The Decline of Activist Stabilization Policy: Natural Rate Misperceptions, Learning, and Expectations

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Abstract

Natural rate misperceptions generated the potential of significant upward inflationary pressure in the late 1960s and 1970s. With the activist stabilization policy in place during this period, these misperceptions led to a series of persistent policy errors that inadvertently destabilized the economy and inflation expectations. We develop a model that highlights the interaction of these policy errors with an endogenous expectations formation process as the origin of the stagflationary episode of the 1970s. The experience of unexpectedly rising inflation in the late 1960s and early 1970s led agents to modify their views of the behavior of monetary policy and the economy, unmooring inflation expectations and significantly worsening policy options. The interaction of policy mistakes and learning turned what could have been a relatively mild inflationary episode into stagflation. By contrast, adoption of policies that downplay the activist pursuit of employment and output gaps would have avoided this outcome. We argue that out of the experience of the 1970s policymakers eschewed activist policies in favor of policies that concentrated on the achievement of price stability, resulting in the improved macroeconomic performance of the U.S. economy since the Great Inflation.

Keywords: Monetary policy, stagflation, rational expectations, learning.

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1 Introduction

The distinguishing feature of the "New Economics" of the 1960s was the adoption of activist policies aiming to achieve full employment of economic resources with great precision. By actively managing aggregate demand so as to counteract any shortfalls or excesses relative to the economy's potential, this new approach to policy promised to dampen the business cycle, if not entirely eliminate it from the economic lexicon, achieving the holy grail of macroeconomic policy—sustained prosperity with price stability. Conceptually, the "New Economics" reflected the natural outgrowth of advances in quantitative methods and modeling that finally permitted replacement of the crude macroeconomic policies of earlier eras with the more finely tuned regulators that knowledge of optimal control methods could yield.[1] As Walter Heller pointed out in 1966:

> The promise of modern economic policy, managed with an eye to maintaining prosperity, subduing inflation, and raising the quality of life, is indeed great. And although we have made no startling conceptual breakthroughs in economics in recent years, we *have*, more effectively than ever before, harnessed the existing economics—the economics that has been taught in the nation's college classrooms for some twenty years—to the purposes of prosperity, stability, and growth. (Heller, 1966, p. 116, emphasis in the original.)

The "New Economics" was practiced with apparent success during the first half of the 1960s. But this success did not last. In the second half of that same decade prosperity came not with price stability but at the cost of rising and largely unexpected inflation (Figure 1). Worse, the prosperity of the 1960s was soon to be overshadowed by macroeconomic instability and the malaise of stagflation that followed in the 1970s. With inflation spiraling seemingly out of control, by the end of the decade monetary policymakers appeared to change course, apparently eschewing the finely tuned methods of managing aggregate demand and concentrating instead on achieving and maintaining price stability. Then, following the costly disinflation in the early 1980s, in another reversal of fortune, a period of growth and relative stability returned once again.

[1] See Heller (1966), Tobin (1966, 1972) and Okun (1970) for discussions of the ideas associated with the "New Economics" of the 1960s. Application of control methods for macroeconomic stabilization had been discussed at least as early as Lerner (1944), and formalized by Phillips (1954). Friedman's (1947) review of Lerner (1944) offers an early critique of the application of these methods for macroeconomic stabilization.

We argue that the interaction of natural rate misperceptions, activist policy, and the evolution of inflation expectations explain these reversals in macroeconomic fortune over the past four decades. The dismal experience of the 1970s led to a fundamental reevaluation of the nature of expectations and the benefits of activist policies, resulting in a shift to less reliance on activist management in the early 1980s.

The first ingredient in the recipe for disaster was misperceptions regarding the natural rate of unemployment combined with an activist approach to policy. Policymakers were far too optimistic, in retrospect, of how low the unemployment rate could go before igniting inflation pressures. Given the activist bent of policymakers in the 1960s and 1970s, such natural rate misperceptions generated the potential for instability and significant upward inflationary pressure, as argued by Orphanides (2002, 2003a,b, forthcoming) and Orphanides and Williams (2002).

The second ingredient, which has received less attention in the literature, is the adaptive evolution of the formation of expectations in an environment of overly stimulative monetary policy and rising inflation. The period of the 1960s was one of policy experimentation that arguably contributed to public confusion regarding the behavior of the economy and the Federal Reserve's objectives. Expectations formation, which had been well anchored during the previous decade of price stability, evolved in response to economic developments, exacerbating the direct effects of the policy errors.

Building on these ideas, we develop a model that highlights the interaction of policy errors due to natural rate misperceptions with an endogenous expectations formation process as the origin of the stagflationary episode of the 1970s. The model offers an accounting of history as well as a framework that allows counterfactual historical experiments which permits us to investigate the likely outcomes that would have resulted had alternative policies been pursued over time.

Our approach highlights the role of imperfect knowledge of the precise structure of the economy and the policymakers' preferences on the part of economic agents and the implications of this imperfect knowledge for the formation of expectations. With imperfect knowledge, economic agents are engaged in perpetual learning of the economic environment and the expectations formation process in the economy is constantly evolving. As argued by Orphanides and Williams (2003, forthcoming) the presence of such learning increases the sensitivity of inflation expectations to policy errors, complicating policymaker efforts to stabilize economic activity in subtle ways that may be overlooked in the policy design process. Indeed, if policy errors are sufficiently persistent, a risk arises that inflation and the inflation expectations process may be destabilized, imparting potentially substantial, though likely unforeseen and certainly unintended, costs upon the economy.

During the early part of the 1960s, policymakers faced a very favorable inflation expectations process. Inflation appeared well anchored and expectations that an environment of low and stable inflation would persist appeared well entrenched in the public psyche. This environment could be largely attributed to the greater emphasis on price stability relative to economic stabilization before the decade of the 1960s.[2] But with the "New Economics" of the 1960s and, in particular, the experience of rising inflation in the late 1960s and early 1970s, agents gradually modified their views of the behavior of inflation. Expectations of inflation rose and became more persistent, worsening policy options. Policymakers, however, initially attributed this deterioration to exogenous factors. The detrimental effect of activist stabilization policy on the inflation expectations process was only understood later in the 1970s, and not before expectations had already become unmoored. This interaction of policy mistakes and learning turned what could have otherwise been a relatively mild inflationary episode, into stagflation.

Recognition of this mistake towards the end of the 1970s provided the impetus that eventually led to the drastic change in U.S. monetary policy during 1979. Already in 1978, *before* he became Chairman of the Federal Reserve Board, Paul Volcker alluded to the nature of the required change:

> Wider recognition of the limits on the ability of demand management to keep the economy at a steady full employment path, especially when expectations are hypersensitive to the threat of more inflation, provides a more realistic starting point for policy formulation. (1978 p. 61.)

And during the early stages of the disinflation pursued following the 1979 policy change, Chairman Volcker often stressed the importance of policies anchoring inflation expectations. Our model helps explain this evolution in the understanding of the role of monetary policy

[2]See Romer and Romer (2002) and Orphanides (2003c) for discussions highlighting some underappreciated positive aspects of the policy environment during this period.

and the critical nature of maintaining well anchored inflation expectations as a means for ensuring long-term economic stability.

2 Natural Rate Misperceptions and Policy Activism

The main difficulty with activist stabilization policy is that it requires an accurate assessment of the economy's "natural" rate of employment (and output)—which by definition corresponds to the economy's long-run non-inflationary potential. The success of activist stabilization policy rests on the assumption that the natural rate can serve as a useful policy target. Under that assumption, adjusting aggregate demand relative to the economy's natural rate becomes the focus of short-term stabilization policy. Many of the policy errors associated with the Great Inflation can be traced to the activist pursuit of a perceived natural rate that retrospectively proved overambitious. Figure 2 plots the rate of unemployment in the U.S. economy since the end of 1965 (the beginning of the Great Inflation) against two measures of the natural rates, a real-time measure reflecting perceptions as of the time shown, and a retrospective measure, reflecting a current estimate. (Additional details on these series are provided below). Consider the policy error of the early 1970s. With unemployment rising during and after the recession that started at the end of 1969, and in light of available estimates of the natural rate of unemployment, policymakers could have reasonably held the view that the economy was operating with considerable slack. The activist policy prescription at the time was clear cut. Additional monetary expansion should have been pursued to stabilize the economy. Moreover, inflation should have gradually fallen during the expansion so that even with the policy of monetary ease some welcome disinflation ought to have been expected. Indeed, such a policy was pursued at the time. But based on the retrospective estimates of the natural rate, it is now clear that that policy prescription represented a large error. The economic expansion pursued in 1971-73 pushed aggregate demand far above the economy's potential, as this is currently understood, generating economic instability and fueling an acceleration in inflation. A similar error was to be repeated later in the decade, following the 1975 recession, contributing to more instability, and further fueling the inflationary process.

The fundamental problem plaguing the activist approach to stabilization policy is that all too frequently not only the size of the gap in economic activity relative to the natural rate is hard to assess when decisions must be made but even the sign of the gap retrospectively proves to have been incorrect.[3] Comparison of the real-time perceptions likely held by policymakers at the time and our best current measures of the natural rate, then, provide a summary indicator of the potential policy errors that may be committed when an activist approach to stabilization policy is pursued.

For the purposes of our analysis, we take the current Congressional Budget Office (CBO) (2001, 2002) estimates of the natural rate of unemployment as truth. We construct a real-time series for the natural rate based on historical documents. The top panel of Figure 3 shows the current CBO estimates of the natural rate of unemployment from 1965 through 2003, as well as our baseline series of real-time estimates. We construct this baseline real-time estimate guided by written documents that offer glimpses of the thinking of policymakers of the 1960s and 1970s. During the 1960s, 4 percent was widely accepted as a reasonable working definition of the full employment rate of unemployment, a goal that was believed feasible consistent with price stability. Recollections of key policymakers of that period, including Walter Heller, Arthur Okun and Herbert Stein, who served as members and chairs of the Council of Economic Advisers in the 1960s and early 1970s, as well as Federal Reserve Chairman Arthur Burns serve as evidence of the wide acceptance of that estimate.[4] During the 1970s, estimates of the natural rate rose, as seen in published accounts of Federal Reserve Board model exercises and estimates by the Council of Economic Advisers reported in the *Economic Report of the President.* We do not have precise information for the evolution of real-time perceptions of the natural rate of unemployment for the early 1970s but do know that many estimates rose during that period, as reflected in various policy-related studies.[5] From the late 1970s to the present, the CBO has regularly reported explicitly or implicitly, its estimates of the natural rate in its publications regarding the economic and budget outlook, and we use the contemporaneous values for our real-time estimates from these CBO publications. To complete our series for the early 1970s, we posit that perceptions rose to around 4.5 percent in 1970 from the 4 percent estimates that prevailed

[3] See Orphanides and van Norden (2002) and Orphanides and Williams (2002) for summary documentation of the magnitude of the problem of real-time measurement of the natural rates of output and unemployment, respectively.

[4] Burns (1979), Heller (1966), Okun (1962, 1970), Stein (1984, 1996).

[5] See, for example, the discussion in Hall (1970) and Perry (1970).

earlier.[6] The real-time and retrospective natural rate estimates of the most recent five years are identical, reflecting the fact that the CBO's estimates are unchanged over that period.

The bottom panel of Figure 3 plots the implied natural misperceptions—measured as the "true" value minus the real-time estimate—from 1965 through 2003. As seen in the figure, natural rate misperceptions have tended to be highly persistent. The first-order serial correlation of this series over this sample is 0.98. Interestingly, the average magnitude of real-time misperceptions has declined over the past several decades. This appearance of diminishing errors may be overstated, however, because these calculations of "errors" implicitly assume that the current CBO method of estimating the natural rate is correctly specified. The real-time and retrospective estimates in the latter part of the sample are constructed using the same method (based on a Kalman filter), while the "misperceptions" in the earlier part of the sample also reflect differences in methodology. If the current methodology used by the CBO proves to be inadequate, then in the future the difference between real-time estimates and retrospective estimates in the 1980s and 1990s may widen.[7]

3 A Simple Estimated Model of the U.S. Economy

We examine the interaction of natural rate misperceptions, learning, and expectations for alternative monetary policy rules using a simple quarterly forward-looking model we developed in Orphanides and Williams (2002). The specification of the model is unchanged from that paper; however, we have reestimated the structural equations using the retrospective and real-time estimates of the natural rate of unemployment reported in the preceding section and, for simplicity, we have imposed a constant implicit natural rate of interest.

3.1 The Structural Model

The model consists of the following two structural equations:

$$\pi_t = \phi_\pi \pi^e_{t+1} + (1-\phi_\pi)\pi_{t-1} + \alpha_\pi (u^e_t - u^*_t) + e_{\pi,t}, \quad e_\pi \sim \text{iid}(0, \sigma^2_{e_\pi}), \tag{1}$$

[6] As a robustness check, we considered alternative paths for the real-time estimates in the model-based simulation exercises reported below. The precise dating of the evolution of perceptions regarding the rise of the natural rate from 4 percent in the late 1960s to 5 percent in the late 1970s does not materially influence our simulations as both the pattern and size of the resulting misperceptions remains broadly similar under such alternatives, given that the retrospective estimates for this period, at about 6 percent, are always higher by a considerable margin.

[7] See Orphanides and Williams (2002) for a detailed discussion of the sensitivity of measures of natural rate misperceptions to the assumption of the correct estimation method.

$$u_t = \phi_u u^e_{t+1} + \chi_1 u_{t-1} + \chi_2 u_{t-2} + (1-\phi_u - \chi_1 - \chi_2) u^*_t + \alpha_u (\tilde{r}^a_{t-1} - r^*) + e_{u,t}, \quad e_u \sim \text{iid}(0, \sigma^2_{e_u}), \tag{2}$$

where π denotes the annualized log difference of the GNP or GDP price deflator, u denotes the unemployment rate, u^* denotes the true natural rate of unemployment, and $\tilde{r}^a$ denotes the real interest rate based on the one-year Treasury bill, and r^* the natural real rate of interest. This model combines forward-looking elements of the New Synthesis model studied by Goodfriend and King (1997), Rotemberg and Woodford (1999), Clarida, Gali and Gertler (1999), and McCallum and Nelson (1999), with intrinsic inflation and unemployment inertia as in Fuhrer and Moore (1995), Batini and Haldane (1999), and Smets (2000).

The "Phillips curve" in this model (equation 1) relates inflation (measured as the annualized percent change in the GDP price index) during quarter t to lagged inflation, expected future inflation, and expectations of the unemployment gap during the quarter, using the retrospective estimates of the natural rate discussed below. The estimated parameter ϕ_π measures the importance of expected inflation on the determination of inflation. The unemployment equation (equation 2) relates the unemployment gap during quarter t to the expected future unemployment gap, two lags of the unemployment gap, and the lagged real interest rate gap. Here two elements importantly reflect forward-looking behavior. The first element is the estimated parameter ϕ_u, which measures the importance of expected unemployment, and the second is the duration of the real interest rate, which serves as a summary of the influence of interest rates of various maturities on economic activity. Because data on long-run inflation expectations are lacking, we limit the duration of the real rate to one year.

In estimating this model we are confronted with the difficulty that expected inflation and unemployment are not directly observed. Instrumental variable and full-information maximum likelihood methods impose the restriction that the behavior of monetary policy and the formation of expectations be constant over time, neither of which appears tenable over the sample period that we consider (1969–2002). Instead, as we did in Orphanides and Williams (2002), we follow the approach suggested by Roberts (1997) and rely on the Survey of Professional Forecasters as a proxy for expectations. Specifically, we employ the median values of the forecasts provided in the Survey and posit that the relevant expectations are those formed in the previous quarter; that is, we assume that the expectations determining π_t and u_t are those collected in quarter $t-1$. Finally, to match the inflation and unemployment data as best as possible with these forecasts, we use first announced estimates of these series.[8,9] Our primary sources for the data we employ for estimation are the Real-Time Dataset for Macroeconomists and the Survey of Professional Forecasters, both currently maintained by the Federal Reserve Bank of Philadelphia (Zarnowitz and Braun (1993), Croushore (1993) and Croushore and Stark (2001)). Using ordinary least squares, we obtain the following estimates for our model over 1969:1 to 2002:2 period:[10]

$$\pi_t = \underset{(0.086)}{0.529}\ \pi^e_{t+1} + \underset{(--)}{0.471}\ \pi_{t-1} - \underset{(0.093)}{0.304}\ (u^e_t - u^*_t) + e_{\pi,t}, \tag{3}$$

$$SER = 1.38,\ DW = 2.09,$$

$$u_t = \underset{(0.080)}{0.221}\ u^e_{t+1} + \underset{(0.104)}{1.262}\ u_{t-1} - \underset{(0.068)}{0.529}\ u_{t-2} + \underset{(0.022)}{0.045}\ u^*_t + \underset{(0.013)}{0.033}\ (\tilde{r}^a_{t-1} - r^*) + e_{u,t}, \tag{4}$$

$$SER = 0.29,\ DW = 2.08,$$

In these results the numbers in parentheses are the estimated standard errors of the corresponding regression coefficients. The estimated unemployment equation also includes a constant term which provides an estimate of the natural real interest plus the average premium of the one-year Treasury bill rate we use for estimation over the federal funds rate, which corresponds to the natural rate of interest estimates we employ in the model. Assuming this premium equals the average difference between the one-year rate and federal funds rate during this sample, the estimation suggests an estimate of 3.2 percent for the natural rate of interest in this sample. To complete our model for simulations we impose the expectations theory of the term structure whereby the one-year rate equals the expected average of the federal funds rate over four quarters.

[8] This implies that the relevant expectations surprises influencing current outcomes are those perceived on the basis of first announced data and not those defined retrospectively on the basis of subsequent revisions. We adopt this simplification for its parsimony, recognizing that subsequent revisions of historical data may at times affect economic decisions in a more complicated manner.

[9] This is also common in forecast evaluation experiments, for example, Romer and Romer (2000) employ first announced outcomes in their evaluation of Federal Reserve Board Greenbook forecasts.

[10] The starting point of this sample reflects the availability of the Survey of Professional Forecasters data.

3.2 Historical Monetary Policy

In addition to the equations for inflation and the unemployment rate, we estimate a monetary policy rule according to which the federal funds rate is determined by the lagged funds rate, the forecast of inflation over the next year (defined to be the four-quarter change from $t-1$ to $t+3$ where t denotes the period for which the funds rate is set), the forecasted changed in the unemployment rate over the next year, and the level of the unemployment gap (the unemployment rate less the real-time estimate of the natural rate) forecasted to occur in three quarters:

$$i_t = \theta_i i_{t-1} + (1-\theta_i)(r^* + \pi^*) + \theta_\pi(\pi^e_{t+3} - \pi^*) + \theta_u(u^e_{t+3} - \hat{u}^*_t) + \theta_{\Delta u}(u^e_{t+3} - u_{t-1}) + \epsilon_{i,t}$$

For both estimation and simulation purposes, we assume that the central bank responds to the private sector forecasts of inflation and the unemployment rate in setting policy. As discussed in Orphanides (2003c) and Orphanides and Williams (2002), this specification nests both a version of the classic Taylor rule (Taylor, 1993), which excludes the change in unemployment and lagged interest rate terms (that is sets $\theta_i = \theta_{\Delta u} = 0$), as well as rules robust to natural rate misperceptions (the limiting case with $\theta_i = 1$ and $\theta_u = 0$)

To allow the rule to capture the reduction of activism in Federal Reserve policy following the summer of 1979, we allow for a break in the policy rule at that time. Other things equal, a reduction in activism should be reflected in this rule by a reduction in the policy responsiveness to the perceived gap in the forecast of unemployment from its natural rate, θ_u. To examine this effect in a parsimonious manner we follow the suggestion in Orphanides (forthcoming) and focus on a specification that allows for a break in the θ_u parameter, keeping remaining parameters of the policy reaction functions fixed.[11] Allowing for this break, our estimated policy rule is given by:

[11] A stability test rejects the constancy of all parameters over the two subsamples. However, once we allow for the break in θ_u, the stability of individual remaining parameters over the two subsamples cannot be rejected. As a robustness check for our model, we also examined simulations based on a specification of the policy rule that allows breaks in two paramaters, θ_u and θ_π. In that specification, the point estimates of both θ_π and θ_u are slightly lower in the first subsample but the difference is small and does not qualitatively influence our simulation results.

$$
\begin{aligned}
i_t = \underset{(0.044)}{0.750}\ i_{t-1} + \underset{(---)}{0.250}\ (r^* + \pi^*) + \underset{(0.130)}{0.779}\ (\pi^e_{t+3} - \pi^*) - \underset{(0.210)}{0.673}\ (u^e_{t+3} - u_{t-1}) + \\
(-\underset{(0.197)}{1.131} + \underset{(0.158)}{0.561}\ D)\,(u^e_{t+3} - \hat{u}^*_t) + \epsilon_{i,t}, \qquad (5) \\
SER = 1.02,\ DW = 1.90,
\end{aligned}
$$

where D is a dummy variable equalling zero before 1979q3 and one thereafter. Conditional on a value for the natural rate of interest, r^*, estimation of this policy rule also provides an estimate of the implicit inflation target, π^*. Assuming $r^* = 3.2$ percent, as suggested by the estimation of equation 2, yields an estimate of 2.7 percent for π^* with a standard error equal to 0.15 percent.

As can be seen, and consistent with the narrative evidence, the estimated policy reaction function points to a substantial reduction in policy activism following the summer of 1979, compared to the earlier period. We note that this policy rule satisfies the standard stability condition in models with adaptive or rational expectations that the long-run response of the nominal interest rate to a change in the inflation rate exceeds unity. We do not find evidence that policy was inherently destabilizing in the pre-1979 sample, but instead only that it was more activist.[12]

4 Expectations Formation

Following Orphanides and Williams (2003, forthcoming), we assume that agents reestimate their forecasting models each period using a constant gain algorithm that places more weight on recent observations.[13] Given the structure of the model, agents need to forecast inflation, the unemployment rate, and the federal funds rate for up to four quarters in the future. As noted above, we assume the policymaker uses private agents' forecasts in setting policy.

[12] This contasts the well known findings reported by Clarida, Gali and Gertler (2000), based on a similar specification, but employing the output gap (instead of the unemployment gap) and relying on instrumental variables analysis with ex post data (instead of real-time data and forecasts). They suggested that the response of policy to inflation was unstable in the pre-1979 period. However, as documented by Orphanides (forthcoming), their findings are overturned when information actually available to policy makers in real time is employed to estimate the policy rule that they specify. Even when we allow for breaks in both the policy response to expected inflation and response to perceived unemployment gap in our rule, which, as noted earlier suggests that the coefficient on the inflation forecast is a bit lower in the pre-1979 sample, we find that the estimation provides no evidence supporting the hypothesis of policy instability.

[13] See also Sargent (1999), Cogley and Sargent (2001), Evans and Honkapohja (2001) and Gaspar and Smets (2002) for related treatments of learning.

4.1 Least Squares Learning with Finite Memory

Under perfect knowledge with no shocks to the natural rate of unemployment, the predictable component of inflation, the unemployment rate, and the funds rate each depend on a constant, one lag of inflation and the funds rate and two lags of the unemployment rate. We assume that agents estimate forecasting equations for the three variables using a restricted VAR of this form. They then construct multi-period forecasts from the estimated VAR.

To fix notation, let Y_t denote the 1×3 vector consisting of the inflation rate, unemployment rate, federal funds rate, each measured at time t: $Y_t = (\pi_t, u_t, i_t)$. Let X_t be the 5×1 vector of regressors in the forecast model: $X_t = (1, \pi_{t-1}, u_{t-1}, u_{t-2}, i_{t-1})$ let c_t be the 5×3 vector of coefficients of the forecasting model.

Using data through period t, the least squares regression parameters for the forecasting model can be written in recursive form:

$$c_t = c_{t-1} + \kappa_t R_t^{-1} X_t (Y_t - X_t' c_{t-1}), \tag{6}$$

$$R_t = R_{t-1} + \kappa_t (X_t X_t' - R_{t-1}), \tag{7}$$

where κ_t is the gain.

Under the assumption of least squares learning with infinite memory, $\kappa_t = 1/t$, so as t increases, κ_t converges to zero. As a result, as the data accumulate this mechanism converges to the correct expectations functions and the economy converges to the perfect knowledge benchmark solution. As noted above, to formalize perpetual learning—as would be required in the presence of structural change such as shifts in the natural rate of unemployment—we replace the decreasing gain in the infinite memory recursion with a small constant gain, $\kappa > 0$.[14]

With imperfect knowledge, expectations are based on the perceived law of motion of the inflation process, governed by the perpetual learning algorithm described above. The model under imperfect knowledge consists of the structural equation for inflation, the output gap equation, and the monetary policy rule, and the forecasts generated from the forecasting model.

[14]In terms of forecasting performance, the "optimal" choice of κ depends on the relative variances of the transitory and permanent shocks, as in the relationship between the Kalman gain and the signal-to-noise ratio in the case of the Kalman filter.

We emphasize that in the limit of perfect knowledge (that is, as $\kappa \to 0$) and assuming a constant natural rate of unemployment, the expectations function above converges to rational expectations and the stochastic coefficients for the forecasting model converge to those implied by the structural model equations under rational expectations. As explained in Orphanides and Williams (forthcoming), this modeling approach accommodates the Lucas critique in the sense that expectations formation is endogenous and adjusts to changes in policy or structure, and although expectations are "imperfectly" rational, in that agents are required to estimate the reduced form processes needed to form expectations, the resulting expectations are close to being efficient.

4.2 Calibrating the Learning Rate

A key parameter for the constant-gain-learning algorithm is the updating rate κ. To calibrate this parameter we examined how well different values of κ fit either the expectations data from the Survey of Professional Forecasters, or, based on our model, the actual data on inflation and unemployment.

To examine the fit of the Survey of Professional Forecasters, we generated a time series of forecasts using a recursively estimated VAR for the inflation rate, unemployment rate, and the federal funds rate. In each quarter we reestimated the model using all historical data available during that quarter (generally from 1948 through the most recent observation). We allowed for discounting of past observations by using geometrically declining weights. We found that discounting past data at about 1 percent per quarter yielded forecasts closest on average to the SPF over 1968–2002.[15] This corresponds to an updating gain of about 2 percent percent per quarter during the 1970s and 1-1/2 percent in the 1990s.

To examine the degree of discounting that best fits the historical data on inflation and unemployment, given our structural model and learning process, we simulated the model from 1966 forward for alternative values of κ and examined the mean squared deviations of the simulated path from the actual paths of inflation and unemployment. (Details on simulation of the model and setting of initial conditions are provided below.) These simulations suggested that our model with values of κ between 0.01 and 0.04 matched the data better than when κ was set at lower or higher values.

[15] This finding is also in line with the discounting reported by Sheridan (2003) as best for explaining the inflation expectations data reported in the Livingston Survey.

In light of these results, in the following, we use $\kappa = 0.02$ as a baseline value. As a robustness check, we also examined the sensitivity of our model to lower and higher values.

5 The Interaction of Learning, Misperceptions and Policy

We examine a set of alternative counterfactual simulations to investigate the role of learning, natural rate misperceptions, and policy for understanding the behavior of inflation and unemployment and evolution of policy. We start our simulations at the beginning of 1966, which corresponds to what many observers consider to be the beginning of the Great Inflation in the United States.

5.1 Initial Conditions

The states of the model economy with learning are: the current value and one lag each of the inflation rate and the federal funds rate, the current value and two lags of the unemployment rate, the true natural rate of unemployment, the real-time estimate of the natural rate, the shocks to the structural equations, and the matrices C, and R for the forecasting model. We initialize the C and R matrices using estimates of the forecasting model by ordinary least squares on data from 1948 through 1965.

Based on our calibration of the learning rate using survey data, we set $\kappa = 0.02$ and compute the implied forecasts of inflation, the unemployment rate, and the federal funds rate over 1966q1 – 2003q2. Using these forecasts as data, we then compute tracking residuals for all model equations so that the model identically matches the data over the full sample.

5.2 The Role of Natural Rate Misperceptions

Our first experiment is a simulation in which policy follows the estimated policy rule (including residuals) but the policymaker is assumed to observe the true value of the natural rate of unemployment in real time. That is, there are no natural rate misperceptions. Note that because the policy rule matches history under the assumption that the policy was based on the real-time estimates of the natural rate, the simulation boils down to adding innovations to the policy rule equal to the coefficient on the unemployment gap multiplied by the real-time misperceptions shown in Figure 3.

Absent natural rate misperceptions, inflation would have been relatively stable in the

1970s according to the model. Figure 4 shows the historical paths (the thick lines) and the simulated paths of the rates of inflation (four-quarter change in the price level) and unemployment. In contrast to the historical experience when inflation reached into double digits, the inflation rate with no natural rate misperceptions remains in a relatively narrow range of about two and four percent during the 1970s.

The stability in inflation is achieved through a tighter path for policy starting in 1966 that drives up the unemployment rate above its historical path. In the simulation, the natural rate during the entire 1970s. As a result of this effective stabilization of inflation, the rise in unemployment associated with the Volcker disinflation occurring at the end of the decade and into the early 1980s is avoided.

The policy without natural rate misperceptions avoids the damaging shift in the perceived law of motion of inflation evident in the historical data. The thick solid line in Figure 5 shows the estimated sum of coefficients on inflation expectations in forecasting equation based on the learning model. This statistic summarizes agents' perceptions of the persistence in inflation. For these calculations, the coefficient on the lagged funds rate is included, so that the model is one where lags of inflation, the unemployment rate, and the lagged real funds rate is used to predict inflation. Based on the historical data, the perceived persistence in inflation rises to about 0.9 by 1975. Indeed this is a manifestation, in terms of our model, of the evidence in favor of the "accelerationist" hypothesis regarding inflation dynamics that became widely accepted at that time. In contrast, under the same policy, but absent natural rate misperceptions, the perceived persistence in inflation remains moderate throughout the 1960s and 1970s. In this simulation, the trend rise in inflation associated with the "Great Inflation" is avoided and inflation expectations remained well anchored.

5.3 The Role of Learning

Even in the presence of policy errors driven by misperceptions of the natural rate of unemployment, economic outcomes during the Great Inflation could have been mush less unfavorable if expectations had remained well anchored and governed by the forecasting processes earlier in place. With regard to the persistence of inflation, had the policy errors of the late 1960s and 1970s not resulted in its steep increase, inflation would have been contained much more easily and price stability restored at a lower cost. To illustrate the role of learning in this case, Figure 6 presents a counterfactual experiment where the historical policy rule is followed, and policy continues to make the errors associated with natural rate misperceptions, but the process governing the formation of expectations is unaffected by the resulting adverse outcomes and continues to be governed by the reduced form VAR in place at the beginning of the simulation, in 1966. Thus, in this simulation, expectations of inflation remain, by design well anchored through time. As can be seen, despite the policy errors due to the natural rate misperceptions, in the absence of learning, that is if the favorable expectations mechanism in place before the Great Inflation could have been maintained, economic outcomes would have been significantly better.

5.4 The Role of Policy Activism

The simulations above suggest that under some conditions the activist policy pursued during the Great Inflation could have been successful. In particular, if policymakers could have avoided misperceptions in the natural rate or, if expectations could have remained favorable even in the face of the policy errors caused by the combination of policy activism and natural rate misperceptions, the stagflation of the 1970s would not have occured. But, of course, neither of these conditions could be taken for granted as the basis for policy design and the possibility that they may fail, as they did during the Great Inflation, limits the scope for activist stabilization policy. An insufficient understanding of these limits, in particular, of the long-term damage to expectations formation resulting from activist policy errors likely contributed to the policy failure of the 1970s.

A natural question is whether a less activist approach, such as the one adopted following the policy change in 1979 would have represented better policy during the Great Inflation as well. To examine the role of policy activist, our third set of experiments examines what the historical outcomes could have been in the presence of learning and the observed natural rate are given by our real-time estimates, if policy were driven by a less activist approach than the one observed. Figures 7 and 8 summarize the results from these experiments. If policy had followed the post-1979 policy from 1966 on (the thin solid line), that would have dramatically reduced rise in inflation in 1970s. A policy of not responding to the unemployment gap (the dashed line) leads to stable inflation, similar to that under the hypothetical case of no natural rate misperceptions described earlier.

Importantly, as can be seen in Figure 8, under either policy, and even with the perpetual learning process governing the formation of expectations, the natural rate misperceptions of the 1960s and 1970s would not have been sufficient to destabilize the inflation expectations. By maintaining well anchored expectations throughout the 1970s, these policies would have avoided the stagflationary outcomes of the decade.

Indeed, the realization of the role of the policy mistakes of the 1970s in destabilizing inflation expectations, was a key reason leading to the policy change in 1979. As Stephen Axilrod summarized:[16]

> Not all exogenous forces are purely exogenous. Rising inflationary expectations in the late 1970s were in part the product of earlier monetary policies (as well as other events) as these policies affected attitudes toward the future, ... but once embedded the expectations were exogenous to and influenced current policies—as in October 1979. (1985, p. 14.)

5.5 Robustness

As a robustness check for our key results regarding the wisdom of reduced policy activism, we also examined counterfactual simulations under alternative assumptions regarding learning and the formation of expectations. We concentrated our attention on the robustness of the finding that had policy during the Great Inflation followed the less activist approach adopted after 1979, inflation expectations would have remained well behaved during the 1970s and the stagflation experienced during that decade would have been avoided.

We considered the sensitivity of results to the updating parameter κ by comparing counterfactual simulations for three different values of $\kappa = 0.01, 0.02, 0.03$ for the experiment where policy. Qualitatively, the results are quite similar across the three values of κ. In fact, the rise in the rate of inflation during the late 1970s appears less pronounced both for the smaller and larger values of κ than in the baseline case of $\kappa = 0.02$. In this sense, our baseline choice for κ is conservative in terms of the effects of the interaction of learning and policy errors.

We also examined the sensitivity of our results for the choice of initial conditions governing the formation of expectations. Instead of the initial conditions as could be estimated

[16]Stephen Axilrod, a member of the Federal Reserve Board staff, served as the FOMC Economist at the time of the 1979 policy change.

in 1966, we examined simulations with estimated initial conditions later in the sample. Alternatively, of estimated initial conditions, we imposed as initial conditions the reduced form functions corresponding to the model-consistent solution of the model, corresponding to the estimated model structure and policy rule. In both of these alternatives, these initial conditions are somewhat less favorable than the ones actually in place in 1966. As a result, inflation outcomes for the turn of the 1970s, which are heavily influenced by the initial conditions in the simulations, are worse under these alternatives relative to out baseline. However, even with these less favorable initial conditions had policy followed throughout the estimated post-1979 rule, our simulations suggest that inflation in the mid and late 1970s would have been considerably lower, and as a result the stagflation of the 1970s would not have occured.

6 Conclusion

The activist approach to economic stabilization behind the monetary policy decisions of the late 1960s and 1970s could in principle have been successful in stabilizing economic fluctuations while maintaining price stability. Success of that approach, however, rested on the availability of an accurate assessment of the economy's natural rate, which could have usefully served as a guide for aggregate demand management. In the event, large and persistent natural rate misperceptions implied that perceptions regarding the economy's natural rate served as poor guides for policy. Even with these misperceptions, if only the expectations formation process could have remained as favorable as it had been before the Great Inflation got underway, the 1970s stagflation would have been avoided. But in a dynamic economy with agents engaging in perpetual learning to form expectations, the policy errors resulting from the presence of natural rate misperceptions in the face of the activist approach to stabilization led to an unmooring of inflation expectations during the 1970s and stagflation. Towards the end of the decade, the consequences of this policy blunder became understood. Out of this experience grew the realization that a decline in policy activism could achieve better outcomes with respect to price stability as well as better stabilization performance. In 1979, this policy improvement finally took hold, paving the way for the change of fortune evidenced in the macroeconomic outcomes since then.

References

Axilrod, Stephen (1985), "U.S. Monetary Policy in Recent Years: An Overview," *Federal Reserve Bulletin*, January, 14-24.

Batini, Nicoletta and Andrew Haldane (1999), "Forward-looking Rules for Monetary Policy," in *Monetary Policy Rules*, John B. Taylor (ed.), Chicago: University of Chicago.

Burns, Arthur (1979), *The Anguish of Central Banking*, The 1979 Per Jacobsson Lecture, Belgrade, Yugoslavia, September 30.

Clarida, Richard, Jordi Gali, and Mark Gertler (1999), "The Science of Monetary Policy," *Journal of Economic Literature*, 37(4), 1661-1707, December.

Clarida, Richard, Jordi Gali, and Mark Gertler (2000), "Monetary Policy Rules and Macroeconomic Stability: Evidence and Some Theory," *Quarterly Journal of Economics*, 147-180, February.

Cogley, Timothy and Sargent, Thomas (2001), "Evolving Post-World War II U.S. Inflation Dynamics." in *NBER Macroeconomics Annual*.

Congressional Budget Office (2001), "CBO's Method for Estimating Potential Output: An Update," Washington, DC: Government Printing Office (August).

Congressional Budget Office (2002), *The Budget and Economic Outlook: An Update.* Washington DC: Government Printing Office (August).

Croushore, Dean (1993), "Introducing: The Survey of Professional Forecasters," Federal Reserve Bank of Philadelphia *Business Review*, November/December, 3-13.

Croushore, Dean and Tom Stark (2001), "A Real-Time Data Set for Macroeconomists," *Journal of Econometrics* 105, 111-130, November.

Evans, George and Honkapohja, Seppo (2001), *Learning and Expectations in Macroeconomics.* Princeton: Princeton University Press.

Fuhrer, Jeffrey C. and George R. Moore (1995), "Inflation Persistence," *Quarterly Journal of Economics*, 110(1), 127-59.

Friedman, Milton (1947), "Lerner on the Economics of Control," *Journal of Political Economy*, 55(5), October, 405-416.

Gaspar, Vitor and Smets, Frank (2002), "Monetary Policy, Price Stability and Output Gap Stabilisation," *International Finance*, 5(2), Summer, 193–211.

Goodfriend, Marvin, and Robert King (1997), "The New Neoclassical Synthesis and the Role of Monetary Policy," *NBER Macroeconomics Annual*, (12), 231-283.

Hall, Robert E. (1970), "Why Is the Unemployment Rate So High at Full Employment?" *Brookings Papers on Economic Activity*, 3, 369-402.

Heller, Walter W. (1966), *New Dimensions of Political Economy*, Cambridge, MA: Harvard University.

Lerner, Abba (1944), *The Economics of Control*, New York: Macmillan.

Levin, Andrew, Volker Wieland and John Williams (1999), "Robustness of Simple Monetary Policy Rules under Model Uncertainty," in *Monetary Policy Rules*, John B. Taylor (ed.), Chicago: University of Chicago.

Levin, Andrew, Volker Wieland and John Williams (2003), "The Performance of Forecast-Based Policy Rules under Model Uncertainty," *American Economic Review.*

McCallum, Bennett T. and Edward Nelson (1999), "Performance of Operational Policy Rules in an Estimated Semiclassical Structural Model." in *Monetary Policy Rules*, John B. Taylor (ed.), Chicago: University of Chicago.

Okun, Arthur (1962), "Potential Output: Its Measurement and Significance," in *American Statistical Association 1962 Proceedings of the Business and Economic Section*, Washington, D.C.: American Statistical Association.

Okun, Arthur (1970), *The Political Economy of Prosperity*, Brookings, Washington D.C.

Orphanides, Athanasios (2002), "Monetary Policy Rules and the Great Inflation," *American Economic Review,* 92(2), 115-120, May.

Orphanides, Athanasios (2003a), "Monetary Policy Evaluation With Noisy Information," *Journal of Monetary Economics*, 50(3), 605-631, April.

Orphanides, Athanasios (2003b), "The Quest for Prosperity Without Inflation," *Journal of Monetary Economics*, 50(3), 633-663, April.

Orphanides, Athanasios (2003c), "Historical Monetary Policy Analysis and the Taylor Rule," *Journal of Monetary Economics*, 50(5), 983-1022, July.

Orphanides, Athanasios (forthcoming), "Monetary Policy Rules, Macroeconomic Stability and Inflation: A View from the Trenches," *Journal of Money, Credit and Banking.*

Orphanides, Athanasios and Simon van Norden (2002), "The Unreliability of Output Gap Estimates in Real Time," *Review of Economics and Statistics*, 84(4), 569-583, November.

Orphanides, Athanasios and John C. Williams (2002), "Robust Monetary Policy Rules with Unknown Natural Rates", *Brookings Papers on Economic Activity*, 2:2002, 63-118.

Orphanides, Athanasios and John C. Williams (2003), "Inflation scares and forecast-based monetary policy", FRB San Francisco Working Paper, 2003-11 and FEDS 2003-41, August.

Orphanides, Athanasios and John C. Williams (forthcoming) "Imperfect Knowledge, Inflation Expectations and Monetary Policy," in *Inflation Targeting*, Ben Bernanke and Michael Woodford (eds), University of Chicago Press.

Perry, George L. (1970), "Changing Labor Markets and Inflation," *Brookings Papers on Economic Activity*, 3, 411-448.

Phillips, A. W. (1954), "Stabilisation Policy in a Closed Economy," *Economic Journal*, 290-323, June.

Roberts, John M. (1997), "Is Inflation Sticky?" *Journal of Monetary Economics*, 39, 173–196.

Romer, Christina D. and David H. Romer (2000), "Federal Reserve Information and the Behavior of Interest Rates," *American Economic Review*, 90(3), June, 429-457.

Romer, Christina and David Romer (2002), "A Rehabilitation of Monetary Policy in the 1950s" *American Economic Review,* 92(2), May.

Rotemberg, Julio J. and Michael Woodford (1999), "Interest Rate Rules in an Estimated Sticky Price Model," *Monetary Policy Rules*, John B. Taylor (ed.), Chicago: University of Chicago.

Sargent, Thomas J. (1999), *The Conquest of American Inflation*, Princeton: Princeton University Press.

Sheridan, Niamh (2003), "Forming Inflation Expectations," Working Paper, April.

Smets, Frank (2000), "What Horizon for Price Stability," European Central Bank Working Paper No 24.

Stein, Herbert (1984), *Presidential Economics*, New York: Simon and Schuster.

Stein, Herbert (1996), "A Successful Accident: Recollections and Speculations about the CEA," 10(3), 3-21, Summer.

Taylor, John B. (1993), "Discretion versus Policy Rules in Practice," Carnegie-Rochester Conference Series on Public Policy, 39, December, 195-214.

Tobin, James (1966), *National Economic Policy*, New Haven: Yale University Press.

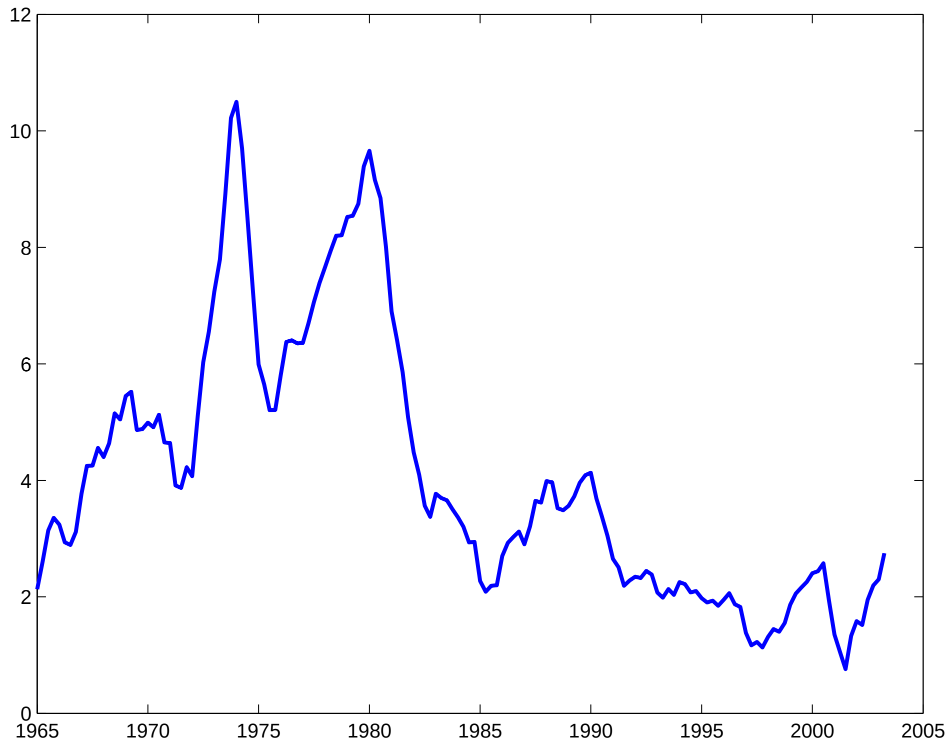
Tobin, James (1972), *New Economics One Decade Older*, Princeton: Princeton University Press.

Volcker, Paul, A. (1978), *The Rediscovery of the Business Cycle*, The Free Press, New York.

Zarnowitz, Victor and Phillip A. Braun (1993), "Twenty-two Years of the NBER-ASA Quarterly Economic Outlook Surveys: Aspects and Comparisons of Forecasting Performance," in Stock and Watson (1993).

Figure 1

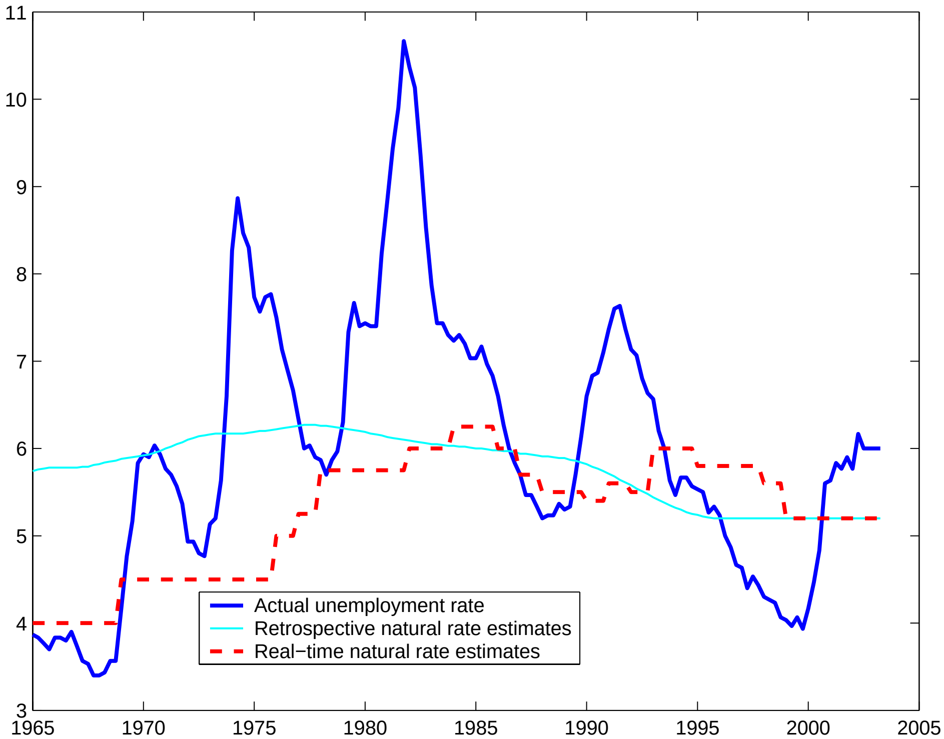
Inflation Rate



Notes: Inflation, in percent at an annual rate, as the rate of change of the output deflator using using log differences.

Figure 2

Unemployment and its Natural Rate

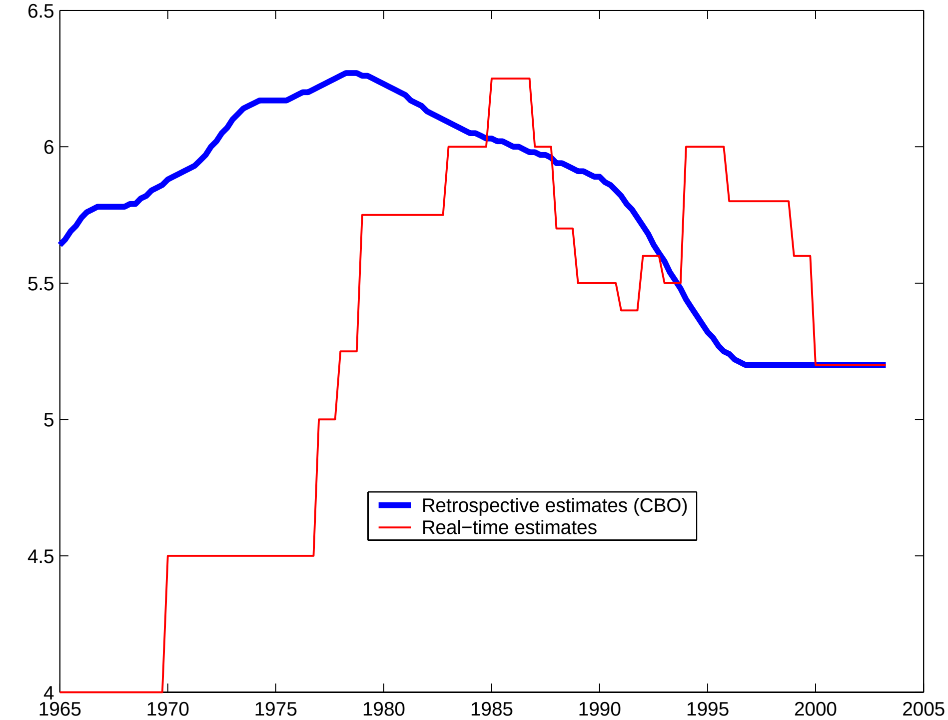


Notes: The retrospective natural rate reflects the current estimate of the NAIRU from the Congressional Budget Office. The real-time series is as described in the text. All series in percent.

Figure 3

The Natural Rate and Natural Rate Misperceptions

Estimates of the Natural Rate of Unemployment



Real-Time Misperceptions of the Natural Rate

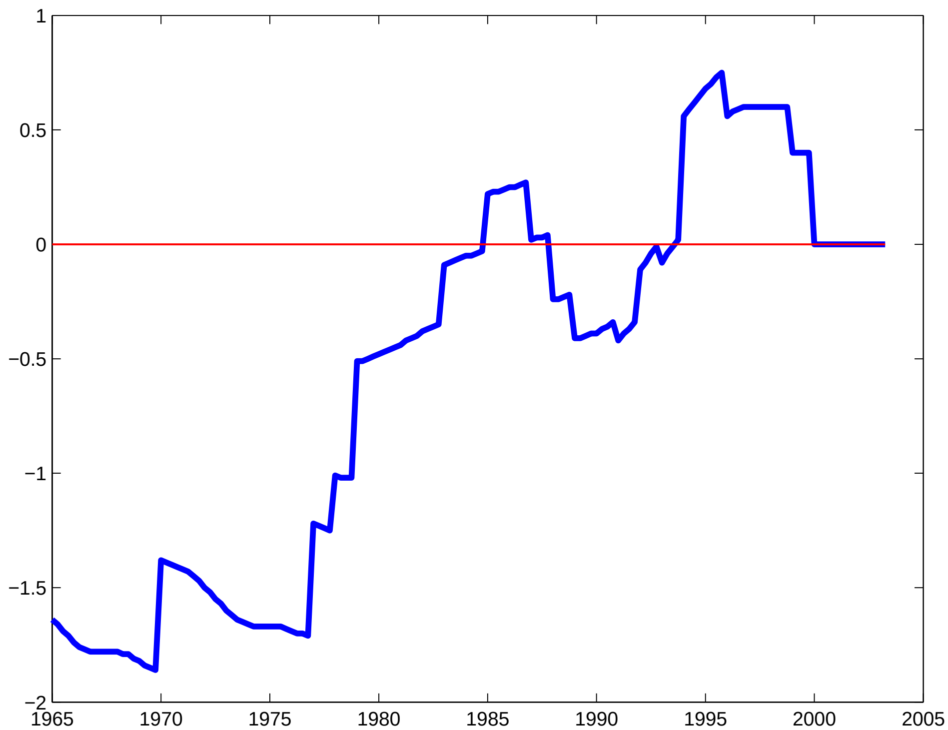
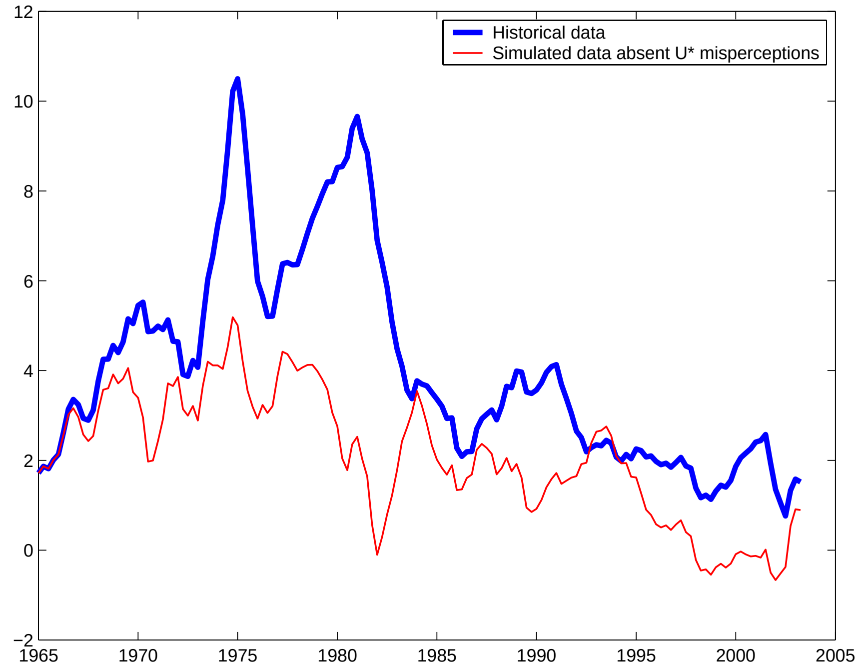


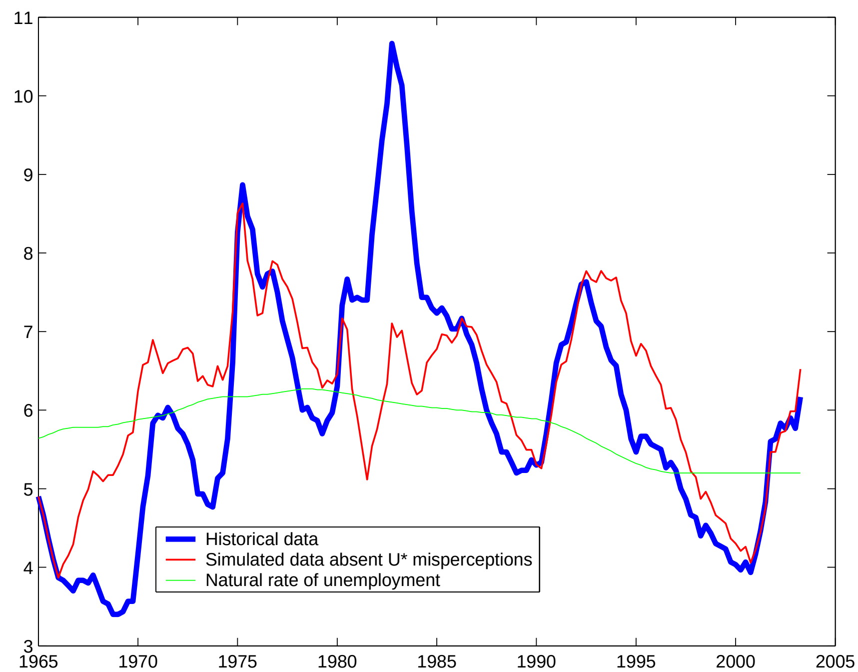
Figure 4

Outcomes with No Natural Rate Misperceptions

Inflation Rate



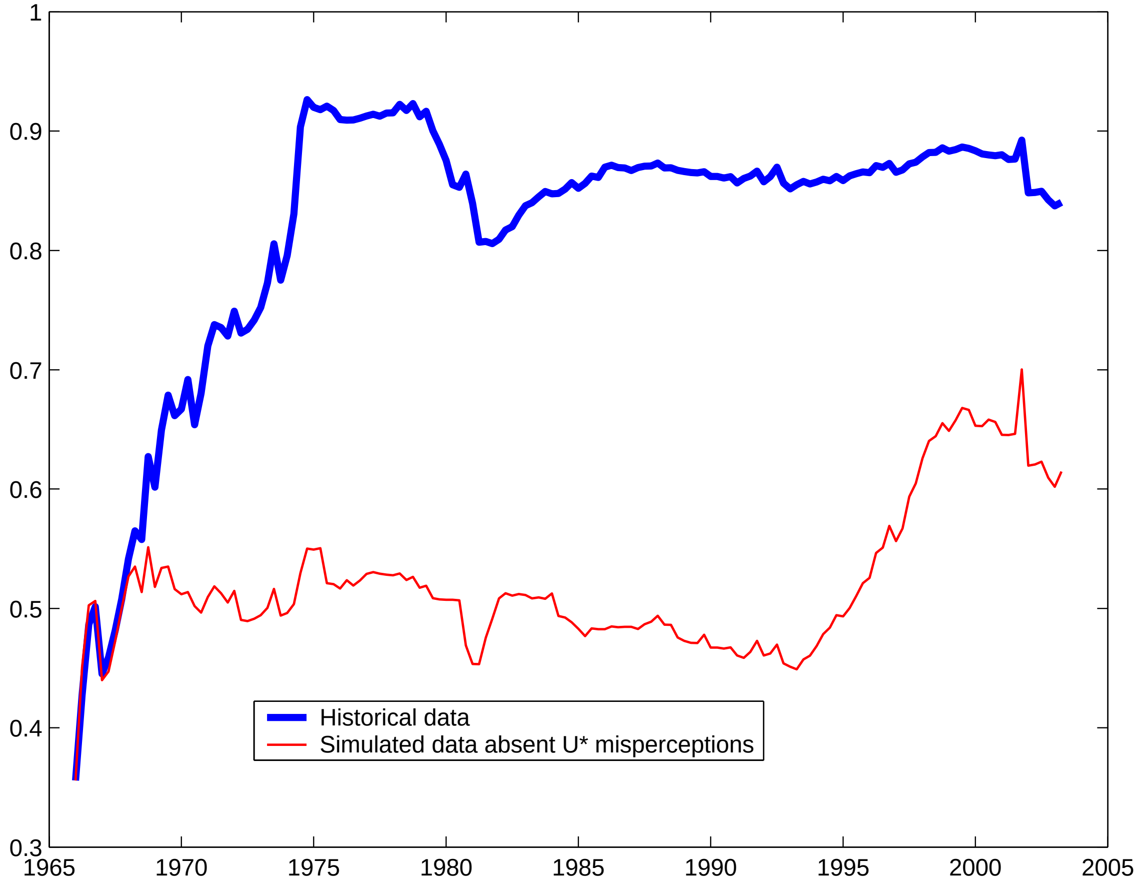
Unemployment Rate



Notes: The two panels show historical and simulated paths of the rates of inflation and the unemployment. The thick solid lines show the historical data. The thin solid lines show the simulated paths assuming that the monetary policymaker knows the true value of the natural rate of unemployment in real time. The lightly-shaded thin solid line in the lower panel shows the assumed path for the natural rate of unemployment. Each simulation starts in the first quarter of 1966.

Figure 5

Evolution of Inflation Persistence in Inflation Forecasting Equation

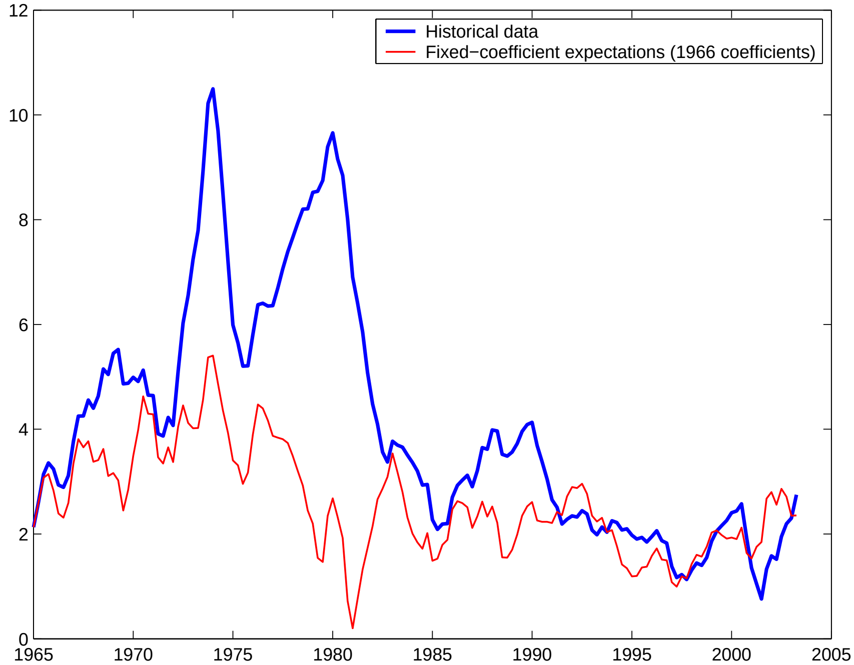


Notes: The lines show the simulated paths of the sum of the coefficients on lagged inflation in agents' inflation forecasting equations. The path shown by the thick line is based on the historical data. The thin line shows the simulated path in which the policymaker knows the true value of the natural rate of unemployment in real time. Each simulation starts in the first quarter of 1966.

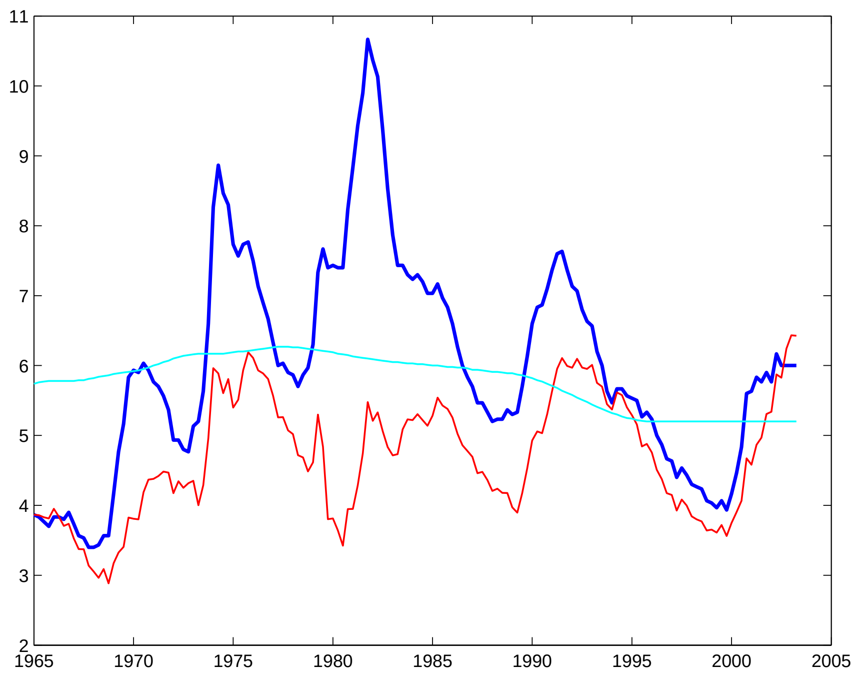
Figure 6

Outcomes with Fixed-Coefficient Expectations

Inflation Rate



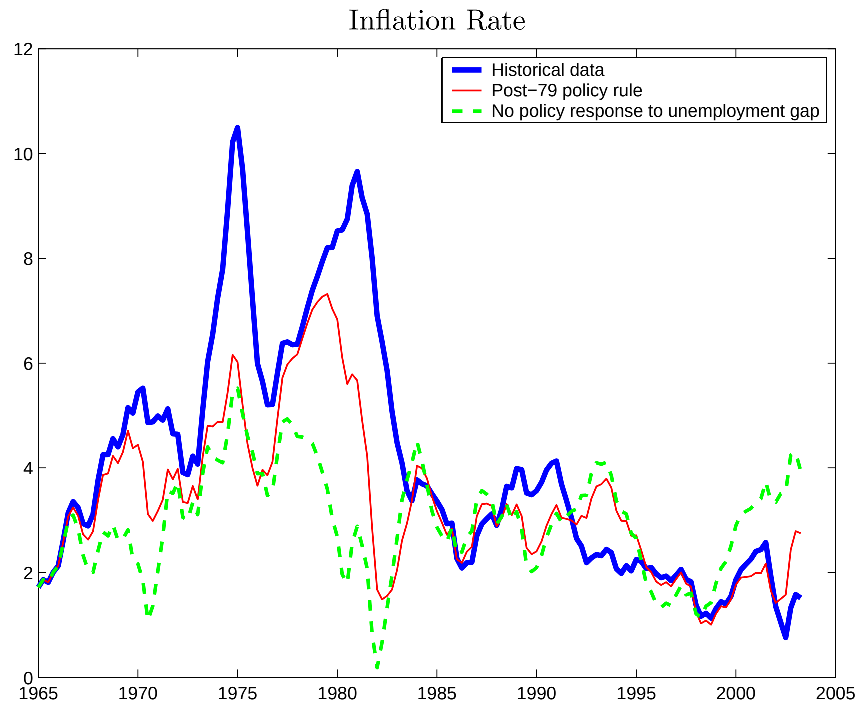
Unemployment Rate

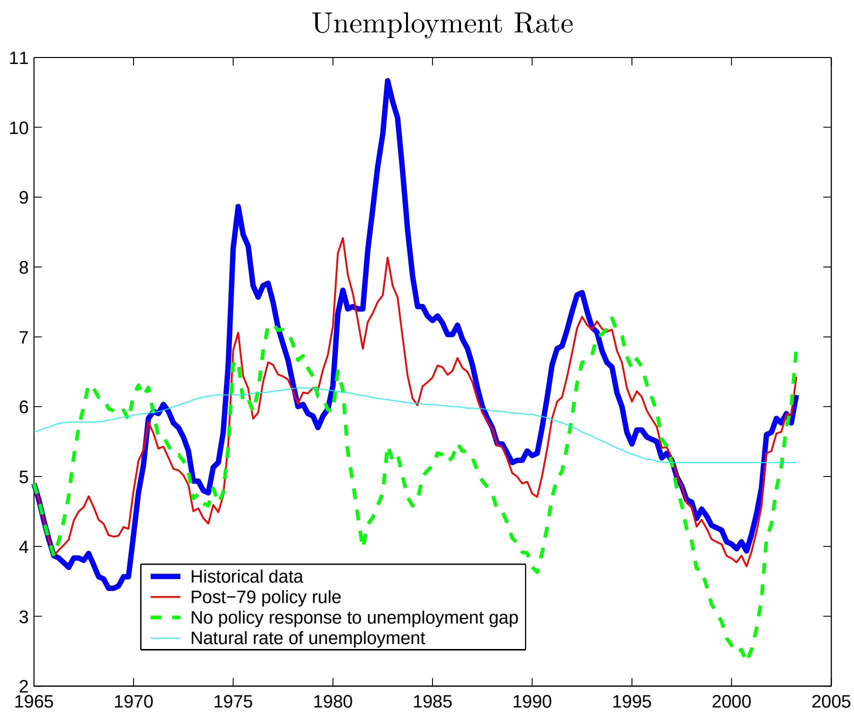


Notes: The two panels show historical and simulated paths of the rates of inflation and the unemployment. The thick solid lines show the historical data. The thin solid lines show the simulated paths assuming that the agents do not update their forecasting models from 1966 on. Each simulation starts in the first quarter of 1966.

Figure 7

Outcomes with Alternative Policy Rules

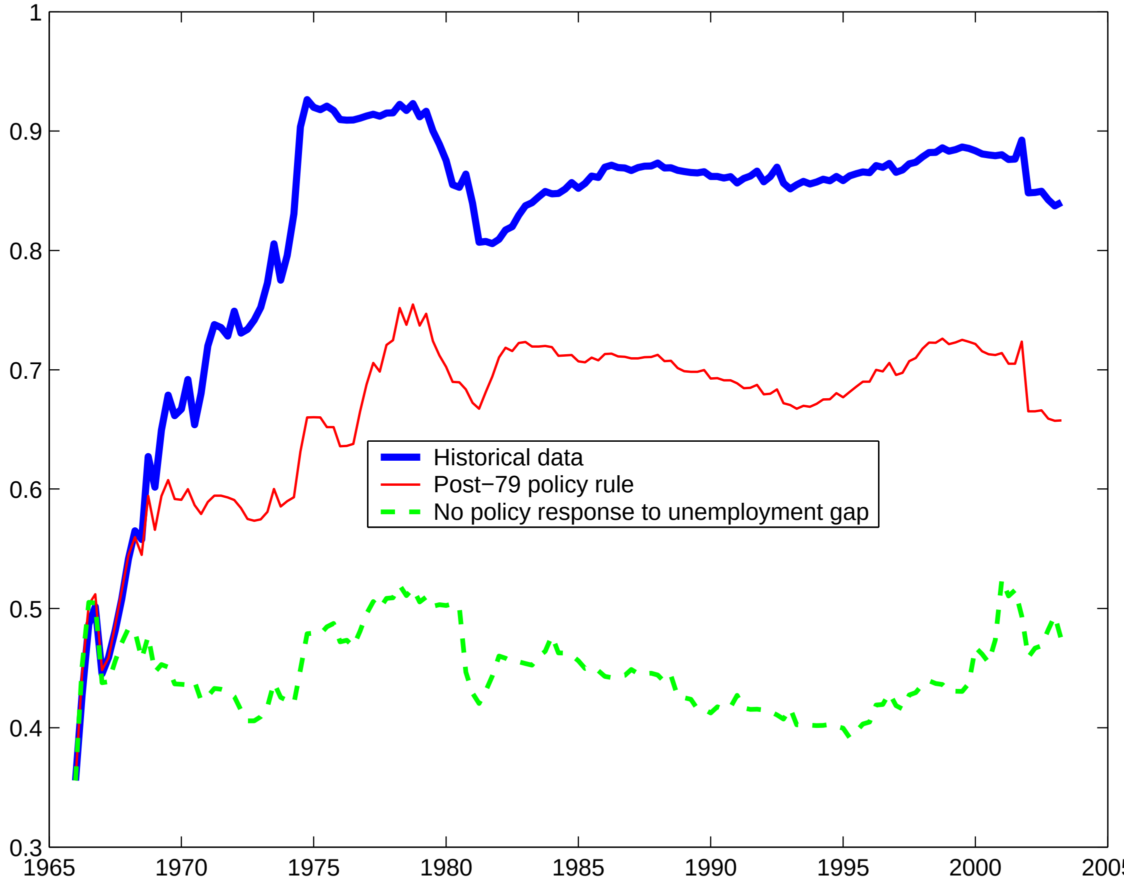




Notes: The two panels show historical and simulated paths of the rates of inflation and the unemployment. The paths shown by the thick solid lines are based on the historical data. The thin solid lines show the simulated paths in which monetary policy follows the post-1979 policy rule. The thick dashed lines show the simulated paths when policy does not respond to the unemployment gap. Each simulation starts in the first quarter of 1966.

Figure 8

Evolution of Inflation Persistence with Alternative Policy Rules



Notes: The lines show the simulated paths of the sum of the coefficients on lagged inflation in agents' inflation forecasting equations. The path shown by the thick solid line is based on the historical data. The thin solid line shows the simulated path in which monetary policy follows the post-1979 policy rule. The thick dashed line shows the simulated path when policy does not respond to the unemployment gap. Each simulation starts in the first quarter of 1966.