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The decline of activist stabilization policy: Natural rate misperceptions, learning, and expectations

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Abstract

We develop an estimated model of the U.S. economy in which agents form expectations by continually updating their beliefs regarding the behavior of the economy and monetary policy. We explore the effects of policymakers' misperceptions of the natural rate of unemployment during the late 1960s and 1970s on the formation of expectations and macroeconomic outcomes. We find that the combination of monetary policy directed at tight stabilization of unemployment near its perceived natural rate and large real-time errors in estimates of the natural rate uprooted heretofore quiescent inflation expectations and contributed to poor macroeconomic performance. Had monetary policy reacted less aggressively to perceived unemployment gaps, inflation expectations
ha!
would have remained anchored and the stagflation of the 1970s would have been avoided. Indeed, we find that less activist policies would have been more effective at stabilizing *both* inflation and unemployment. We argue that policymakers, learning from the experience of the 1970s, eschewed activist policies in favor of policies that concentrated on the achievement of price stability, contributing to the subsequent improvements in macroeconomic performance of the U.S. economy. Published by Elsevier B.V.

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1. Introduction

The 'New Economics' of the 1960s prescribed activist policies aimed at achieving and maintaining full employment of economic resources. According to this view, active management of aggregate demand would counteract any shortfalls or excesses relative to the economy's potential and thus attain the holy grail of macroeconomic policy: sustained prosperity with price stability. This faith in macroeconomic stabilization policy reflected the culmination of methodological advances in macroeconomic modeling, econometrics, and optimal control.[1] The zeitgeist of the 'New Economics' is nicely summarized by Walter Heller (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. (p. 116, emphasis in original)

The enviable performance of the U.S. economy in the first half of the 1960s appeared to validate the claims of Heller, but this success proved to be fleeting. In the second half of the 1960s, prosperity was purchased at the cost of rising inflation, as seen in Fig. 1. Worse, the prosperity of the 1960s was soon overshadowed by the stagflation – high inflation accompanied by high unemployment – of the 1970s.

In this paper, we reexamine the sources of stagflation in the 1970s, and argue that the combination of monetary policy directed at tight stabilization of the unemployment rate near its perceived natural rate and severe underestimation of the natural rate, rather than adverse supply shocks, explains much of the woeful performance of the U.S. economy in the 1970s. With hindsight, it is clear that policymakers in the 1960s and much of the 1970s were far too optimistic of how low the unemployment rate could go before igniting inflationary pressures. Given the activist bent of policymakers influenced by the 'New Economics,' these natural rate misperceptions contributed to an extended period of excessively stimulative policy, resulting in rising inflation.[2]

A key element in our analysis is the endogenous evolution of expectations formation in response to the tumultuous economic developments of the late 1960s

[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. Arguments regarding activist control of the economy remained at the center of the 'monetarists' versus 'activists' debate in subsequent decades. Note that one should not confuse this use of activism with the more recent use of the term 'active' monetary policy referring to policy rules in which the nominal interest rate responds more than one-for-one with a movement in inflation.

[2]See also Orphanides (2002, 2003a, b, 2004), Orphanides and Williams (2002), Bullard and Eusepi (2005), Collard and Dellas (2004), and Cukierman and Lippi (2005).

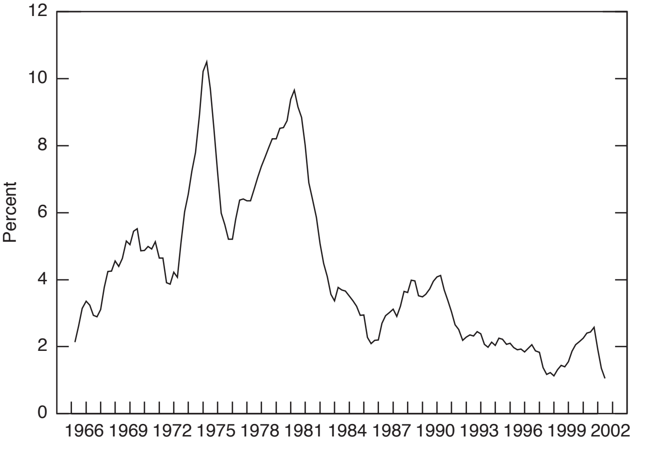

Fig. 1. Inflation rate. Notes: Inflation measured by the change of the output deflator (annual rate).

and 1970s. We develop an estimated model of the U.S. economy in which private agents have imperfect knowledge of the true structure of the economy and policy. In the model, agents are assumed to continuously update their beliefs about the reduced-form structure of the economy and monetary policy. As discussed in Orphanides and Williams (2004), this process of perpetual learning propagates the direct effects of policy errors onto inflation expectations and back onto the economy.

According to our model, the combination of stimulative monetary policy and rising inflation during the late 1960s and 1970s contributed to private sector confusion regarding the Federal Reserve's objectives and the behavior of inflation. Although inflation expectations were initially well anchored, owing to the period of price stability in the 1950s and early 1960s, this advantage was squandered during the late 1960s as policy errors and the resulting rise in inflation caused inflation expectations to drift upward.[3] By the time that the supply shocks of the 1970s hit, inflation expectations were already shifting, exacerbating the response to the shocks and contributing to stagflation. It is worth emphasizing that we obtain our results under an estimated feedback rule that features a greater than one-for-one response of nominal rates to inflation. What is crucial for our results is that policy responded strongly to perceived unemployment rate gaps during the pre-1979 period when natural rate misperceptions were pronounced and highly persistent.

We find that had monetary policy not reacted as aggressively to perceived unemployment gaps as it did, inflation expectations would have remained anchored and the stagflation of the 1970s would have been avoided, despite the dramatic

[3]The favorable environment of inflation expectations in the early 1960s can be largely attributed to the greater emphasis on price stability relative to economic stabilization before the decade of the 1960s. See Romer and Romer (2002) and Orphanides (2003c) for discussions highlighting some underappreciated positive aspects of the policy environment during this period.

increases in oil prices and the productivity slowdown during that period. Importantly, according to our model, less activist policies would have done a better job of stabilizing *both* inflation and unemployment in the 1970s. This is a lesson that policymakers themselves appeared to recognize by the end of the decade. At that time, with inflation seemingly spiraling out of control, monetary policymakers in the United States changed course, eschewing the fine-tuning of the 'New Economics' and concentrating instead on the goal of price stability. Indeed, in 1978, Paul Volcker, before he became Chairman of the Federal Reserve Board of Governors, alluded to the nature of the required change[4]:

> 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. (Volcker, 1978, p. 61)

Following the costly disinflation of the early 1980s, less activist monetary policy, as evidenced by a reduced policy responsiveness to the perceived unemployment gap, contributed to a new era of relatively stable inflation and unemployment. Our model helps explain this evolution in the understanding of the role of monetary policy 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 success of activist stabilization policy rests on the assumption that the natural rate is 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 of the late 1960s and 1970s can be traced to the pursuit of too low of a target of the natural rate of unemployment.

Fig. 2 plots the rate of unemployment in the United States since the end of 1965 (the beginning of the Great Inflation) and two measures of the natural rate: a real-time measure, that is, perceptions as of the time shown, and a retrospective measure, that is, a current estimate. 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 guided by written documents that offer glimpses of the thinking of policymakers of the 1960s and 1970s. During the 1960s, 4% was widely accepted as a reasonable working definition of the full employment rate of unemployment.[5] Although we do not have precise information for the evolution of

[4]During the early stages of the disinflationary policy pursued following the 1979 policy change, Chairman Volcker often stressed the importance of policies anchoring inflation expectations.

[5]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 this estimate. See Burns (1979), Heller (1966), Okun (1962, 1970), and Stein (1984, 1996).

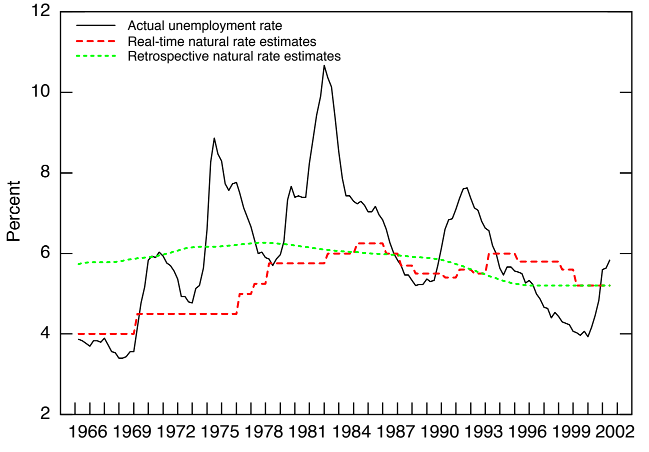

Fig. 2. Unemployment and its natural rate. Notes: The retrospective natural rate reflects the current estimate of the NAIRU from the Congressional Budget Office. The real-time series is as described in the text.

real-time perceptions of the natural rate of unemployment in the early 1970s, we do know that many estimates rose during that period, as reflected in various policy-related studies.[6] Correspondingly, we posit that perceptions of the natural rate rose to around 4.5% in 1970 from the 4% estimates that prevailed earlier.[7] Published accounts of Federal Reserve Board model exercises and estimates by the Council of Economic Advisers reported in the *Economic Report of the President* indicate that natural rate estimates continued to rise during the 1970s. 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 for those years we use the contemporaneous values from these CBO publications for our real-time estimates.[8]

Comparison of the real-time perceptions likely held by policymakers at the time and our best current measures of the natural rate provides a summary indicator of the potential policy errors that may be committed when an activist approach to stabilization policy is pursued. The top panel of Fig. 3 shows our real-time and retrospective estimates of the natural rate of unemployment. The bottom panel of

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

[7]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% in the late 1960s to 5% in the late 1970s does not materially influence our simulations, as both the pattern and size of the resulting misperceptions remain broadly similar under such alternatives, given that the retrospective estimates for this period, at about 6%, are always higher by a considerable margin.

[8]The real-time and retrospective natural rate estimates of the most recent 5 years are identical, reflecting the fact that the CBO's estimates are unchanged over that period.

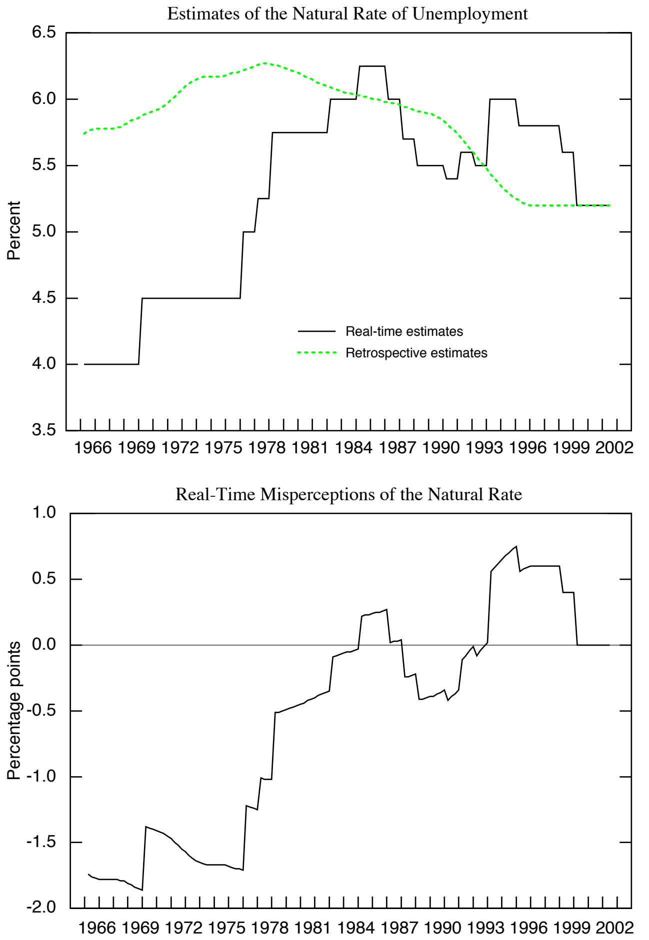

Fig. 3. The natural rate and natural rate misperceptions.

the figure plots the implied natural rate 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 have been constructed by the CBO using a consistent methodology, while the ‘misperceptions’ in the earlier part of the sample also reflect changes in methodology. If the current methodology used by the CBO proves to be inadequate, then the difference between real-time estimates and retrospective estimates in the 1980s and 1990s may widen in the future.[9]

Examples from the 1970s illustrate the problem associated with adopting an activist approach to stabilization policy when one may be mistaken as to the size or the sign of the unemployment (or output) gap in real time.[10] 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: pursue additional monetary expansion to bring the unemployment rate down. Moreover, the existing slack should have led to some welcome disinflation despite the additional stimulus. Indeed, such a policy was pursued at the time. But, based on the retrospective estimates of the natural rate, it is now clear that this policy prescription represented a large error. The economic expansion pursued in 1971–1973 pushed aggregate demand far above the economy's potential, as this is currently understood, fueling an increase in inflation. A similar error occurred after the 1975 recession, contributing to a further rise in inflation.

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:

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

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

[9]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.

[10]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.

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, $\tilde{r}^a$ 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 et al. (1999), McCallum and Nelson (1999), and others, with the intrinsic inflation and inertia in the level of economic activity featured in Fuhrer and Moore (1995), Brayton et al. (1997), Smets (2000), Fuhrer and Rudebusch (2004), and others.

The 'Phillips curve' in this model (Eq. (1)) relates inflation (measured as the annualized percent change in the GNP or GDP price index, depending on the period) 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 (Eq. (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 maturity of the real interest rate in the equation. In estimating our model, we use an interest rate with 1-year maturity.

One difficulty in estimating this model is 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 our sample period (1969–2002). These techniques may be also sensitive to identification problems in this case. To circumvent these difficulties, as in Orphanides and Williams (2002), we follow the approach suggested by Roberts (1997), and also employed by Rudebusch (2002), and use the Survey of Professional Forecasters (SPF) as the source for proxies for expectations. Specifically, we use the median values of the forecasts provided in this 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.[11,12] Our primary sources for our data 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).

[11]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.

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

Using ordinary least squares, we obtain the following estimates for our model between 1969:1 and 2002:2[13]:

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

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

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

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

The numbers in parentheses are the estimated standard errors of the corresponding regression coefficients. The estimated unemployment equation also includes a constant term that provides an estimate of the natural real interest rate plus the average premium of the 1-year Treasury bill rate we use for estimation over the federal funds rate, which corresponds to the natural rate of interest estimates we use in the model. If this premium equals the average difference between the 1-year rate and the federal funds rate during this sample, then the estimation suggests that the natural rate of interest in this sample is 3.2%. To complete our model for simulations, we impose the expectations theory of the term structure whereby the 1-year rate equals the expected average of the federal funds rate over four quarters.

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, $\bar{\pi}^e_{t+3}$ (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 change in the unemployment rate over the next year, and the unemployment gap (the unemployment rate less the real-time estimate of the natural rate) forecasted to occur in three quarters:

$$\begin{aligned} i_t = {} & \theta_i i_{t-1} + (1-\theta_i)(r^* + \pi^*) + \theta_\pi(\bar{\pi}^e_{t+3} - \pi^*) + \theta_u(u^e_{t+3} - \hat{u}^*_t) \\ & + \theta_{\Delta u}(u^e_{t+3} - u_{t-1}) + \varepsilon_{i,t}. \end{aligned} \tag{5}$$

Estimation of this policy rule also provides an implicit estimate of the inflation target, π^*. 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 $\theta_u = 0$).

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

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. To examine this effect in a parsimonious manner, we follow the suggestion in Orphanides (2004) and focus on a specification that allows for a break in the θ_u parameter, keeping remaining parameters of the policy reaction functions fixed. Other things equal, a reduction in the policy responsiveness to the perceived gap in the forecast of unemployment from its natural rate, θ_u, would reflect a reduction in activism in this policy rule. Interestingly, 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 remaining individual parameters over the two subsamples cannot be rejected.[14] Allowing for this break, our estimated policy rule is given by

$$\begin{aligned} i_t = {} & \underset{(0.044)}{0.750}\, i_{t-1} + (1 - \underset{(0.044)}{0.750})(r^* + \pi^*) + \underset{(0.130)}{0.779}(\bar{\pi}^e_{t+3} - \pi^*) - \underset{(0.210)}{0.673}(u^e_{t+3} - u_{t-1}) \\ & + (-\underset{(0.197)}{1.131} + \underset{(0.158)}{0.561}\, D)(u^e_{t+3} - \hat{u}^*_t) + \varepsilon_{i,t}, \end{aligned} \tag{6}$$

$$SER = 1.02, \quad DW = 1.90,$$

where D is a dummy variable equaling zero before 1979:3 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 $r^* = 3.2\%$, as suggested by the estimation of Eq. (2), yields an estimate of 2.7% for π^* with a standard error equal to 0.15%.

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 that it was more activist. This contrasts with the well-known findings reported by Clarida et al. (2000), based on a similar specification, but

[14] As a robustness check for our model, we also examined simulations based on a specification of the policy rule that allows breaks in the policy responsiveness to both the inflation forecast and perceived unemployment gap, θ_π and θ_u:

$$\begin{aligned} i_t = {} & \underset{(0.043)}{0.738}\, i_{t-1} + (1 - \underset{(0.043)}{0.738})(r^* + \pi^*) - \underset{(0.209)}{0.644}(u^e_{t+3} - u_{t-1}) \\ & + (-\underset{(0.219)}{0.990} + \underset{(0.220)}{0.377}\, D)(u^e_{t+3} - \hat{u}^*_t) + (\underset{(0.144)}{0.687} + \underset{(0.159)}{0.155}\, D)(\bar{\pi}^e_{t+3} - \pi^*) + \varepsilon_{i,t}, \end{aligned}$$

$$SER = 1.02, \quad DW = 1.90.$$

The point estimates suggest that in addition to the larger response to the perceived unemployment gap, policy in the first subsample was also somewhat less responsive to the inflation forecast. The difference in these estimates from our baseline specification is small, however, and does not qualitatively influence our simulation results.

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 insufficient to yield a unique rational expectations equilibrium in the pre-1979 period. However, as documented by Orphanides (2004), their findings are overturned when information actually available to policymakers in real time is used to estimate the policy rule that they specify. Even when we allow for breaks in the policy response to both expected inflation and to the 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 advanced by Clarida et al. (2000).

4. Expectations formation

Following Orphanides and Williams (2004, 2005), we assume that agents reestimate their forecasting models each period using a constant gain algorithm that places more weight on recent observations.[15] 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.

4.1. Perpetual learning with least squares

Under perfect knowledge with no shocks to the natural rate of unemployment, the predictable components of inflation, the unemployment rate, and the funds rate each depend on a constant, one lag each of the inflation and the ex post real funds rate (the difference between the nominal funds rate and the inflation 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, the unemployment rate, and the 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: $X_t = (1, \pi_{t-1}, u_{t-1}, u_{t-2}, i_{t-1} - \pi_{t-1})$; 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 following recursive form:

$$c_t = c_{t-1} + \kappa_t R_t^{-1} X_t (Y_t - X_t' c_{t-1}), \tag{7}$$

[15] See also Sargent (1999), Cogley and Sargent (2001), Evans and Honkapohja (2001), and Gaspar and Smets (2002) for related treatments of learning. A separate strand of the literature has focused on the problem of estimating the implicit inflation target of the central bank, assuming that other parameters are known. See e.g. Bomfim et al. (1997), Erceg and Levin (2003), Kozicki and Tinsley (2003), and Rudebusch and Wu (2003).

$$R_t = R_{t-1} + \kappa_t(X_t X_t' - R_{t-1}), \tag{8}$$

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. Assuming a constant natural rate of unemployment, as the data accumulate this mechanism converges to the correct reduced-form VAR model and the economy converges to the perfect knowledge rational expectations equilibrium. That is, in our model the perceived law of motion that agents employ for forecasting corresponds to the correct specification of the equilibrium law of motion under rational expectations.[16] In addition, it is straightforward to show that the model with a constant natural rate of unemployment is expectationally stable in the sense of Evans and Honkapohja (2001) under least squares learning under either the estimated pre-1979 or post-1979 policy rules.[17]

As noted above, to formalize perpetual learning – as would be implied by the presence of structural changes such as shifts in the natural rate of unemployment – we replace the decreasing gain implied by the infinite memory recursion with a small constant gain, $\kappa > 0$.[18] 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 equations for inflation, the unemployment gap, the federal funds rate (the monetary policy rule), and the forecasts generated from the forecasting model. As explained in Orphanides and Williams (2004), 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 the expectations data from the Survey of Professional Forecasters.

To examine the fit of the survey, we generated a time series of forecasts using a recursively estimated VAR for the inflation rate, the 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

[16] This assumption is in contrast to learning models where agents are restricted to form expectations using misspecified models, e.g. Sargent (1999).

[17] We thank Bruce McGough for kindly confirming that the E-stability conditions detailed in Evans and Honkapohja (2001) are satisfied for our model.

[18] 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.

geometrically declining weights. This procedure resulted in reasonably accurate forecasts of inflation and unemployment, with root mean squared errors comparable to the residual standard errors from the estimated structural Eqs. (3) and (4). We found that discounting past data at about 1% per quarter yielded forecasts closest on average to the SPF over 1968–2002.[19] This corresponds to an updating gain of about 2% per quarter during the 1970s and $1\frac{1}{2}$% per quarter in the 1990s.[20] In light of these results, we adopted $\kappa = 0.02$ as a baseline value for our simulations, but also examined the sensitivity of our model to somewhat 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 the 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 from our forecasting model of inflation, the unemployment rate, and the federal funds rate over the 1966–2002 period. We treat the forecasts generated by the learning model as the true data for agents' expectations and then compute tracking residuals, that is the values of the historical residuals for the equations for the unemployment rate, the inflation rate, and the federal funds rate for 1966–2002. Thus, given these residuals, the model's predictions will exactly match the historical paths for all endogenous variables. We then conduct counterfactual experiments in which we modify assumptions regarding policy or the learning process, but do not change the paths for the equation residuals for unemployment, inflation, and the federal funds rate, which we assume are

[19] 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.

[20] As a robustness check, we also examined the degree of discounting that best fits the historical data on inflation and unemployment, given our structural model and learning process. To this end, we simulated our 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.

exogenous. Each counterfactual simulation starts in the first quarter of 1966 and ends in the second quarter of 2002.

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 Fig. 3.

Absent natural rate misperceptions, inflation would have been relatively stable in the 1970s according to the model. Fig. 4 shows the historical and 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 2–4% during the 1970s. The stability in inflation is achieved through a tighter path for policy starting in 1966 that drives the unemployment rate above its historical path. This effective stabilization of inflation avoids the rise in unemployment associated with the Volcker disinflation occurring at the end of the decade and into the early 1980s.

The policy without natural rate misperceptions also avoids the damaging shift in the perceived law of motion of inflation evident in the historical data. Absent the rise in inflation in the late 1960s and 1970s, the expected level of inflation also remains subdued. In addition, the perceived persistence in inflation remains moderate. The solid line in Fig. 5 shows the estimated coefficient on lagged inflation in the forecasting equation for inflation that incorporates learning, as described above. This statistic usefully summarizes agents' perceptions of the persistence in inflation. Based on the historical data, the perceived persistence in inflation rises to about 0.9 by 1975.[21] In contrast, under the same policy, but absent natural rate misperceptions, the perceived persistence in inflation would have remained moderate throughout the 1960s and 1970s. In this simulation, the trend rise in inflation associated with the 'Great Inflation' is avoided and inflation expectations remain 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

[21] This rise in perceived inflation persistence in our model is a manifestation of the real-world accumulation of evidence against the hypothesis of a long-run tradeoff between unemployment and inflation and in favor of the 'accelerationist' view during the 1970s.

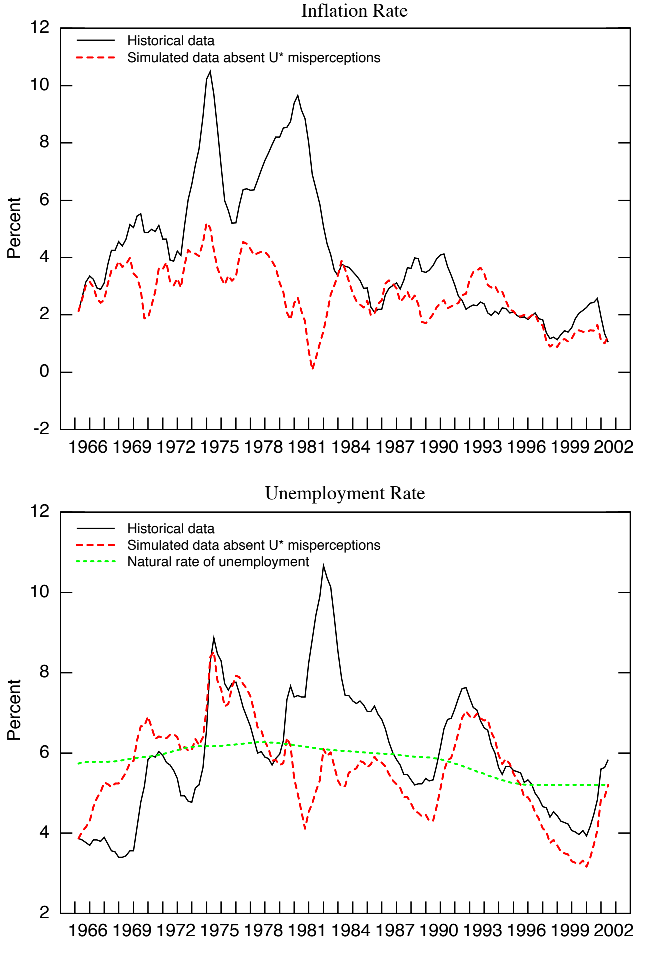

Fig. 4. Outcomes with no natural rate misperceptions. Notes: The two panels show historical and simulated paths of the rates of inflation and unemployment. The solid lines show the historical data. The dashed lines show the simulated paths assuming that the monetary policymaker knows the true value of the natural rate of unemployment in real time. Each simulation starts in the first quarter of 1966.

much less unfavorable if expectations had remained well anchored and governed by the forecasting processes in place before. In particular, had the policy errors of the late 1960s not resulted in the steep increase in the persistence of inflation (as shown in Fig. 5) the inflationary impulses of the late 1960s and early 1970s would have been contained much more easily and price stability restored at a lower cost.

To illustrate the role of learning in this case, in Fig. 6 we examine two counterfactual experiments where the historical policy rule is followed, but the process governing the formation of expectations is assumed to remain unchanged and is governed by the reduced form VAR in place at the beginning of the

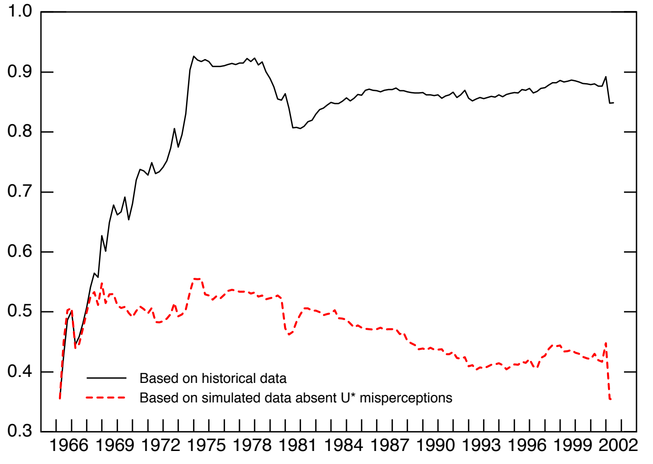

Fig. 5. Evolution of inflation persistence in the inflation forecasting equation. Notes: The lines show the simulated paths of the estimated coefficient on lagged inflation in agents' inflation forecasting equations, which reflects agents' perceptions of inflation persistence. The path shown by the solid line is based on the historical data. The dashed 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.

simulation, in 1966. Thus, in these simulations, expectations of inflation remain well anchored through time by design. In the simulation shown with the dashed lines, we posit that policy continues to make the errors associated with natural rate misperceptions. As can be seen, despite the policy errors due to the natural rate misperceptions, if the favorable expectations mechanism in place before the Great Inflation could have been maintained, that is in the absence of learning, economic outcomes would have been significantly better.

In addition, had the inflation expectations process remained as favorable, the role of the policy errors induced by the misperceptions of the natural rate would have been much less important. To illustrate this point, the dash-dot lines in the figure present a counterfactual simulation in which both expectations formation remains unchanged, and the policymaker is assumed to avoid natural rate misperceptions in setting policy. As can be seen, the difference in the path of inflation in the two simulations is not very dramatic. This confirms the importance of the interaction of policy errors due to natural rate misperceptions with the learning dynamics regarding expectations for understanding the Great Inflation.

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

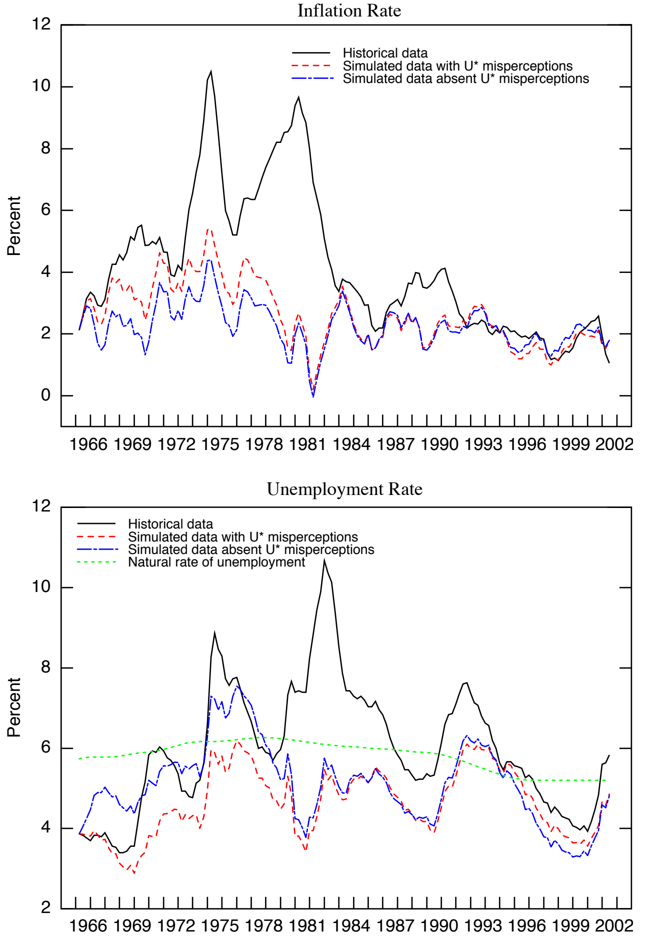

Fig. 6. Outcomes with fixed-coefficient expectations. Notes: The two panels show historical and simulated paths of the rates of inflation and unemployment. The solid lines show the historical data. The dashed and dash-dot lines show the simulated paths assuming that the agents do not update their forecasting models from 1966 on. Each simulation starts in the first quarter of 1966.

stagflation of the 1970s would not have occurred. But, of course, neither of these conditions could be taken for granted as the basis for policy design, and the possibility that they might fail, as they did during the Great Inflation, limits the scope for activist stabilization policy. An insufficient understanding of these limits and 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 activism, our third set of experiments examines what the historical outcomes could have been in the presence of learning and of the observed natural rate given by our real-time estimates if policy were driven by a less activist approach than the one observed.[22] Figs. 7 and 8 summarize the results from two such experiments. In one, policy does not respond to the unemployment gap at all, and in the other, policy follows the estimated post-1979 reaction function.

If policymakers had followed either of these policies starting in 1966, the rise in inflation in the 1970s would have been less pronounced and the unemployment rate would have been lower on average than it actually was. The finding that both inflation and unemployment would have been lower in the 1970s if the Fed had followed the estimated post-1979 reaction function during the late 1960s and 1970s, or if the Fed had not responded to the unemployment (or output) gap, differs from the results of Judd and Rudebusch (1998) and Orphanides (2003b), respectively, who find that such policies would have implied lower inflation, but at the cost of lower output during the 1970s (implying a higher unemployment rate). An important difference is that these analyses were based on the assumption of backward-looking accelerationist models that implicitly treat inflation expectations as invariant to monetary policy. Our results illustrate the importance of endogenous formation of expectations in affecting the tradeoffs available to policymakers in designing monetary policies.

A key result in our analysis is that under the less activist policies, the natural rate misperceptions of the 1960s and 1970s would not have been sufficient to cause significant deterioration in inflation expectations even with the perpetual learning process governing the formation of expectations. Importantly, as can be seen in Fig. 8, the reduced activism would have avoided the dramatic increase in agents' perceptions of the persistence of inflation. By maintaining well-anchored inflation expectations throughout the 1970s, these policies would have avoided the stagflationary outcomes of the decade. Our simulations also suggest that, in line with the results in Orphanides and Williams (2004), the reduced activism would have facilitated the formation of somewhat more accurate forecasts. The root mean square of agent's forecast errors for both inflation and unemployment are slightly smaller under the alternative simulations relative to the baseline.

Indeed, the realization of the role of the policy mistakes of the 1970s in changing the formation of private inflation expectations was a key reason leading to the policy change in 1979. As Stephen Axilrod summarized[23]:

> 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

[22]This experiment is a first step towards investigating the design of *efficient* monetary policy in our estimated model, accounting for the role of perpetual learning and its influence on the inflation expectations process. An active literature over the past several years has been exploring issues related to efficient policy design in the presence of uncertainty regarding models, data, and natural rates. See e.g. Levin et al. (1999, 2003), Orphanides (2003a), Orphanides et al. (2000), Orphanides and Williams (2002), Rudebusch (2001, 2002), and references therein.

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

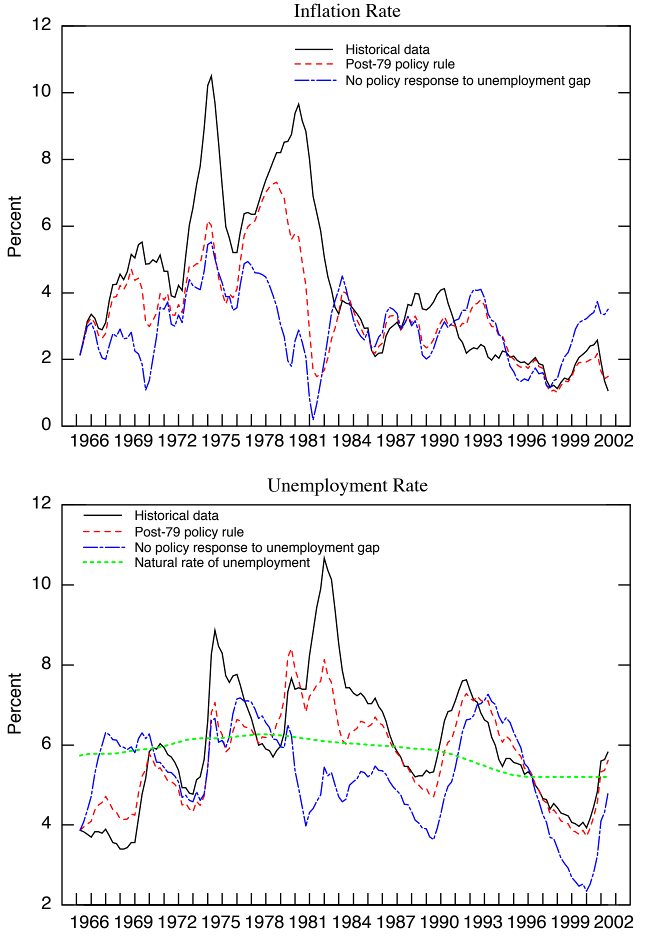

Fig. 7. Outcomes with alternative policy rules. Notes: The two panels show historical and simulated paths of the rates of inflation and the unemployment. The paths shown by the solid lines are based on the historical data. The dashed lines show the simulated paths in which monetary policy follows the post-1979 policy rule. The dash-dot lines show the simulated paths when policy does not respond to the unemployment gap. Each simulation starts in the first quarter of 1966.

> 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. (Axilrod, 1985, p. 14.)

5.5. International comparisons

The interplay between natural rate misperceptions, monetary policy and inflation dynamics that we explore in this paper may also help improve our understanding of the historical experience in other nations. Historical evidence suggests that natural

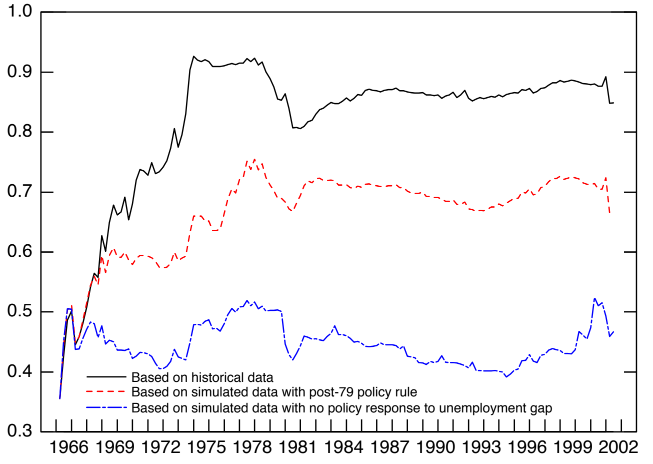

Fig. 8. Evolution of inflation persistence with alternative policy rules. Notes: The lines show the simulated paths of the estimated coefficient on lagged inflation in agents' inflation forecasting equations, which reflects agents' perceptions of inflation persistence. The path shown by the solid line is based on the historical data. The dashed line shows the simulated path in which monetary policy follows the post-1979 policy rule. The dash-dot line shows the simulated path when policy does not respond to the unemployment gap. Each simulation starts in the first quarter of 1966.

rate misperceptions, not dissimilar in magnitude to those seen in the United States, misled policymakers in several other countries during the 1970s and early 1980s.[24] Among these countries, Australia, Canada, the United Kingdom and New Zealand experienced an inflation problem arguably considerably worse than that seen in the United States while Germany largely avoided this malaise. Intriguingly, Nelson (2005a,b) documents that policy in Australia, Canada, the United Kingdom and New Zealand had an activist bent bearing similarities to our description of policy in the United States during the Great Inflation. By contrast, as documented by Gerberding et al. (2005), the monetary policy framework of the Bundesbank from the 1970s to 1998 did not exhibit such activism. This suggests that the differences in the inflationary experiences in these countries are consistent with our analysis and predictions for the United States and points to a closer comparison of the interactions of monetary policy, learning, and inflation dynamics across these countries as a fruitful avenue for further research.

5.6. Robustness

As a robustness check for our key results regarding the wisdom of reduced policy activism, we also examined counterfactual simulations under alternative

[24] In particular, the output gap mismeasurement documented by Gerberding et al. (2005) for Germany; Nelson and Nikolov (2003) for the United Kingdom; and Nelson (2005b) for Australia, Canada, and New Zealand, is similar in magnitude to that documented by Orphanides (2003b) for the United States.

assumptions regarding learning and the formation of expectations. We concentrated our attention on the robustness of the finding that if policy during the Great Inflation had 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 our results to the updating parameter κ by comparing counterfactual simulations for three different values of $\kappa = 0.01$, 0.02, 0.03 for our experiments. 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 to the choice of initial conditions governing the formation of expectations. Instead of the initial conditions estimated through the end of 1965, we examined simulations with estimated initial conditions later in the sample. We also considered as initial conditions the reduced-form coefficients corresponding to the model-consistent solution of the model. In either case, these alternative initial conditions are somewhat less favorable than the ones used in the simulations reported before. As a result, inflation outcomes for the early 1970s are worse under these alternatives relative to our baseline specification. However, our simulations suggest that even with these less favorable initial conditions, inflation in the mid- and late-1970s would have been considerably lower if policy had followed the estimated post-1979 rule. As a result, if the post-1979 policy had been in place during the late 1960s and throughout the 1970s, the stagflation of the 1970s would not have occurred.

6. Conclusion

In principle, the activist approach to macroeconomic stabilization that underlay the monetary policy decisions of the late 1960s and 1970s in the United States could have been successful in stabilizing economic fluctuations while maintaining price stability if policymakers had accurate assessments of the natural rate of unemployment. In the event, the natural rate estimates proved to be highly inaccurate, and the unemployment gap (and the related output gap) turned out to be a poor guide for policy in practice. On their own, these policy errors would not have been disastrous to macroeconomic performance if inflation expectations had remained as favorable as they were before the Great Inflation got underway. But, in a dynamic economy with agents continuously learning, the rise in inflation resulting from the policy errors and the activist approach to stabilization policy unmoored inflation expectations, eventually resulting in the stagflation of the 1970s. Towards the end of that decade, the fatal flaw in activist policy strategies was recognized leading to a greater focus on price stability.

Similar to the experience in the United States, some other nations pursuing activist macroeconomic policies, such as Australia, Canada, the United Kingdom and New

Zealand experienced stagflationary episodes during the 1970s and in the 1980s. These countries subsequently adopted inflation targeting as an alternative policy framework designed to anchor inflation expectations and place a high priority on inflation stabilization. In contrast, Germany, where monetary policy did not exhibit a similar activist bend, largely avoided the stagflationary malaise. Out of these experiences, in the United States and elsewhere, grew the realization that active control of resource utilization should be downplayed and that policies focusing on price stability could achieve better outcomes in terms of the stabilization of both inflation and unemployment.

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