaches.

This paper proceeds by showing that imperfect policy credibility is capable of explaining empirical rejections of the expectations hypothesis based on three standard tests. In the next section, survey data on long-horizon inflation expectations is used as a proxy for market perceptions of the Federal Reserve's implicit inflation target. Tests of the expectations hypothesis based on spread predictions of long rate changes are reviewed within the context of imperfect policy credibility using the information provided by the survey data. Section 3 revisits the evidence that led Campbell and Shiller (1991) to conclude that variations in risk premiums are large. The empirical analysis contrasts the implications of using different VAR proxies for market expectations in constructions of theoretical spreads. Section 4 examines tests of the expectations hypothesis based on spread predictions of short rate changes. The implications of imperfect policy credibility are isolated by contrasting simulation results from a structural model with asymmetric information and learning to those from a similar model with symmetric information. Section 5 offers concluding comments.

2 Implications of Imperfect Policy Credibility for Spread Predictions of Long-Rate Changes

Shiller (1979) and Campbell and Shiller (1991) report that when the spread between longer-term yields and shorter-term yields is relatively high, subsequent movements in the longer-term yields are inconsistent with the expectations hypothesis. This section suggests that their empirical findings are consistent with the presence of lags between shifts in inflation and shifts in the perceived long-run inflation goal of monetary policy.

The empirical evidence against the expectations hypothesis considered in this section is obtained from regressions of long-rate changes on yield spreads. In particular, the evidence is based on coefficient estimates of γ in the regression

$$R_{n-m,t+m} - R_{n,t} = \alpha + \gamma(m/(n-m))(R_{n,t} - R_{m,t}) + resid_t, \qquad (2)$$

where estimates of γ significantly different from the null hypothesis of one are interpreted as evidence against the expectations hypothesis.[9] Shiller, Campbell, and Schoenholtz (1983), Mankiw and

[9]This equation can be derived using (1) under the assumpton that the term premium, $R_{n,t} - (1/n)\sum_{i=1}^{n} E_t R_{t+i}$, is a constant, possibly depending on n.

Summers (1984), Campbell and Shiller (1991), and Evans and Lewis (1994) find that coefficient estimates of γ tend to be significantly different from one, and that typically the point estimates are negative.

The historical behavior of actual inflation and long-horizon inflation expectations may help explain the negative estimates of γ obtained when estimating equation (2). Long-horizon expectations of inflation are built into long-term nominal yields. When the gap between long-horizon inflation expectations and current inflation is large, the spread between long and short rates will also be relatively large reflecting the perceived low credibility of policy. As credibility for the inflation policy increases, long-horizon expectations of inflation will converge toward inflation and the gap between long-term interest rates and short-term interest rates will decrease. In other words, a large spread that reflects low policy credibility with long-horizon expectations of inflation above the current inflation rate will precede falling long rates if the credibility of policy improves.

An analysis of survey data on long-horizon inflation expectations and historical inflation supports this hypothesis. A comparison of movements in inflation and in survey expectations indicates that there are lengthy lags between movements in inflation and adjustments of long-run expectations of inflation. Average 4-quarter inflation rates and survey data on long-horizon expectations are shown in figure 1. At the end of the 1970s, inflation rates exceeded 12 percent. Following the appointment of Paul Volcker as Chairman of the Federal Reserve Board, monetary policy was tightened considerably in starting in October 1979. By 1983, inflation rates had fallen substantially to levels averaging around 4 percent. Inflation rates remained low through the mid-1980s before rising somewhat. Survey data on long-horizon expectations, however, remained relatively high. Thus, the downward path of long-horizon expectations in the 1980s lagged considerably the trend movements in actual inflation. These data are consistent with the view that agents did not immediately believe that the lower inflation rates achieved by the Volcker disinflation would be sustained. The gradual decline in the survey data suggest that, as relatively low inflation rates persisted, policy gained credibility and private agents began to cautiously revise down their perceptions of the long-run inflation goal of policy.

Empirical results from estimation of the long-rate change equation in (2) are given in Table 1. Results are provided for 11 different (m, n) pairings and for 5 different sample periods. For m-values of 1, 3, or 12 months, the dependent variable in (2), $R_{n-m,t+m} - R_{n,t}$ was approximated by the change in the long rate, $R_{n,t+m} - R_{n,t}$. This approximation is generally regarded as reasonable for small values of m and large values of n.[10] Table 1 contains estimates of the coefficient γ and asymptotic standard errors corrected for residual serial correlation and heteroskedasticity following Newey and West (1987), with the Newey and West (1994) automatic lag selection routine. Boldface entries are significantly different from 1, based on an asymptotic 95 percent confidence band.

Four results are noteworthy. First, when estimated over a sample during which shifts in long-run inflation expectations were less likely to have occurred, empirical results do not provide evidence against the expectations hypothesis. In particular, for the December 1946 - December 1961 and December 1946 - December 1971 samples, all but one or two estimates of γ are insignificantly different from one for the (m, n) maturity pairings considered. Second, coefficients estimates of γ are generally negative and significantly different from one when estimated over a sample that contains shifts in long-horizon inflation expectations. Third, for $(m, n) =$ (60,120), regression results do not reject the expectations hypothesis. Since expected five-year inflation rates are likely very close to expected ten-year inflation rates, the size of the spread between 10-year yields and 5-year yields will not be driven by the gap between long-horizon inflation expectations and current inflation. Thus, regression results for $(m, n) =$ (60,120) are probably not being driven by credibility issues. Fourth, bias concerns raised by Bekaert, Hodrick, and Marshall (1997a) may explain rejections of the expectations hypothesis that occur when point estimates of γ are significantly greater than one. In particular, shifts in long-run expectations are least likely to be an issue for $(m, n) =$ (60,120) and for estimations over December 1946 - December 1961. And, in these instances, point estimates of γ are often greater than one in magnitude, as would be expected if coefficient estimates are upward biased due to persistence in the short-rate process.

Under the interpretation suggested above, the gap between long-horizon expected inflation and short-term expected inflation should predict ex post changes in long-horizon inflation expectations with a negative coefficient. Consequently, the following two regression equations were also estimated:

$$(1-\tau_{t+m})^{-1}\pi_{s,t+m} - (1-\tau_t)^{-1}\pi_{s,t} = \alpha + \gamma(m/(n-m))(1-\tau_t)^{-1}(\pi_{s,t} - \pi_t) + resid_t \qquad (3)$$

[10] Shiller, Campbell, and Schoenholtz (1983) and Campbell and Shiller (1991) use this approximation. Mankiw and Summers (1984) implicitly made this substitution. Although the equation they report appears to suggest that no approximation is necessary, their derivation is based on the yield on a consol, an infinitely lived bond, rather than the yield on a finite-maturity bond. However, in their empirical work, they approximate the yield on a consol with the yield on a constant maturity 20-year Treasury security.

and

$$\pi_{s,t+m} - \pi_{s,t} = \alpha + \gamma(m/(n-m))(\pi_{s,t} - \pi_t) + resid_t \tag{4}$$

where $\pi_{s,t}$ is survey data on 10-year inflation expectations, and τ is an estimate of the tax rate on bond earnings. The format of both equations assumes that m is small, n is large, and that expectations of annualized $(n-m)$-month inflation are roughly equal to expectations of annualized n-month inflation. The first equation contains tax adjustments to more closely approximate the movements of the inflation components implicitly contained in the pre-tax bond rate version of the regression equation in (2). Under positive tax rates, nominal rates will move more than one-for-one with expected inflation.[11]

Empirical results from estimation of these inflation change equations are provided in Table 2 for two different sample periods using available survey data on long-horizon inflation. Empirical results are somewhat sensitive to inclusion of the first two years of data. This is not surprising as the Federal Reserve was following a different policy regime from October 1979 through September 1982 than afterwards.[12] The bottow panel of Table 2 includes results from estimation of long-rate change equations over the two sample periods for comparison purposes.

Results in the top two panels of Table 2 suggest that when long-horizon inflation expectations are above current inflation, market participants revise *down* their long-horizon inflation expectations. Comparison of results in the top panel with those in the middle panel suggest that the presence of non-trivial taxes magnifies the result. The results support our view that subsequent to the high inflation episodes in the 1970s and 1980s, monetary policy was not viewed as credibly controlling long-run inflation. In particular, survey respondents did not initially believe that, over the long-run, policy could maintain the low inflation rates achieved by the Volcker disinflation of the early 1980s. As inflation remained below long-horizon expectations, the Federal Reserve gradually gained credibility and survey data indicates that long-horizon inflation expectations slowly moved closer to observed inflation rates.

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[11]Crowder and Hoffman (1996) indicate nontrivial tax rate effects in nominal interest rates. Estimated tax rates on earnings from Treasuries are based on a high-order smoothing polynomial fit to the sample for tax rates reported in McCulloch and Kwon (1993). As noted in Green and Odegaard (1997), tax rates fell substantially after 1986. The estimated tax rate series used here drops from about 0.22 in 1978 to about 0.06 after the late 1980s. This generates a substantial fall in the tax rate multiplier $(1-\tau)^{-1}$.

[12]See, for example, the discussion of the history of U.S. monetary policy presented by Meulendyke (1998).

3 Implications of Alternative Models of Expectations for Comparisons of "Theoretical" Spreads to Actual Spreads

The previous section used survey data to suggest that imperfect policy credibility, particularly in the 1980s, is an important feature of U.S. economic history that could explain empirical rejections of the expectations hypothesis. This section moves from survey data to proxies of agent expectations based on forecasts from time-series models. The point of this section is to show that some empirical rejections of the expectations hypothesis based on comparisons of "theoretical" spreads to actual spreads are fragile to the specification of the time-series model used to proxy for expectations. When model specifications generate long-horizon forecasts that resemble measures of long-horizon market expectations, the strong evidence against the expectations hypothesis largely disappears. Furthermore, the evidence that led Campbell and Shiller to conclude that variations in risk premiums are large turns out to be fragile.

The strategy of this section follows Campbell and Shiller (1991). Actual spreads are equal to

$$S_{n,m,t} = R_{n,t} - R_{m,t} \tag{5}$$

where $R_{k,t}$ is the yield on a k-period bond. Theoretical spreads excluding term premiums are constructed by replacing yields, $R_{k,t}$, with empirical proxies of average expected one-period yields. VARs are used to proxy expectations. In companion form, the VARs can be represented as:

$$X_{t+1} = H^i X_t + (I - H^i)\mu_\infty^{(t)} + \epsilon_{t+1} \tag{6}$$

where for a VAR with p lags, X_t is a stacked vector containing contemporaneous and $p-1$ lags of the VAR variables, and $\mu_\infty^{(t)}$ is a vector of endpoints of the VAR variables (i.e., limiting conditional expectations with $\mu_\infty^{(t)} = \lim_{k\to\infty} E_t X_{t+k}$).[13] Using these VAR proxies and defining ι to be a vector of zeros with a single one identifying the position of R_t in X_t, "theoretical" k-period yields excluding term premium are:

$$(1/k)\sum_{i=1}^{k} E_t R_{t+i} = (1/k)\sum_{i=1}^{k} \iota'[H^i X_t + (I - H^i)\mu_\infty^{(t)}] \tag{7}$$

and "theoretical" spreads (excluding term premium) between yields on n- and m-period yields are:

$$S_{n,m,t}^T = (1/n)\sum_{i=1}^{n} \iota'[H^i X_t + (I - H^i)\mu_\infty^{(t)}] - (1/m)\sum_{i=1}^{m} \iota'[H^i X_t + (I - H^i)\mu_\infty^{(t)}]. \tag{8}$$

[13]Campbell and Shiller (1991) provide a description of companion form representation of VARs and Kozicki and Tinsley (1998 and 2001b) provide more details on endpoints.

Comparing $S^T_{n,m,t}$ with $S_{n,m,t}$ aids in assessing the relative contributions to variation in bond yields of time variation in term premiums and shifts in expected short rates. If the VAR adequately approximates market expectations, and time variation in term premiums is small relative to movements in expected short rates, then $S^T_{n,m,t}$ and $S_{n,m,t}$ should be highly correlated and the ratio of their standard deviations should be close to one.

Three different VAR specifications are used to approximate the expectations of agents.[14] Each VAR contains three variables: a one-month nominal interest rate, inflation, and the rate of capacity utilization. The VARs differ only in their assumptions about the long-run behavior of interest rates and inflation rates. Although VARs are generally regarded as atheoretic, long-run conditional forecasts of inflation from the VARs (i.e., the inflation endpoints) can be interpreted as corresponding to implied inflation targets.[15] Consequently, differences in the long-run behavior of interest rates and inflation rates in the VAR proxies for expectations imply different views on the perceived inflation target of monetary policy.

Two of the VARs include standard atheoretic assumptions that variables are I(0) or I(1). However, as shown by Kozicki and Tinsley (1998 and 2001a), proxies for long-horizon inflation expectations based on forecasts from standard mean-reverting and first-differenced AR and VAR models do not match survey estimates. The third VAR considered is a shifting-endpoint VAR for which the properties of long-horizon forecasts resemble measures of market expectations. Kozicki and Tinsley (1998 and 2001a) showed that proxies for long-horizon expectations based on forecasts from shifting-endpoint AR and VAR models were more successful at capturing aspects of imperfect policy credibility as evident in survey data. In particular, shifting-endpoint AR and VAR models are capable of generating series for long-horizon inflation expectations that adjust slowly and with a significant lag compared to actual inflation, similar to the properties of long-horizon survey data.[16]

The first VAR is a *fixed endpoints VAR*. In this VAR, interest rates and inflation rates are

[14]The VARs used in this paper are identical to those used in Kozicki and Tinsley (2001a). More details on the VAR specifications and interpretation can be found in this reference.

[15]This follows from an assumption that in the long run, the inflation goal of monetary policy is expected to be achieved.

[16]Another approach to accounting for shifts in inflation targets and long-horizon expectations of inflation is to model the inflation target using a regime-shifting model. Hamilton (1988), Lewis (1991), Evans and Lewis (1994), Sola and Drifill (1994), and Bekaert, Hodrick, and Marshall (1997b) examine how changes in regime affect empirical analyses of the term structure. However, none of these models incorporate asymmetric information. In addition, as noted by Kozicki and Tinsley (2001a), these regime-switching specifications presume ex ante knowledge of the number and characteristics of all of the possible policy regimes.

included in levels. Point estimates of VAR coefficients are such that long-horizon forecasts of interest rates and inflation converge to their respective sample means. The macroeconomic interpretation of this property is that the first VAR assumes that the perceived inflation goal of monetary policy is equal to the sample mean of inflation and did not change over the estimation sample.[17]

The second VAR is a *moving average endpoints VAR*. In this VAR unit root restrictions are imposed on interest rates and inflation rates.[18] With unit root restrictions imposed, the inflation endpoint is a moving average of inflation and the interest rate endpoint is a moving average of interest rates. The macroeconomic interpretation of this property is that the second VAR assumes that the perceived inflation target follows recent inflation quite closely.

The third VAR is a *shifting endpoints VAR*. Interest rate endpoints are extracted from bond yields with the nominal rate endpoint approximated as:

$$\frac{n'(r_{n',t} - \theta_{n'}) - n(r_{n,t} - \theta_n)}{n' - n}. \tag{9}$$

Inflation endpoints are taken from Kozicki and Tinsley (2001a). These endpoints are constructed from a learning model and roughly follow long-horizon survey data. Thus, in this VAR, the perceived inflation target matches long-horizon survey data reasonably.

Campbell and Shiller (1991) calculated the standard deviation ratios and correlations between $S^T_{n,m,t}$ and $S_{n,m,t}$ across a range of maturity pairings (n, m) for one VAR specification. They found that correlations were almost always positive and often very high and that the standard deviation of $S^T_{n,m,t}$ to the standard deviation of $S_{n,m,t}$ was typically around one-half. They concluded that the spread is too variable to accord with the simple expectations model.[19] However, their conclusion rests on the assumption that the VAR they used adequately approximates market expectations. As will be shown, estimates of the theoretical spread are very sensitive to VAR endpoint specifications. When theoretical spreads are constructed using the VAR specification with shifting endpoints—the

[17]Mean-reversion of real interest rates may be a reasonable assumption. Barr and Campbell (1997) provide evidence to suggest that, at least for U.K. data, the real rate is relatively stable at long horizons. Evans and Lewis (1995) find that after accounting for rationally anticipated shifts in the inflation process, evidence from U.S. data is consistent with a stationary ex ante real rate. However, mean-reversion of nominal interest rates and inflation is controversial.

[18]Although interest rates and inflation may be cointegrated after accounting for tax effects, the presence of time-varying tax rates complicates modeling cointegration. Cointegration with time-varying cointegrating coefficients is beyond the scope of this paper.

[19]Simulations in Bernanke, Gertler, and Watson (1997) suggest a strong term premium response to changes in the short policy rate (about the same strength as the response of the average of expected short rates).

VAR that does the best job at matching survey data on market expectations—evidence is generally supportive of the expectations hypothesis.

Table 3 compares the theoretical spread, $S^T_{120,1,t}$ with the actual spread $S_{120,1,t}$ for six different estimation periods and across the three VAR specifications. The table reports correlations between the theoretical and actual spreads and the ratio of the standard deviation of the theoretical spread to the standard deviation of the actual spread. Results are consistent across all subsamples. In all cases, correlations of theoretical spreads calculated using the shifting endpoints VAR are closer to one than the theoretical spreads calculated using either of the other two VAR specifications. In all but one sample, standard deviation ratios are also closer to one when theoretical spreads are calculated using the shifting endpoints VAR.

For the VAR proxy of market expectations that comes closest to matching survey data, i.e., the shifting endpoints VAR, the empirical evidence is generally supportive of the expectations hypothesis and suggests that variation in long rates is likely primarily due to variation in expected short rates, not to time-varying term premium. This evidence supports another plausible interpretation of the results in Campbell and Shiller (1991). In particular, tests of the expectations hypothesis with model-based expectations are tests of the joint hypothesis that the expectations hypothesis is valid and that the forecasting model used adequately approximates market expectations. Results in Table 3 suggest that empirical rejections could be indicating that a particular VAR specification is a poor proxy for market expectations.

4 Implications of Imperfect Policy Credibility for Spread Predictions of Short-Rate Changes

Imperfect policy credibility with lags between movements in inflation and movements in market expectations of long-horizon inflation expectations is consistent with historical data and appears to be a possible explanation of empirical rejections of the expectations hypothesis. This section considers a third class of empirical tests of the expectations hypothesis based on spread predictions of short rate changes. Two complementary explanations of the empirical results are presented. One explanation focuses on empirical rejections for short horizon short-rate changes. This explanation argues that imperfect policy credibility may explain empirical rejections. Results from simulation of a small forward-looking structural macro model are offered in support of this explanation. The second explanation focuses on non-rejections at the long end of the term structure. Correlation results from both historical data and simulated data suggest estimated coefficients from test regressions are picking up correlations between the current short rate that is used in defining both the regressor and regressand.

The empirical evidence examined in this section is obtained from regressions of ex post short-rate changes on yield spreads. In particular, evidence is based on coefficient estimates of γ in the regression

$$\begin{aligned}\sum_{i=1}^{k-1}(1-i/k)\Delta^m R_{m,t+im} &= 1/k\sum_{i=1}^{k-1} R_{m,t+im} - R_{m,t} \\ &= \alpha + \gamma(R_{n,t} - R_{m,t}) + resid_t \qquad (10)\end{aligned}$$

where $k = n/m$ and $\Delta^m R_{m,t+im} = R_{m,t+m} - R_{m,t}$.[20] An empirical rejection of the null hypothesis that γ equals one is taken as evidence against the expectations hypothesis. Empirical results from estimation of the short-rate change equation (10) are given in Table 4 for nine (m, n) pairings and five sample periods. Similar to the findings of Campbell and Shiller (1991), evidence is generally consistent with the null hypothesis for relatively large n. However, for n equal to 3 months or 12 months, the evidence is less supportive of the null hypothesis. Nevertheless, contrary to the results for the long-rate change regressions, regression coefficient estimates always imply predictions for short-rate changes in the direction predicted by the expectations hypothesis.[21]

4.1 Imperfect Policy Credibility

The first explanation of the empirical results is based on the observation that even if the expectations hypothesis is true, ex post short rates may not on average correspond with ex ante forecasts of short rates. Differences may exist on average if the market-perceived goals of policy differ from the true goals of policy. In previous sections it was suggested that at times gaps likely existed between the actual inflation goals of the Federal Reserve policymakers and the policy goals inferred by the market. Given the absence of announced credible inflation targets in the United States, market participants were unaware of the Federal Reserve's price and/or inflation goals and had to make inferences about policy based on observable Federal Reserve actions. Through the 1980s, a

[20] A derivation of the short-rate change regression test can be found in Campbell and Shiller (1991).

[21] These results are similar to those in Mankiw and Miron (1986), Fama (1984), and Evans and Lewis (1994). See also the summaries in Rudebusch (1995) and McCallum (1994).

monetary policy goal of low and stable inflation was not viewed as credible. Furthermore, survey data suggests that market perceptions of the Federal Reserve's implicit inflation target adjusted very slowly. Thus, for U.S. data that includes the 1980s, it shouldn't be surprising to find that ex post short rates don't correspond on average with ex ante forecasts of short rates based on spreads.

A pair of similar structural macro models are used to evaluate the validity of the hypothesis that imperfect policy credibility may contribute to empirical rejections of the expectations hypothesis. The difference between the two models is that one assumes symmetric information on the part of policymakers and other economic agents whereas the other assumes that policymakers have more information about their inflation goal than other economic agents. In both models, long-term interest rates are constructed according to the expectations hypothesis but with the constant term premium set equal to zero, i.e., according to (1) with $\theta_{n,t} = 0$. Consequently, one might expect that in both models, spreads between long rates and short rates should on average forecast short-rate changes as predicted by the expectations hypothesis. However, if tests based on the credible policy model do not reject but tests based on the imperfect policy credibility model do reject, then the exercise provides evidence to support the proposed explanation—namely, that imperfect policy credibility may explain empirical rejections of the expectations hypothesis.

The structural macro model with policy credibility (symmetric information) is a simplified version of a Fuhrer-Moore model, but with an explicit inflation target that may shift over time.[22] The model is a hybrid with some characteristics of the small optimizing models of, for example, Rotemberg and Woodford (1999), McCallum and Nelson (1999), and Clarida, Gali, and Gertler (1999) and some of the persistence properties of reduced form models, such as Rudebusch and Svensson (1999), designed to improve realism of outcomes.[23] An innovation in this paper is the explicit treatment of the inflation target as a separate variable.

Inflation, π_t, depends on the expectation of the next period's inflation rate, lagged inflation, the deviation of output from potential, y_t, and a shock, $\epsilon_{\pi,t}$:

$$\pi_t = 0.5 E_t \pi_{t+1} + 0.5 \pi_{t-1} + 0.05 y_t + \epsilon_{\pi,t}. \tag{11}$$

Fuhrer and Moore (1995b) and Fuhrer (1995) show how this specification can be obtained from a

[22] See Fuhrer and Moore (1995a and 1995b).

[23] See the surveys by Goodfriend and King (1997), Walsh (1998), and Clarida, Gali, and Gertler (1999) for more discussion, and additional examples in Taylor (1999). Kozicki and Tinsley (2001c) suggest an alternative approach to improving data-based realism.

two-period wage contracting model that is a variant of Taylor (1980).[24]

The aggregate spending relation assumes persistence of demand, with changes in the output gap (or equivalently in the specification given here, the deviation of output growth from the percent change in potential output), responding negatively to the deviation of the expected real policy rate, $r_t^e - E_t\pi_{t+1}$, from its steady state value, $\bar{rr}$, and positively to shocks, $\epsilon_{y,t}$,

$$y_t = y_{t-1} - 0.2(r_t^e - E_t\pi_{t+1} - \bar{rr}) + \epsilon_{y,t}. \tag{12}$$

Although some specifications, including Fuhrer (1995a and 1995b), assume that aggregate spending depends on a long-term interest rate, such a specification was purposely avoided here.[25] A specification with output depending on a long rate would be preferred, but (12) is a standard specification in atheoretic VARs and insulates test results against feedback from the long rate to the short rate. If aggregate spending were to depend on a long rate, then feedback from long rates to the policy rate in the reduced form model might affect the properties of the test statistics.[26]

Monetary policy is assumed to set the nominal policy rate, r_t, according to a Taylor (1993) rule, but with an added transitory policy shock, $\epsilon_{r,t}$. The Taylor rule prescribes that the nominal rate equal inflation, plus one-half of the gap between inflation and the inflation target, $\pi_t - \pi_t^T$, and one-half of the output gap. Thus, the short rate equation is,

$$r_t = 1.5\pi_t - 0.5\pi_t^T + 0.5y_t + \bar{rr} + \epsilon_{r,t}. \tag{13}$$

Expected short rates, r_t^e, depend on contemporaneous values of inflation, the inflation target, and the output gap, but not on the transitory policy shock:

$$r_t^e = 1.5\pi_t - 0.5\pi_t^T + 0.5y_t + \bar{rr}. \tag{14}$$

Combined with the assumption that aggregate spending depends on the expected short rate, this assumption implies that transitory policy shocks occur at the end of the period. In addition, because aggregate spending depends on the expected policy rate rather than on the policy rate, the policy

[24]Alternatively, Roberts (1998) shows how this inflation equation can be obtained from New Keynesian optimizing models with expectations that are less than fully rational.

[25]Kozicki and Tinsley (2001c) show that the optimizing IS specification suggests that output is a function of bond rates and they provide empirical results to support such a specification.

[26]McCallum (1994) found that coefficient estimates used in construction of the expectations hypothesis test statistics would be biased down if short rates were persistent and depended on long rates.

shock doesn't directly affect the economy. The presence of the transitory policy shock is important, however, as it means that in the second version of the model, the unobserved inflation target can not be directly inferred from the observed policy rate. Unlike McCallum (1994), Dotsey and Otrok (1995), Rudebusch (1995) and Fuhrer (1996), the policy excludes an interest rate smoothing motive on behalf of the monetary authority. In the model, persistence in the policy rate is driven by persistence in either inflation, the inflation target, or the output gap.

The inflation target, π_t^T, is assumed to remain the same from one period to the next unless changed by a permanent target shock, $\epsilon_{T,t}$,

$$\pi_t^T = \pi_{t-1}^T + \epsilon_{T,t} \tag{15}$$

In the implementation of the model, $\epsilon_{T,t}$ is usually equal to zero—reflecting that changes in the policy target are infrequent. The inflation target is assumed to be credibly observed by private agents.

The n-period yield is defined according to the expectations hypothesis, but, without loss of generality, the constant term premium is set equal to zero,

$$r_{n,t} = 0.25 \sum_{i=0}^{n} E_t r_{t+i}^e. \tag{16}$$

As noted earlier, the n-period yield doesn't enter into other equations, so no endogenous feedback effects will alter the regression-based test statistics.

The structural macro model with imperfect policy crediblity (asymmetric information) is almost the same as the model with policy credibility as described above in equations (11) - (16). The fundamental difference is that the inflation target is assumed to be unobserved by private agents who gradually adjust their perceptions based on deviations of economic outcomes from their expectations. Since the inflation target is not observed, in the model with imperfect policy credibility, the equation for the expected short rate (14) is replaced by:

$$r_t^e = 1.5\pi_t - 0.5\pi_t^P + 0.5y_t + \bar{rr} \tag{17}$$

in which the perceived target, π^P, replaces the target inflation rate, π^T. In addition, an equation is added to describe the process by which private agents update their perceptions of the policy target. Agents are assumed to update their perceptions of the policy target according to their error in forecasting the policy rate in the previous period,

$$\pi_t^P = \pi_{t-1}^P + 0.05(r_{t-1}^e - r_{t-1}). \tag{18}$$

The forecast errors, $r_{t-1}^e - r_{t-1}$, contain two components: the policy shock ϵ_r and the error in the perceptions of the target $\pi^T - \pi^P$. Consequently, agents are not able to perfectly infer their misperceptions about the inflation target. In updating their perceptions, if the policy rate was higher than expected, then policy was tighter than expected and agents realize that the true inflation target may be lower than their perceived target. Consequently, the perceived target is lowered in response to an underprediction of the policy rate. Similarly, the perceived target is increased in response to an overprediction of the policy rate. Summarizing, the model with imperfect policy credibility is described by equations (11) - (13) and (15) - (18).

Each model is simulated for 320 time periods (representing 320 quarters, or 80 years). Over the simulation period the inflation target is subject to two non-zero shocks. Initially, the inflation target is set at 2 percent. After 170 quarters, the target is shifted up to 10 percent and, after an additional 59 quarters, the target is shifted back to 2 percent. Figure 2 shows the path of the policy target used in all the simulations with a representative path of the perceived target from a simulation of the model with imperfect policy credibility. Shocks to $\epsilon_{r,t}$, $\epsilon_{\pi,t}$, and $\epsilon_{y,t}$ are drawn from independent normal distributions with a zero mean and standard deviation equal to 0.4 percent.

Prior to estimating the short-rate change regression in (10) with $m = 1$, the first 100 simulated observations are dropped to eliminate starting value effects, if any. Regressions are estimated over the next 200 observations (50 years) of simulated data, with the last 20 obervations necessary to construct the last 20 observations of the regressand (defined as ex post averages of short rate changes). This exercise is repeated 10,000 times for both models. Table 5 reports the summary statistics from the short rate change regressions averaged over the 10,000 repetitions. Reported are average estimates of γ, standard deviations of estimates of γ, and the mean of the t-test statistic used to test the null hypothesis that $\gamma = 1$. In constructing the test statistics, standard errors were corrected for residual serial correlation using a Newey-West (1987) correction with 6 lags.

Results for the model with symmetric information are reported in the column labeled *Credible Policy*. For both the 4-period horizon and the 20-period horizon, estimates of γ are very close to one. In addition, tests of the expectations hypothesis do not reject the null hypothesis that γ equals one. Results for the model with asymmetric information are reported in the column labeled

Imperfect Policy Credibility. These results are very different. Mean estimates of γ continue to be positive, but are no longer close to one. For the 4-period horizon, the mean estimate of γ is only 0.270 and the mean test statistic provides strong evidence against the null hypothesis. The mean estimate of γ is closer to one for the 20-period horizon experiment, however, evidence against the null hypothesis that $\gamma = 1$ continues to be strong.

Rejections of the expectations hypothesis under imperfect policy credibility occur despite the fact that term premium are constrained to equal zero in the simulations. In other words, even though by construction all variation in long rates is attributable to variation in expected short rates, the test of the expectations hypothesis rejects.

4.2 An econometric issue

The second explanation of the empirical results argues that the regression specification, although well-suited for short-rate processes with unit roots, is poorly suited for short-rate processes that are mean-reverting, or that revert to a shifting endpoint. For such specifications regression coefficients may pick up correlation between the current short rate embedded in the definition of the regressand (ex post short rate changes) and the current short rate embedded in the definition of the regressor (the spread).

The intuition for this argument is as follows. First, an n-period moving average of a series that follows a mean-reverting process is less variable than the underlying series. Consequently, if the stochastic process followed by short rates is mean-reverting then, for large n, most of the variation in the regressand, i.e., in the difference between the n-period forward moving average of short rates and the current short rate, will be due to variation in the current short rate. Second, most of the variation in the regressor constructed as the spread between a long rate and a short rate is due to variation in the short rate. Third, regression techniques generate coefficient estimates designed to minimize unexplained variation in the regressand. Putting these three observations together, estimates of γ in the standard short-rate change regression may largely be driven by the dominating presence of the short rate in both the regressand and the single non-constant regressor (the spread). As duration/horizon increases, this phenomenon becomes more important.

Correlation results from historical data and simulated data support this explanation. Table 6 provides correlations between an ex post estimate of the spread, an ex post average of short rates, the long rate, the short rate, and the spread between the long rate and the short rate. The ex post estimate of the spread is equal to the regressand in the short rate change regressions. As hypothesized, the correlation between the ex post spread and the spread increases with n in both the historical data and the simulated data.

The source of the positive relationship between the spread correlations and n appears to be due to correlations between the spreads and the short rate. As expected, the ex post spread is positively correlated with the ex post average of short rates and negatively correlated with the short rate. In all cases, the negative correlation between the ex post spread and the short rate is stronger than the positive correlation between the ex post spread and the ex post average of short rates. Furthermore, the negative correlation between the ex post spread and the short rate increases as n increases. This regularity is also apparent in correlations between the spread, the yield, and the short rate. In particular, correlations between the spread and the short rate are more strongly negative for larger n. Additionally, for large n, the negative correlation between the spread and the short rate is stronger than the correlation between the spread and the yield.

This section has illustrated that imperfect policy credibility and an econometric property of averages may explain empirical rejections of the expectations hypothesis based on short rate change regressions. Empirical results similar to those observed in U.S. data were obtained using simulated data from a structural macro model with asymmetric information about the policy target and agent learning. The empirical rejections were obtained using the simulated data even though long rates were constructed to satisfy the expectations hypothesis.

5 Concluding Comments

This paper reviewed three standard empirical tests of the expectations hypothesis: spread predictions for long rate changes, comparisons of theoretical spreads to actual spreads, and spread predictions for short rate changes. Empirical evidence was shown to be consistent with what would be expected if market perceptions of the Federal Reserve's implicit inflation target shifted historically, and with a lag relative to actual policy. In other words, it was argued that empirical rejections might reflect incorrect assumptions about expectations formation rather than incorrect assumptions about the theoretical link between long rates and short rates.

An important lesson to be taken from the analysis of this paper is that empirical rejections of the expectations hypothesis need not negate the validity of a standard transmission channel of monetary policy.[27] The presence of asymmetric information, in the form of imperfect monetary policy credibility in this paper, can lead to empirical rejections of the expectations hypothesis even when the general theory that long rates primarily reflect expected short rates is valid.

Finally, one caveat is in order. Although this paper offers an economic explanation of the empirical rejections of the expectations hypothesis based on asymmetric information, it should not be taken as reflecting a view on the part of the authors that term premium are not time-varying. The hypothesis that expected short rates are an important transmission channel of monetary policy does not require an assumption that the term premium is constant.

[27]This lesson applies more broadly than illustrated by this paper. Researchers should be careful when using empirical results from tests of the expectations hypothesis to evaluate the term structure of interest rates as a transmission channel of monetary policy. An important criticism of empirical tests of the expectations hypothesis is that they rely heavily on the validity of the constant term premium assumption. Researchers may be interested in assessing whether whether variation in bond rates is *primarily* due to variation in short rate expectations. Time variation in term premium, particularly if only a secondary contributor to variation in bond rates, may not be an objectionable property. However, if term premium are positively correlated with short rates, as proposed by Cox, Ingersoll, and Ross (1985) and many subsequent studies, then γ is likely to be less than one. Thus, empirical tests may reject the null hypothesis that $\gamma = 1$ and the expectations hypothesis even when changing anticipations of future short rates are primarily driving bond rates.

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Table 1: Predicting Long-Rate Changes with the Term Structure Spread

$$R_{n-m,t+m} - R_{n,t} = \alpha + \gamma[(m/(n-m))(R_{n,t} - R_{m,t})] + resid_t$$

		Estimates of γ (Standard Errors in Parentheses)				
		Estimation Period				
m (months)	n (months)	46m12 to 61m12	46m12 to 71m12	46m12 to 81m12	46m12 to 91m12	46m12 to 97m10
1	12	-.17	**-.42**	-.48	**-.88**	**-.77**
		(.63)	(.51)	(.78)	.(64)	(.61)
1	36	.08	-1.53	-.67	**-1.83**	**-1.68**
		(1.77)	(1.46)	(1.63)	(1.15)	(1.09)
1	60	.52	-2.03	-1.17	**-2.66**	**-2.40**
		(2.58)	(2.09)	(1.92)	(1.46)	(1.35)
1	120	.59	-3.41	-2.47	**-4.43**	**-3.88**
		(3.91)	(3.28)	(2.51)	(2.11)	(1.83)
3	12	-.02	**-.40**	**-.86**	**-1.19**	**-1.09**
		(.90)	(.63)	(.59)	(.48)	(.47)
3	36	.88	-.48	-.67	**-1.74**	**-1.64**
		(1.82)	(1.33)	(1.21)	(.88)	(.81)
3	60	1.76	-0.50	-1.05	**-2.37**	**-2.19**
		(2.41)	(1.35)	(1.57)	(1.16)	(1.02)
3	120	2.31	-1.19	-2.37	**-3.84**	**-3.45**
		(3.26)	(1.73)	(2.10)	(1.66)	(1.35)
12	60	**4.26**	.94	**-1.04**	**-1.51**	**-1.47**
		(1.17)	(1.27)	(.70)	(.99)	(.81)
12	120	3.56	.16	**-2.18**	**-2.49**	**-2.38**
		(1.46)	(1.32)	(.96)	(1.59)	(1.20)
60	120	.02	.04	1.25	2.72	1.02
		(.64)	(.73)	(.97)	(1.57)	(1.44)

Standard errors are corrected for serial correlation and heteroskedasticity following Newey and West (1987) using the Newey and West (1994) automatic lag selection routine. Boldface estimates of γ are significantly different from one based on asymptotic 5 % critical values.

Table 2: Predicting Changes in Long-Horizon Inflation Expectations

m (months)	n (months)	Estimates of γ (Standard Errors in Parentheses) Estimation Period 80m10 to 97m9	82m10 to 97m9
		$(1-\tau_{t+m})^{-1}\pi_{s,t+m} - (1-\tau_t)^{-1}\pi_{s,t} = \alpha + \gamma[(m/(n-m))(1-\tau_t)^{-1}(\pi_{s,t} - \pi_t)] + resid_t$	
1	60	-.77	-1.27
		(.59)	(.61)
1	120	-1.56	-2.56
		(1.19)	(1.23)
3	60	-.29	-.81
		(.28)	(.28)
3	120	-.60	-1.67
		(.58)	(.58)
		$\pi_{s,t+m} - \pi_{s,t} = \alpha + \gamma[(m/(n-m))(\pi_{s,t} - \pi_t)] + resid_t$	
1	60	-.60	-1.02
		(.56)	(.59)
1	120	-1.21	-2.06
		(1.14)	(1.19)
3	60	-.14	-.58
		(.27)	(.27)
3	120	-.30	-1.19
		(.56)	(.56)
		$R_{n-m,t+m} - R_{n,t} = \alpha + \gamma[(m/(n-m))(R_{n,t} - R_{m,t})] + resid_t$	
1	60	-4.04	-1.59
		(1.75)	(1.73)
1	120	-5.83	-2.41
		(2.44)	(2.63)
3	60	-3.62	-2.06
		(1.25)	(1.46)
3	120	-4.60	-2.65
		(1.79)	(2.13)

Standard errors are corrected for serial correlation and heteroskedasticity following Newey and West (1987) using the Newey and West (1994) automatic lag selection routine.

Table 3: Comparing Theoretical Spreads, $S^T_{120,1}$, to Actual Spreads, $S_{120,1,t}$

	Estimation Period					
	66m1 to 97m9	70m12 to 78m12	79m1 to 87m12	82m10 to 87m12	79m1 to 97m9	82m10 to 97m9
Fixed Endpoints VAR						
Correlation	.47	.86	.68	.14	.59	.27
SD Ratio	1.50	.97	1.28	1.77	1.56	1.38
Moving Average Endpoints VAR						
Correlation	.16	.06	.45	.41	.37	.13
SD Ratio	.59	.73	.57	.83	.53	.47
Shifting Endpoints VAR						
Correlation	.96	.96	.97	.85	.96	.94
SD Ratio	1.16	1.10	1.15	1.12	1.18	1.14

Table 4: Predicting Short-Rate Changes with the Term Structure Spread

$$1/k \sum_{i=0}^{k-1} R_{m,t+im} - R_{m,t} = \alpha + \gamma(R_{n,t} - R_{m,t}) + resid_t \qquad k = n/m$$

		Estimates of γ (Standard Errors in Parentheses) **Estimation Period**				
m (months)	n (months)	46m12 to 61m12	46m12 to 71m12	46m12 to 81m12	46m12 to 91m12	46m12 to 97m10
1	3	**.28**	**.26**	.83	.72	.68
		(.14)	(.15)	(.25)	(.20)	(.18)
1	12	**-0.00**	**.02**	.52	**.26**	**.32**
		(.27)	(.21)	(.31)	(.21)	(.21)
1	36	.78	**.43**	1.03	.45	.50
		(.21)	(.22)	(.30)	(.32)	(.30)
1	60	1.13	**.56**	1.03	.53	.59
		(.25)	(.20)	(.17)	(.35)	(.29)
1	120	**.48**	1.32	1.05	**1.47**	.62
		(.22)	(.09)	(.16)	(.19)	(.38)
3	12	.16	**.21**	.58	**.20**	**.25**
		(.46)	(.32)	(.29)	(.27)	(.26)
3	36	1.24	.68	1.31	.48	.53
		(.33)	(.26)	(.28)	(.36)	(.32)
3	60	1.31	.74	**1.34**	.63	.62
		(.24)	(.25)	(.17)	(.39)	(.32)
3	120	**.36**	**1.37**	1.18	**1.57**	.67
		(.18)	(.09)	(.18)	(.20)	(.43)

Standard errors are corrected for serial correlation and heteroskedasticity following Newey and West (1987) using the Newey and West (1994) automatic lag selection routine. Boldface estimates of γ are significantly different from one based on asymptotical 5 % critical values.

Table 5: Simulation Results

	n	Credible Policy	Imperfect Policy Credibility
Mean Estimate of γ	4	0.974	0.270
Std. Dev. of Estimates of γ	4	0.078	0.033
Mean of EH Test Statistics	4	-0.402	-13.986
Mean Estimate of γ	20	1.006	0.776
Std. Dev. of Estimates of γ	20	0.154	0.057
Mean of EH Test Statistics	20	0.096	-6.396

Entries are over 10,000 repetitions.

Table 6: Correlations of Yields, Spreads, and Ex Post Average Rates

	Ex Post Spread	Ex Post Average	Yield	Short Rate
Historical Data (m=1 month, n=12 months)				
Ex Post Average	0.17			
Yield	-0.31	0.86		
Short Rate	-0.37	0.86	0.97	
Spread	0.21	0.12	0.26	0.01
Historical Data (m=1 month, n=120 months)				
Ex Post Average	0.17			
Yield	-0.74	0.26		
Short Rate	-0.89	0.30	0.85	
Spread	0.35	-0.08	0.17	-0.38
Simulated Data - Imperfect Policy Credibility (m=1 quarter, n=4 quarters)				
Ex Post Average	0.05			
Yield	-0.08	0.83		
Short Rate	-0.31	0.93	0.82	
Spread	0.43	-0.46	-0.03	-0.59
Simulated Data - Imperfect Policy Credibility (m=1 quarter, n=20 quarters)				
Ex Post Average	0.14			
Yield	0.31	0.88		
Short Rate	-0.72	0.58	0.37	
Spread	0.95	0.06	0.36	-0.73

Figure 1
Inflation and Long-horizon Inflation Expectations
Annual Rates

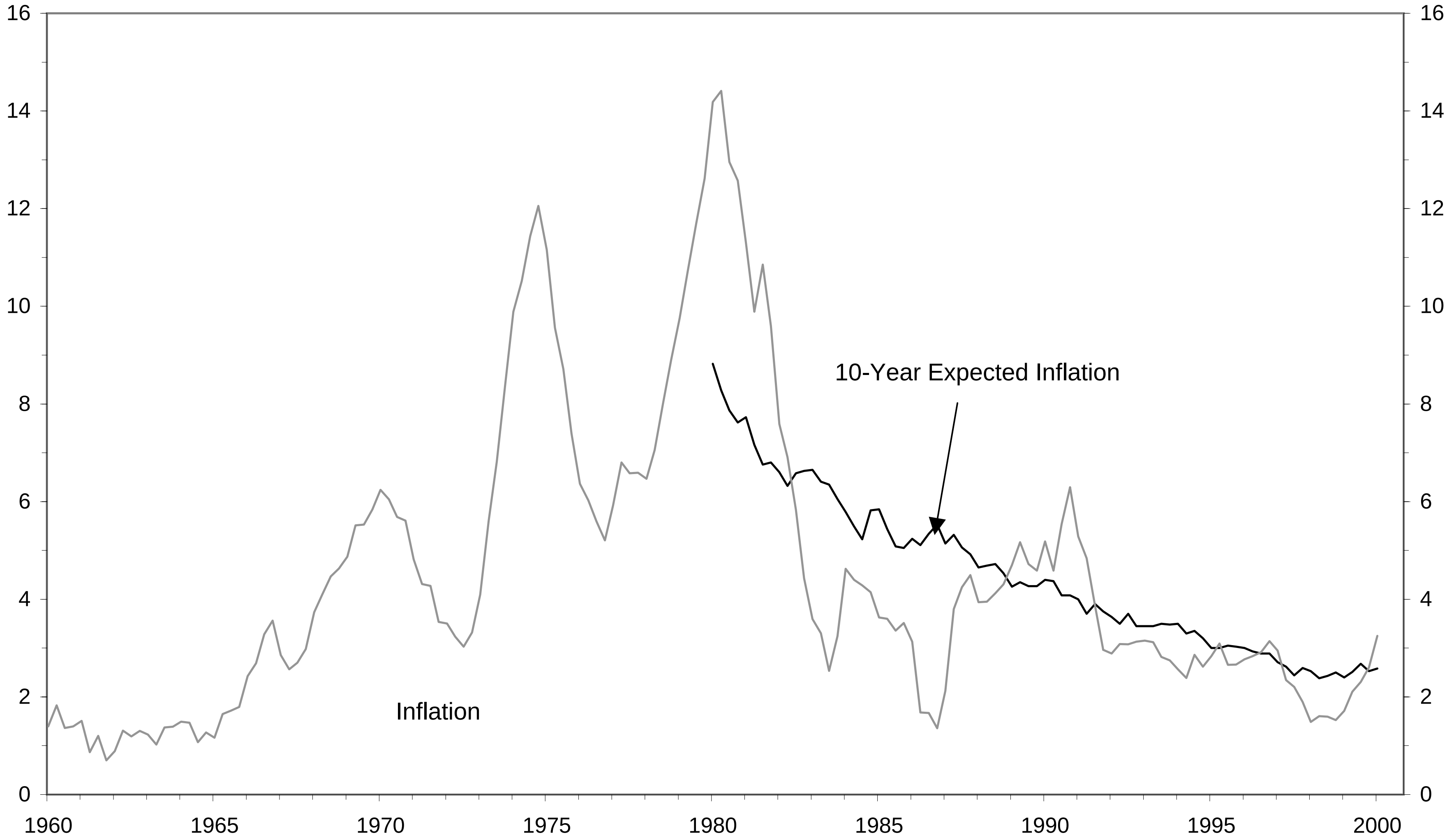

Figure 2: Shock to Inflation Target