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Perhaps the FOMC Did What It Said It Did: An Alternative Interpretation of the Great Inflation

Sharon Kozicki and Peter Tinsley

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PERHAPS THE FOMC DID WHAT IT SAID IT DID: AN ALTERNATIVE INTERPRETATION OF THE GREAT INFLATION

Sharon Kozicki and P.A. Tinsley*

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Abstract: This paper uses real-time briefing forecasts prepared for the Federal Open Market Committee (FOMC) to provide estimates of historical changes in the design of US monetary policy an in the implied central bank target for inflation. Empirical results and FOMC transcripts support a neglected interpretation of policy during the Great inflation of the 1970's.

Keywords: Asymmetric information; the Great Inflation; time-varying policy responses.

JEL classification: E3, E5, N1

*Authors' addresses are Vice President and Economist, Research Department, Federal Reserve Bank of Kansas City, 925 Grand Boulevard, Kansas City, MO, 64198, USA, sharon.kozicki@kc.frb.org; and Visitor, Department of Economics, George Washington University, 3840 Beecher St., NW, Washington, DC 20007, USA, ptinsley@gwu.edu. We are grateful to Normand Bernard and staff of the FOMC Secretariat for access to historical FOMC documents. Views expressed are those of the authors and do not necessarily represent those of the Federal Reserve Bank of Kansas City or the Federal Reserve System.

1 Introduction

For more than a decade, discussions of U.S. monetary policy have been organized around variants of the benchmark description advanced by Taylor (1993),

$$r_t = \bar{\rho} + \bar{\pi} + c_2(\pi_t - \bar{\pi}) + c_3(y_t - \bar{y}_t) + \epsilon_{r,t}, \tag{1}$$

where r denotes the short-term policy rate controlled by the central bank; $\bar{\rho}$ is the natural rate of the real interest rate; $\pi - \bar{\pi}$ measures the gap between inflation and the central bank target for inflation; and $y - \bar{y}$ is the log output gap. Although this description was based on data from 1987-1992, a period that includes the initial five years of Federal Open Market Committee (FOMC)[1] decisions under the Greenspan tenure, variations have been applied to the behavior of many other central banks and to the historical behavior of the FOMC.

In applying this description to US monetary policy in earlier decades, empirical studies have suggested modifications to one or more arguments of equation (1).[2] In particular, several variations of (1) have been advanced to rationalize the behavior of US monetary policy in the 1970s.

Calibration exercises can support a large number of possible policy variations in the 1970s. If we assume, for the purpose of discussion, that equation (1) provides an adequate characterization of the responses of postwar US monetary policy, then the three natural rates (of output, $\bar{y}_t$, inflation, $\bar{\pi}$, and the real interest rate, $\bar{\rho}$) and two parameters of this equation fully describe the determinants of policy. Under this assumption, significant differences in one or more of these five arguments during the 1970s must necessarily explain the accommodative US monetary policy during the Fed chairmanships of Arthur Burns and William Miller. Indeed, if combinations of variations in the five arguments are considered, it would not be surprising if calibration exercises using alternative initializations of equation (1) could support $\sum_{i=1}^{5} \binom{5!}{i!(5-i)!} = 31$ possible theories of policy failure during the Great Inflation.[3]

Among data-based interpretations of US policy in the 1970s, there appear to be two dominant empirical interpretations of the 1970s: one involving changes in the response

[1] The FOMC is responsible for the actions of U.S. monetary policy through open market operations.

[2] A sizeable literature explores regression estimates of US policy responses over postwar samples, including Judd and Rudebusch (1998), Taylor (1999), Romer and Romer (2002), and Nelson (2005).

[3] Inconclusive calibration exercises of two competing theories of the Great Inflation are discussed in Collard and Dellas (2004). Recent surveys of alternative interpretations of US inflation in the 1970s are presented in Velde (2004) and Nelson (2005).

coefficients and the other based on alternative characterizations of the central bank perceptions of natural rates.[4]

One interpretation has been labelled the *passive policy* explanation. In the influential work of Clarida, Gali, and Gertler (2000), this interpretation is supported by empirical estimates of the policy rate equation that indicate the estimated policy response of the funds rate in the 1970s did not keep pace with inflation.[5] One limitation of documented regression analyses of historical policy responses is that the central bank target for inflation is assumed to be invariant and captured in a fixed equation intercept. A more subtle identification problem is raised by Beyer and Farmer (2004) where estimation of reduced form policy response functions, using only historical realizations of inflation and output, may be unable to distinguish between competing dynamic specifications of central bank responses and of other structural relationships in the macro system. Under asymmetric information, this source of ambiguity can be mitigated by using prior information on the structure of central bank forecast models and by fitting policy responses to the central bank historical forecasts.

The other leading explanation of the Great Inflation is the *natural rate error* interpretation. In a series of important papers, Orphanides (2003a, 2003b, forthcoming) suggests policy responses in the 1970s to inflation and the output gap, such as c_2 and c_3 in equation (1), were consistent with stable policy responses. However, lower levels of the policy rate were induced by substantial and persistent overestimation by the central bank of the natural rate for output, $\bar{y}_t$. Although this research has instigated useful work on consequences of real-time errors in estimates of the natural rate of output and trend productivity, the applicability to policy formation in the 1970s is conjectural. A major obstacle to confirming this interpretation of monetary policy in the 1970s is the lack of a continuous historical record of central bank estimates of the natural rate for output. In the absence of historical

[4]A third notable interpretation is that the Fed attempted to exploit a perceived permanent tradeoff between unemployment and inflation, as in Sargent (1999) and Sargent, Williams, and Zha (2004). This conjecture is not supported by central bank real-time implementations of the Phillips curve in the 1970s, as in Enzler and Pierce (1974) which assumed the absence of a long-run tradeoff. Notwithstanding, Cogley and Sargent (2005) ingeniously suggest policy may have optimized a collection of competing macro models, including the permanent tradeoff specification, where a subset of models (with low posterior odds) predict infinite costs for disinflations in the 1970s.

[5]In terms of equation (1), the passivity of policy is summarized by the inequality, $\hat{c}_2 < 1$. Analytical determinacy conditions for a variety of interest rate response formats are explored in Woodford (2003). In the absence of a stable policy response to inflation, Clarida et al. (2000) suggest that private sector expectations of inflation in the 1970s may have been driven by non-fundamental (sunspot) shocks. However, using the model suggested by Clarida et al. (2000) for the 1970s, Honkapohja and Mitra (2004) demonstrate that neither fundamental nor sunspot RE equilibria were accessible to agents using adaptive learning.

briefing estimates of $\bar{y}_t$ by the central bank, Orphanides (2003a) uses output natural rates presented in annual reports of the Council of Economic Advisors (CEA) as a real-time proxy. However, given representative specifications of aggregate pricing equations in the 1970s, it is more likely that the FOMC used aggregate unemployment to gauge real resource slack.[6]

Curiously, there appears to be little empirical work to recover the implied inflation target of the US central bank, $\bar{\pi}_t$. This paper will draw on the history of forecasts presented to the FOMC to estimate the evolution of the policy response function and movements in the implied inflation target.[7] An important difference from prior studies is that the effective inflation target is not treated as implicit in fixed intercepts or assumed to be a known constant. The empirical results generally support the passive policy theory of Clarida et al. (2000). However, the results suggest also an alternative interpretation that provides additional insights into the design of US monetary policy in the 1970s.

Section 2 discusses estimates of the inflation target implied by historical policy responses to Greenbook forecasts. The empirical results suggest a reconsideration of policy responses in the 1970s. Consequently, section 3 explores an alternative description of US monetary policy in that period. Section 4 concludes.

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[6]CEA natural rate estimates are infrequently cited in the FOMC *Memorandum of Discussion* (MOD) during the 1970s, and do not appear to have been supported by staff forecasts. Examples include: "(T)he potential GNP as estimated by the Council of Economic Advisers is based on a 3.8 per cent unemployment rate. That may well be too low an unemployment target for sustainable economic growth without inflation," Partee, FOMC Economist (MOD, 11/17/1970, p.31) and "Mr. Partee observed that the target for the unemployment rate referred to in the Annual Report of the Council of Economic Advisers already seemed to have been increased from 4 to 4-1/2 percent....according to the (Greenbook) projections, even a 5 per cent unemployment rate would be associated with considerable continuing inflation in the short run." (MOD, 3/19/1973, p.28). Staff estimates of the "high-employment fiscal surplus or deficit" are reported in Greenbook forecasts since April 1970 to measure changes in discretionary fiscal policy, based on the methodology suggested in Okun and Teeters (1970), but estimates of high-employment GNP are not recorded in 1970s Greenbook forecasts or used to gauge inflationary pressure.

[7]Kozicki and Tinsley (2005) presents constructions of central bank real-time perceptions of the natural rate of unemployment. Note that the estimated inflation target is an *effective* target, implied by the structure of the policy response function. Of course, the estimate may not correspond to the intentions of policy-makers. Although an individual decision-maker may maintain an invariant preference distribution over the domain of policy objectives, the historical record of FOMC discussions suggests differences in preference distributions among members of the FOMC. Because US monetary policy is determined by a twelve-member subset of the FOMC, rotations of voting eligibility and of tenure on the FOMC, as well as variations in framing voting choices, vid. Arrow (1951), imply that the effective target for inflation selected by the central bank will likely vary over time.

2 Historical policy responses and estimates of the effective inflation target

This section discusses implicit estimates of the central bank target for inflation, $\bar{\pi}_t$, from time-varying descriptions of the policy response to recent and projected developments in macro indicators. Real-time data on macro indicators are obtained from central bank briefing documents (Greenbooks) prepared in advance of FOMC meetings.

Policy responses are estimated for a full sample, January 1969 through December 1997, and for two subsamples that combine the tenures of Arthur Burns and G. William Miller as chairmen of the FOMC, February 1970 through July 1979, and tenures of Paul Volcker and Alan Greenspan, August 1979 through December 1997.

Implied estimates of $\bar{\pi}_t$ from time-varying policy response equations

Under asymmetric information, the private sector perception of the central bank target for inflation plays a major role in anchoring forward expectations of inflation, which appear in both the pricing equations of firms and the forward policy rate perceptions of traders in financial asset markets. However, the true central bank target for inflation explicitly appears only in the description of policy rate responses, such as equation (1). Consequently, estimation in this section uses the policy response function to identify variations in the effective policy target for inflation.

The following description of FOMC policy responses is explored where, as noted earlier, the unemployment gap provides a plausible indicator of historical policy objectives regarding economic slack. In the absence of policy rate smoothing, the desired setting of the federal funds rate at the FOMC meeting in period t_f is the forward-looking specification

$$r^*_{t_f} \quad = \quad \bar{\rho}_t + \bar{\pi}_t + c_{2,t}(\pi^k_{t|t_g} - \bar{\pi}_t) + c_{3,t}(u_{t+k|t_g} - \bar{u}_t) + c_{4,t}\Delta u_{t|t_g}, \tag{2}$$

where the subscript t_g denotes the date of the relevant Greenbook forecast, t_f the date of the FOMC meeting, $t_f > t_g$, and, generally, both are contained in the current quarter, t. The inflation and unemployment regressors on the rhs of equation (2) are drawn from the Greenbook in period t_g. The inflation measure, $\pi^k_{t|t_g}$, is a four-quarter average of forecasts up to quarter $t+k$ in the forecast horizon and may also include Greenbook estimates of recent inflation, and $u_{t+k|t_g}$ is the Greenbook forecast of the unemployment rate in quarter $t+k$. The desired policy rate may also be a function of the projected change in the unemployment

rate, $\Delta u_{t|t_g}$. This addition approximately nests several alternative specifications of FOMC policy responses.[8]

Dynamic adjustments of the funds rate are represented by

$$r_{t_f} = \beta_{5,t}\Delta r_{t_f-1} + (1-\beta_{6,t})r^*_{t_f} + \beta_{6,t}r_{t_f-1} + a_{t_f}, \tag{3}$$

which contains a term capturing any continuation of the policy rate change selected in the last Greenbook; a partial adjustment of the funds rate level to the desired setting; and an i.i.d. stochastic shock, a_{t_f}. Combining equations (2) and (3) gives

$$\begin{aligned} r_{t_f} &= \beta_{1,t} + \beta_{2,t}\pi^k_{t|t_g} + \beta_{3,t}(u_{t+k|t_g} - \bar{u}_{t|t_g}) + \beta_{4,t}\Delta u_{t|t_g} \\ &\quad + \beta_{5,t}\Delta r_{t_f-1} + \beta_{6,t}(r_{t_f-1} - \bar{\rho}_t) + \bar{\rho}_t + a_{t_f}. \end{aligned} \tag{4}$$

To identify the central bank effective target for inflation, the Greenbook perception of the natural rate of unemployment, $\bar{u}_t$, is drawn from Kozicki and Tinsley (2005); subsample averages of $\bar{u}_t$ are shown in the last column of Table 1.[9] The natural rate of the real policy rate, $\bar{\rho}_t$, is approximated by an HP filter of the historical funds rate less the Greenbook forecast of inflation, $r - \pi$.[10] Under these assumptions, the central bank target for inflation implied by equation (4) is $\bar{\pi}_t = -\beta_{1,t}/(\beta_{2,t} + \beta_{6,t} - 1)$.

The policy rate on the lhs of equation (4) is the average of federal funds rates in the interval following the FOMC meeting in t_f to the next meeting in $t_f + 1$. The lagged policy rate regressor, r_{t_f-1}, is the average funds rate since the previous FOMC meeting.[11]

Data description and time-varying parameter (tvp) specifications

Other than the policy rate, all data are drawn from historical Greenbooks. The Greenbook is a staff briefing document presented to FOMC members before a policy meeting of the

[8] Judd and Rudebusch (1998) and Lansing (2002) suggest FOMC policies after the 1970s placed a greater emphasis on the change in output.

[9] The remaining columns of Table 1 are discussed below.

[10] Following Ravn and Uhlig (2002), the Hodrick-Prescott smoothing parameter is 2^4 x $1600 = 25,600$, as the FOMC has met at least eight times a year during the sample used. The average of the natural rate construction is 2.6 over the full sample, with $\bar{\rho}_t$ falling below the average value in the mid-1970s and rising above the average in the first half of the 1980s. The principal effect of alternative natural real rate measures is to alter the implied estimate of the central bank target for inflation. Denoting $\delta\bar{\rho}_t$ as the deviation of the natural real rate from a constant, the time-varying adjustment to the implied estimate of target inflation is $\frac{\delta\bar{\rho}_t}{c_{2,t}-1}$, where the sign of the adjustment depends on the stability of the long-run response to inflation, $c_{2,t}$.

[11] As FOMC dates are not evenly spaced over the calendar, the number of days in the funds rate averages will vary but time-varying parameters may partially compensate for this. Fixed-coefficient regressions of meeting-to-meeting adjustments of the funds rate are explored in Froyen and Waud (2002).

FOMC. Part II contains background analyses of recent economic and financial data, and Part I presents the staff multiperiod forecast of economic activity. The baseline Greenbook forecast is a "judgemental" forecast. Components of the forecast are selected in a series of meetings by the senior staff and sectoral specialists, who prepare initial projections for their area of expertise.

The baseline Greenbook forecast is considered the modal, or most-likely, outcome, given recent policy decisions and objectives. Forecast assumptions conditioned on perceived current policy and objectives include the senior staff's judgement of likely outcomes in financial markets over the forecast horizon.

Because Greenbook forecasts are constructed on the basis of assumptions about current and future policy, in principle, it would be desirable to incorporate information also about expected future policy rates. However, as of mid-2005, Greenbook forecast assumptions about future policy rates over the forecast horizon are not publicly available. To facilitate some smoothing of estimates and reporting at a fixed frequency, data associated with Greenbook dates falling in the same quarter, t, are stacked in the relevant observation vectors and matrices for quarter t. To simplify subscript notation, the FOMC and Greenbook conditioning dates, t_f and t_g, are generally suppressed in the remaining discussion.

As reviewed in the appendix, three specifications are used to capture time-variation in the coefficients of the policy response equation. One, the *random walk intercept* specification, assumes time-variation in the implied inflation target is represented by a random walk of the intercept, $\beta_{1,t}$. However, as noted above, extraction of the implied inflation target also depends on $\beta_{2,t}$ and $\beta_{6,t}$, and modest variations in these coefficients may lead to large changes in the constructed inflation target, $\bar{\pi}_t$. Consequently, a second specification, *random walk coefficients* extends the random walk specification to the remaining unrestricted coefficients of the policy response function. While tractable, random walk specifications have some questionable implications, including assumptions that all parameter change is permanent and that parameters can evolve over time without finite bounds. Consequently, a third specification, *stationary coefficients*, assumes time-variation in all unrestricted coefficients can be captured by autoregressive movements about fixed means.

After examining a number of time-varying parameter (tvp) applications, our experience is that the means of the coefficients, the maximum and minimum of the implied inflation

targets, and the variance decomposition for the stationary coefficients estimate (see appendix) provide useful summary contrasts among alternative specifications. Where relevant, these statistics are shown in the tables that follow for the three tvp specifications: the random walk intercept (RWI) model; the random walk coefficients (RWC) format; and the stationary coefficients (SC) specification.

Full-sample results, 1969-1997

The horizon of forward expectations, k, in historical Greenbooks is limited in early years of the sample. In Table 2, inflation is averaged over four quarters, including Greenbook estimates of inflation in the two preceding quarters, $h = -2, -1$, and the inflation forecasts for the current and next quarter in the policy horizon, $h = 0, 1$.[12]

Using the two-quarter lead, $k = 1$, the policy equation (4) is estimated by the three tvp specifications over a 1969 - 1997 sample containing 280 Greenbooks.[13] The tvp specifications accommodate two shifts in the variance of the measurement error, σ_a, to account for the change in operating procedures from 1979Q4 to 1982Q3.[14]

The top panel of Table 2 uses $\bar{u}_t$, the natural rate of unemployment implied by Greenbooks, discussed in Kozicki and Tinsley (2005). The bottom panel uses $\bar{u}_t^b$, an alternative Greenbook-based estimate of the natural rate of unemployment that is closer to that reported by Romer and Romer (2002). Differences between the two Greenbook-based estimates of the unemployment natural rate are illustrated in Table 1, which compares subsample averages of the two estimates with averages reported in Romer and Romer (2002) and with averages of the retrospective construction by the Congressional Budget Office (2004). Both the Romer and Romer estimates and $\bar{u}_t^b$ are based on a Phillips equation with

[12] Although both Clarida, Gali, Gertler (2000) and Orphanides (forthcoming) estimate forward-looking policy rules, a number of studies including Taylor (1999) have estimated policy responses to backward-looking averages. As both recent measurements and forecasts of inflation can be subject to sizeable revisions over time, it seems plausible that FOMC members may differ in the emphasis placed on forecasts or recent measurements in weighing their policy decisions. Policy equations were also estimated for two-quarter averages, $h = 0, 1$ with estimation results similar to those in Table 2. In the case of the stationary coefficients specifications, likelihood ratios prefer the use of four-quarter averages for the inflation rate, and four-quarter averages are used in subsequent tables.

[13] The Greenbook of November 15, 1972 contains only a current-quarter forecast, i.e. the Greenbook forecast horizon, H, in that quarter is equal to the first period of the forecast, $h = 0$. For this Greenbook, the current-quarter forecast is repeated when a two-quarter forecast horizon is required, as for $k = 1$.

[14] The use of a nonborrowed reserves instrument during the 1979-82 interval increased the effective variance of a_t by introducing shocks from money demand and the banking reserves market, vid. Tinsley, von zur Muehlen, and Fries (1982). In the case of random-walk specifications of the FOMC policy response rule, a mid-sample changepoint test estimates the local-to-zero parameter as $\lambda = 11.1$ (see discussion and references to the median unbiased estimator in the appendix).

backwards-looking inflation expectations, and imply substantial real-time underestimates of the CBO retrospective measure in the first half of the 1970s, of 2-3 percentage points (a 30-50% error). By contrast, the retrospective underestimation by $\bar{u}_t$ is less than one percentage point in the first half of the 1970s (a 17% error). The $\bar{u}_t$ estimate is based on a "hybrid" Phillips curve, with both forward- and backwards-looking inflation expectations, vid Kozicki and Tinsley (2005).[15]

In both panels of Table 2, the maximum and minimum bounds of the implied central bank target for inflation, $\bar{\pi}_t$, are large, suggesting difficulty in identifying $\bar{\pi}_t$ over part of the sample. The variance decomposition indicates a substantial source of stochastic variation in the policy rate is due to time-varying movements in the response to inflation, $\beta_{2,t}$.[16] This suggests that estimated variations in the policy response to inflation may be contributing to the implausible movements of the implied inflation target.

Estimates of the long-run policy responses to inflation, $c_{2,t}$, from the three tvp specifications in the top panel of Table 2 are charted in Figure 1. In the case of the fixed-slope specification, RWI, the long-run response to inflation is stable but close to unity, $c_2 = 1.1$. For the RWC and SC specifications, the estimated long-run responses are substantially greater than one for much of the sample, but large estimates of the central bank inflation target, $\bar{\pi}_t$, occur when $c_{2,t}$ enters the neighborhood of unity. As shown in Figure 1, there are two unit crossings by $c_{2,t}$ in the 1970s for the SC specification and an additional unit crossing in the 1990s for the RWC specification.

Previous studies, such as Orphanides (2002, forthcoming), have suggested that the policy response equation exhibits stable responses to inflation, $c_2 > 1$, when real-time estimates of the natural rate of real activity are used in the policy regression. The lower panel of Table 2 uses the natural rate of unemployment, $\bar{u}_t^b$, that represents an upper bound on real-time measurement errors of the natural rate implied by Greenbook forecasts. However, even with the larger unemployment gaps associated with $\bar{u}_t^b$, the problem of implausible lower and upper bounds on the effective target for inflation persists in the lower panel of Table 2 due

[15] Interestingly, the $\bar{u}_t$ natural rate estimate of 5.6, shown in Table 1 for $\bar{u}_t$ in the 1996Q1-97Q4 interval, is precisely the natural rate of unemployment assumed in the February 1997 Greenbook, as reported in Svensson and Tetlow (2005)

[16] Steady-state variance decompositions of the separate contributions of individual time-varying coefficients, weighted by the relevant regressors, are available only for the stationary coefficients (SC) specification. Construction of the decomposition is reviewed in the appendix.

to unit crossings of the response to inflation, $c_{2,t}$, in the 1970s and 1990s.

Tests for structural changes in the coefficients of the policy equation indicate a major shift at the end of the 1970s.[17] Consequently, as neither adjustments for shifts in the variance of the measurement error of the policy response equation, σ_a^2, nor an alternative construction of the natural rate for unemployment, $\bar{u}_t^b$, are sufficient to explain the policy transition, the remainder of this section explores estimations of separate policy responses for the Burns/Miller and the Volcker/Greenspan tenures.

Policy during the Burns/Miller tenures

Results of fitting equation (4) to Greenbook forecasts in the Burns/Miller era are presented in the top panel of Table 3. The policy regime, 1970Q1 through 1979Q2, spans 38 quarters and 115 Greenbooks. In the top panel of Table 3, mean responses to both inflation and the first-difference of unemployment are statistically significant.[18] The mean response to the unemployment gap, $u_{t+1} - \bar{u}_t$, is marginally significant, with p-values of .09 for the RWI specification and .11 for the SC specification. However, the lower bounds for the implied natural rate of inflation are negative for all three tvp specifications.

Fixed coefficient regression studies of US monetary policy generally indicate that policy in the 1970s responded significantly to gap measures of real activity.[19] In exploring this suggestion, the second panel in Table 3 drops the unemployment change regressor and the third panel eliminates the unemployment gap regressor.

When the first-difference of the unemployment rate is dropped as a regressor in the middle panel of Table 3, mean policy responses to the unemployment gap, $\bar{\beta}_3$, are insignificant, with p-values around .20. By contrast, mean policy responses to the first-difference of the unemployment rate in the bottom panel of Table 3 are significant, as are the mean responses to inflation.[20]

[17] The test statistics are robust to residual heteroskedasticity. The largest test statistics occur in early 1980 with zero p-values, using the tables in Hansen (1997).

[18] Examining the significance of the mean policy responses to inflation and the two unemployment measures are meaningful as there are no zero crossings by the tvp coefficients on these regressors in the remaining sections of the paper.

[19] Significant mean responses to output gaps in the 1970s are reported in Judd and Rudebusch (1998), Taylor (1999), Clarida, Gali, and Gertler (2000), Nelson (2005), and Orphanides (forthcoming).

[20] In addition to the statistical insignificance of mean policy responses to the unemployment gap, $\bar{\beta}_3$, a Chi-squared test of the likelihoods of the SC equations in the top and bottom panels of Table 3 does not reject zero restrictions on the additional parameters required for a tvp policy response to the unemployment gap.

In all three panels of Table 3, the upper bounds for the implied central bank target for inflation, $\bar{\pi}_t$, are large for the random walk coefficients specification, RWC. The principal reason is that the estimated long-run response to inflation, $c_{2,t}$, either remains in the neighborhood of unity or exhibits a unit crossing. Figure 2 charts estimates of $c_{2,t}$ for the three tvp policy rules of the bottom panel in Table 3. The long-run policy response to inflation remains below unity for both the RWI and SC policy equations, but $c_{2,t}$ has a unit crossing in 1972 for the RWC policy equation. In addition, the estimated long-run response to inflation falls in 1974 for both the RWC and SC equations.

Recalling the two leading interpretations of US policy in the 1970s, the evidence of the tvp specifications presented in this section supports the passive policy interpretation. Indeed, the natural rate error explanation appears to be largely irrelevant, as there is little empirical support for a systematic policy response to the unemployment gap.[21] An alternative interpretation of US policy in the 1970s is explored in section 3.

Policy during the Volcker/Greenspan tenures

The policy equation (4) is estimated for the Volcker/Greenspan policy era, 1979Q3 through 1997Q4, a span of 75 quarters and 152 Greenbooks.[22] Estimates of the three tvp specifications are summarized in Table 4.

The construction of the inflation regressor, π_t^k, varies in the two panels of Table 4. Inflation is averaged over the first two quarters of the Greenbook horizon and the two preceding quarters in the top panel, $h = -2, -1, 0, 1$. In addition, given the availability of longer Greenbook forecast horizons in the Volcker/Greenspan sample, the four-quarter inflation average is shifted ahead by two quarters in the bottom panel, $h = 0, 1, 2, 3$.

The estimated mean policy responses to all regressors, including both the unemployment gap and the first-difference in unemployment, are generally statistically significant in Table 4. The lower bound of the implied inflation target, $\bar{\pi}_t$, is negative for the random walk

[21] The absence of a policy response to unemployment gaps also casts doubt on interpretations of 1970s US monetary policy based on a difference between the natural rate of unemployment and a central bank target for unemployment, such as posited in the time inconsistency literature or the central bank misperception analysis of Sargent, Williams, and Zha (2004).

[22] Fixed-coefficient residuals, u_t, exhibit less volatility in the Volcker/Greenspan sample than in the Burns/Miller sample. The estimate of the local-to-zero parameter for median unbiased estimators for the Volcker/Greenspan sample is lowered to $\lambda = 6.9$, a result consistent with a mid-sample changepoint test for the Volcker/Greenspan observations. Estimated outcomes in the Burns/Miller sample, such as statistical insignificance of mean policy responses to the unemployment gap, are maintained if the lower local-to-zero parameter is used also for the 1970s.

coefficients, RWC, equations in both panels. As with the policy equations estimated for the Burns/Miller sample, these negative bounds are due to unit crossings of the estimated long-run policy response to inflation, $c_{2,t}$. Figure 3 displays estimates of the policy response to inflation for the three tvp specifications of the top panel. The $c_{2,t}$ response estimate by the SC equation is smaller in the early 1990s but remains above one throughout the sample, whereas the response by the random walk coefficients, RWC, equation continues to drop and falls below one in 1994.

The estimated characteristics of the stationary coefficients specification, SC, are similar in both panels of Table 4. A likelihood ratio suggests a slight advantage for the specification in the top panel where the four-quarter average of inflation, π_t^k, contains both forward forecasts and backward real-time estimates, $h = -2, -1, 0, 1$.[23] The time profile of the central bank target for inflation, $\bar{\pi}_t$, in the Volcker/Greenspan sample is shown in Figure 4, as implied by the SC equation in the top panel of Table 4. The remaining variables in Figure 4 are discussed in the next section.

3 An alternative interpretation of policy in the 1970s

"If you can remember anything about the sixties (and seventies), you weren't really there" - Paul Kantner

Simple policy response equations that relate movements of the policy interest rate, r, to changes in arguments of the central bank preference function, such as inflation, π, and real economic activity, y or Δy, are the basis of many useful empirical descriptions of historical monetary policy. However, positing a direct link between the policy instrument and ultimate policy objectives conceals a major flaw in the design of monetary policy in the 1970s. This section indicates that intermediate targeting of monetary aggregates–a monetarist strategy that dominated FOMC policy in the 1970s–provides a unified interpretation of the Great Inflation, explaining the irrelevance of the natural rate error interpretation and providing a more historically accurate description of policy design in the 1970s.

The gathering influence of monetarism on US monetary policy

[23] Several papers demonstrate that indeterminacy may occur if policy responds to arguments in distant forecasts; see the numerical analysis in Batini and Pearlman (2002).

In a collection of highly influential essays, Milton Friedman (1960) indicated that "I share the doubts that the Federal Reserve has repeatedly expressed about the desirability of using price level stability as an intermediate guide to policy." Instead, he proposed that the central bank pursue constant growth of the money stock. In 1960, a unified measure of the money supply was published in the October Federal Reserve *Bulletin*. In the June 1966 FOMC meeting, the FOMC Policy Directive to the trading desk of the Federal Reserve Bank of New York contained the first "proviso" reference to the required reserves aggregate as a secondary target. Finally, in the second FOMC meeting chaired by Arthur Burns, the Policy Directive adopted at the March 10, 1970 meeting selected the growth of monetary aggregates as principal targets of US monetary policy.

Policy forecasting and FOMC policy discussions in the 1970s were shaped by the two-stage design that is characteristic of intermediate targeting. Greenbook forecasts of economic activity were conditioned on the assumption of a trajectory for the money supply over the forecast horizon, vid. Kalchbrenner and Tinsley (1977).[24] As noted earlier, to assist sectoral specialists, the senior staff translated the money supply assumption into staff expectations of bond yields over the forecast horizon.

By contrast, short-run policy options were formulated as competing money growth paths associated with alternative settings of the policy instrument, usually the funds rate. In principle, the competing options for the money supply represented different short-run paths toward the baseline money supply trajectory assumed in the Greenbook. These short-run policy options were presented in the Blue Book. Each Blue Book contained a brief summary of recent activity in money and banking markets and suggested, generally, three policy options for discussion by the FOMC.[25] Forecasts of money growth associated with alternative

[24]Generally, the monetary policy assumption of the Greenbook forecast was the M_1 growth rate target selected at the last FOMC meeting. For example: "That growth rate of money (4%) had been assumed for projection purposes because the Committee had been employing such a rate as a target over the past several months." Partee, FOMC Economist (MOD, 6/23/70, p.31); and "In developing our base projection, which is laid out in detail in the green book, we have adopted several policy assumptions. The monetary policy assumption calls for a continuation of the present policy stance through 1976, as indexed by the growth in the narrow money supply at around the 6-1/4 per cent midpoint of the range that has been announced by the Committee." Partee (MOD 6/16/75, p.4).

[25]Two examples of staff interpretations of the Bluebook policy options are: "Mr. Axilrod observed that among the alternative sets of relationships between monetary aggregates and money market conditions presented in each blue book, there was always one that represented a continuation of the Committee's current longer-run target for the aggregates. There was always another alternative that represented a continuation of prevailing money market conditions." (MOD, 11/20/72, p.52); and "Mr. Partee said it might be helpful if he explained how the staff proceeded in formulating the blue book alternatives. One of the alternatives always shown involved the maintenance of prevailing money market conditions; in the present case, that was alternative C, the tightest of the three. Another alternative

policy rate settings appear in the Blue Book presented at the first FOMC meeting chaired by Arthur Burns on February 10, 1970. Although alternative forecasts of the money supply were initially limited to the current quarter, as in the February 4 Bluebook, or also included the next quarter ahead, as in the March 4 Bluebook, horizons of the Bluebook conditional money supply forecasts were eventually lengthened to four-quarter horizons in 1975, including the current quarter, $h = 0, 1, 2, 3$.

Empirical evidence for intermediate targeting in the Burns/Miller era

Intermediate targeting of the money supply is summarized by three equations,

$$\Delta m_t = \pi_t + \Delta y_t - \Delta v_t, \tag{5}$$

$$\Delta \bar{m}_t = \bar{\pi}_t + \Delta \bar{y}_t - \Delta \bar{v}_t, \tag{6}$$

$$r^*_{t_f} = \bar{\rho}_t + \bar{\pi}_t + c_{2,t}(\Delta m_t - \Delta \bar{m}_t + (\Delta v_t - \Delta \bar{v}_t)), \tag{7}$$

where equation (5) is the monetarist equation of exchange that links Greenbook forecasts of inflation and output growth to the projected growth of the monetary aggregate. Equation (6) is a natural rate variant that indicates what target growth of the monetary aggregate is consistent with the natural rates for inflation and output growth. The desired setting of the funds rate at the FOMC meeting in period t_f is defined by equation (7). This is an adjusted variant of intermediate targeting, where monetary aggregate growth is adjusted for the staff prediction of transient velocity growth, $\Delta v_t - \Delta \bar{v}_t$.[26]

always shown involved the longer-run growth rate for M1 adopted by the Committee at its previous meeting. Since on this occasion that alternative called for a rather sizeable near-term decline in the Federal funds rate followed by an upturn before the end of the 6-month projection period, the staff thought it probably would be as liberal a policy as the committee was likely to consider within the range of reasonableness. Consequently, that alternative was labeled "A," and the third was formulated to fall between the other two." (MOD, 1/21/75, pp. 61-2).

[26]By construction, a persistent shift in trend velocity alters the natural rate estimate, $\Delta \bar{v}_t$. "Shift-adjusted"' monetary aggregate targets, to account for the estimated effects of financial innovations such as the nationwide introduction of negotiable order of withdrawal (NOW) accounts, were not publicly announced until 1981. The transient velocity growth adjustment, $\Delta v_t - \Delta \bar{v}_t$, of equation (7) approximates the "zone of indifference" the FOMC adopted in the 1970s to accommodate transient movements within growth rate target ranges. The evolution of the "zone of indifference" is illustrated by the following selections from the *Memorandum of Discussion*: "On balance he would not object to some shading of the funds rate if the aggregate growth rates appeared to be close to the upper or lower limits. However, more vigorous action should be taken only if the growth rates appeared to be outside the range." Burns, (MOD 10/17/72, p.40). "Chairman Burns remarked at the last meeting he had initially defined the ranges for the aggregates as zones of no action. He had then modified that–in response to Mr. Holmes' remarks–to provide for a movement in the funds rate of up to but no more than 1/8 of 1 percentage point as the aggregates approached their limits. In the event that the aggregates appeared to be moving beyond their limits, however, full and free use was to be made of the range for the funds rate." (MOD, 11/20/72 p. 50). "(Governor Partee's) preference was for (a range) of 4 to 8...for M-1...with a zone of indifference of 5 to 7....Chairman Burns observed that he could accept the zones of indifference proposed by Mr. Partee." (MOD, 3/16/76, p.74).

Substituting the first two equations, (5) and (6), into the third equation (7), gives the desired funds rate explicitly conditioned on averages of Greenbook forecasts,

$$\begin{aligned} r^*_{t_f} &= \bar{\rho}_t + \bar{\pi}_t + c_{2,t}((\pi^k_t - \bar{\pi}_t) + (\Delta y^k_t - \Delta \bar{y}_t)), \\ &= \bar{\rho}_t + \bar{\pi}_t + c_{2,t}(x^k_t - \bar{x}_t), \end{aligned} \tag{8}$$

where $x^k_t - \bar{x}_t$ is a proxy for the gap of nominal output growth using Okun's Law, $x^k_t - \bar{x}_t = \pi^k_t - \bar{\pi}_t - a'\Delta u^k_t$;[27] and the superscript, k, indicates four-quarter averaging over forecast periods through $h = k$.

Note that equation (8) is a restricted version of the desired funds rate equation specified earlier in (2). Three restrictions are required by money growth intermediate targeting: First, the policy response to the unemployment gap is zero, $c_{3,t} = 0$. Second, the difference in the unemployment rate, Δu^k_t, is averaged over the same number of periods as the inflation rate regressor. Third, the long-run policy responses to the inflation average, π^k_t, and the average of the unemployment rate difference proxy, $-a'\Delta u^k_t$, are the same, $c_{2,t}$. The dynamic adjustment of the funds rate is the same as that specified earlier in equation (3).

Time-varying estimates of the policy rate response equation implied by money growth intermediate targeting are presented in Table 5. Equations in the bottom panel are estimates of the policy response equation when all three restrictions associated with intermediate targeting of the money growth are imposed. The unemployment gap regressor, $u_{t+k} - \bar{u}_t$, is added to equations in the top panel of Table 5. Similar to the results in section 2, the estimated mean policy responses to the unemployment gap, $\bar{\beta}_3$, are statistically insignificant. In addition, the average difference in the unemployment rate, Δu^k_t, is added to the equations reported in the middle panel of Table 5. These equations also indicate that the mean policy response of the Burns/Miller sample to the difference in the unemployment rate does not differ significantly from the response expected under money growth intermediate targeting.

Although not shown, the estimated long-run policy responses, $c_{2,t}$, to the nominal growth proxies, x_t, implied by the tvp specifications in the bottom panel of Table 5 move between 0.5 and 0.7 during the 1970s. Thus, the implied long-run responses to inflation are even further below one than those estimated in section 2 for the Burns/Miller sample.

Finally, differences between the central bank target for inflation implied by Greenbook

[27] The Okun's Law coefficient, $a' = 2.2$, is based on estimates for the 1970s in Tatom (1977).

forecasts, $\bar{\pi}_t$, and estimates of private agent perceptions of the central bank inflation target, $\bar{\pi}_t^p$, are charted in Figure 4. The two thick lines are estimates of $\bar{\pi}_t$ for the Burns/Miller era from 1970Q1 through 1979Q2 (from the SC specification in the bottom panel of Table 5), and for the Volcker/Greenspan sample from 1979Q3 through 1997Q4 (from the SC specification in the top panel of Table 4). The thick dashed line is a concatenation of real-time survey estimates of long-term inflation expectations by private agents.[28] The thin line is an estimate of the evolution of private sector perceptions of the central bank target for inflation, $\bar{\pi}_t^p$, from Kozicki and Tinsley (2001).[29]

Using the vertical distance between the private perception, $\bar{\pi}_t^p$, and the central bank target for inflation, $\bar{\pi}_t$, as a measure of the credibility of the US central bank, Figure 4 suggests that credibility was positive and large at the beginning of the 1970s and steadily evaporated over the decade. By the beginning of the 1980s, the gap in credibility was negative and quite large, about five percentage points, and only slowly returned to a value near zero by the end of the sample.

Consequences of money growth intermediate targeting

The most striking outcomes of the tvp specifications of policy in the 1970s are the rather high estimates of the central bank target for inflation, $\bar{\pi}_t$, and the uniformly low estimates of the long-run policy responses, $c_{2,t}$.

A monetary policy that targets the growth rate of the money supply is vulnerable to two types of fundamental shocks, and both occurred in the 1970s. Renormalizing equation (6), the effective central bank target for inflation under intermediate targeting is defined by

$$\bar{\pi}_t = \Delta\bar{m}_t - \Delta\bar{y}_t + \Delta\bar{v}_t. \tag{9}$$

Given a target growth rate for the money supply, $\Delta\bar{m}_t$, the effective inflation target is increased if the central bank is unable to detect a reduction in the natural rate trend of output, $\Delta\bar{y}_t$, or an increase in trend velocity, $\Delta\bar{v}_t$. The natural rate of trend output growth

[28] Until July 1990, survey estimates are drawn from the Hoey survey of expected inflation in the second five years of a 10-year forecast horizon. The remainder of the series is long-run expected inflation from the Survey of Professional Forecasters, published by the Federal Reserve Bank of Philadelphia.

[29] This estimate is based on multinomial logit aggregation of alternative changepoint estimators of $\bar{\pi}_t$. Although this estimate of perceived long-run inflation is similar to the survey of long-term expected inflation, survey information was not used in the estimated learning model of private sector perceptions.

slowed in the late 1960s and early 1970s.[30] Subsequently, due to financial innovations fuelled by higher inflation and deregulation of banking and financial markets, the trend of velocity began a long march of upward shifts in the mid-1970s. Both an unexpected reduction in $\Delta\bar{y}$ and unexpected increases in $\Delta\bar{v}$ induced a higher effective central bank target for inflation in the 1970s under money supply intermediate targeting.

Note that the policy errors caused by erroneous predictions of trend velocity are unique to a policy based on money supply intermediate targeting. The unpredicted shift in trend velocity was not small. The December 12, 1980 Bluebook contains an analysis of money demand models. Conditioned on retrospective measurements of explanatory variables, the annual underestimate of velocity growth over the last half of the 1970s by the 1980 vintage of the staff model was 1.8 percentage points, including errors of 5.1 percentage points in 1975 and 2.9 percentage points in 1976.[31]

The second unusual characteristic of policy in the 1970s is that the estimated long-run policy response to the money supply growth proxy, $c_{2,t}$, remained well below one in the Burns/Miller sample.

Contemporaneous critiques of money growth targeting in the 1970s included criticism of the relatively tight FOMC ranges on inter-meeting variations of the policy rate, vid. Poole (1975). The inter-meeting tolerance ranges on the policy rate are charted in Figure 5. It is evident that tight inter-meeting ranges did not prevent sizeable meeting-to-meeting adjustments of the policy rate in 1973 and 1974. By contrast, FOMC decisions led to flat or modest meeting-to-meeting adjustments of the policy rate level after 1974, until the large upward adjustments of the policy rate in the initial FOMC meetings chaired by Paul Volcker after October 1979 (not shown).

The passivity of policy through much of the second-half of the 1970s is also illustrated in Figure 6 where the policy rate is plotted against the Greenbook prediction of the four-quarter average of the nominal growth proxy, $x_t^1 = \frac{1}{4}\sum_{h=-2}^{1} x_{t+h}$. Even if velocity had been perfectly predicted, variations of the funds rate did not keep pace with Greenbook predicted movements of nominal growth during most of the 1970s.

[30] See a literature review of estimated shifts in trend productivity in Bullard and Duffy (2004).

[31] Goldfeld (1976) indicates that a representative money demand model of the early 1970s generates larger prediction errors, with an out-of-sample RMSE of 6.3 percentage points from 1974Q1 to 1975Q2.

One interpretation of the 1970s is that the FOMC did not believe it had popular support for large increases in the policy rate, vid. DeLong (1997) and Meltzer (2005). This explanation is not consistent with policy actions in mid-1974, when the funds rate was driven near 13%, nor with discussion in the FOMC *Memorandum of Discussion*:

> "Chairman Burns said he might offer his appraisal of the existing support for current Federal Reserve policy. He agreed that support in Congress was strong; he had been receiving almost no critical mail from that source. Of the letters that reached his desk from individuals across the country, a majority were still commendatory." (MOD, 6/18/74, p.62).
>
> "More generally, in his many recent conversations with Congressman he had found widespread acceptance of the need for slow economic growth: they reported their constituents were more anxious about inflation than unemployment." Burns (MOD, 7/16/74, p.34)[32]

Another possible interpretation is that the FOMC may have become disenchanted with intermediate targeting of the monetary aggregates in the mid-1970s. The role of intermediate targets in operational policy was reviewed in the Stage II report of the Subcommittee on the Directive (1976) distributed to FOMC members in early 1976.[33] The initial portion of this report reviewed a staff proposal that the policy instrument, such as the funds rate or nonborrowed reserves, directly target ultimate objectives, such as unemployment and inflation, relegating the money supply to one of many potential indicators of unobserved movements in ultimate objectives. However, the remainder of the report endorsed the two-stage strategy of intermediate targeting with monetary aggregates. FOMC discussion of this report in the 3/15/76 meeting supported a continuation of intermediate targeting:

> "Mr. Wallich added that if optimal control were applied to monetary policy it would tend to focus attention on such ultimate objectives as full employment and price

[32] It might be noted that these real-time quotes differ considerably from the retrospective Per Jacobsson Lecture, often cited by policy historians, where Burns (1979) suggests: "As the Federal Reserve, for example, kept testing and probing the limits of its freedom to undernourish the inflation, it repeatedly evoked violent criticism from both the Executive Branch and the Congress."

[33] The Subcommittee was chaired by Governor Holland, with Governor Wallich, President Balles (Federal Reserve Bank of San Francisco), and President Morris (Federal Reserve Bank of Boston) as members.

stability. However, he had strongly endorsed the Subcommittee's recommendation that monetary policy continue to focus primarily on intermediate objectives, rather than on ultimate objectives....In further discussion individual members of the Subcommittee commented on the reasons why they had not favored directly relating an operational instrument, such as nonborrowed reserves or the federal funds rate, to ultimate objectives. These reasons included the difficulty of linking instrumental variables to ultimate objectives, both intuitively or through use of econometric models; the problem of reaching an agreement on necessary tradeoffs among ultimate objectives; and the complications created by the fact that monetary policy was but one of many influences on the ultimate objectives." (MOD, 3/15/76, p.16)

The FOMC *Memorandum of Discussion* (MOD) suggests several issues that may have contributed to passive responses to nominal growth gaps.

One possibility is that the FOMC may been optimistic about interest rate elasticities, selecting policy rate adjustments that were too small to reverse predicted nominal growth gaps.[34] In particular, two procedures could have led to effective overstatement of interest rate effects:

In framing final voting choices, FOMC members were free to pick policy rates from one Bluebook option and monetary target ranges from another option. The problem of inconsistent choices from an "a la carte menu" was occasionally addressed in Bluebook presentations.

"The blue book can be viewed as a menu of consistent targets....The Committee is, of course, free to choose among the various objectives presented, taking due account of the risks being run. There is the risk, for instance, of choosing incompatible objectives. However, this risk has to be weighed against the probability there will be errors in the staff's estimates of relationships likely to prevail among bank reserves, monetary aggregates, and interest rates." Axilrod, FOMC Economist (MOD, 11/20/72, p.43)

A more direct route to optimistic views of interest rate effects is that projections of interest rates associated with alternative options were judgmentally adjusted by senior staff.

[34]The full system interest rate elasticity of the money supply is necessarily greater than the interest rate elasticity of nominal output if the interest rate elasticity of money demand is also negative.

Especially after staff models began to overpredict M_1 growth in the mid-1970s, there appear to have been nontrivial downward judgmental adjustments of interest rate changes associated with alternative money growth paths.

> "(Mr. Partee) believed that (interest) rates would be especially high if the rate of growth in M1 was at the midpoint of the Committee's long-run range....Actually, the econometric model had yielded still higher rates, but the staff believed the model tended to overstate rate increases." (MOD, 8/19/75, p.58)

> "Mr. Gramley said there was considerable uncertainty about the projections of interest rates, which were among the most difficult variables to project. As Committee members knew, the staff tended to make rather large judgmental adjustments to the interest rate projections produced by the model. In the latest projection,...the model had produced a short-term interest rate in the fourth quarter of 1976 that was 2-3/4 percentage points above the staff's judgementally projected rate." (MOD, 9/16/75, p.25)

> "In view of recent projection errors of the model, the staff had tended to lower the level of interest rates it associated with any assumed rate of monetary growth." Axilrod (MOD, 11/18/75, p.33)

A second interpretation of the effective passivity of policy is that increased uncertainty about properties of empirical money demand functions after the mid-1970s may have induced more cautious policy adjustments.

> "Shortfalls in M1 growth may also reflect a weakening of economic activity relative to staff projections....one option for the Committee to consider is whether it wishes to await somewhat more sustained weakness in M1 before contemplating a policy that permits relatively sizeable interest rate declines." Axilrod, FOMC Associate Economist (MOD, 9/10/74, pp.35)

> "In recent years, the Committee had been focusing more on monetary aggregate targets because of the problems it had experienced earlier with interest rate targets. At present there would be less risk associated with a reduction in interest rates than, say, 2 months ago, both because the aggregates had been falling short of the Committee's targets

and because the economic outlook had weakened considerably. Even so, the precise consequences of a sharp reduction in interest rates remained unclear. Growth in the aggregates would be stepped up substantially, but it is hard to say by how much; and the effects, over time, that the rate reduction would have on expectations and on spending behavior were highly uncertain. To advocate a prompt, sizeable reduction in rates was to ignore all such uncertainties." Partee, FOMC Senior Economist (MOD, 12/17/74, p.71)

"The actual stock of money has been running well short of what either our quarterly or monthly money market models would have predicted for some time, given actual GNP and interest rates....given uncertainties with respect to the meaning of recent money supply behavior as well as still unresolved issues affecting the municipal market, the committee may wish to consider giving somewhat more weight than usual to money market conditions in framing its instructions." Axilrod, FOMC Economist (MOD, 11/18/75, pp.33-5)

"Mr. Volcker said he felt rather strongly that the right approach to policy today was to hold interest rates fairly steady....Mr. Axilrod's remarks, which he had found stimulating and even persuasive, provided a further indication of how little was known about the short-term relationship between interest rates and the money supply." (MOD, 11/18/75, p. 39)

"Mr. Axilrod said he felt highly uncertain about the current projection. In particular, he was not sure whether the demand for money would keep shifting down, stabilize, or shift back up." (MOD, 3/16/76, p. 60)

"(A)n additional element of uncertainty was introduced by the disparity between the projections made by the New York staff and those made by the Board staff for the coming period–with the former showing stronger growth, particularly for M1. Against that background, this did not seem to him to be an appropriate time for a major change in policy.....Turning to the specifications for the Federal funds rate, he favored maintaining the present range and keeping the rate at about its current 4-3/4 per cent level." Volcker (MOD, 3/16/76, pp. 63-4)

Finally, a third conjecture concerning the framing of policy choices is that differences in the underlying relationships and forecast horizons of the short-run policy options of the Bluebook and of the multiperiod predictions of the Greenbook may have made it difficult for FOMC deliberations to connect current policy decisions to longer-run predicted outcomes.[35]

> "Mr. MacLaury remarked that he was disturbed by what he perceived as a lack of clarity in the Committee's methodology. While the Committee now was publicly announcing its longer-term targets, he has less confidence than before in his understanding of the path by which these objectives were to be achieved....it seemed strange for the blue book to state that all of the three alternatives it presented were generally consistent with the 12-month ranges. He believed it made a difference whether the Committee embarked on the path indicated by the high alternative or on that indicated by the low alternative." (MOD, 5/20/75, p.59)

4 Concluding remarks

Recent studies, including Kozicki and Tinsley (forthcoming), indicate that dynamic properties of empirical macro models are often more realistic if allowance is made for differences in perceptions among private and public agents regarding the central bank target for inflation. The current paper provides estimates of the target for inflation implied by empirical policy response functions, where the real-time conditioning information is based on Greenbook briefing forecasts presented before FOMC meetings from the 1970s through the mid-1990s.

In contrast to the assumption of a fixed inflation target, the inflation target constructions not only vary considerably over time but are substantially different from available survey

[35] Judgemental adjustments of interest rates associated with alternative policy options, discussed earlier, were motivated not only by money demand forecast errors in the 1970s but also by differences among competing staff models, such as the monthly money market model used in Bluebook analyses and quarterly models used for Greenbook analyses. "Mr. Gramley replied that the staff's interest rate projections depended on the relationship between growth in money and growth in nominal GNP. Personal income was used only in the monthly model, because no better monthly indicators of aggregate expenditures was available....Mr. Axilrod remarked that recent work done by the Board's staff indicated that in the first year of recovery interest rate projections based on nominal GNP were too high while those based on personal income were too low. In making its interest rate projections for the blue book, the staff had taken those results into account." (MOD, 9/16/75, pp. 32-3) As noted earlier, it is not historically accurate to assume that all judgemental forecast adjustments were confined to intercept adjustments. Kalchbrenner and Tinsley (1977) discuss differences between policy use of auxiliary measurements and use of competing models.

information on the long-horizon inflation expectations of private sector agents.

Regarding the conjecture that US inflation in the 1970s is due largely to central bank overestimation of potential output or, equivalently, underestimation of the natural rate of unemployment, there is little evidence that policy responses in the 1970s were directed at central bank perceptions of expected levels of the unemployment rate and the natural rate of unemployment.

Of two leading empirical interpretations of the Great Inflation, the *passive policy* description is perhaps the most optimistic, as empirical analyses of historical US monetary policy generally indicate stable policy responses have been maintained since the 1980s. The *natural rate error* description has a seductive appeal for central banks for it suggests that unlucky mistakes were made, but carries also the pessimistic inference that these mistakes will likely occur in the future. The empirical evidence presented in section 3 indicates that monetary policy in the 1970s is better represented by money growth intermediate targeting. This implies that US central bank errors in estimating natural rate gaps for output or the unemployment rate are largely irrelevant to explanations of the Great Inflation.

The empirical evidence in section 3 also supports the passive policy interpretation, as adjustments of the central bank policy rate in the 1970s were not sufficiently vigorous to result in stable responses to movements in inflation. However, the passive policy interpretation is merely a description of unstable policy, not an explanation. A description of the Great Inflation based on intermediate targeting of money supply growth offers a neglected search area for explanations of passive policy responses.

Given the advantage of hindsight, there will always be mistakes in the execution of monetary policy, including errors in estimating current values of conditional equilibria or natural rates. Perhaps the deeper flaw of intermediate targeting in the 1970s is that it obscured the ultimate objectives of policy by shifting the official gauge of policy performance from inflation and economic activity to the growth rate of the money supply. Empirical results in this paper support the assessment of Milton Friedman (2003): "The use of the quantity of money as a target has not been a success."

Appendix: Specifications of time-varying coefficients

The effective measurement equation for the policy response equations is

$$\begin{aligned} y_t &= \Xi_t \vec{\beta}_t + a_t, \\ &= [\tilde{X}_t, X_t] \begin{bmatrix} \tilde{\beta}_t \\ \bar{\beta} \end{bmatrix} + a_t \end{aligned} \tag{10}$$

where the vector y_t contains policy interest rates set at FOMC meetings that reference Greenbooks generated in quarter t. The matrix of regressors, $[\tilde{X}_t, X_t]$, conforms to the dimensions of y_t and the parameter vector, $\vec{\beta}_t$. The matrix X_t contains a unit column vector, in addition to Greenbook observations on $k-1$ regressors. The $\vec{\beta}_t$ vector is partitioned into a $k \times 1$ fixed vector, $\bar{\beta}$, and a $\tilde{k} \times 1$ time-varying vector of deviations, $\tilde{\beta}_t$, whose unconditional mean is zero. The effective time-varying coefficients of the forecast model, β_t, are obtained by summing the fixed and time-varying deviation vectors

$$\beta_t \equiv \bar{\beta} + \begin{bmatrix} \tilde{\beta}_t \\ 0_{k-\tilde{k}} \end{bmatrix}, \tag{11}$$

where $0_{k-\tilde{k}}$ is a $(k-\tilde{k}) \times 1$ zero vector. Note that $\tilde{k} < k$ if the last $k-\tilde{k}$ elements of β_t are invariant over time.[36] The measurement error is normally distributed, $a_t \sim N(0, R_t)$, where $R_t \equiv \sigma_a^2 I$.

The format of the *transition* equation is

$$\vec{\beta}_t = \Phi \vec{\beta}_{t-1} + e_t, \tag{12}$$

where the partitions of the transition matrix and the transition shock vector are

$$\Phi = \begin{bmatrix} \tilde{\Phi} & 0 \\ 0 & I_k \end{bmatrix}, \text{ and } e_t = \begin{bmatrix} \tilde{e}_t \\ 0 \end{bmatrix}. \tag{13}$$

The nonzero transition shocks are also normally distributed, $\tilde{e}_t \sim N(0, \tilde{Q}_t)$.

Empirical results tabulated in this paper use three different specifications of time-varying parameter (tvp) models. Each has appeared in the macro literature, and each amounts to different restrictions on the dimension of the time-varying partition, $\tilde{\beta}_t$, and on the eigenvalues of the associated transition matrix, $\tilde{\Phi}$:

- random walk intercept (RWI).
- random walk coefficients (RWC)
- stationary coefficients (SC).

[36] The matrix $\tilde{X}_t$ is a subset of X_t when $\tilde{k} < k$.

The first specification captures variations in the implied inflation target through a random walk intercept. Estimation of the random walk intercept specification uses the Stock-Watson (1998) median unbiased estimator of the variance of the shocks driving the random walk, $\nu^2\sigma_u^2$, where u denotes residuals of the fixed coefficient regression, $y_\tau = X_\tau\bar{\beta}$.[37] Although means and sampling errors are estimated for the remaining regression coefficients, $\bar{\beta}_i, i = 2, \ldots, k$, the fixed partition of the random walk intercept is the initial condition, $\beta_{1,t_0} = \bar{\beta}_1$. To provide an approximate comparison with estimates of mean coefficients from alternative specifications, the finite sample average of the random walk intercept estimates is reported as the mean of estimates over the T-period sample, $\hat{\bar{\beta}}_1 \equiv \frac{1}{T}\sum_{t=1}^{T}\hat{\beta}_{1,t}$, along with the standard deviation of this finite sample average.

Because modest changes in the response to inflation can imply much larger variations in the implied inflation target, the second specification extends the random walk description to all unrestricted coefficients in the policy response equation, using the estimator developed by Boivin (forthcoming).

Finally, the stationary coefficients specification assumes variation in coefficients can be represented by a mean-reverting, first-order VAR, estimated by maximum likelihood. In the case of stationary parameters, the steady-state variance of the dependent variable due to variation in β is

$$\mathrm{var}(y) \quad = \quad \tilde{X}V(\beta)\tilde{X}',$$

where elements of the $\tilde{k} \times \tilde{k}$ steady-state covariance of the stationary parameters, $V(\beta)$, can be recovered from the column stack

$$\mathrm{vec}V(\beta) \quad = \quad [I_{\tilde{k}^2} - \tilde{\Phi} \otimes \tilde{\Phi}]^{-1}\mathrm{vec}\tilde{Q}.$$

A steady-state variance decomposition is reported for the stationary coefficient specification, where[38]

$$\mathrm{vardecom}(\beta_j) \quad \equiv \quad \frac{100}{\mathrm{var}(y)}[\tilde{X}_j^2 V_{jj} + \frac{1}{2}\sum_{i \neq j}\tilde{X}_i\tilde{X}_j V_{ij}]. \tag{14}$$

Estimation of the three specifications is discussed in Kozicki and Tinsley (2005).

[37] $\nu = \frac{\lambda}{T}$, where the probability of a zero pileup by maximum likelihood varies inversely with the local-to-zero parameter, λ, vid. Stock and Watson (1998, Table 1).

[38] Equation (14) assigns half of the covariance, V_{ij}, to β_i and β_j, following Swamy and Tinsley (1980). Consequently, some elements of the variance decomposition may be negative under this convention.

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Table 1: Alternative estimates of unemployment natural rates (%)

policy regime	natural rate source			
	CBO (2004)	Romer & Romer (2002)	$\bar{u}_t^b$ [1]	$\bar{u}_t$ [2]
Burns$_1$ 70Q1-75Q2	6.0	3.1	3.9	5.2
Burns$_2$ 75Q3-78Q1	6.2	8.2	4.3	5.3
Miller 78Q2-79Q2	6.3	4.6	4.3	5.3
Volcker 79Q3-87Q2	6.1	8.0	5.4	5.6
Greenspan$_1$ 87Q3-96Q4	5.7	6.7	5.7	6.2
Greenspan$_2$ 96Q1-97Q4	5.2	n.a.	5.0	5.6

1. Implied by a Phillips equation with backwards-looking inflation expectations, using Greenbook forecasts of inflation and unemployment, Kozicki & Tinsley (2005).
2. Implied by a Phillips equation with both backwards- and forward-looking inflation expectations, using Greenbook forecasts, vid. Kozicki and Tinsley (2005).

Table 2: Federal Funds Rate Policy Rule,
full sample [1]

$$
\begin{aligned}
r_t^* &= \bar{\rho}_t + \bar{\pi}_t + c_{2,t}(\pi_t^k - \bar{\pi}_t) + c_{3,t}(u_{t+1} - \bar{u}_t) + c_{4,t}\Delta u_t, \\
r_t &= (1 - \beta_{6,t})r_t^* + \beta_{5,t}\Delta r_{t-1} + \beta_{6,t} r_{t-1} + a_t, \\
&= \beta_{1,t} + \beta_{2,t}\pi_t^k + \beta_{3,t}(u_{t+1} - \bar{u}_t) + \beta_{4,t}\Delta u_t + \beta_{5,t}\Delta r_{t-1} + \beta_{6,t}(r_{t-1} - \bar{\rho}_t) + \bar{\rho}_t + a_t, \\
\bar{\pi}_t &= -\beta_{1,t}/(\beta_{2,t} + \beta_{6,t} - 1).
\end{aligned}
$$

tvp format	estimated $\bar{\beta}_i$ [2]						estimated $\bar{\pi}_t$	
	$\bar{u}_t$, preferred estimate[3]							
	$\bar{\beta}_1$	$\bar{\beta}_2$	$\bar{\beta}_3$	$\bar{\beta}_4$	$\bar{\beta}_5$	$\bar{\beta}_6$	max	min
random walk	-.002	.149	-.081	-.269	.428	.866	5.6	-4.2
intercept	[.99]	[.00]	[.00]	[.00]	[.00]	[.00]		
random walk	-.110	.207	-.084	-.345	.400	.835	805.0	-171.8
coefficients	[.80]	[.36]	[.51]	[.61]	[.45]	[.00]		
stationary	-.150	.249	-.099	-.362	.400	.806	28.0	-30.0
coefficients	[.07]	[.00]	[.00]	[.00]	[.00]	[.00]		
(var decomp %)	8	49	1	0	0	42		
	$\bar{u}_t^b$, lower bound estimate[3]							
	$\bar{\beta}_1$	$\bar{\beta}_2$	$\bar{\beta}_3$	$\bar{\beta}_4$	$\bar{\beta}_5$	$\bar{\beta}_6$	max	min
random walk	.009	.141	-.061	-.260	.435	.876	5.2	- 6.0
intercept	[.95]	[.00]	[.00]	[.00]	[.00]	[.00]		
random walk	-.083	.199	-.066	-.305	.396	.844	5.1	-50.7
coefficients	[.87]	[.28]	[.43]	[.62]	[.49]	[.00]		
stationary	-.096	.182	-.055	-.283	.412	.859	63.7	-77.1
coefficients	[.21]	[.00]	[.01]	[.00]	[.00]	[.00]		
(var decomp %)	8	45	1	0	0	46		

1. sample 1969Q1-1997Q4; $r-$ avg federal funds rate in FOMC meeting-to-meeting intervals; u - GB unemployment rate forecast; π^k - GB annualized inflation, averaged over the forecast periods, h = -2, -1, 0, 1; k = 1.

2. [.] - p-values; $\bar{\beta}_i-$ sample average of $\beta_{i,t}$ for random walk specifications.

3. See footnotes of Table 1.

Table 3: Federal Funds Rate Policy Rule
Burns/Miller sample [1]

$$
\begin{aligned}
r_t^* &= \bar{\rho}_t + \bar{\pi}_t + c_{2,t}(\pi_t^k - \bar{\pi}_t) + c_{3,t}(u_{t+1} - \bar{u}_t) + c_{4,t}\Delta u_t, \\
r_t &= (1 - \beta_{6,t})r_t^* + \beta_{5,t}\Delta r_{t-1} + \beta_{6,t} r_{t-1} + a_t, \\
&= \beta_{1,t} + \beta_{2,t}\pi_t^k + \beta_{3,t}(u_{t+1} - \bar{u}_t) + \beta_{4,t}\Delta u_t + \beta_{5,t}\Delta r_{t-1} + \beta_{6,t}(r_{t-1} - \bar{\rho}_t) + \bar{\rho}_t + a_t, \\
\bar{\pi}_t &= -\beta_{1,t}/(\beta_{2,t} + \beta_{6,t} - 1).
\end{aligned}
$$

tvp format	estimated $\bar{\beta}_i$ [2]						estimated $\bar{\pi}_t$	
	$\bar{\beta}_1$	$\bar{\beta}_2$	$\bar{\beta}_3$	$\bar{\beta}_4$	$\bar{\beta}_5$	$\bar{\beta}_6$	max	min
random walk	.025	.116	-.067	-.229	.532	.893	-.10	-3.7
intercept	[.60]	[.01]	[.09]	[.03]	[.00]	[.00]		
random walk	.052	.132	-.081	-.240	.521	.879	193	-207
coefficients	[.77]	[.01]	[.06]	[.08]	[.00]	[.00]		
stationary	.017	.120	-.066	-.242	.523	.891	1.1	-9.0
coefficients	[.90]	[.01]	[.11]	[.03]	[.00]	[.00]		
(var decomp %)	17	42	1	0	0	40		
random walk	.148	.076	-.057		.604	.908	10.7	6.1
intercept	[.00]	[.07]	[.20]		[.00]	[.00]		
random walk	.166	.084	-.058		.584	.899	21.6	8.4
coefficients	[.38]	[.08]	[.17]		[.00]	[.00]		
stationary	.111	.081	-.048		.606	.908	15.6	8.2
coefficients	[.41]	[.06]	[.24]		[.00]	[.00]		
(var decomp %)	23	37	1		0	38		
random walk	.049	.073		-.208	.551	.920	9.7	6.5
intercept	[.31]	[.04]		[.04]	[.00]	[.00]		
random walk	.070	.078		-.204	.545	.914	287	- 16.8
coefficients	[.61]	[.01]		[.01]	[.00]	[.00]		
stationary	.045	.075		-.209	.545	.920	14.8	6.7
coefficients	[.74]	[.04]		[.05]	[.00]	[.00]		
(var decomp %)	19	38		0	0	42		

1. sample 1970Q1-1979Q2; $r-$ avg federal funds rate in FOMC meeting-to-meeting intervals; π^k - GB annualized inflation forecasts, averaged over the forecast periods, h = -2, -1, 0,1; k =1.

2. [.] - p-values; $\bar{\beta}_i-$ sample average of $\beta_{i,t}$ for random walk specifications.

Table 4: Federal Funds Rate Policy Rule,
Volcker/Greenspan sample [1]

$$
\begin{aligned}
r_t^* &= \bar{\rho}_t + \bar{\pi}_t + c_{2,t}(\pi_t^k - \bar{\pi}_t) + c_{3,t}(u_{t+k} - \bar{u}_t) + c_{4,t}\Delta u_t, \\
r_t &= (1-\beta_{6,t})r_t^* + \beta_{5,t}\Delta r_{t-1} + \beta_{6,t} r_{t-1} + a_t, \\
&= \beta_{1,t} + \beta_{2,t}\pi_t^k + \beta_{3,t}(u_{t+k} - \bar{u}_t) + \beta_{4,t}\Delta u_t + \beta_{5,t}\Delta r_{t-1} + \beta_{6,t}(r_{t-1} - \bar{\rho}_t) + \bar{\rho}_t + a_t, \\
\bar{\pi}_t &= -\beta_{1,t}/(\beta_{2,t} + \beta_{6,t} - 1).
\end{aligned}
$$

tvp format	estimated $\bar{\beta}_i$ [2]						estimated $\bar{\pi}_t$	
	π^k - GB forecast average, h = -2, -1, 0,1; k = 1.							
	$\bar{\beta}_1$	$\bar{\beta}_2$	$\bar{\beta}_3$	$\bar{\beta}_4$	$\bar{\beta}_5$	$\bar{\beta}_6$	max	min
random walk	-.159	.222	-.073	-.296	.364	.833	3.5	2.2
intercept	[.05]	[.00]	[.01]	[.01]	[.00]	[.00]		
random walk	-.170	.234	-.074	-.336	.377	.817	6.3	-31.9
coefficients	[.47]	[.04]	[.11]	[.43]	[.07]	[.00]		
stationary	-.154	.229	-.066	-.286	.406	.819	3.4	3.1
coefficients	[.20]	[.02]	[.03]	[.09]	[.00]	[.00]		
(var decomp %)	5	58	0	0	0	37		
	π^k - GB forecast average, h = 0,1,2,3; k = 3.							
	$\bar{\beta}_1$	$\bar{\beta}_2$	$\bar{\beta}_3$	$\bar{\beta}_4$	$\bar{\beta}_5$	$\bar{\beta}_6$	max	min
random walk	-.205	.214	-.050	-.237	.361	.845	4.0	2.7
intercept	[.02]	[.00]	[.08]	[.04]	[.00]	[.00]		
random walk	-.165	.203	-.046	-.285	.361	.838	69.9	-39.8
coefficients	[.49]	[.02]	[.23]	[.40]	[.07]	[.00]		
stationary	-.149	.194	-.049	-.273	.371	.846	4.0	3.5
coefficients	[.19]	[.00]	[.06]	[.03]	[.00]	[.00]		
(var decomp %)	14	37	1	0	0	48		

1. sample 1979Q3-1997Q4; $r-$ avg federal funds rate in FOMC meeting-to-meeting intervals; $\bar{u}_t-$ tvp average expectations.

2. [.] - p-values; $\bar{\beta}_i-$ sample average of $\beta_{i,t}$ for random walk specifications.

Table 5: Federal Funds Rate Policy Rule,
Burns/Miller sample: money growth targeting [1]

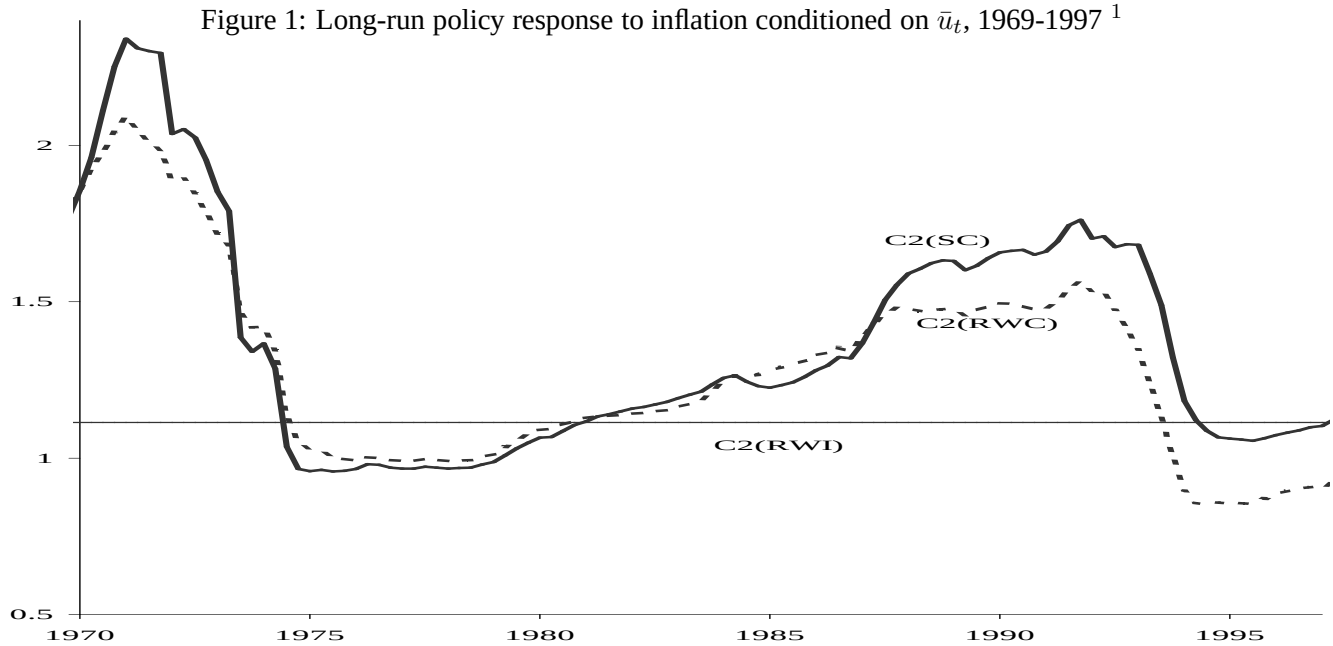
$$
\begin{aligned}
r_t^* &= \bar{\rho}_t + \bar{\pi}_t + c_{2,t}(x_t^k - \bar{x}_t) + c_{3,t}(u_{t+1} - \bar{u}_t) + c_{4,t}\Delta u_t^k, \\
x_t^k - \bar{x}_t &= \pi_t^k - \bar{\pi}_t - a'\Delta u_t^k, \\
r_t &= (1-\beta_{6,t})r_t^* + \beta_{5,t}\Delta r_{t-1} + \beta_{6,t} r_{t-1} + a_t, \\
&= \beta_{1,t} + \beta_{2,t}x_t^k + \beta_{3,t}(u_{t+k} - \bar{u}_t) + \beta_{4,t}\Delta u_t^k + \beta_{5,t}\Delta r_{t-1} + \beta_{6,t}(r_{t-1} - \bar{\rho}_t) + \bar{\rho}_t + a_t, \\
\bar{\pi}_t &= -\beta_{1,t}/(\beta_{2,t} + \beta_{6,t} - 1).
\end{aligned}
$$

tvp format	estimated $\bar{\beta}_i$ [2]						estimated $\bar{\pi}_t$	
	$\bar{\beta}_1$	$\bar{\beta}_2$	$\bar{\beta}_3$	$\bar{\beta}_4$	$\bar{\beta}_5$	$\bar{\beta}_6$	max	min
random walk	.156	.037	-.008		.518	.942	7.5	6.3
intercept	[.00]	[.03]	[.80]		[.00]	[.00]		
random walk	.189	.039	-.018		.499	.936	8.5	7.0
coefficients	[.23]	[.07]	[.67]		[.00]	[.00]		
stationary	.149	.040	-.009		.509	.940	7.8	6.8
coefficients	[.21]	[.02]	[.78]		[.00]	[.00]		
(var decomp %)	30	11	2		0	56		
random walk	.024	.093		.114	.557	.906	27.1	9.4
intercept	[.61]	[.02]		[.12]	[.00]	[.00]		
random walk	.040	.102		.130	.540	.894	360	-27
coefficients	[.82]	[.03]		[.19]	[.00]	[.00]		
stationary	.037	.092		.114	.545	.904	118	7.4
coefficients	[.78]	[.02]		[.13]	[.00]	[.00]		
(var decomp %)	16	33		0	0	51		
random walk	.146	.037			.523	.941	7.1	6.1
intercept	[.00]	[.03]			[.00]	[.00]		
random walk	.169	.038			.511	.937	7.6	6.4
coefficients	[.27]	[.07]			[.00]	[.00]		
stationary	.142	.038			.515	.940	7.2	6.5
coefficients	[.21]	[.02]			[.00]	[.00]		
(var decomp %)	32	10			0	58		

1. sample 1970Q1-1979Q2; $r-$ avg federal funds rate in FOMC meeting-to-meeting intervals; $\pi^k, \Delta u^k$ - GB annualized forecasts, averaged over the forecast periods, $h = -2, -1, 0, 1; k = 1$.

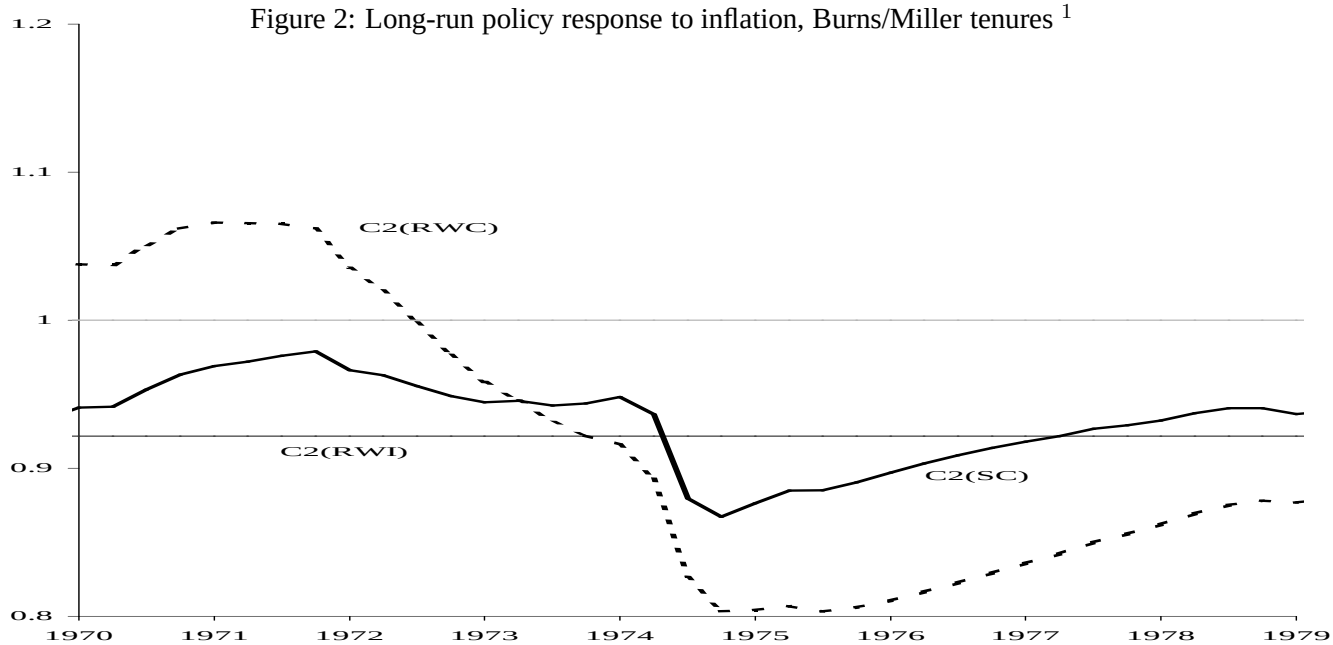
2. [.] - p-values; $\bar{\beta}_i-$ sample average of $\beta_{i,t}$ for random walk specifications.

Figure 1: Long-run policy response to inflation conditioned on $\bar{u}_t$, 1969-1997 [1]



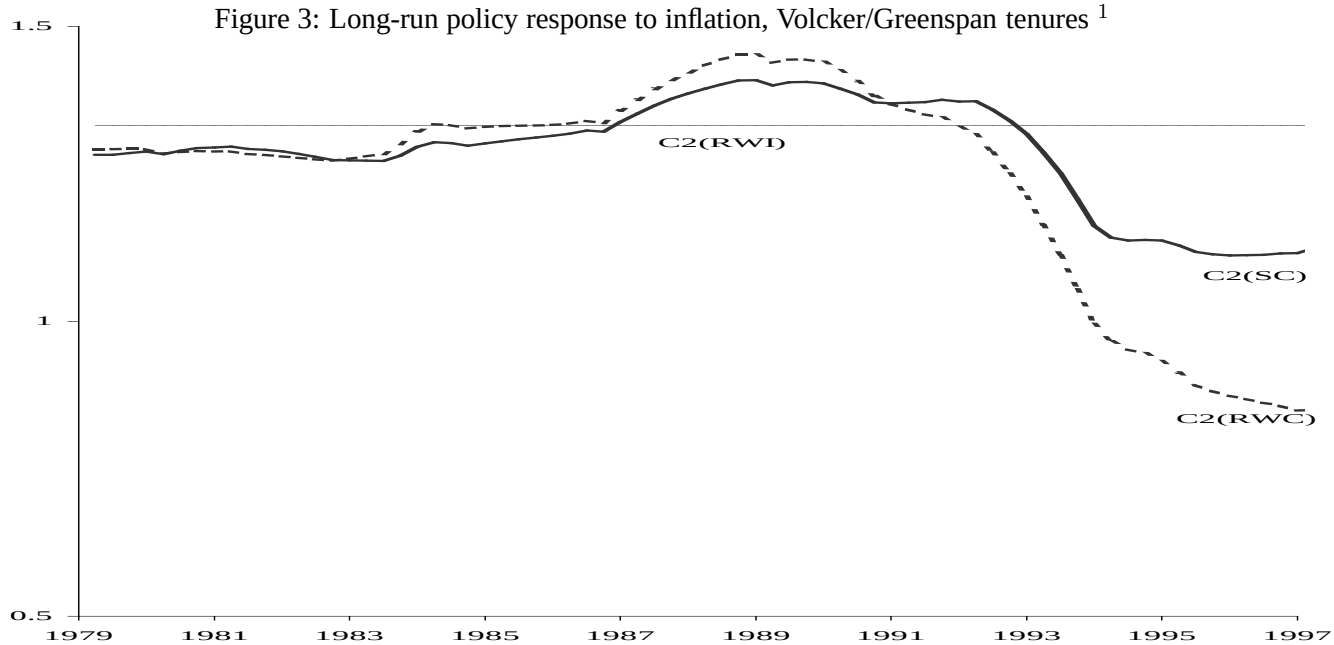
1. Coefficients from specifications in top panel of Table 2, using the natural rate, $\bar{u}_t$.
   C2(RWI) - $c_{2,t}$ from random walk intercept specification, RWI.
   C2(RWC) - $c_{2,t}$ from random walk coefficients specification, RWC.
   C2(SC) - $c_{2,t}$ from stationary coefficients specification, SC.

Figure 2: Long-run policy response to inflation, Burns/Miller tenures [1]



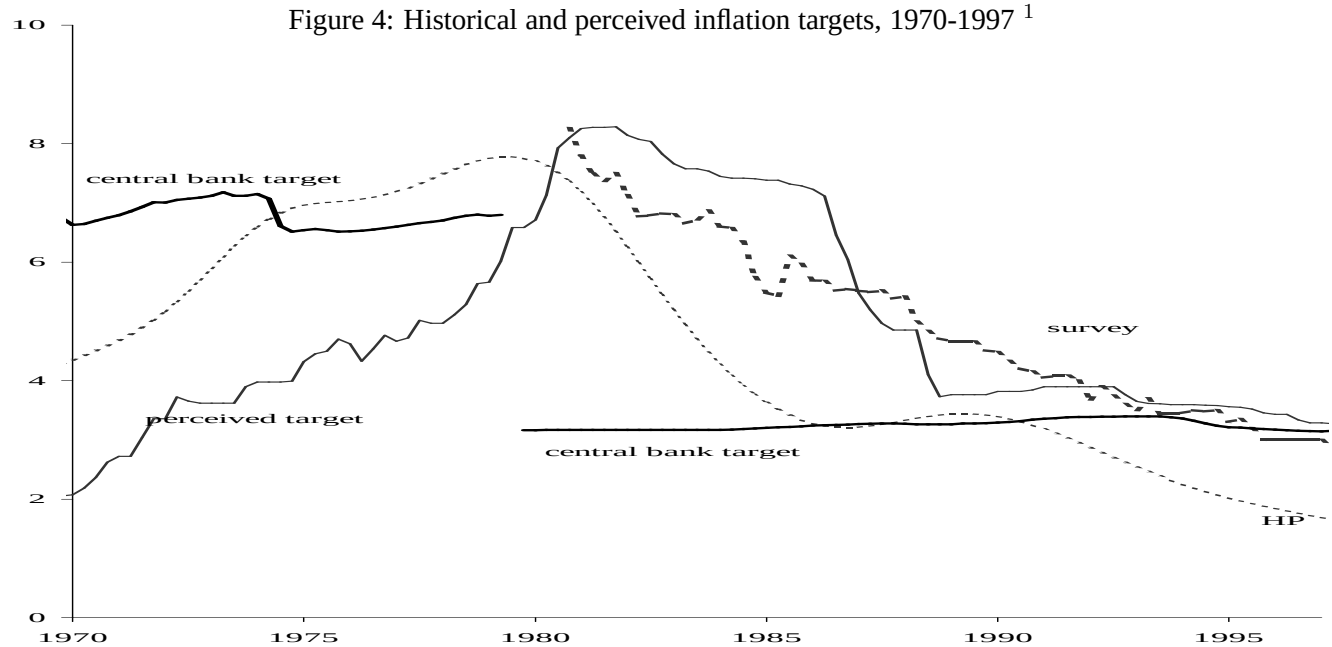
1. Coefficients from specifications in the bottom panel of Table 3.
   C2(RWI) - $c_{2,t}$ from random walk intercept specification, RWI.
   C2(RWC) - $c_{2,t}$ from random walk coefficients specification, RWC.
   C2(SC) - $c_{2,t}$ from stationary coefficients specification, SC.

Figure 3: Long-run policy response to inflation, Volcker/Greenspan tenures [1]



1. Coefficients from specifications in the top panel of Table 4.
   C2(RWI) - $c_{2,t}$ from random walk intercept specification, RWI.
   C2(RWC) - $c_{2,t}$ from random walk coefficients specification, RWC.
   C2(SC) - $c_{2,t}$ from stationary coefficients specification, SC.

Figure 4: Historical and perceived inflation targets, 1970-1997 [1]



1. Central bank target - $\bar{\pi}_t$ implied by SC specification: bottom panel of Table 5 for Burns/Miller sample and top panel of Table 4 for Volcker/Greenspan sample.
   Perceived target - private sector perception, $\bar{\pi}_t^p$, from Kozicki and Tinsley (2001).
   Survey - Hoey survey of 5-10 year expected inflation (see text).
   HP - HP filter of real-time inflation.

Figure 5: Federal funds rate and FOMC tolerance ranges, Burns/Miller tenures

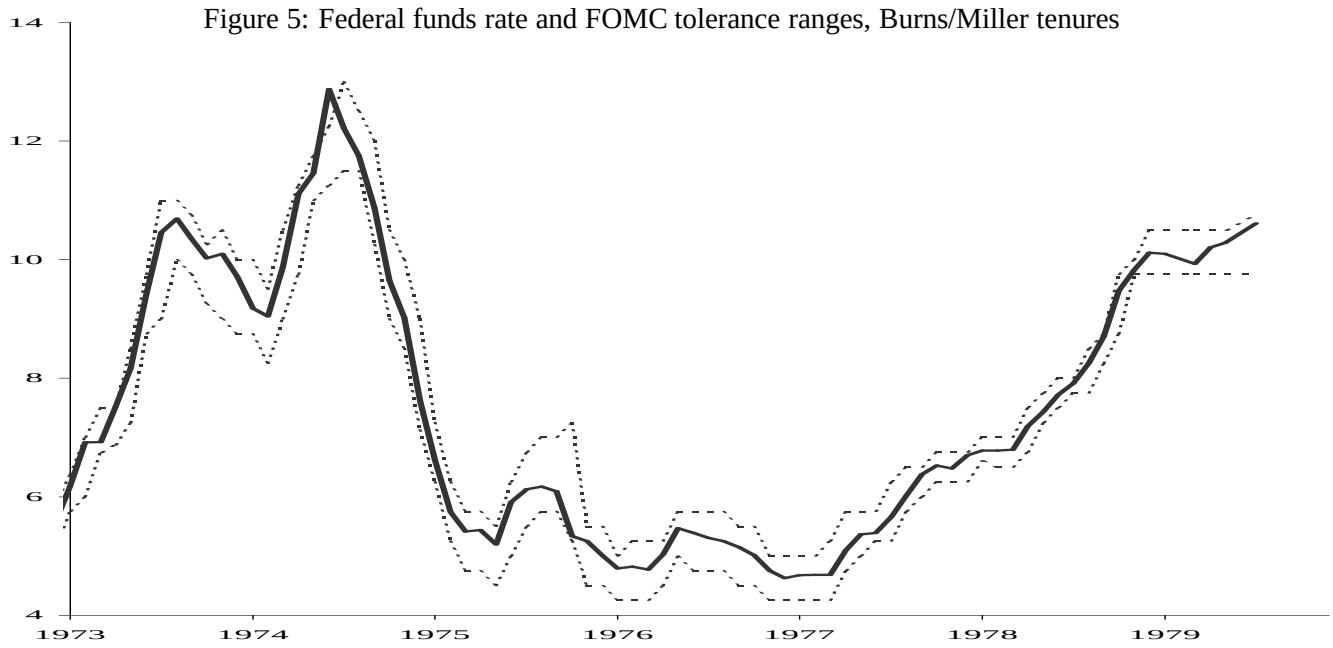
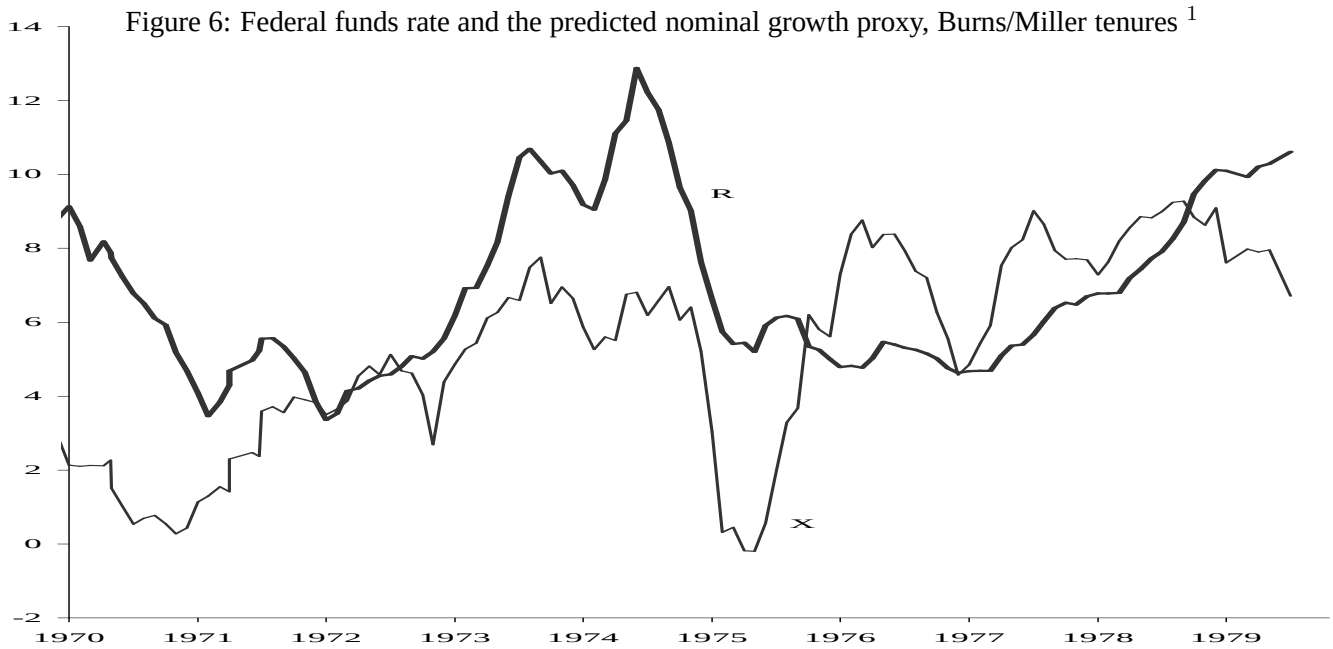


Figure 6: Federal funds rate and the predicted nominal growth proxy, Burns/Miller tenures [1]



1. R - Federal funds rate; X - 4-qtr avg of the predicted nominal growth proxy, using Greenbook estimates for forecast periods, $h = -2, -1, 0, 1$; (see text).