Preliminary
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Inertia in the Fed's Monetary Policy Rule

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Abstract

Using the sensitivity of the Federal funds rate to contemporaneous and lagged macroeconomic news, I document that the Fed's monetary policy rule exhibited minimal inertia prior to 1994. Conflicting estimates in the literature rely on techniques that can substantially overestimate inertia unless the policy rule is precisely measured. In early 1994 Chairman Greenspan effectively changed the policy rule, emphasizing meeting markets' expectations of short-run changes in the funds rate. Markets anticipated inertial policy, thus the Fed delivered it. I argue that both the policy change and the markets' anticipation of inertial policy were grounded in the experience of the 1990–1991 recession and its aftermath.

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I estimate properties of the Federal Reserve's monetary policy rule for the Fed funds rate, emphasizing the role of inertia. An inertial rule specifies both a target, determined by current forecasts of economic conditions, and an incremental speed of adjustment towards the target. The sample period ranges from 1969 until the global financial crisis, excluding the Volcker disinflation from mid-1979 through 1982. Key evidence comes from regressions of changes in the funds rate on Greenbook revisions in forecasts of output growth and inflation.

Separate estimates characterize inertia for the pre-disinflation period, the post-disinflation period through 1993, and 1994 until the financial crisis. Motivation for the end-1993 breakpoint comes from Chairman Greenspan's discussion at the February 1994 meeting of the Federal Open Market Committee (FOMC). In his words, he"went berserk" at the meeting, pleading with the other FOMC members to begin a tightening cycle by initially raising the funds rate only 25 b.p. rather than 50 b.p.[1] I find that this event initiated a marked change in both the nature of the FOMC's deliberations and the gradualism embedded in its policy rule.

The evidence supports four main conclusions. First, prior to 1994, the Fed funds rate responds quickly to Greenbook forecast revisions. Consider a target-rate revision as of FOMC meeting t. Point estimates imply that the funds rate immediately reflects about half of the revision. By meeting $t + 2$, the funds rate incorporates more than 80% of the target-rate revision. Meetings were held monthly during the pre-disinflation period and every six weeks beginning in the early 1980s. Thus prior to 1994, the bulk of the funds rate response occurs within a quarter.

Second, from 1994 until the beginning of the global financial crisis, the funds rate responds with considerably more inertia. The point estimate implies that it takes three quarters (six meetings) for the funds rate to incorporate 80% of a target-rate revision. Third, in all three periods, point estimates of inertia associated with news about expected output growth substantially exceed the corresponding estimates associated with news about expected inflation. This conclusion casts doubt the simple target/inertia model of the policy rule. Fourth, investors appear to price these patterns into Treasury bonds; both the change in inertia after 1993 and the difference in the speed of adjustment to output growth news relative to inflation news.

[1] He uses this phrase at the May 2004 FOMC meeting to describe his remarks at the February 1994 meeting. Transcript of the May 2004 FOMC meeting, p. 86.

My conclusions about the magnitude of inertia prior to the mid-1990s conflict starkly with the existing literature. In an influential article, Clarida, Galí, and Gertler (2000) estimate monetary policy rules over the sample 1960 through 1996. They estimate "…only between 10 and 30 percent of a change in the interest rate target is reflected in the Funds rate within a quarter of the change." (pp. 157-158) Their results, confirmed by subsequent research in the same vein such as Carvalho, Nechio, and Tristão (2021), lead Coibion and Gorodnichenko (2012) to observe "…much of the recent macroeconomics literature has simply assumed interest-rate smoothing on the part of central bankers …" (p. 128).

I argue that standard empirical approaches, which use regression coefficients on lagged interest rates to infer inertia, rely on the assumption that the econometrician's model correctly measures the Fed's target rate. For concreteness, assume the policy rule exhibits no inertia; the funds rate equals the true target. Also assume the econometrician's measure of the target is only imperfectly correlated with the true target. The true target follows a persistent process because economic conditions are persistent. Therefore, even in the absence of inertia, lagged funds rates are correlated with the current rate through the target's persistence. Thus, both the model's mis-measured target and the lagged funds rate help explain the current funds rate. Simulation evidence shows that even in the absence of true inertia, regression coefficients on lagged funds rates can be large.

My approach does not require precise identification of the Fed's target rate. I treat Greenbook-to-Greenbook revisions in forecasts of output growth and inflation as news that affects the Fed's choice of the target. The sensitivity of the funds rate to contemporaneous and lagged news, combined with the persistence of expected output growth and expected inflation, can be used to estimate the magnitude of inertia.

What accounts for the change in policy in the mid-1990s? Transcripts and other information from FOMC meetings suggest that the Fed's policy change is only indirectly related to a goal of policy inertia. Instead, to avoid destabilizing stock and bond markets, the Fed begins to place heavy emphasis on matching financial markets' expectations of short-run changes in the funds rate. Chairman Greenspan's interpretation of the previous easing cycle, from 1990 through 1992, drives this emphasis. During this same easing cycle, market participants begin to anticipate inertial behavior, perhaps because they misinterpret policy during the cycle. The Fed repeatedly lowered the funds rate in 25 b.p. steps, although FOMC transcripts document that these actions were not part of an inertial strategy.

The analysis here connects most closely with the research of Coibion and Gorodnichenko (2012). Their extensive empirical evaluation of inertia includes using types of macroeconomic news to infer the parameters of a monetary policy rule. In principle, their instrumental variable approach, which differs from my approach, also avoids the need to specify correctly the functional form of the policy target. However, I show that in practice they ask too much of their data, rendering their inference uninformative.

Rudebusch (2002) inspires my term structure analysis, but his empirical approach also differs considerably from the approach here. Although Rudebusch's logic is largely correct, the statistical test he employs cannot be used to infer the presence (or absence) of inertia.

My research connects to other empirical work that that generalizes the fixed-coefficient partial adjustment model of the Fed's policy rule. Aasstveit, Cross, Furlanetto, and van Dijk (2024) and Florio (2006) introduce state-dependence in policy inertia, concluding that it depends on both the easing/tightening cycle and the identity of the Fed chair. However, the existing literature does not consider the possibility that the magnitude of inertia depends on the type of news.

Although the analysis here is entirely empirical, the results have implications for monetary theory. A long-established literature studies optimal inertia. One branch of the theory, suggested by Goodfriend (1991) and formalized by Woodford (2003), considers how partial adjustment affects the contemporaneous sensitivity of long-term rates to the funds rate through expectations of future changes in the funds rate. This branch connects inertia to the principle of Taylor (1999) that central banks should respond more than one-to-one to changes in inflation. Consistent with Taylor, I find the principle is not satisfied prior to the disinflation period.

Another branch of theory asks how parameter uncertainty affects optimal monetary policy. This literature builds off of a generic result of Brainard (1967) and informal descriptions of actual monetary policy such as Blinder (1997) and Goodhart (1999). Formal analyses in Sack (1998), Svensson (1999), and Söderström (2002) conclude that the precise nature of the parameter uncertainty determines whether partial adjustment is optimal. This literature does not consider whether it is optimal for the speed of partial adjustment to differ between output and inflation innovations. This is perhaps surprising. Orphanides (2002) emphasizes that policymakers observe inflation but do not observe the output gap, and argues that the inflation of the 1970s might have been avoided if the Fed had put less weight on its (incorrect) estimates of the output gap. This reasoning also suggests that partial adjustment may be more valuable as a response to output news than to inflation news. However, Carceller and van den End (2023) argue that uncertainty about the level of the output gap also creates uncertainty about the proper policy response to inflation shocks.

Section 1 critically reviews standard approaches to infer the magnitude of inertia in the Fed's policy rule. Section 2 proposes an alternative approach that Section 3 takes to the data. Section 4 presents evidence explaining the breakpoint at the beginning of 1994. Section 5 concludes.

1 Standard Estimation of Inertial Policy Rules

This section discusses and appraises standard methods of estimating monetary policy rules with inertia. It concludes that these methods are likely to support the existence of inertia even if the true policy rule exhibits none. In brief, policy rules studied by researchers are plausibly misspecified and estimated using noisy data. Both sources of mismeasurement induce spuriously large estimates of inertia.

Denote the policy rate by i_t and the Fed's target policy rate by i_t^*. This notation presupposes the existence of something that we can usefully characterize as a target. Models of monetary policy treat the target as a well-defined object capturing the endogenous reaction of the policy rate to information about output and inflation. One such model of Ireland (2004) allows the target rate to vary with the expectations of the output gap x_t, inflation π_t, and real output growth g_t. Formally,

$$i_t^* = c + \phi_x E_t x_{t+k_x} + \phi_\pi E_t \pi_{t+k_\pi} + \phi_g E_t g_{t+k_g} \tag{1}$$

where k_x, k_π, and k_g are forecast horizons.

Cursory examination of transcripts from FOMC meetings makes clear that functions such as (1) are simplistic. Discussions at meetings consider a wide variety of other information, such as credit conditions, asset valuations, labor markets, planned Treasury debt issuance, elections, and anticipated fiscal policy. Taylor (1993) observes that policymakers do not follow mechanically rules such as the classic Taylor specification, but that does not mean they are not following a rule. "...in my view, a policy rule need not be a mechanical formula, but here there is more disagreement among economists. A policy rule can be implemented and operated more informally by policymakers who recognize ... that operating the rule requires judgment and cannot be done by computer." (p. 198)

Standard specifications of monetary policy connect the observed policy rate to the target rate through an equation such as

$$\text{Policy Rule 1:} \qquad i_t = (1-\rho)i_t^* + \rho i_{t-1} + \epsilon_t. \tag{2}$$

The label "Rule 1" distinguishes this rule from one introduced in Section 2.1. The coefficient ρ captures any inertia on the part of the Fed. To help interpret the coefficient, consider a permanent innovation in the target at t. The funds rate impounds immediately a fraction $(1-\rho)$ of the innovation and $(1-\rho^n)$ after n periods. Given the objectives of this research, there is nothing to be gained by generalizing the first-order autoregressive form of (2) to higher orders.

The residual's role in (2) depends on the expansiveness of the target rate function. With a narrow interpretation of the target as in (1), the residual is labeled a "monetary disturbance" and acts as a catch-all for everything the Fed considers when setting the policy rate that is not included in the specified functional form of the target. With this interpretation, the monetary disturbance follows a persistent stochastic process. For example, if credit conditions are tight today, we anticipate that credit conditions will also be tight next month.

A broader view of the target narrows the interpretation of the residual. When the target includes all endogenous responses of the Fed to economic information, the residual picks up pure random discretionary policy (e.g., effectively flipping a coin). It also picks up some variations in the policy rate that occur during periods when the Fed targeted growth rates of money and credit aggregates rather than the policy rate directly. Economic conditions sometimes unexpectedly change the relation between targeted aggregate growth rates and the policy rate. With this interpretation, we can view the residual as close to white noise.

Absent additional structure, differences between these interpretations are largely semantic. The analysis that follows treats the residual of (2) as white noise, with occasional discussion of the version in which the residual is a catch-all.

1.1 An instrumental variable approach

Clarida et al. (2000), hereafter CGG, estimate monetary policy functions using instrumental variables. They follow the rule of Taylor (1993) by excluding output growth term from (1). I estimate the combination of their target-rate specification and (2) with Two Stage Least Squares (TSLS) and quarterly data. Forecast horizons for the output gap and inflation are both one quarter ahead, therefore the funds rate at quarter t is regressed on the realized output gap and inflation at quarter $t+1$. Instruments are dated $(t-1)$ and earlier because inflation and the output gap are observed with a lag.

The output gap is the log of real GDP in quarter t from the National Income and Product Accounts (NIPA) less the log of potential output from the Congressional Budget Office (CBO). Inflation is the log change in the GDP deflator (NIPA) from quarter $(t-1)$ to quarter t, multiplied by four to convert it to annual units. The Fed funds rate is the mean daily effective funds rate during the last month in the quarter.[2] The instruments are four lags of the output gap, inflation, and the Fed funds rate. Nonlinear TSLS implemented with Generalized Method of Moments (GMM) produces the parameter estimates. Standard errors are adjusted for one lag of moving-average residuals using Newey and West (1987).

Table 1 contains parameter estimates for three sample periods. The first sample begins in 1960 and ends with Volcker's chairmanship. The disinflation period is excluded, thus the second sample begins in 1983 and ends with 2008Q3, the beginning of the global financial crisis. The third sample is a subset of the second, chosen to align with the sample period used with real-time data in the next subsection. Four quarterly observations are reserved for the lagged instruments.

The table also reports the statistic developed by Stock and Yogo (2005) to test the hypothesis that the instruments are collectively weak. These statistics flash strong warning signs about the applicability of standard IV estimation. They are all close to zero, well below the critical value for rejecting the hypothesis of weak instruments at even the 25% level.[3]

[2]The literature typically uses the mean funds rate during the quarter. NIPA releases advance estimates of GD a month after quarter-end, and second estimates a month later. These estimates are part of the information set for the funds rate as of the last month of the quarter, but not for the average funds rate during the quarter. In practice, using the quarter-average funds rate reduces the precision of the estimated coefficients on the output gap and inflation.

[3]Lewis and Mertens (2025) generalize Stock and Yogo (2005) to settings with conditional heteroskedas-

That said, the objective here is to examine properties of typically estimated monetary policy rules rather than using estimation techniques robust to weak instruments. The table reports parameter estimates for the pre-Volcker period that are similar to those reported by CGG for the same period. The target rate increases in both the output gap and inflation. The point estimate of the target-rate response to inflation is statistically indistinguishable (using standard statistical inference) from one. The estimated inertial parameter implies that it takes about five quarters for the funds rate to incorporate 80% of an innovation in the target.

The two sets of estimates for the post-disinflation period are almost indistinguishable from each other. However, they are considerably different than those for the pre-Volcker period. The target rate is much more sensitive to output and inflation. The coefficient on expected inflation satisfies the principle of Taylor (1999) that central banks should respond more than one-to-one to changes in inflation. According to the estimate of ρ, the funds rate exhibits substantial inertia. It takes almost four years for the funds rate to incorporate 80% of an innovation in the target.

1.2 Real-time data with ordinary least-squares

Weak instruments are not the only concern with the TSLS methodology. Orphanides (2001) argues that policy rules estimated using real-time data differ considerably from those estimated with ex-post revised data. I therefore follow Coibion and Gorodnichenko (2012), estimating monetary policy functions using real-time data from the Federal Reserve.

Federal Reserve Board staff produce economic forecasts prior to every meeting of the FOMC. I use the term "Greenbook forecast," although the Fed now includes them in Tealbook A. Forecasts of real quarterly output growth (GNP prior to 1992Q1, then GDP) and the associated implicit price deflator are included in every Greenbook. The Federal Reserve Bank of Philadelphia maintains Greenbook datasets. The Philadelphia Fed also maintains a dataset of output gap forecasts used by Board staff in the construction of Greenbook forecasts. Output gap forecasts begin with the FOMC meeting of August 1987, the first observation of the sample period studied here.

The target rate is (1), using the contemporaneous output gap and one-quarter-ahead

ticity and autocorrelation. Their test statistics are 1.11, 0, and 4.03 respectively, well below critical values at any desirable level of significance. Thanks to the authors for making their Matlab code available.

forecasts of both inflation and real GDP growth. As with the TSLS estimates presented previously in Section 1.1, data are quarterly and the Fed funds rate is the average of the last month in the quarter. Real-time macroeconomic forecasts are taken from mid-quarter Greenbooks.

Table 2 reports estimates for a version of the target rate that excludes real output growth, and thus is comparable to the version estimated by Clarida, Galí, and Gertler (2000). Label this the "limited" version. The table also reports estimates for the full version. Ordinary least-squares (OLS) produces estimates of $\phi_x(1-\rho)$, $\phi_\pi(1-\rho)$, $\phi_g(1-\rho)$ and ρ. Standard errors for ϕ_x, ϕ_π, and ϕ_g use the delta method. All standard errors are adjusted for one lag of moving-average residuals using Newey and West (1987).

Both the limited and full estimated models accurately fit the Fed funds rate, with R^2s of 0.96 and 0.98. Yet they differ considerably in both the target rate parameters and the estimated magnitude of inertia. The full model assigns a large role to expected output growth. Consider a one standard deviation increase in expected one-quarter output growth. For this sample the standard deviation is, in annualized terms, about 1.5%. The point estimate for the full model implies an increase in the funds target of more than 2.25%. Moreover, the estimated coefficient on expected inflation with the full version is much larger than is the corresponding coefficient with the limited version. Overall, the target rate is substantially more volatile with the full than with the limited version.

Figure 1 displays time series of fitted target rates for these models, as well as for the model estimated with TSLS over the same time period. For the purposes of this paper, the most important feature of the figure is the wide disagreement across the estimated models in the fitted target rates. The fitted target rate associated with the limited model in Table 2 most closely tracks the actual funds rate, although they differ by as much as 2.6% over the sample. The other two fitted target rates vary widely around the actual funds rate, and also differ substantially from each other. The target rate for the full model in Table 2 ranges from -5% in 2001Q4 to 14% in 1989Q1. The target rate for the model estimated with TSLS is somewhat less volatile, ranging from about -3% to about 11%. They differ from each other by as much as 7% over the sample.

Tables 1, 2, and the figure illustrate two important messages for research into monetary policy rules. The first message is that the misspecification of rules used in economic models is important in practice. The beginning of this section discussed the simplistic nature of these rules. The evidence of Table 2 and Figure 1 pushes this point further, documenting that including another measure of anticipated real activity changes wildly the estimated properties of the Fed's target funds rate.

The second message is that measurement error is also important in practice. Tables 1 and 2 contain estimates for the same rule over the same time period. In Table 1, consensus expectations of the FOMC are proxied by first-stage regression projections. In Table 2, FOMC expectations are proxied by forecasts of Federal Reserve Board staff. The parameter estimates and corresponding fitted target rates differ substantially from each other because the proxies differ from each other. Neither proxy necessarily equals FOMC expectations. Transcripts of FOMC meetings show that members' expectations often diverge from historical patterns ("this time is different") as well as staff forecasts.

1.3 Estimation properties with a mis-measured target rate

The evidence above shows that mismeasurement contaminates standard regression methods of estimating policy rules. This section examines potential effects of mismeasurement on estimates of inertia. The idea first appears in Rudebusch (2002). He considers a model in which a component of monetary policy is not included in the target, but instead is represented by an autoregressive residual in (2). The framework here embeds the misspecification in the target.

Assume that we have a parameterized candidate for the Fed's target rate,

$$\hat{i}_t^{*c} = \beta x_t \tag{3}$$

where x_t is observed and β is an unknown parameter. Constant terms are ignored here. The "c" superscript indicates that this is a candidate policy function, not necessarily the true function. For the moment, assume nothing about the dynamics of x_t other than that it follows a positively autocorrelated process.

Assume we observe x_t, and thus do not need to use instrument variable techniques. To infer both the target rate function and the magnitude of inertia, we can estimate with OLS the regression

$$i_t = b_1 x_t + b_2 i_{t-1} + e_t. \tag{4}$$

Estimates of β in the candidate target rate function (3) and ρ in (2) are

$$\hat{\beta} = \frac{\hat{b}_1}{1 - \hat{b}_2}, \qquad \hat{\rho} = \hat{b}_2. \tag{5}$$

These estimates converge to the true parameters as the number of observations goes to infinity when (3) is correctly specified.

To set up the argument to follow, consider the no-inertia case of $\rho = 0$. Since the policy rate follows a persistent process, both variables on the right side of (4) are positively correlated with the variable on the left side. Yet when (3) is correctly specified, there is no additional role for the lagged policy rate since x_t is included in the regression.

Our interest is in situations when (3) is contaminated by noise or otherwise misspecified. This creates an errors-in-variables problem with the proxy for the policy target, opening the door for the lagged interest rate to help explain the current interest rate even in the absence of policy inertia. Thus the OLS estimate of b_2 is an inconsistent estimate of ρ.

A toy model with no inertia illustrates how the magnitude of noise and/or misspecification affects parameter estimates of (4). Assume that the true policy target is the sum of two variables that follow independent AR(1) processes,

$$i_t^* = x_{1,t} + x_{2,t}, \tag{6}$$

$$x_{j,t} = \delta_j x_{j,t-1} + \eta_{j,t}, \qquad \eta_{j,t}\ iid,\ E(\eta_{j,t}^2) = \sigma_j^2,\ j = 1, 2. \tag{7}$$

The Fed sets the policy rate equal to this target,

$$i_t = i_t^*. \tag{8}$$

The policy function has no inertia nor any residual.

An econometrician does not know the true target function (6). Instead, she uses the candidate function (3), where x_t is a noisy measure of one of the variables included in the true policy function.

$$x_t = x_{1,t} + \omega_t, \qquad \omega_t\ iid,\ E(\omega_t^2) = \sigma_\omega^2. \tag{9}$$

Thus the econometrician's target rate is both misspecified (missing $x_{2,t}$) and noisy (contaminated by ω_t).

In this setting, analytic expressions for infinite-sample regression coefficients of (4) are easily calculated. They are reported in the Online Appendix. Two special cases eliminate misspecification and noise respectively. When only noise is present, the OLS asymptotic estimate of inertia is

$$\rho = 0,\ \sigma_2^2 = 0 : \qquad \operatorname*{plim}_{T\to\infty} \hat{\rho} = \frac{\delta_1 \sigma_\omega^2}{\sigma_1^2 + \sigma_\omega^2}. \tag{10}$$

When only misspecification is present, the OLS asymptotic estimate of inertia is

$$\rho = 0,\ \sigma_\omega^2 = 0 : \qquad \operatorname*{plim}_{T\to\infty} \hat{\rho} = \frac{\delta_2 \mathrm{Var}(x_{2,t})}{\sigma_1^2 + \mathrm{Var}(x_{2,t})}. \tag{11}$$

Table 3 reports asymptotic estimates of inertia ρ for various choices of model parameters. The variance σ_1^2 is set to 1.0. The persistence parameters δ_1 and δ_2 are both set to 0.9. Variances of the missing component of the target rate and the contaminating noise are listed in the table. They can be interpreted as fractions of the variance of innovations to $x_{1,t}$, the random variable shared by the true target function and the mismeasured target function.

Mismeasurement of the target rate raises estimates of inertia because the lagged policy rate acts as a catch-all for missing and obscured components of the true target rate. The table reveals that mismeasurement, especially through omitting a persistent component of the true target rate, results in spuriously high estimates of inertia. When the excluded persistence component has a variance only half of the shared component, the estimate of ρ is 0.65 even in the absence of contaminating noise. The estimate of ρ exceeds 0.7 with a higher variance of the omitted component and/or noise.

It is possible to disentangle the role of inertia from persistence of misspecified components if we are willing to assume a dynamic functional form for misspecified components of the funds rate. Such an approach follows Rudebusch (2002), English, Nelson and Sack (2003), and Coibion and Gorodnichenko (2012). The next subsection describes an approach due to Coibion and Gorodnichenko (2012) that approaches the problem differently.

1.4 IV estimation using innovations

Coibion and Gorodnichenko (2012) estimate a monetary policy rule with instrumental variables, using contemporaneous and lagged shocks as instruments rather than levels of output, inflation, and policy rates. Accurate estimates of inertia require only that the shocks are strongly correlated with innovations to the true target rate. The shocks do not need to span all innovations to the target. In other words, this approach is robust to misspecification. It is, however, affected by noise in the shocks used as instruments.

I illustrate a variant of this approach using the toy model contained in the previous subsection. Rather than estimate (4) with OLS, or with instruments that include the lagged policy rate, estimate it using only contemporaneous and lagged innovations to x_t as instruments. With this approach, all variation in the lagged policy rate that is unrelated to x_t—in other words, variation created by a component of the target rate missing from x_t—drops out. This prevents the lagged rate from acting as a catch-all for misspecification. It does not solve the problem of noise in x_t.

For concreteness, since there are two explanatory variables in the regression (4), I use two instruments. They are the contemporaneous and first lag of the innovations to x_t. I also allow for inertia in the policy rate function. This function, replacing (6), is

$$i_t = (1 - \rho)i_t^* + \rho i_{t-1}. \tag{12}$$

As with (6), there is no residual term.

The combination of (7), (8), and (12) implies that the first-stage projections are[4]

$$E(x_t|\eta_{1,t} + \omega_t, \eta_{1,t-1} + \omega_{t-1}) = \eta_{1,t} + \omega_t + \delta_1 \frac{\sigma_1^2}{\sigma_1^2 + \sigma_\omega^2}(\eta_{1,t-1} + \omega_{t-1}), \tag{13}$$

$$E(i_{t-1}|\eta_{1,t} + \omega_t, \eta_{1,t-1} + \omega_{t-1}) = (1 - \rho)\frac{\sigma_1^2}{\sigma_1^2 + \sigma_\omega^2}(\eta_{1,t-1} + \omega_{t-1}). \tag{14}$$

The resulting asymptotic IV estimate of inertia is

$$\operatorname*{plim}_{T\to\infty} \hat{\rho}^{IV} = \rho + \frac{\delta_1 \sigma_\omega^2}{\sigma_1^2 + \sigma_\omega^2}.$$

In the absence of noise, this approach produces a consistent estimate of inertia even when the target rate function is misspecified. Noise affects this IV estimate in the same way that it affects the OLS estimate (10).

[4]For tractability, I assume that the econometrician observes separately $x_{1,t}$ and ω_t, but does not recognize that ω_t is noise. This assumption implies that from the econometrician's perspective, the innovation in x_t is the sum of the innovation to $x_{1,t}$ and ω_t.

Coibion and Gorodnichenko (2012) use similar logic to motivate estimating the combination of the target rate function (1) and the inertial policy rule (2). The explanatory variables are real-time versions of the expectations from Greenbooks. Coibion and Gorodnichenko (2012) want to identify the parameters from structural shocks, rather than simply using innovations in Greenbook expectations. Thus they use as instruments lags zero through two of innovations to five plausibly structural variables. They are permanent technology shocks, purified innovations to the Solow residual, news shocks, oil supply shocks, and tax shocks.

The IV estimates they report support the conclusion that the policy function exhibits substantial inertia, with estimates of ρ around 0.8 in quarterly data. However, the authors do not report first-stage F statistics to help evaluate whether their instruments are weak. Instead, they use Monte Carlo simulations of a dynamic New Keynesian model to show that the structural shocks in New Keynesian model can be used as instruments to identify the model's monetary policy rule.

Using their data, I calculate the Stock-Yogo statistic, as well as first-stage F statistics for their IV regression.[5] The instruments are not just weak; they are, for the most part, irrelevant. The Stock-Yogo statistic is only 0.25. Moreover, F-statistics cannot reject the hypothesis at the 20% level that the instruments collectively have *no* explanatory power for any of expected inflation, the expected output gap, or the lagged Fed funds rate. Only the F-statistic for real output growth (2.16) is statistically different from zero at the 5% level.

Their regression is uninformative because the instruments do not satisfy the relevance requirement for instrumental variables. Yet the intuition that innovations can help identify inertia is valuable. I apply it extensively in Section 2, but first examine an indirect method of inferring inertia.

1.5 A term structure approach

Rudebusch (2002) argues that the magnitude of inertia implied by the estimates reported in Tables 1 and 2 should be detectable in term structure dynamics. When the Fed changes its target rate, investors anticipate that the policy rate will adjust slowly. Expectations-hypothesis logic implies that the anticipated future changes will immediately change prices

[5]Details are in the Online Appendix. Thanks to the authors for posting their data on the journal's website.

of futures contracts on Eurodollar rates up to a year ahead. These changes in futures prices should then predict future changes in the policy rate.

Rudebusch proposes to test for substantial inertia using regressions such as

$$i_{t+3} - i_{t+2} = b_0 + b_1 \left(ED(t+3)_t - ED(t+2)_t \right) + e_{t+2,t+3} \tag{15}$$

where $ED(t+j)_t$ is the rate on a Eurodollar futures contract at t that expires in j quarters. Using quarterly data from 1988Q1 through 2000Q1, he finds that such regressions have R^2s close to zero, and claims that this evidence is inconsistent with high inertia.

However, connecting R^2s of regressions such as (15) to inertia is not straightforward. The logic works best if we assume that the target funds rate follows a martingale. Then, in the absence of inertia, changes in the funds are are unforecastable. The slope of the term structure varies over time only due to time-varying risk premia or other pricing effects unrelated to the funds rate. This is Rudebusch's framework. He generates data from a simple New Keynesian model, concluding that without inertia, predictable variations in the target rate implied by the model are too small to generate much variation in conditional expectations of future changes in the policy rate.

The problem with this stark model is that it is difficult to reconcile the model with the observed variation in the slope of the term structure. Figure 2 displays two measures of the slope of the short end of the term structure from January 1969 through August 2008. The top panel plots a one-year Treasury bond yield less the Fed funds rate and the bottom panel plots the one-year yield less a three-month Treasury bill yield. Both measures are highly volatile, even outside the disinflationary period from mid-1979 through 1982. Excluding the disinflationary period, the standard deviations of the top and bottom slope measures are about 0.9 percent and 0.5 percent respectively. Thus conditional $\mathcal{Q}$-expectations of future changes in short rates vary materially over time. Since conditional risk premia have little effect on short-maturity bond yields, it is a stretch to attribute the bulk of the variation documented in Figure 2 to sources other than ($\mathcal{P}$-measure) expected future Fed funds rates.

Using long time series, Campbell and Shiller (1991) find that the shape of the term structure predicts future changes in short rates in "...roughly the way implied by the expectations theory." (p. 510). Therefore the low R^2s in Rudebusch (2002) might be driven by sampling error in the short time series he considers. More broadly, a better way determine the amount of predictable variation in short rates over, say, the next year is to look directly at the variation in the slope of the short end of the yield curve.

That said, both inertia and predictable variations in the target rate drive the slope of the short end of the term structure. As noted above, Rudebusch relies on a New Keynesian model to argue that target rates are close to martingales. But empirically, fitted target rates are highly volatile and mean-reverting, as shown in Figure 1. The disinflation period serves as an extreme example. Figure 2 shows that the slope of the short end of the term structure varies widely across this period. Yet 'gradualist' is not a term typically applied to monetary policy during the disinflation. Instead, investors predicted future changes in the target rate.

In sum, the test applied by Rudebusch (2002) does not help pin down the magnitude of inertia. The next section describes how I apply his term structure intuition, using innovations to draw inferences about inertia in the Fed's policy rule.

2 Estimation Using News

This section describes estimation procedures that rely on news about expected future real output growth and inflation. Section 2.1 shows how to draw inferences about inertia from dynamic responses of the policy rate to news. Section 2.2 interprets the contemporaneous response of yields to news. Section 2.3 describes how to take these estimation procedures to data.

2.1 Using news to study Fed funds dynamics

I consider a form of the policy rule that generalizes inertia, allowing different speeds of adjustment to news about output and inflation. This generalization is motivated by the empirical evidence that follows, rather than any theory of monetary policy. To introduce the ideas, consider the policy rate function

$$\text{Policy Rule 2:} \qquad i_t = c + \phi_g \Psi_{g,t} + \phi_\pi \Psi_{\pi,t} + \epsilon_t, \tag{16}$$

where $\Psi_{g,t}$ and $\Psi_{\pi,t}$ are weighted averages of current and past expected output growth and expected inflation, defined by

$$\Psi_{g,t} \equiv (1-\rho_g)E_t\left(g_{t+k_g}\right) + \rho_g \Psi_{g,t-1}, \qquad \Psi_{\pi,t} \equiv (1-\rho_\pi)E_t\left(\pi_{t+k_\pi}\right) + \rho_g \Psi_{\pi,t-1}. \tag{17}$$

Parameters k_g and k_π are fixed forecast horizons. Measures of policy inertia for output growth and inflation are ρ_g and ρ_π respectively. All other influences on the policy rate are combined in ϵ_t.

Unlike the policy rule (1) studied in the previous section, (16) does not explicitly include the output gap. Including it adds nothing here. Section 3 takes policy rule (16) to the data by projecting it on observed news about expected real output growth and inflation. In practice, for short forecast horizons (one or two quarters) news about k-ahead output growth differs little from news about the k-ahead output gap. Thus their effects on the policy rate cannot be disentangled in the empirical work that follows.

To derive the model-implied properties of this projection on news, begin by solving the recursions (17). Assuming that the output growth and inflation are bounded processes, the solutions are

$$\Psi_{g,t} = (1-\rho_g)\sum_{i=0}^{\infty}\rho_g^i E_{t-i}\left(g_{t-i+k_g}\right), \qquad \Psi_{\pi,t} = (1-\rho_\pi)\sum_{i=0}^{\infty}\rho_\pi^i E_{t-i}\left(\pi_{t-i+k_\pi}\right). \tag{18}$$

Define news as one-period innovations in the conditional expectations included in (17). The innovations are

$$\eta_{g,t} \equiv \left(E_t - E_{t-1}\right)\left(g_{t+k_g}\right), \qquad \eta_{\pi,t} \equiv \left(E_t - E_{t-1}\right)\left(\pi_{t+k_\pi}\right). \tag{19}$$

The policy rate depends on both current and lagged news. Lagged news works through two channels. First, expected output growth and inflation follow persistent processes, thus news today affects expected future output growth and inflation. Second, policy inertia creates a lagged response to news. Keeping track of these two channels requires some calculations.

To simplify notation, denote the output and inflation news for the K periods t through $t-(K-1)$ as

$$\mathcal{N}_{t,K} \equiv \{\eta_{g,t}, \ldots, \eta_{g,t-(K-1)}, \eta_{\pi,t}, \ldots, \eta_{\pi,t-(K-1)}\}.$$

Assume a linear relation between news and future conditional expectations, allowing news about (say) output growth to contain information about both future output growth and future inflation. The expression linking expected output growth and news is

$$E\left(E_t(g_{t+k_g})\middle|\mathcal{N}_{t,K},\Omega_{t-K}\right) = \sum_{k=0}^{K-1}\left(\delta_{g,g,k}\eta_{g,t-k} + \delta_{g,\pi,k}\eta_{\pi,t-k}\right) + E(g_{t+k_g}|\Omega_{t-K}), \tag{20}$$

where Ω_{t-K} is a set of information known at $t-K$. The expression for inflation expectations is symmetric. The parameter $\delta_{g,m,k}$ measures the sensitivity of expected output growth to lag k of m-type news, where m is either output growth or inflation.

Armed with (20) and its counterpart for expected inflation, condition (16) on contemporaneous and lagged news. After some algebra using (18), the result is

$$\begin{aligned} E\left(i_t|\mathcal{N}_{t,K},\Omega_{t-K}\right) = &\sum_{k=0}^{K-1}\left(\eta_{g,t-k}\sum_{j=0}^{k}\left(\phi_g(1-\rho_g)\rho_g^j\delta_{g,g,k-j} + \phi_\pi(1-\rho_\pi)\rho_\pi^j\delta_{\pi,g,k-j}\right)\right.\\ &\left.+\,\eta_{\pi,t-k}\sum_{j=0}^{k}\left(\phi_\pi(1-\rho_\pi)\rho_\pi^j\delta_{\pi,\pi,k-j} + \phi_g(1-\rho_g)\rho_g^j\delta_{g,\pi,k-j}\right)\right)\\ &+ E(c+\phi_g\Psi_{g,t}+\phi_\pi\Psi_{\pi,t}|\Omega_{t-K}) + E(\epsilon_t|\mathcal{N}_{t,K},\Omega_{t-K}). \end{aligned} \tag{21}$$

The conditional expectation (21) shows how contemporaneous and lagged news about output growth and inflation affects the policy rate. The parameterized components on the right can be identified only by assuming that the news has no influence on the other determinants of the policy rate as summarized by ϵ_t. Thus in practice, as noted at the beginning of this section, the parameterized components will pick up all variation in the policy rate that is tied to news about expected output growth or expected inflation. For example, consider a policy rule that depends on the output gap, expected future output growth, and asset prices. To the extent that these all load on news about expected future output growth, the empirical analysis that follows cannot distinguish among them.

2.2 Using news to interpret the term structure

This subsection describes how to apply the term structure intuition of Rudebusch (2002) to innovations. News that affects the contemporaneous policy rate also affects expected future policy rates. I illustrate this joint response using the toy model with target rate (6), target rate dynamics (7), and policy rule with inertia (12). The time-t innovation in the k-ahead expected policy rate is

$$(E_t - E_{t-1})\, i_{t+k} = (1-\rho) \sum_{j=0}^{k} \rho^{k-j} \left(\delta_1^j \eta_{1,t} + \delta_2^j \eta_{2,t}\right). \tag{22}$$

With sufficiently positive inertia, these innovations increase with the horizon k before declining. For concreteness, consider a innovation $\eta_{1,t}$ equal to $(1-\rho)^{-1}$ percent. This innovation raises the contemporaneous policy rate by one percentage point. Figure 3 shows the corresponding innovations in expected future policy rates for two values of ρ. The AR(1) coefficient δ_1 is set to 0.9. With no inertia, expected future policy rates respond less than one-for-one to the current policy rate, reversing the current innovation. More broadly, when $\delta_1 + \rho < 1$, the immediate increase in the policy rate is monotonically partially reversed over time. With an inertial parameter $\rho = 0.8$, similar to those reported in Table 1 for quarterly data, expected future policy rates increase through five periods ahead before eventually reversing.

Assume that the weak form of the expectations hypothesis holds, such that the yield on an n-period bond is, aside from a constant, the expected average policy rate over the life of the bond,

$$y_t^{(n)} = c_n + \frac{1}{n} \sum_{k=0}^{n-1} E_t\left(i_{t+k}\right). \tag{23}$$

Denote innovations from $t-1$ to t with tildes, as in

$$\tilde{y}_t^{(n)} \equiv y_t^{(n)} - E_{t-1}\left(y_t^{(n)}\right). \tag{24}$$

From (22) this yield innovation is

$$\tilde{y}_t^{(n)} = L(n; \delta_1, \rho)\omega_{1,t} + L(n; \delta_2, \rho)\omega_{2,t}, \tag{25}$$

$$L(n; \delta, \rho) \equiv \frac{1}{n}\left(\frac{1-\delta^n}{1-\delta} - \rho \frac{\delta^n - \rho^n}{\delta - \rho}\right). \tag{26}$$

With $\delta = 0.9$ and $\rho = 0.8$, the parameters underlying one of the curves in Figure 3, the function (26) is increasing in maturity for $n < 11$. The function is monotonically declining in maturity for $\delta < 1$ and $\rho = 0$.

An informal test of moderate to high persistence combines the weak form of the expectations hypothesis with the intuition of (23). With sufficiently high persistence, an short-maturity (say, one year) Treasury bond yield will respond more to target-rate news than will the contemporaneous policy rate. Thus the informal test is whether the contemporaneous responses of the three-month and one-year Treasury bond yields to news about expected output growth and inflation exceed the contemporaneous responses of the policy rate.

2.3 Implementation

This subsection describes the data, the estimation procedures, and the sample periods.

2.3.1 Data

Measure time by regularly-scheduled FOMC meetings. Denote the calendar quarter of FOMC meeting t as q_t, and the k-ahead quarter as $q_t + k$. Use the notation E^G to refer to a Greenbook forecast. Define Greenbook forecast innovations of real output growth and inflation as

$$\eta^G_{g,t,k} \equiv \left(E^G_t - E^G_{t-1}\right) g_{q_t+k}, \qquad \eta^G_{\pi,t,k} \equiv \left(E^G_t - E^G_{t-1}\right) \pi_{q_t+k}. \tag{27}$$

The G superscripts and k subscripts distinguish these observed innovations from the theoretical innovations defined by (19). Each date has a term structure of forecast innovations. The maximum forecast horizon varies over time. Beginning December 1968, all FOMC meetings have forecast innovations for at least zero quarters ahead (also known as a nowcast) and one quarter ahead. Greenbook reports output growth and inflation forecasts as quarterly growth rates compounded to an annual horizon.

I measure the Fed funds rate at t as the median daily effective rate across the three days immediately after FOMC meeting t. This timing treats a change in the funds rate immediately after meeting t as contemporaneous with Greenbook innovations for meeting t. Prior to February 1994 the Fed did not immediately announce the outcome of any FOMC meeting. The three-day window allows actions taken by the open market desk in line with the FOMC's directive at t to be incorporated in the funds market. Similarly, I measure the three-month and one-year Treasury yields at t as median daily rates during the three days immediately after the FOMC meeting. Daily Fed funds rates and three-month Treasury bill yields are from the Federal Reserve Bank of St. Louis's FRED database. Daily one-year zero-coupon Treasury yields are produced by the Federal Reserve Board using the methodology of Gürkaynak, Sack, and Wright (2007).

2.3.2 Regressions

Regressions allow us to interpret the conditional expectation (21). Although the left side of (21) is the level of the policy rate, I work with changes in the Fed funds rate to improve statistical efficiency. (The funds rate follows a highly persistent process.) Subtracting a lagged funds rate from both sides does not alter the interpretation of (21) as long as the lag is in the information set Ω_{t-K}.

Forecast horizons k_g and k_π need to be chosen before grappling with the conditional expectation (21). I regress meeting t's change in the Fed funds rate on contemporaneous Greenbook output growth and inflation forecast innovations at various forecast horizons. The chosen forecast horizons k_g and k_π are those horizons for which the news is most closely associated with contemporaneous changes in the funds rate. This choice determines the time series of news about expected output growth and news about expected inflation.

Since the data are observed at discrete FOMC meeting dates while real time is continuous, it helps to think about the notion of 'contemporaneous.' Information arrives between meetings $t-1$ and t. The information affects forecasts of inflation and output growth at various forecast horizons. The Fed changes its target rate in response to these forecast revisions. The Fed then changes the funds rate, perhaps between meetings $t-1$ and t, or immediately after meeting t. For the purposes of the empirical work here, any change made more than three days after meeting $t-1$ through three days after meeting t is 'contemporaneous' with the news.

The next regression investigates the dynamic response of the funds rate to the macroeconomic news. It projects changes in the funds rate on contemporaneous and two lags of Greenbook forecast innovations, putting no parametric restrictions on the coefficients. Meetings occurred roughly every month through 1980, and later every six weeks. Therefore the estimated coefficients describe the dynamic response of the funds rate to macroeconomic news over two-month to three-month horizons.

The conditional expectation (21) depends on the persistence of expected output growth and expected inflation. I estimate persistence with regressions that take the form of (20). I then put these pieces together by estimating (21) with nonlinear GMM.

Finally, I examine the behavior of the short end of the term structure by comparing the responses of the funds rate, the three-month Treasury bill yield, and one-year Treasury bond yield to news about expected output growth and inflation. The regressions provide information about $\mathcal{Q}$-measure expected dynamic responses of the funds rate to news.

2.3.3 Sample periods

The data sample ranges from the FOMC meeting in December 1968 through the meeting in August 2008, just prior to the bankruptcy filing of Lehman Brothers. I exclude the monetarist experiment/disinflation period of September 1979 through December 1982. The disinflation period is too short to draw reliable conclusions from the empirical approach taken here. Yet the data during this period are so volatile that combining the data with either an earlier or later sample obscures the data-generating process of the other sample.

Regressions are estimated for three time periods. The first uses data through the FOMC meeting in September 1979. The second spans the meeting in February 1983 through the meeting in December 1993. The introduction notes the effort by Chairman Greenspan at the meeting of February 1994 to persuade the other members of the FOMC committee to raise the funds rate gradually. Section 4 takes a closer look at the events surrounding this breakpoint. The third begins at the meeting in February 1994 and ends at the meeting in August 2008.

3 Empirical Evidence

Equation (21) uses the combination of the monetary policy rule and the dynamics of expected output growth and inflation to describe how the policy rate responds to forecast revisions. This section takes that equation to the data in a series of steps. Section 3.1 chooses the forecast horizons of output growth and inflation that enter into the policy rule for the Fed funds rate. Section 3.2 estimates the response of the funds rate to the forecast revisions without imposing any restrictions associated with the policy rule. Section 3.3 estimates the dynamics of the macroeconomic forecasts. Section 3.4 estimates parameters of the policy rule, including inertia. Finally, Section 3.5 examines the response of the short end of the term structure to the forecast revisions.

3.1 Forecast horizons

This subsection considers how to summarize the information in the term structures of Greenbook forecast innovations. The existing empirical literature uses various summary statistics. For example, Clarida, Galí, and Gertler (2000) uses one-quarter-ahead forecasts for both the output gap and inflation, while Coibion and Gorodnichenko (2012) uses the contemporaneous output gap and the average of one-quarter-ahead and two-quarter-ahead inflation forecasts. My summary of the Greenbook data uses nowcast innovations as news about the present and one-quarter-ahead innovations as news about the future. The choice to exclude longer-horizon forecast innovations maximizes the number of observations with non-missing data. I discuss the use of longer-horizon forecast innovations later in this subsection.

I regress changes in the funds rate on contemporaneous forecast innovations for output growth and inflation, including both nowcast and one-quarter-ahead innovations,

$$i_t - i_{t-2} = b_0 + \sum_{k=0}^{1} b_{g,k}\eta^G_{g,t,k} + \sum_{k=0}^{1} b_{\pi,k}\eta^G_{\pi,t,k} + e_t. \tag{28}$$

The regression coefficients are b_0, $b_{g,k}$, and $b_{\pi,k}$ for $k = 0, 1$. For each sample I reserve the first two observations for lags that are used in regressions that follow.

Note the left side of (28) measures the change from $t-2$ to t, although the innovations on the right are measured from $t-1$ to t. The difference adjusts for the timing mismatch between Greenbook dates (a few days before a meeting) and the funds rate (just after a meeting). Consider macroeconomic information that arrives just before or during meeting $t-1$. This information is not in the Greenbook forecast for $t-1$, thus it first affects Greenbook forecasts for meeting t. The Fed knows the information at the time it sets the policy rate at $t-1$. Therefore the right side of (28) covaries with i_{t-1} as well as i_t. Owing to the overlapping observations, asymptotic standard errors are adjusted using Newey and West (1987) with one lag of moving average residuals. Using three lags produces almost identical standard errors.

Equation (28) does not imply that the Fed changes the funds rate only at meeting dates. Until the mid-1990s the Fed routinely changed the rate between meetings. For example, macroeconomic information arriving between meetings $t-1$ and t might cause the Fed to immediately change the funds rate. The data used with (28) cannot distinguish between intermeeting changes in the policy and changes that occur at meetings.

The results, in Table 4, reveal that the Fed's setting of the funds rate has become more forward-looking over time. First consider output news. Only the nowcast innovation matters in the early sample. The nowcast and one-quarter-ahead innovations are roughly equally important in the middle sample. By the ending sample, only the one-quarter-ahead forecast innovation matters. A similar trend applies to inflation news. The nowcast and one-quarter-ahead innovations are equally relevant in the early sample. In the middle sample and late samples, the one-quarter-ahead forecast revision plays the dominant role.

The importance of forward-looking forecasts in the middle and late samples suggests that longer-horizon innovations may help explain variations in the funds rate. Indirect evidence supporting this conclusion comes from the time-varying composition of Greenbooks. Greenbooks in the early sample do not include as many long-horizon forecasts as Greenbooks in the middle and late samples. For example, the early sample has 128 observations with non-missing one-quarter-ahead forecast innovations (contemporaneous and two lags). The number of valid observations drops to 114 and 80 when including two-quarter-ahead and three-quarter-ahead innovations respectively. The middle and late samples have no missing observations of two-quarter-ahead and three-quarter-ahead forecast innovations.

That said, results in the Online Appendix do not find any incremental role for longer-horizon forecasts. The appendix considers an expanded version of (28) that add two-quarter-ahead forecast innovations on the right side. The additional estimated coefficients, produced for the middle and late samples, are statistically indistinguishable from zero. All of the t-statistics on the relevant coefficients are less than one in absolute value.

The evidence here allows us to compress the information in Greenbook forecast revisions. One variable summarizes relevant news about output growth and another summarizes news about inflation. The variable definitions vary across the three samples, in line with the increasingly forward-looking nature of the policy rate over time.

For the early sample, output growth news is the nowcast innovation, while inflation news is the mean of the innovations to the inflation nowcast and the one-quarter-ahead inflation forecast. For the middle sample, output news is the average of the innovations to the output growth nowcast and the one-quarter-ahead output growth forecast. Inflation news is the innovation to the one-quarter-ahead inflation forecast. For the late period, both output and inflation news are innovations to their corresponding one-quarter-ahead forecasts. The shorthand notation is

$$\hat{\eta}_{g,t} \equiv \begin{cases} \eta^G_{g,t,0}, & \text{early sample;} \\ \frac{1}{2}\left(\eta^G_{g,t,0} + \eta^G_{g,t,1}\right), & \text{middle sample;} \\ \eta^G_{g,t,1}, & \text{late sample,} \end{cases} \tag{29}$$

$$\hat{\eta}_{\pi,t} \equiv \begin{cases} \frac{1}{2}\left(\eta^G_{\pi,t,0} + \eta^G_{\pi,t,1}\right), & \text{early sample;} \\ \eta^G_{\pi,t,1}, & \text{middle and late samples.} \end{cases} \tag{30}$$

Section 3.5 uses similar shorthand notation for conditional expectations of output growth and inflation that I define here,

$$\hat{E}_t(g) \equiv \begin{cases} E^G_t(g_t), & \text{early sample;} \\ \frac{1}{2}\left(E^G_t(g_t) + E^G_t(g_{t+1})\right), & \text{middle sample;} \\ E^G_t(g_{t+1}), & \text{late sample,} \end{cases} \tag{31}$$

$$\hat{E}_t(\pi) \equiv \begin{cases} \frac{1}{2}\left(E^G_t(\pi_t) + E^G_t(\pi_{t+1})\right), & \text{early sample;} \\ E^G_t(\pi_{t+1}), & \text{middle and late samples.} \end{cases} \tag{32}$$

3.2 Fed fund rate dynamics

This subsection examines how the Fed adjusts the funds rate over the course of a few FOMC meetings in response to output and inflation news. No restrictions associated with the policy rule are imposed. To briefly summarize, in all three periods the funds rate continues to change in the same direction following forecast revisions in output growth. By contrast, prior to 1994 the contemporaneous response of the funds rate to forecast revisions in inflation is quickly partially reversed. Only in the 1994 through 2008 period does the funds rate continue to change in the same direction following inflation news.

I regress the change in the funds rate on lags zero through two of forecast innovations. Using the shorthand notation (29) and (30), the regression is

$$i_t - i_{t-4} = b_0 + \sum_{j=0}^{2} b_{g,j}\hat{\eta}_{g,t-j} + \sum_{j=0}^{2} b_{\pi,j}\hat{\eta}_{\pi,t-j} + e_{i,t}. \tag{33}$$

The change on the left side from $t-4$ to t ensures that all of the forecast innovations on the right side covary only with the ending rate i_t rather than the initial rate i_{t-4}. For each sample I reserve the first two observations for lags.

The coefficients $b_{g,0}$ and $b_{\pi,0}$ capture the contemporaneous relation between forecast innovations and the funds rate. If the Fed maintains the contemporaneous response through the next two FOMC meetings, then the coefficients on the first lags $b_{g,1}$ and $b_{\pi,1}$, as well as those on the second lags $b_{g,2}$ and $b_{\pi,2}$, will equal their contemporaneous counterparts. If instead the Fed continues to change rates in the same direction for the next two meetings, then the coefficients on the lags will exceed the contemporaneous coefficients.

Panel A of Table 5 reports parameter estimates. The statistical tests in Panel A evaluate the null hypotheses that the individual coefficients equal zero. In other words, they test whether we reject the hypothesis that the Fed's response to a forecast innovation dies off completely within a meeting or two. Panel B of the table reports tests of the hypothesis that the coefficient on lag j equals the coefficient on lag $j+1$. These tests evaluate whether the Fed tends to change rates in the same direction subsequent to a forecast innovation. Asymptotic standard errors are adjusted using Newey and West (1987) with three lags of moving average residuals.

The results in Panel A reveal that across all three samples, the estimated responsiveness of the funds rate to output news increases over time. The estimated coefficient on twice-lagged output news is between 1.5 and 1.7 times the estimated coefficient on contemporaneous output news. However, there is so much uncertainty in these estimates that the hypothesis of coefficient equality cannot be rejected. In Panel B, the largest t-statistic of this hypothesis is about one.

The point estimates tell a substantially different story about the response of the funds rate to inflation news. Until the mid-1990s, the estimated responsiveness of the funds rate to inflation news drops substantially during the next two FOMC meetings. The estimates are so small that for three of the four coefficients, the hypothesis the coefficients equal zero cannot be rejected at even the 10% level. By contrast, during the 1994 to 2008 sample, the estimated coefficient on the second inflation lag is about 1.4 times the estimate on contemporaneous inflation news. All of the coefficients are statistically reliably different from zero. However, as with the coefficients on output news, Panel B shows that there is so much uncertainty that the hypothesis of coefficient equality cannot be rejected.

3.3 Persistence of output growth and inflation

This subsection estimates the coefficients of (20) and its counterpart for inflation expectations. The regressions characterize the persistence of expected output growth and inflation. As with the regressions that link forecast revisions to the Fed funds rate, these regressions modify (20) by explaining changes rather than levels. Using the shorthand notation (29), (30), (31), and (32), the estimated versions are

$$\hat{E}_t(g) - \hat{E}_{t-3}(g) = \delta_{g,0} + \sum_{j=0}^{2} \delta_{g,g,j}\hat{\eta}_{g,t-j} + \sum_{j=0}^{2} \delta_{g,\pi,j}\hat{\eta}_{\pi,t-j} + e_{g,t}, \tag{34}$$

$$\hat{E}_t(\pi) - \hat{E}_{t-3}(\pi) = \delta_{g,0} + \sum_{j=0}^{2} \delta_{\pi,\pi,j}\hat{\eta}_{\pi,t-j} + \sum_{j=0}^{2} \delta_{\pi,g,j}\hat{\eta}_{g,t-j} + e_{\pi,t}. \tag{35}$$

The results in Table 6 support two broad conclusions. First, output growth forecasts are only modestly persistent. Across all three periods, between 0.4 and 0.6 of a meeting-t innovation persists to meeting $t+2$. Second, inflation forecasts are highly persistent only in the pre-disinflation period. Pre-disinflation, about 0.85 of a meeting-t innovation persists to meeting $t+2$. This coefficient drops to less than 0.4 for the 1983 through 1993 sample and drops further to less than 0.25 for 1994 through 2008.

The combination of these results and those of Table 5 point to a sharp tension concerning inertia in the policy rule. The low persistence of expected output growth, combined with the evidence in Table 5 that the funds rate continues to move in the same direction as the contemporaneous change, strongly suggests a role for inertia in the policy rule in all three periods. Yet the high persistence of expected inflation in the pre-disinflationary period, combined with quick reversal of the funds rate in response to inflation news (again, documented in Table 5) is difficult to reconcile with inertia in the policy rule. In the post-disinflationary periods the tension is not as stark, but the next subsection documents that it holds in those samples as well.

3.4 Estimates of the policy rule

This subsection estimates inertia in the monetary policy rule by imposing restrictions from the policy rule on the regression (33). The restricted version of the regression is

$$\begin{aligned} i_t - i_{t-4} =& b_0 + \sum_{k=0}^{2} \left(\hat{\eta}_{g,t-k} \sum_{j=0}^{k} \left(\phi_g^* \rho_g^j \delta_{g,g,k-j} + \phi_\pi^* \rho_\pi^j \delta_{\pi,g,k-j} \right) \right. \\ & \left. + \hat{\eta}_{\pi,t-k} \sum_{j=0}^{k} \left(\phi_\pi^* \rho_\pi^j \delta_{\pi,\pi,k-j} + \phi_g^* \rho_g^j \delta_{g,\pi,k-j} \right) \right) + e_{i,t}, \end{aligned} \tag{36}$$

$$\phi_g^* \equiv \phi_g(1-\rho_g), \qquad \phi_\pi^* \equiv \phi_\pi(1-\rho_\pi).$$

I jointly estimate (36) and the forecasts' persistence (34) and (35) with GMM. The moment vector combines the usual moments of the regressions

$$m_t = \text{vec}\left(\begin{pmatrix} e_{g,t} & e_{\pi,t} & e_{i,t} \end{pmatrix}' \begin{pmatrix} 1 & \hat{\eta}_{g,t} & \hat{\eta}_{g,t-1} & \hat{\eta}_{g,t-2} & \hat{\eta}_{\pi,t} & \hat{\eta}_{\pi,t-1} & \hat{\eta}_{\pi,t-2} \end{pmatrix} \right). \tag{37}$$

There are 21 moments and 19 parameters. Five parameters characterize the policy equation (36); a constant, the sensitivities of the funds rate to output growth news and inflation news, and the inertia associated with both types of news. I report estimates of ϕ_g^* and ϕ_π^* rather than ϕ_g and ϕ_π because the former are more reliably estimated than the latter. Seven parameters characterize both of the forecasts' persistence regressions (34) and (35). Estimation details are reported in the Online Appendix.

Table 7 reports parameter estimates and J-statistics associated with the overidentifying restrictions. Panel A restricts $\rho_g = \rho_\pi$ and Panel B allows the two estimates of inertia to differ. Although the primary focus here is on inertia, a few comments on the sensitivity of the funds rate to inflation are in order. The cumulative response of the funds rate to news about inflation is ϕ_π, or equivalently $\phi_\pi^*/(1-\rho)$. In Panel A, the point estimate of the cumulative response is less than one during the pre-disinflationary period and greater than one in the other two periods. However, the standard errors on the response to inflation are particularly large—so large that the hypothesis the response equals zero cannot be rejected at the 5% level in either of the latter two periods. In Panel B, the standard errors on the response to inflation are even larger than they are in Panel A.

Readers can interpret the results concerning inertia in either one of two ways depending how strongly the reader is committed to the idea that there is a single coefficient of inertia. If we adopt that view that there is a single coefficient of inertia, the relevant estimates are in Panel A. In brief, inertia is neither economically nor statistically significant prior to 1994. The earlier-period point estimates of 0.51 and 0.56 imply that about half of the funds response occurs contemporaneously, and more than 80% occurs within the next two FOMC meetings. Neither the pre-disinflation estimate nor the 1983–1993 estimate is statistically different from zero at the 5% level. By contrast, the estimate for 1994 through 2008 of 0.79 implies that only 21% of the response occurs contemporaneously, and only half occurs within the next two FOMC meetings. The estimate differs from zero at the 1% level.

Alternatively, we can adopt the view that there are different coefficients of inertia for output growth and inflation. The conclusions drawn from Panel B markedly differ from those based on Panel A. In all three periods, the Fed responds to output growth news with inertia. The three point estimates are all statistically different from zero at the 10% level, although only the pre-disinflation point estimate differs from zero at the 5% level. The point estimate for 1994 to 2008 is close to one, implying extremely slow adjustment to innovations in the target rate. By contrast, any inertial response to inflation news is economically and statistically insignificant. This conclusion holds for all three periods.

There is no evidence in Table 7 that clearly favors one of these two interpretations. From a classical inference perspective, the hypothesis of a single inertial coefficient cannot be rejected in favor of the hypothesis of separate inertial coefficients for output growth and inflation. Panel B reports tests of this hypothesis for the 1983–1993 and 1994–2008 periods. The t-statistics are both less than 1/2. The same test cannot be applied to the pre-disinflation period because the estimate of inflation inertia is zero, on the boundary of the parameter space. For this period we can look to the J-statistic in Panel A. This test cannot reject the three overidentifying restrictions.

3.5 Term structure comovement

This subsection studies how short-term Treasury yields respond contemporaneously to Greenbook forecast innovations. The results shed light on whether investors anticipate substantial inertia in the policy rule. It is worth emphasizing that these contemporaneous responses tell us only investors' beliefs about the Fed's policy rule, not the policy rule itself. This distinction plays a prominent role in Section 4.

Changes in Fed funds rates, three-month Treasury bill yields, and one-year Treasury zero-coupon bond yields are regressed on output growth news and inflation news:

$$z_t - z_{t-2} = b_0 + b_1 \hat{\eta}_{g,t} + b_2 \hat{\eta}_{\pi,t} + e_t, \qquad z_t \in \{i_t,\ y_t^{3m},\ y_t^{1yr}\}. \tag{38}$$

The coefficients of the Treasury yield regressions are the response to the news of average $\mathcal{Q}$-expected short rates over the life of the security. Therefore differences between coefficients of Treasury yield regressions and coefficients of the Fed funds regression tell us whether investors expect (under $\mathcal{Q}$) the contemporaneous change in the funds rate to be followed by a change in the same direction, or instead to be partially reversed during the life of the security.

Table 8 contains estimation results. The point estimates support two conclusions. First, investors understand inertia is higher in the post-1993 period. Second, investors understand inertia is higher for output news than inflation news. Panel C shows that for the 1994—2008 period, both the three-month Treasury yield and the one-year Treasury yield respond more to output news and inflation news than does the funds rate. Panel D tests the hypothesis that the responses of the Treasury yields equal the responses of the funds rate. The hypothesis is rejected for output news (10% level for the three-month yield and 5% level for the one-year yield) but not inflation news.

There is considerably less evidence for inertia in the earlier periods. Panel A shows that in the pre-disinflation period, the Treasury yields and the funds rate respond similarly to output news, while the Treasury yields respond less than the funds rate to inflation news. Panel B shows that for the 1983—1993 period, the Treasury yields respond more to output news than does the funds rate, while the opposite result holds for inflation news. Panel D reports only weak evidence that the Treasury yields respond differently than the funds rate to the news.

On balance, these results tell the same story that the results of the previous subsection tell. Any evidence for inertia in the monetary policy rule is concentrated in news about expected output growth, and in the post-1993 sample. The next section investigates the breakpoint at the end of 1993.

4 Early 1994 as a Break Point

This section argues that the Fed begins following an high-inertia strategy in 1994 as a response to the recession and subsequent anemic recovery during 1990 through 1992. One lesson the Fed takes from this period is the importance of avoiding, when possible, asset-market disruptions created by surprise monetary policy actions. Beginning in 1994, the Fed heavily weights private-sector beliefs when setting monetary policy. At this time the private sector incorrectly believes that the Fed already follows a high-inertia policy. This belief is plausibly tied to the Fed's policy actions during 1990 through 1992. In a nutshell, the Fed adopts an inertial policy in 1994 because markets happen to expect it.

4.1 Learning during 1990 through 1992

The breakpoint at the beginning of 1994 has its roots in earlier changes of market participants' perceptions of short-rate persistence. During 1992 and 1993, market participants begin to price into bonds expectations of substantially higher short-rate inertia than they expected in previous years.

Evidence of participants' beliefs comes from contemporaneous comovement among Treasury bond yields. Regressions of daily changes in longer-term yields on contemporaneous changes in shorter-term yields reveal investors equivalent-martingale expectations of the persistence of short-rate innovations. Concretely, consider the regression

$$\Delta y_t^{(1yr)} = \beta \Delta y_t^{(3mon)} + e_t. \tag{39}$$

For short periods such as a day or two, changes in the three-month bill yield are largely driven by news at t of $\mathcal{Q}$-expected future short rates for the next three months. This news also changes $\mathcal{Q}$-expected future short rates for the next year. Greater inertia in short rates—or, more precisely, greater perceived inertia—corresponds to greater sensitivity of innovations in the one-year yield to innovations in the three-month yield.

Table 9 reports coefficient estimates for one-day and two-day changes in yields. The key observation to take from the table is that the 1992–1993 period exhibits substantially higher sensitivity than in early periods. Results are displayed for four samples, ending just before 1994. From 1969 through August 1979, estimates are below a half. In other words, investors price the one-year bond as if they expect an innovation in short rates to die out quickly. This long–short sensitivity increases modestly through 1991. From 1983 through 1989 the estimated coefficients are about a half. Estimates for the next two years, 1990 and 1991, are around 0.65. Estimates then jump to at least one for the 1992–1993 period.

The table cannot tell us why market participants anticipated such high persistence of short rates in 1992–1993 relative to their beliefs prior to 1992. The most obvious explanation is that participants learned from recent Fed funds dynamics. Figure 4 displays daily values of the Fed funds rate from January 1983 through August 2008.[6] The eyeball test strongly suggests that the Fed has followed an inertial policy throughout the 1990s. In a speech titled "Gradualism," Bernanke (2004), who joined the Fed Board of Governors in 2002, agrees with the eyeball test, stating

> As a general rule, the Federal Reserve tends to adjust interest rates incrementally, in a series of small or moderate steps in the same direction. . . . The easing that spanned the 1990-91 recession and subsequent recovery is a better example of how drawn out the process of adjusting rates can be. That episode lasted for more than three years, from June 1989 to September 1992, and involved twenty-four policy actions that cumulated to a total reduction of 675 basis points in the funds rate. Of these twenty-four actions, twenty-one were rate cuts of 25 basis points, and three were cuts of 50 basis points. (p. 1)

However, transcripts of the FOMC meetings from 1990 through 1992 make clear that the Committee was not following anything like an inertial policy. Instead, the Committee was repeatedly surprised by the recession of 1990–1991 and the continued economic weakness into late 1992. The Online Appendix contains extensive quotes from the transcripts supporting this conclusion. In particular, at no point does Chairman Greenspan advocate persistent

[6]It shows the DFEDTAR series from FRED, constructed from FOMC meeting transcripts and FOMC statements.

future changes in the funds rate. Instead, at meeting after meeting, his view is that no additional reductions in the funds rate may be necessary.

As noted by Bernanke, the Fed reduced the funds rate in repeated 25 b.p. increments. This pattern is largely a consequence of the operating procedures at the time. Rather than changing rates only at scheduled meetings, the FOMC routinely held conference calls whenever Greenspan decided that new information required a discussion about changing the funds rate.

The NBER Dating Committee identifies the trough of the recession as May 1991. The subsequent recovery is historically weak. By mid-1992, Greenspan expresses substantial concern that he might be wrong about the underlying sources of economic sluggishness. At this point he begins to focus on the role of asset prices, bubbles, and the balance sheets of households and firms. For example, at the June 30/July 1 and August 1992 meetings he contrasts the standard aggregate demand/aggregate supply model that he uses to inform policy choices with a different model. Greenspan's new model focuses on the willingness of households and firms to borrow as a function of their balance sheets. His emphasis on balance sheets continues as the Fed confronts a rapidly growing economy in early 1994.

4.2 Tightening in early 1994

The funds rate was 3% at the end of January 1994. The rate had not changed since the Fed lowered it from 3.25% in September 1992 and had not increased since May 1989. At the FOMC meeting of February 3/4 1994, committee members debated whether to immediately raise the funds rate by 25 b.p. or by 50 b.p. Greenspan wraps up the debate on February 4 by advocating forcefully for a small adjustment. He does not want to surprise financial markets, potentially creating large declines in stock and bond prices. Extensive quotations from his remarks at the meeting are contained in the Online Appendix. At the same meeting he reversed his long-standing opposition to the FOMC publicly announcing its policy directives.[7] He wants market participants to understand clearly what the Fed is doing.

At the next FOMC meeting on March 22 1994, Greenspan explains his reasoning in more detail. He explicitly advocates a series of small increases in the funds rate to achieve his desired target, with these increases implemented immediately after regularly-scheduled

[7] The exception is announcements of changes in the rate charged by the Fed's discount window.

meeetings. His view is that participants will see a small step, know it is insufficient to achieve the necessary tightening, and therefore anticipate additional small steps at future meetings. He argues these small steps will not damage balance sheets and lead to greateer certainty on the part of households and firms.

Two permanent changes to FOMC procedures soon follow these meetings. First, beginning with the May 1994 meeting, the staff Bluebook (now Tealbook B, a document describing monetary policy alternatives for the FOMC) prominently discusses near-term and medium-term expectations of changes in the funds rate implied by Fed funds futures prices.[8] Second, the FOMC announces in February 1995 that all changes in monetary policy will be immediately publicly announced.

Of course, this new policy framework does not guarantee that Fed policy actions are always anticipated. For example, the cumulative 300 b.p. increase in the funds frate rom February 1994 through January 1995 greatly surprises the Treasury market. See Kliesen (2025) for a recent review of the episode. On average, though, market predictions of near-term Fed policy actions are much more accurate beginning in 1994 than earlier. Lang, Sack, and Whitesell (2003) show that from 1994 through 2000, one-month-ahead and two-month-ahead changes in the monthly average effective Fed funds rate are strongly forecastable with Fed funds futures contract prices. They also show that forecastability using futures prices is much weaker during 1989 through 1993.

The above discussion points to the post-1993 period as one in which the monetary policy rule is, in some sense accidental. The seeds of the equilibrium are planted during the drawn-out easing during the 1990–1991 recession and its aftermath. Market participants see 24 successive reductions in the Fed funds rate and reasonably, although incorrectly, conclude the Fed follows an inertial strategy. The Fed simultaneously places a new emphasis on meeting the market's expectations, and chooses to follow the inertial strategy.

5 Conclusion

Standard approaches to estimate inertia in the monetary policy rule overestimate inertia when the rule is mismeasured. A more robust approach exploits the contemporaneous and lagged sensitivity of the Fed funds rate to news about expected output growth and inflation.

[8]The Chicago Board of Trade began trading of Fed fund futures contracts in October 1988.

The evidence reveals that the prior to 1994, the funds rate exhibited little inertia. About 80% of the cumulative response to this macroeconomic news occurred within a quarter.

Chairman Greenspan led a regime change at the beginning of 1994 that resulted in substantially more inertia in the policy rule. Yet greater inertia is a byproduct of the regime change rather than the objective. Instead, since 1994 the Fed placed great emphasis on not surprising markets. The marketplace anticipates inertia, thus the Fed acts with inertia.

Both the regime change and the marketplace's anticipation of inertia appear to be grounded in the recession of 1990–1991 and the anemic economic growth that followed. The experience led Greenspan to focus on the effects that Fed actions have on stock and bond values, and thus on the balance sheets of households and firms. The experience led market participants to expect the Fed to act with inertia, even though long sequence of rate cuts during the period was not planned by the Fed.

The most puzzling pattern documented here is the greater inertia associated with news about expected output growth than news about expected inflation. The pattern holds across distinct periods from 1969 to 2008, suggesting it is not simply an artifact of sampling error. At this point, any proposed explanation is mere speculation.

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Table 1. Two Stage Least Squares Estimates of a Monetary Policy Rule

The table reports robust nonlinear two stage least squares estimates of the Fed's target rate and policy inertia. The target rate depends on expectations of the one-quarter-ahead output gap and the one-quarter-ahead inflation. The funds rate is a weighted average of the previous funds rate, with coefficient ρ, and the target, with coefficient $(1 - \rho)$. The instruments are lags one through four of the three explanatory variables. Heteroskedasticity-consistent asymptotic standard errors are adjusted for one lag of moving average residuals, but not adjusted for weak instruments. One, two, and three asterisks represent p-values of two-sided tests at the ten, five, and one percent levels respectively. The Stock-Yogo statistic tests the null hypothesis that the instruments are collectively weak. The 25%, 10% and 5% critical values are 8.66, 9.69, and 10.34 respectively.

		Parameter Estimates		
Sample (Num Obs)	Stock-Yogo Statistic	Output Gap	Inflation	Lagged Fed Funds
1961Q1 – 1979Q2	2.80	0.39***	0.92***	0.72***
(74 quarters)		(0.15)	(0.09)	(0.08)
1984Q1 – 2008Q3	5.32	1.88***	2.07***	0.90***
(99 quarters)		(0.40)	(0.69)	(0.02)
1987Q3 – 2008Q3	3.56	2.05***	2.42***	0.90***
(85 quarters)		(0.39)	(0.66)	(0.02)

Table 2. Ordinary Least Squares Estimates of a Monetary Policy Rule

The table reports OLS estimates of the Fed's target rate and policy inertia. The target rate depends on the contemporaneous output gap and one-quarter-ahead expectations of both inflation and expected real output growth. The funds rate is a weighted average of the previous funds rate, with coefficient ρ, and the target, with coefficient $(1 - \rho)$. Output gap and expectations are real-time estimates from Greenbooks closest to the middle of the quarter. Heteroskedasticity-consistent asymptotic standard errors, constructed with the delta method, are adjusted for one lag of moving average residuals. One, two, and three asterisks represent p-values of two-sided tests at the ten, five, and one percent levels respectively. There are 85 observations from 1987Q3 through 2008Q3.

Output Gap	Expected Inflation	Expected Output Growth	Lagged Fed Funds	R^2
0.85***	1.76***		0.74***	0.96
(0.15)	(0.56)		(0.06)	
0.71***	2.45***	1.58***	0.85***	0.98
(0.20)	(0.48)	(0.17)	(0.03)	

Table 3. Simulated Estimates of Policy Inertia For a Policy Rule Without Inertia

The text describes the true target rate function and an econometrician's target rate function that is mismeasured. The mismeasured function is used to estimate the magnitude of inertia in a monetary policy rule. The true policy rule has no inertia. The econometrician's target rate function excludes a variable $x_{2,t}$ that is in the true target rate function. This variable is persistent with innovation variance σ_2. The econometrician's function is also contaminated by iid noise ω_t with variance σ_ω^2. The table reports model-implied population estimates of inertia ρ, given the variances of the excluded persistent component and noise component.

Noise	Excluded Variable Variance σ_2^2				
Variance σ_ω^2	0	0.1	0.5	0.75	1
0	0	0.31	0.65	0.72	0.76
0.1	0.08	0.35	0.66	0.72	0.76
0.5	0.30	0.47	0.69	0.75	0.78
0.75	0.39	0.52	0.71	0.76	0.78
1	0.45	0.56	0.72	0.77	0.79

Table 4. Explaining Changes in the Fed Funds Rate with Contemporaneous Greenbook Innovations

Observations correspond to meetings of the FOMC. The Fed funds rate at t less the Fed funds rate at $t-2$ is regressed on meeting t's forecast innovations in GDP growth and inflation. Innovations in expected output growth (inflation) for meeting t are Greenbook forecasts of k-quarter-ahead growth in real GDP (GDP deflator) less the meeting $t-1$ Greenbook forecast for the same calendar quarter. The Fed funds rate for meeting t is the median of the daily rates for the three trading days immediately after the meeting. Standard errors, in parentheses, are adjusted for generalized heteroskedasticity and one lag of moving-average residuals. One, two, and three asterisks represent p-values versus zero of 10%, 5%, and 1% respectively.

	GDP Growth		Inflation		
Sample	Nowcast	1-Q-Ahead	Nowcast	1-Q-Ahead	R^2
1/1969–7/1979	0.25***	−0.07	0.22	0.23	0.12
(128 Obs)	(0.09)	(0.06)	(0.17)	(0.15)	
5/1983–12/1993	0.17**	0.20**	0.17	0.36**	0.18
(86 Obs)	(0.07)	(0.10)	(0.12)	(0.17)	
5/1994–7/2008	0.04	0.26**	0.07	0.38***	0.15
(115 Obs)	(0.07)	(0.12)	(0.12)	(0.12)	

Table 5. Explaining Changes in the Fed Funds Rate with Contemporaneous and Lagged Innovations in Greenbook Forecasts

Observations correspond to meetings of the FOMC. The funds rate at t less the funds rate at $i-4$ is regressed on forecast innovations in GDP growth and inflation as of meetings t through $t-2$. Innovations in expected output growth (inflation) for meeting t are Greenbook forecasts of k-quarter-ahead growth in real GDP (GDP deflator) less the meeting $t-1$ Greenbook forecast for the same calendar quarter. The text describes the forecast horizons used in the regressions, which vary across the sample periods. The Fed funds rate for meeting t is the median of the daily rates for the three trading days immediately after the meeting. Standard errors, in parentheses, are adjusted for generalized heteroskedasticity and three lags of moving-average residuals. One, two, and three asterisks represent p-values versus zero of 10%, 5%, and 1% respectively.

Panel A. Point Estimates

Forecast Innovation	Lag	1/1969–7/1979 (128 Obs.)	5/1983–12/1993 (86 Obs.)	5/1994–7/2008 (115 Obs.)
GDP growth	0	0.32***	0.28***	0.23
		(0.12)	(0.10)	(0.15)
GDP growth	1	0.40***	0.42***	0.36***
		(0.13)	(0.13)	(0.13)
GDP growth	2	0.46***	0.48***	0.40***
		(0.13)	(0.13)	(0.12)
Inflation	0	0.54**	0.64**	0.48***
		(0.26)	(0.25)	(0.15)
Inflation	1	0.35	0.37	0.47**
		(0.24)	(0.27)	(0.19)
Inflation	2	0.21	0.35*	0.68***
		(0.29)	(0.21)	(0.19)
R^2		0.28	0.38	0.36

Continued on next page

Panel B. Tests of Differences Between Point Estimates

Forecast Innovation	Hypothesis (Lags)	1/1969–7/1979 (128 Obs.)	5/1983–12/1993 (86 Obs.)	5/1994–7/2008 (115 Obs.)
GDP growth	$0 = 1$	0.08	0.14	0.13
		(0.09)	(0.13)	(0.13)
GDP growth	$1 = 2$	0.06	0.06	0.04
		(0.12)	(0.11)	(0.13)
Inflation	$0 = 1$	−0.19	−0.26	−0.02
		(0.30)	(0.24)	(0.19)
Inflation	$1 = 2$	−0.14	−0.03	0.22
		(0.30)	(0.34)	(0.20)

Table 6. The Relation Between Forecasts and Forecast Innovations

Observations correspond to meetings of the FOMC. Innovations in expected output growth (inflation) for meeting t are Greenbook forecasts of k-quarter-ahead growth in real GDP (GDP deflator) less the meeting $t-1$ Greenbook forecast for the same calendar quarter. The change in the forecast from meeting $t-3$ to meeting t is regressed on lags zero through two of the innovations to both output growth and inflation. The text describes the forecast horizons used in the regressions, which vary across the sample periods. Standard errors, in parentheses, are adjusted for generalized heteroskedasticity and three lags of moving-average residuals. One, two, and three asterisks represent p-values versus zero of 10%, 5%, and 1% respectively.

Dependent	GDP Innovations			Inflation Innovations		
Variable	Lag 0	Lag 1	Lag 2	Lag 0	Lag 1	Lag 2
Panel A. 1/1969 – 7/1979 (128 Obs)						
GDP Forecast	1.46***	1.18***	0.53*	0.04	−0.18	−1.03**
	(0.26)	(0.23)	(0.28)	(0.48)	(0.39)	(0.43)
Inflation Forecast	0.05	0.09	0.10*	0.83***	0.79***	0.72***
	(0.08)	(0.07)	(0.06)	(0.11)	(0.11)	(0.10)
Panel B. 5/1983 – 12/1993 (86 Obs)						
GDP Forecast	0.70***	0.62**	0.42**	−0.01	−0.29	−0.64**
	(0.22)	(0.25)	(0.21)	(0.35)	(0.40)	(0.29)
Inflation Forecast	−0.19***	−0.16*	−0.04	1.03***	0.56**	0.40**
	(0.09)	(0.09)	(0.11)	(0.22)	(0.25)	(0.19)
Panel C. 5/1994 – 7/2008 (115 Obs)						
GDP Forecast	0.62***	0.23	0.31**	0.17	0.34	0.04
	(0.15)	(0.18)	(0.14)	(0.27)	(0.26)	(0.25)
Inflation Forecast	0.05	0.08	−0.05	0.95***	0.12	0.22**
	(0.08)	(0.07)	(0.09)	(0.16)	(0.16)	(0.10)

Table 7. Estimates of a Policy Rule with Inertia

Observations correspond to meetings of the FOMC. The Fed funds rate at t less the Fed funds rate at $i-4$ is regressed on forecast innovations in GDP growth and inflation as of meetings t through $t-2$. The regression coefficients are restricted to satisfy a monetary policy rule that exhibits inertial responses to both types of news, which possibly different inertial coefficients. The panels report GMM estimates of the contemporaneous response of the funds rate to each type of news and the inertia coefficients. The notes to Table 5 describe the data. Standard errors, in parentheses, are adjusted for generalized heteroskedasticity and four lags of moving-average residuals. One, two, and three asterisks represent p-values versus zero of 10%, 5%, and 1% respectively. J-statistics of overall goodness of fit are also reported.

Panel A. A Single Inertia Coefficient

Policy Rule Parameter	1/1969–7/1979 (128 Obs.)	5/1983–12/1993 (86 Obs.)	5/1994–7/2008 (115 Obs.)
Contemporaneous Response	0.20***	0.59***	0.42**
to Expected Output Growth	(0.07)	(0.23)	(0.17)
Contemporaneous Response	0.35**	0.57*	0.39
to Expected Inflation	(0.16)	(0.33)	(0.25)
Inertia	0.51	0.56*	0.79***
	(0.34)	(0.30)	(0.30)
J statistic	0.87	0.15	0.18
[p value]	[0.832]	[0.986]	[0.981]

Continued on next page

Panel B. Separate Inertial Coefficients for Output Growth and Inflation

Policy Rule Parameter	1/1969–7/1979 (128 Obs.)	5/1983–12/1993 (86 Obs.)	5/1994–7/2008 (115 Obs.)
Contemporaneous Response to Expected Output Growth	0.18***	0.57**	0.36*
	(0.07)	(0.24)	(0.21)
Contemporaneous Response to Expected Inflation	0.52***	0.61*	0.45
	(0.17)	(0.36)	(0.29)
Output Growth Inertia	0.69**	0.60*	0.96*
	(0.35)	(0.33)	(0.53)
Inflation Inertia	0	0.49	0.53
	-	(0.40)	(0.69)
Difference Between Inertial Coefficients	-	−0.11	−0.43
		(0.46)	(1.05)
J statistic	0.30	0.10	0.02
[p value]	[0.960]	[0.951]	[0.990]

Table 8. Explaining Changes in Interest Rates with Contemporaneous Greenbook Innovations

Observations correspond to meetings of the FOMC. Changes in the Fed funds rate, the three-month Treasury bill yield, and the one-year Treasury bond yield are regressed on Greenbook forecast innovations in GDP growth and inflation. Explanatory variables are either innovations to the nowcast, innovations to the one-quarter-ahead forecast, or the average of these innovations. The funds rate and yields are medians of daily rates for the three trading days immediately after the meeting. Rate and yield changes are measured from meeting $t-2$ to meeting t. Standard errors, in parentheses, are adjusted for generalized heteroskedasticity and one lag of moving-average residuals. One, two, and three asterisks represent p-values versus zero of 10%, 5%, and 1% respectively.

Panel A. January 1969–July 1979 (128 Obs.)

Dependent Variable	Innovation Measure GDP Nowcast	Innovation Measure Inflation Average	R^2
Fed Funds	0.23**	0.47**	0.11
	(0.09)	(0.20)	
Three Mon Yield	0.22***	0.41***	0.14
	(0.07)	(0.16)	
One Year Yield	0.24***	0.34**	0.14
	(0.06)	(0.14)	

Panel B. May 1983–December 1993 (86 Obs.)

Dependent Variable	Innovation Measure GDP Average	Innovation Measure Inflation 1-Q-Ahead	R^2
Fed Funds	0.36**	0.38**	0.17
	(0.09)	(0.18)	
Three Mon Yield	0.44***	0.31*	0.23
	(0.08)	(0.18)	
One Year Yield	0.43***	0.33	0.18
	(0.08)	(0.21)	

Continued on next page

Panel C. May 1994–July 2008 (115 Obs.)

Dependent Variable	Innovation Measure GDP 1-Q-Ahead	Inflation 1-Q-Ahead	R^2
Fed Funds	0.27**	0.36***	0.15
	(0.10)	(0.13)	
Three Mon Yield	0.38***	0.42***	0.25
	(0.09)	(0.13)	
One Year Yield	0.43***	0.44***	0.29
	(0.07)	(0.14)	

Panel D. Tests of Differences Between Point Estimates

	1/1969–7/1979		5/1983–12/1993		1/1994–7/2008	
	GDP	Inflation	GDP	Inflation	GDP	Inflation
3-Month Bill Yield	−0.01	−0.06	0.08*	−0.08	0.11*	0.06
Less Fed Funds Rate	(0.05)	(0.15)	(0.05)	(0.11)	(0.06)	(0.10)
1-Year Bond Yield	0.01	−0.13	0.08	−0.05	0.17**	0.07
Less Fed Funds Rate	(0.08)	(0.17)	(0.06)	(0.16)	(0.07)	(0.12)

Table 9. Sensitivity of the One-Year Yield to the Three-Month Yield

The table reports coefficients from univariate regressions of changes in the one-year Treasury yield on contemporaneous changes in the three-month Treasury yield. Changes are measured over either one or two days. Regressions use daily data. No constant term is included. Asymptotic standard errors, adjusted for generalized heteroskedasticity and (for two-day changes) one lag of moving-average residuals, are in parentheses.

		Change Horizon	
Sample	Obs	One Day	Two Days
January 1969–August 1979	2,657	0.35	0.41
		(0.02)	(0.02)
January 1983–December 1989	1,747	0.45	0.55
		(0.03)	(0.03)
January 1990–December 1991	499	0.63	0.69
		(0.04)	(0.04)
January 1992–December 1993	493	1.00	1.06
		(0.05)	(0.04)

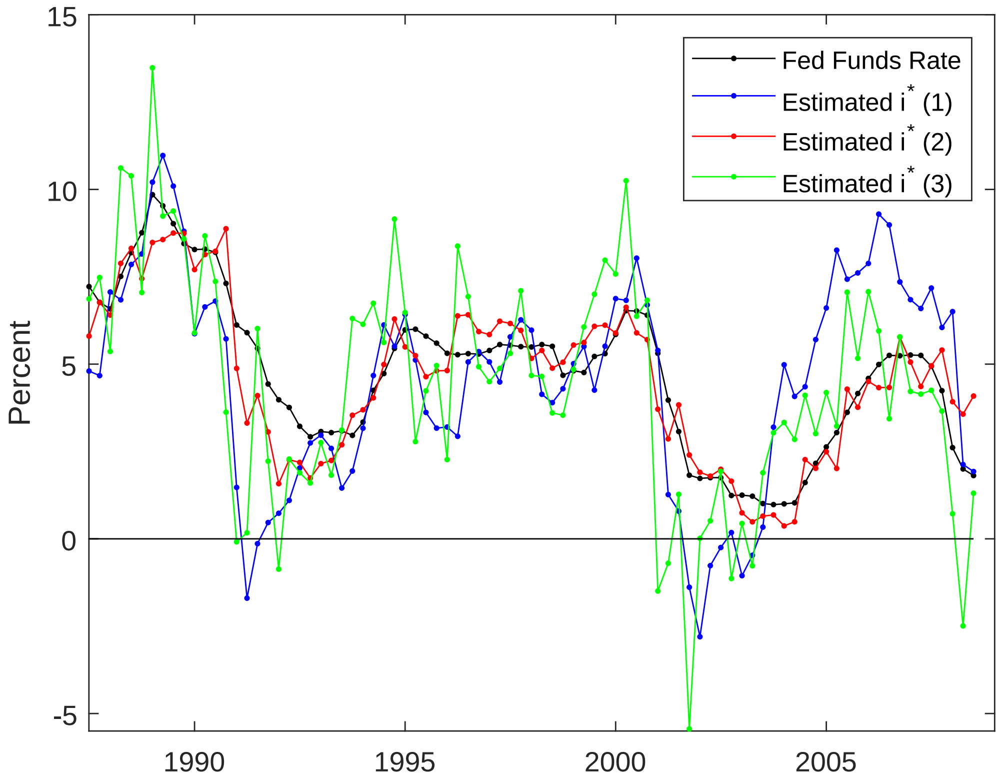

Figure 1. Target Fed funds rate time series implied by different estimates of monetary policy rules. Monetary policy rules with inertia are estimated using quarterly data. The target rate for (1) is linear in the expected one-quarter-ahead output gap and expected one-quarter-ahead inflation. It is estimated with TSLS. The target rate for (2) is linear in the contemporaneous output gap and expected one-quarter-ahead inflation. It is estimated with OLS. The target rate for (3) augments the rule for (2) with one-quarter-ahead expected real output growth.

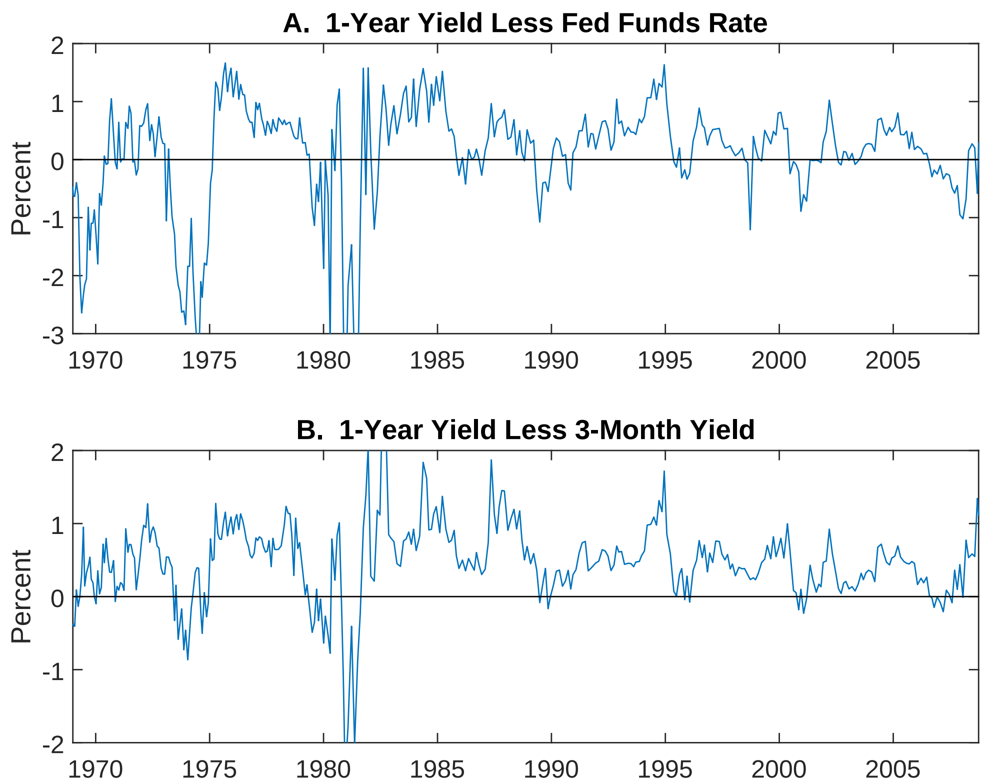

Figure 2. Measures of slope of the short end of the yield curve. The figure displays differences between the one-year zero-coupon Treasury yield and the Federal funds rate (Panel A) or the three-month Treasury bill yield (Panel B). All values are medians of daily observations across the three days immediately after an FOMC meeting.

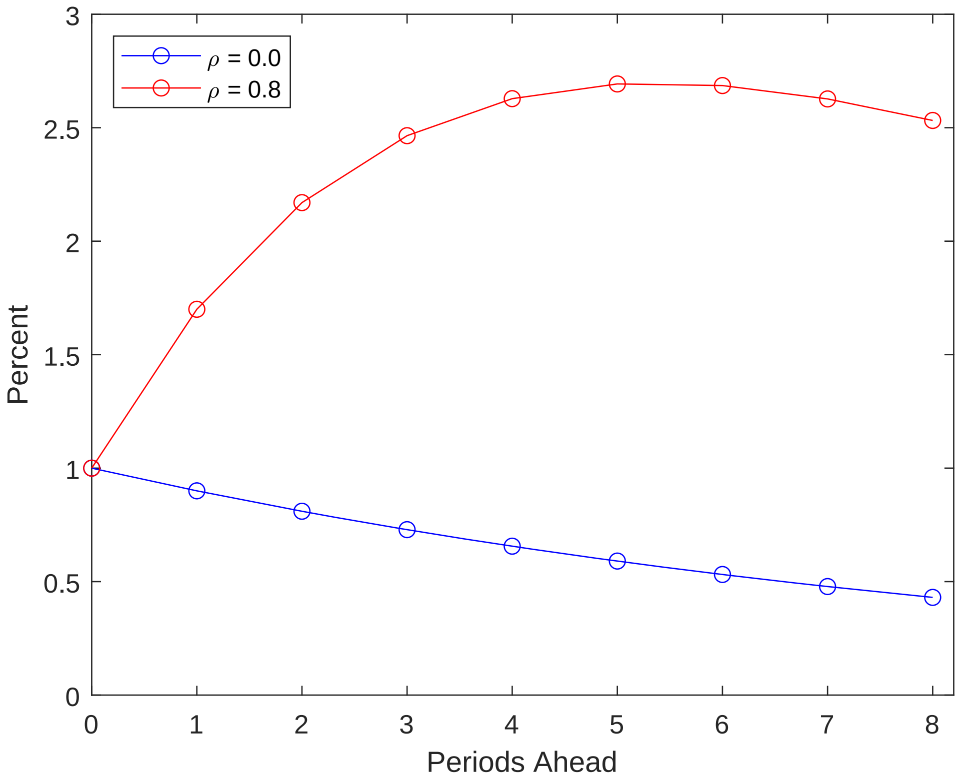

Figure 3. Model-implied innovations in expected future policy rates for a one percentage point innovation in the current policy rate. The figure displays the forecast revision in the 'period ahead' policy rate conditional on a one percentage point increase in the current policy rate. The target policy rate is assumed to follow an AR(1) with persistence parameter 0.9. The inertia coefficient ρ in the monetary policy rule is either zero (no inertia) or 0.8.

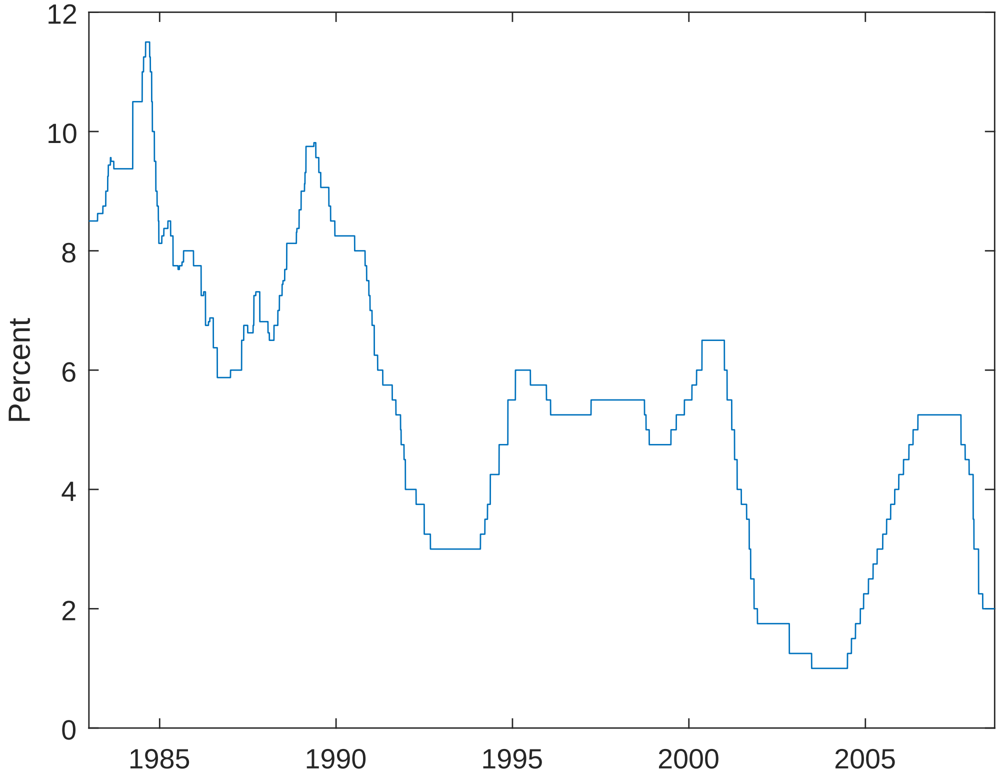

Figure 4. The Federal funds rate from the end of the disinflationary period until the beginning of the global financial crisis. The figure displays the funds rate chosen by the FOMC rather than the effective funds rate displayed in Figure 1.

Inertia in the Fed's Monetary Policy Rule
Online Appendix

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This version: October 2025

1 Additional Calculations

1.1 Regression Coefficients for the Misspecified Model

This subsection calculates the population regression coefficients reported in main text Sections 1.3 and 1.4.

1.1.1 OLS in the special case of no inertia

The true model is, ignoring constant terms,

$$i_t^* = x_{1,t} + x_{2,t}, \tag{40}$$

$$i_t = i_t^*, \tag{41}$$

$$x_{j,t} = \delta_j x_{j,t-1} + \eta_{j,t}, \qquad \eta_{j,t} \ iid, \ E(\eta_{j,t}^2) = \sigma_j^2, \qquad j = 1, 2. \tag{42}$$

Equation (41) does not include an inertia term. The candidate target rate function is misspecified,

$$i_t^{*c} = \beta x_t \tag{43}$$

where the explanatory variable is one of the two variables in (40), and is measured with noise:

$$x_t = x_{1,t} + \omega_t, \qquad \omega_t \ iid, E(\omega_t^2) = \sigma_\omega^2. \tag{44}$$

Both the policy rate and x_t are observed, thus the monetary policy rule can be estimated with OLS using the regression

$$i_t = b_1 x_t + b_2 i_{t-1} + e_t. \tag{45}$$

As the number of observations goes to infinity, the parameter estimates can be written in terms of population variances and covariances of the dependent and independent variables. The formulas are

$$\operatorname*{plim}_{T\to\infty} \hat{b}_1 = \frac{\text{Var}(i_{t-1})\text{Cov}(i_t, x_t) - \text{Cov}(x_t, i_{t-1})\text{Cov}(i_t, i_{t-1})}{\text{Var}(i_{t-1})\text{Var}(x_t) - (\text{Cov}(i_{t-1}, x_t))^2}, \tag{46}$$

$$\operatorname*{plim}_{T\to\infty} \hat{b}_2 = \frac{\text{Var}(x_t)\text{Cov}(i_t, i_{t-1}) - \text{Cov}(x_t, i_{t-1})\text{Cov}(i_t, x_t)}{\text{Var}(i_{t-1})\text{Var}(x_t) - (\text{Cov}(i_{t-1}, x_t))^2}. \tag{47}$$

The variances and covariances in (46) and (47) are

$$\text{Var}(i_t) = \text{Var}(i_{t-1} = \frac{\sigma_1^2}{1-\delta_1^2} + \frac{\sigma_2^2}{1-\delta_2^2},$$

$$\text{Var}(x_t) = \frac{\sigma_1^2}{1-\delta_1^2} + \sigma_\omega^2,$$

$$\text{Cov}(i_t, x_t) = \frac{\sigma_1^2}{1-\delta_1^2},$$

$$\text{Cov}(i_t, i_{t-1}) = \delta_1 \frac{\sigma_1^2}{1-\delta_1^2} + \delta_2 \frac{\sigma_2^2}{1-\delta_2^2},$$

$$\text{Cov}(i_{t-1}, x_t) = \delta_1 \frac{\sigma_1^2}{1-\delta_1^2}.$$

To simplify the math a bit, denote by MV the ratio of the unconditional variance of $x_{2,t}$ to the unconditional variance of $x_{1,t}$. We can think of this as the relative misspecification variance—the variance of the omitted variable relative to the variance of the included variable.

$$MV \equiv \frac{\sigma_2^2}{1-\delta_2^2} \left(\frac{\sigma_1^2}{1-\delta_1^2} \right)^{-1}.$$

Plugging the variances and covariances into (46) and (47) and simplifying produces

$$\operatorname*{plim}_{T\to\infty} \hat{b}_1 = \frac{\sigma_1^2 + (1-\delta_1\delta_2)\frac{\sigma_2^2}{1-\delta_2^2}}{\sigma_1^2 + \frac{\sigma_2^2}{1-\delta_2^2} + \sigma_\omega^2(1+MV)}.$$

$$\operatorname*{plim}_{T\to\infty} \hat{b}_2 = \frac{\delta_2 \frac{\sigma_2^2}{1-\delta_2^2} + \sigma_\omega^2(\delta_1 + \delta_2 MV)}{\sigma_1^2 + \frac{\sigma_2^2}{1-\delta_2^2} + \sigma_\omega^2(1+MV)}.$$

1.1.2 Using Innovations as Instruments

This version of the model includes inertia. Replace (41) with

$$i_t = (1-\rho)i_t^* + \rho i_{t-1}. \tag{48}$$

We can write all of the state variables as infinite sums of innovations. The expressions are

$$x_{j,t} = \sum_{i=0}^{\infty} \delta_j^i \eta_{j,t-i}, \qquad j = 1, 2; \tag{49}$$

$$i_t = (1-\rho)\sum_{i=0}^{\infty}\left(\eta_{1,t-i}\left(\sum_{j=0}^{i}\rho^j\delta_1^{i-j}\right) + \eta_{2,t-i}\left(\sum_{j=0}^{i}\rho^j\delta_2^{i-j}\right)\right). \tag{50}$$

The first-stage regressions are projections of x_t and i_{t-1} on contemporaneous and first-lagged innovations to x_t. These innovations are $\eta_{1,t} + \omega_t$ and $\eta_{1,t-1} + \omega_{t-1}$. Using standard errors-in-variables logic, from (49) the projection of x_t is

$$E(x_t|\eta_{1,t} + \omega_t, \eta_{1,t-1} + \omega_{t-1}) = (\eta_{1,t} + \omega_t) + \delta_1\frac{\sigma_1^2}{\sigma_1^2 + \sigma_\omega^2}(\eta_{1,t-1} + \omega_{t-1}). \tag{51}$$

The projection of i_{t-1} is simpler because only the lagged shock matters. Using the same errors-in-variables logic, from (50) we have

$$E(i_{t-1}|\eta_{1,t} + \omega_t, \eta_{1,t-1} + \omega_{t-1}) = (1-\rho)\frac{\sigma_1^2}{\sigma_1^2 + \sigma_\omega^2}(\eta_{1,t-1} + \omega_{t-1}). \tag{52}$$

To calculate the IV estimate of the regression (45), consider a population regression of the policy rate on the current and lagged innovations,

$$i_t = c_1(\eta_{1,t} + \omega_t) + c_2(\eta_{1,t-1} + \omega_{t-1}) + e_t. \tag{53}$$

From (50), since the innovations are orthogonal, and applying errors-in-variables logic, the coefficients are

$$\operatorname*{plim}_{T\to\infty} \hat{c}_1 = (1-\rho)\frac{\sigma_1^2}{\sigma_1^2+\sigma_\omega^2}, \tag{54}$$

$$\operatorname*{plim}_{T\to\infty} \hat{c}_2 = (1-\rho)(\delta_1+\rho)\frac{\sigma_1^2}{\sigma_1^2+\sigma_\omega^2}. \tag{55}$$

Match population coefficients with the regression (45) using the projections (51) and (52). The results are

$$\operatorname*{plim}_{T\to\infty} \hat{c}_1 = \operatorname*{plim}_{T\to\infty} \hat{b}_1, \tag{56}$$

$$\operatorname*{plim}_{T\to\infty} \hat{c}_2 = \left(\operatorname*{plim}_{T\to\infty} \hat{b}_1\right)\delta_1\frac{\sigma_1^2}{\sigma_1^2+\sigma_\omega^2} + \left(\operatorname*{plim}_{T\to\infty} \hat{b}_2\right)(1-\rho)\frac{\sigma_1^2}{\sigma_1^2+\sigma_\omega^2}. \tag{57}$$

Solving for the population coefficients of (45) results in

$$\operatorname*{plim}_{T\to\infty} \hat{b}_1 = (1-\rho)\frac{\sigma_1^2}{\sigma_1^2+\sigma_\omega^2}, \tag{58}$$

$$\operatorname*{plim}_{T\to\infty} \hat{b}_2 = \rho + \frac{\delta_1\sigma_\omega^2}{\sigma_1^2+\sigma_\omega^2}. \tag{59}$$

2 Additional Empirical Results

2.1 Examining a Regression in Coibion and Gorodnichenko (2012)

Coibion and Gorodnichenko (2012) report second-stage results of IV estimation of the Federal funds rate on expected inflation, the expected output gap, expected real output growth, and the lagged funds rate. Column (2) of their Table 5 contains the estimates.

Using the data posted by the authors on the journal's website I calculate statistics for the first-stage regressions. There are 77 time-series observations for 1987Q4 through 2006Q4. There are five measures of structural shocks. The instruments are lags zero through two of each shock, for a total of 15 instruments (plus a constant term).

2.2 GMM Estimation of Inertia

This subsection provides some detail for the GMM estimation described in Section 3.4. Begin with an initial guess of parameter estimates. The initial guess of the parameters for

(34) and (35) are the OLS estimates reported in Table 6. The initial guess of the policy rule parameters are $\rho_g = \rho_\pi = 0$ (no inertia). The initial guess of the contemporaneous sensitivity of the funds rate to output growth and inflation innovations are the OLS estimates in Table 5 for lag zero. Denote this initial parameter vector by $\hat{\theta}_0$.

Using $\hat{\theta}_0$ I calculate sample moments (37) and construct an estimate of the covariance matrix of the moments using Newey and West (1987) with four lags of moving average residuals. The inverse of this covariance matrix is the initial weighting matrix used to calculate the GMM criterion. A minimization routine produces a consistent estimate of parameters $\hat{\theta}_1$.

I repeat the above procedure using $\hat{\theta}_1$ to construct an estimate of the covariance matrix of the moments and a weighting matrix. The resulting parameter estimates $\hat{\theta}_2$ are consistent and asymptotically efficient. Standard errors are produced using the estimated covariance matrix based on $\hat{\theta}_1$.

3 Discussion of FOMC Transcripts

This section contains extensive quotations from statements by Chairman Greenspan during FOMC meetings. It also contains a few quotes from Greenbooks.

3.1 1990 through 1992

The Fed only belatedly recognizes the 1990–1991 recession. The NBER Business Cycle Dating Committee identifies July 1990 as the start date. Yet Chairman Greenspan, although noting some economic weakness, states at the October 1990 FOMC meeting (all quotes are taken from transcripts available on the Federal Reserve Board's website):

> I still think we're in a situation in which there are forecasts of thunderstorms and everyone is saying well the thunder has occurred and the lightening has occurred and it's raining, but nobody has stuck his hand out the window. And at the moment it isn't raining. (p. 43)

As noted by Bernanke, the Fed reduced the funds rate in repeated 25 b.p. increments. This pattern is largely a consequence of the operating procedures at the time. Rather than changing rates only at scheduled meetings, the FOMC routinely held conference calls whenever Greenspan decided that new information required a discussion about changing the funds rate. In addition, the FOMC occasionally gave the Open Markets Desk contingent directives, authorizing the Desk to change the funds rate between meetings if certain conditions were satisfied. For example, at the meeting where Greenspan does not detect rain, the FOMC directed the Desk to lower the funds rate from 8% to 7.75% if and when a 'meaningful' Federal budget agreement passes Congress. The Desk implemented the reduction four weeks after receiving the directive.

Through the remainder of 1990 and into the summer of 1991, Greenspan views each reduction in the funds rate as perhaps the final cut in the cycle. For example, at the December 1990 meeting he advocates an immediate 25 b.p. reduction in the funds rate to 7%, but expresses concern that cutting too aggressively will spur subsequent inflation. At the March 1991 FOMC meeting the funds rate is 6%. Greenspan anticipates an upturn, although he recognizes that a deepening recession will require further rate cuts:

> By far the highest probability at this stage seems to be that the healing process that we've been observing in recent weeks will continue and will gradually lead into a bottoming out and an economic upturn. . . . That leads me to the second probability . . . in which we could see a failure of the recovery to take hold, continued pressures on profit margins, business confidence falling, and finally a real dive in capital appropriations, which we haven't seen. And that would induce a secondary phase of the recession, which would deepen rather considerably. The probability of that is at this stage still rather moderate to small, but in my judgment non-negligible. I think that leads us then to a policy stance that really gets to this point: If the economy is healing and recovering, then certainly no further easing is required at this stage; but if we get a cumulative erosion, which leads to clear evidence that the capital goods markets are beginning to cave, then I think the proper action is probably a significant drop in the discount rate. (p. 41)

The NBER Dating Committee will eventually determine May is the trough of the recession. In August 1991, when the rate is 5.5%, Greenspan sees no need to lower the funds rate, arguing that the anecdotal evidence the FOMC committee receives is wrong:

> . . . one of the problems I think we're having is that when a recession is over, by definition, the economy is at the lowest point in a cycle and it feels awful. The

> anecdotal reports we're getting from a lot of people are a reflection of the fact that the levels of orders, activity, etc. are exceptionally low. It's very interesting to get a sense [of the views] in the political realm; there is a confusion as to whether "the recession ends" means the receding has come to an end or that the economy is back up to normal. I think the overwhelming evidence is that it's the latter [view] that we run into. ... there is clearly no policy purpose that I can see in moving rates lower immediately ... (pp. 36-37)

However, the recovery remains historically weak. The Greenbook prepared for the December 1991 meeting summarizes recent economic activity and the staff forecast:

> The information received since the last meeting of the FOMC suggests that economic activity leveled off during the summer and may well be slipping lower at present. Employment fell across a broad front last month, and industrial production appears to have dropped noticeably after three months of little change. The staff expects real gross domestic product (GDP) to be essentially flat in the current quarter and to decline somewhat in the first quarter of next year. (p. I-1)

The Fed continues to periodically cut the funds rate. The Greenbook prepared for the August 1992 meeting states "Data received after the last FOMC meeting revealed that the economy entered the summer with even less forward momentum than the staff had thought." (p. I-1). By mid-1992, Greenspan expresses substantial concern that he might be wrong about the underlying sources of economic sluggishness. At this point he begins to focus on the role of asset prices, bubbles, and the balance sheets of households and firms. At the June 30/July 1 and August 1992 meetings he contrasts a standard aggregate demand/aggregate supply macroeconomic model with a different model. From August 1992:

> The alternate significantly less benign model is the one I raised at the last FOMC meeting. It differs from the first model in regard to the presumption about the extent of balance sheet stringency—which you may recall I characterized as having many of the characteristics of the 19th century type of economic processes in the periods when we had a major speculative increase in assets financed by debt, followed by a decline in market value of assets, debt burdens becoming oppressive, and people effectively seizing up on their expenditures in an effort to pay off their debts and restore their balance sheets. The effect is an implosion in

> economic activity. I stipulated at the last FOMC meeting that one way of looking at this process that we are involved in and have been involved in for the last three years is that it is one in which we forestalled this [adjustment] by continuously injecting liquidity—or I should say basically injecting funds and reserves into the system. That stretched out the adjustment process and effectively worked toward ease and toward a sort of relaxing of the grip when we eased, but only for a limited period of time. That is, one can view the essential player in the economy as having a desire to repair the balance sheet very rapidly but the process was being stretched out so to speak by some form of tranquilizer or whatever we may call it. And that tranquilizer has a limited life expectancy so that when we ease we get an economy which is not collapsing but tending to stabilize. But we have to ease continuously in order to get the economy just to stand still and prevent it from seizing up and collapsing. (pp. 38-39)

Greenspan's model focuses on the willingness of households and firms to borrow as a function of their balance sheets. It differs from models of intermediation, largely developed in the aftermath of the global financial crisis, that focus on the supply of lending tied to the balance sheets of intermediaries. His emphasis on balance sheets continues as the Fed confronts a rapidly growing economy in early 1994.

3.2 1994

The FOMC first raises the funds rate at the end of the February 3-4 1994 meeting. Greenspan asks that the members who want a 50 b.p. increase to instead accept a 25 b.p. increase.

> You know, I rarely feel strongly about an issue, and I very rarely sort of press this Committee. But let me tell you something about what's gnawing at me here . . . I would be very concerned if this Committee went 50 basis points now because I don't think the markets expect it. You want to hit a market when it needs to be hit; there is no significant evidence at this stage of imbalances that require the type of action that a number of us have discussed. Were we to go the 50 basis points with the announcement effect and the shock effect, I am telling you that these markets will not hold still . . . I am telling you—and I've seen these markets—this is not the time to do this. . . . I do request that we be willing to move again fairly soon, and maybe in larger increments; that depends on how things are evolving. (p. 55)

At the same meeting he asks to make a public announcement of the decision.

> I am particularly concerned that if we choose to move tomorrow, we make certain that there is no ambiguity about our move . . . I'm very strongly inclined to make it clear that we are doing this but to find a way to do it that does not set a precedent . . . I would very much like to have the permission of the Committee to announce that we're doing it and to state that the announcement is an extraordinary event. (p. 29)

At the next FOMC meeting on March 22 1994, Greenspan explains his reasoning in more detail. He identifies three principles that determine the optimal speed of adjustment. First, from the perspective of standard macroeconomic models of the determinants of inflation and the output gap, he advocates quick adjustment. Second, he recognizes the effects that changes in interest rates have on asset valuations, and thus on balance sheets. Third, he recognizes that predictable policy actions lower the uncertainty faced by borrowers and lenders. Summarizing these principles in the context of the decision the FOMC faces in March 1994,

> I think we have to restore policy to neutrality as fast as we can. . . . If we were dealing strictly with the economic outlook as it stands now, there is no doubt in my mind that this economy could absorb a very large increase in interest rates without a problem. The difficulty I have is that I don't think the financial system can take a very large increase without a break in its tensile strength– which we strained significantly the last time but did not break. . . . there is another characteristic as well. One of the elements that I think we have all been observing with respect to the markets . . . is that when we were perceived as moving on the basis of economic data, the markets had a certain sense of what it was we were doing. . . . Now they are worried that they don't know when we are going to move, so we have this Sword of Damocles hanging over the market. They don't know whether we are going to move in 2 days, 5 days, or 12 days; they have no basis to judge and they are understandably nervous. (pp. 43-44)

We can rephrase his argument in terms of inertia. Zero inertia is optimal in the case when the Fed can move the policy rate to its target without damaging balance sheets. In this case, market participants will not wait for the other shoe to drop because they know the Fed plans no additional changes. Positive inertia is optimal when an immediate jump to the target will damage balance sheets. Optimal adjustments depend on both the fragility of household and firm balance sheets and on what policy actions investors anticipate. For the particular decision faced by the Committee in March 1994, Greenspan states

> A 50 basis point increase would move the funds rate to 3-3/4 percent. In my judgment that would not be perceived of as neutrality or where we ultimately have to be. My own view is that eventually we have to be at 4 to 4-1/2 percent. The question is not whether, but when. If we were to move 50 basis points, I think we would create far more instability than we realize, largely because a half point is not enough to remove the question of where we ultimately are going. I think there is a certain advantage in doing 25 basis points because the markets, having seen two moves in a row of 25 basis points at a meeting, will tend almost surely to expect that the next move will be at the next meeting—or at least I think the probability of that occurring is probably higher than 50/50. If that is the case and the markets perceive that—and they perceive we are going to 4 percent by midyear, moving only at meetings—then we have effectively removed the Damocles Sword because our action becomes predictable with respect to timing as well as with respect to dimension. My own impression, if we decide to move in that direction, is that the last move we might want to make—say, for example, the funds rate was at 3-3/4 percent and we decided 4-1/4 percent might be neutrality—is that perhaps we should add 50 basis points at that point. That would ring the gong as the end and we could in effect withdraw from the race . . . (p. 44)

Table IA1. First Stage Test Statistics for a Regression in Coibion and Gorodnichenko (2012)

Explanatory Variable	F Statistic	p value	R^2
Expected Inflation	1.22	0.285	0.23
Expected Output Gap	0.40	0.975	0.09
Expected Real Growth	2.16	0.018	0.35
Lagged Funds Rate	0.82	0.656	0.17

Table IA2. Explaining Changes in the Fed Funds Rate with Contemporaneous Greenbook Innovations

Observations correspond to meetings of the FOMC. The Fed funds rate at t less the Fed funds rate at $t-2$ is regressed on meeting t's forecast innovations in GDP growth and inflation. Innovations in expected output growth (inflation) for meeting t are Greenbook forecasts of k-quarter-ahead growth in real GDP (GDP deflator) less the meeting $t-1$ Greenbook forecast for the same calendar quarter. The Fed funds rate for meeting t is the median of the daily rates for the three trading days immediately after the meeting. GDP growth is measured in percent/quarter, while inflation and yields are measured in annualized percent. Standard errors, in parentheses, are adjusted for generalized heteroskedasticity and one lag of moving-average residuals. One, two, and three asterisks represent p-values versus zero of 10%, 5%, and 1% respectively.

	GDP Growth			Inflation		
Sample	Nowcast	1-Q-Ahead	2-Q-Ahead	Nowcast	1-Q-Ahead	2-Q-Ahead
5/1983–12/1993	0.17**	0.25*	−0.20	0.14	0.36**	−0.05
(86 Obs)	(0.07)	(0.13)	(0.23)	(0.12)	(0.18)	0.28
5/1994–7/2008	0.03	0.27**	−0.04	0.06	0.40***	−0.03
(115 Obs)	(0.07)	(0.13)	(0.15)	(0.13)	(0.14)	(0.20)