Citizens and Policymakers*

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First Draft

Abstract

We investigate the effectiveness of an aggressive price stabilizing (anti-inflation) policy on the ability of citizens to achieve rational expectations equilibrium (REE) forecasts of inflation. Inflation does not persist when citizens have rational expectations forecasts. In using policy to assist citizens in achieving REE forecasts, policymakers also reduce inflation persistence. An aggressive anti-inflation policy tack consists of (among other things) a willingness to respond more forcefully to deviations from an inflation target. Using an adaptive learning framework, we develop a model that uses a real contracting rigidity in conjunction with an interest rate rule and an IS-curve. The model equilibrium indicates that only an aggressive anti-inflation policy enables citizens to learn the REE inflation forecast. The model also shows that inflation persistence has a negative relationship with policy aggressiveness. We test the model using quarterly inflation data for the period 1960 to 2000. The results indicate that policy becomes aggressive in the early 1980s. A substantial reduction in inflation persistence follows this change in policy.

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1 Introduction

There is general agreement that persistent and volatile inflation is harmful to economic stability and economic development.[1] In the face of this political, social, and economic problem, the issue of what policymakers do to arrest (or aggravate) inflation persistence is salient. One line of research focuses on how policymakers use exchange rate regimes to reduce inflation persistence. The results of this research indicate inflation persists longer under floating exchange rates than under fixed rates (Alogoskoufis and Smith 1991; Alogoskoufis 1992; Obstfeld 1995; and Siklos 1999).

The effect of exchange rate regimes has also been questioned. Bleaney (1999), for example, finds that changes in inflation persistence have nothing to do with the exchange rate regime. Using OECD data for the period 1954 to 1996 and allowing for mean-shifts in the inflation rate, he finds inflation persistence is similar — across countries — regardless of the exchange rate regime. Bleaney concludes that the decline in inflation persistence comes from the changes in inflation (monetary) targets. Yet, inflation targeting may not be enough to reduce inflation persistence either. Siklos (1999), examines inflation targets and compares them to the exchange rate regime. In a sample of 10 OECD countries, he concludes that the adoption of an inflation targeting policy is not sufficient to reduce inflation persistence.

In this paper, we extend the investigation on inflation target effectiveness by determining how the implementation and aggressiveness of maintaining an inflation target affects inflation persistence.[2] Our model has two components. The first component is a fairly standard model of macroeconomic outcomes and policy. We use a relative-real-wage contracting model in combination with a Taylor interest rate rule (Fuhrer 1995; Fuhrer and Moore 1995; Taylor 1993, 1994, 1999).

The second component is that we assume citizens learn in an adaptive manner and form expectations as new data becomes available over time. The model has a unique and stable rational expectations equilibrium (REE) (Evans and Honkapohja 2001)). The stability (E-stability) conditions have direct implications for the relationship between citizens and policymakers. Under the REE, aggressive implementation of an inflation target, reduces inflation persistence. In other words, citizens make more accurate inflation forecasts (learn the REE) when policymakers follow aggressive implementation practices.

We test our equilibrium predictions for the period 1960-2000. We find that inflation persistence decreases with the credible implementation of an aggressive anti-inflation policy target. This policy aggressiveness-inflation persistence link-

[1] See, for example, Bange et al. 1997; Chari, Jones, and Manuelli 1995; DeGregorio 1992, 1993; Easterly et al. 1994; Fischer 1993; Jarrett and Selody 1982; Kormendi and Meguire 1985; Smyth 1994).

[2] An aggressive price stabilizing policy consists of (among other things) a willingness to respond forcefully to deviations from a prespecified inflation target. Price stabilizing policy aggressiveness can also be informally represented as a period of high short-term real interest rates or a ratio of short-term interest rates to inflation that exceeds unity (Granato 1996). A more formal definition follows in Section 2.3.

age begins in late-1982, and we use this as the starting point for both OLS and ARCH analysis. The results indicate, for both types of analysis, inflation persistence is reduced when policy implementation is aggressive. A secondary result is a negative relationship between policy aggressiveness and inflation volatility.

The paper is structured as follows. In Section 2 we formulate our model. Section 3 determines the stability condition. We find the adaptive learning model has unique equilibrium for inflation. Section 4 presents the relationship between aggressive policy implementation and inflation. Section 5 presents the empirical tests and results and Section 6 concludes the paper.

2 The Model of Inflation

2.1 The Relative-Real-Wage Contract Specification

Following tradition, we assume that citizens care about their real wages. However, instead of considering the overlapping nominal wage contracts model (Taylor 1980) we use another contracting specification that is based on the recent contributions of Fuhrer (1995) and Fuhrer and Moore (1995).

The model assumes a two-period contract. For simplicity prices reflect a unitary markup over wages. The price at time $t - (p_t) -$ is expressed as the average of the current (x_t) and the lagged (x_{t-1}) contract wage:

$$p_t = \frac{1}{2}\left(x_t - x_{t-1}\right), \tag{1}$$

where p_t is the logged price level, and x_t is the logged wage level at period t. In addition, citizens are concerned with their real wages over the lifetime of the contract:

$$x_t - p_t = \frac{1}{2}\left[x_{t-1} - p_{t-1} + E_t\left(x_{t+1} - p_{t+1}\right)\right] + \gamma y_t, \tag{2}$$

where y_t is the excess demand for labor[3] at time t and $E_t\left(x_{t+1} - p_{t+1}\right)$ is the expected future real wage level.

The inflation rate (π_t) is defined as the difference between the current and lagged price level, $(p_t - p_{t-1})$. With this definition we substitute equation (2) into equation (1) and obtain[4]:

$$\pi_t = \frac{1}{2}\left(\pi_{t-1} + E_t\pi_{t+1}\right) + \gamma y_t. \tag{3}$$

where $E_t\pi_{t+1}$ is the expected inflation rate over the next period.

Equation (3) captures the main characteristic of inflation persistence. Since citizens care about their real wages over both the past and future periods, the lagged price level (p_{t-1}) is taken into consideration as they adjust (negotiate) their real wage at time t. This model feature allows the inflation rate to depend on both the expected inflation rate as well as the past inflation rate.

[3] We can also define y_t as the log deviation of output from the natural output level.

[4] The output term in equation (3) can be characterized as a moving average of the current and the lagged output gap, $\frac{\gamma}{2}\left(y_t + y_{t-1}\right)$. However, Fuhrer (1995) assumes the output term is the current output gap (γy_t) for simplicity.

2.2 The IS Specification

The IS curve – the demand function – we employ reinforces the use of agent expectations and also provides an avenue for the influence of real interest rates and policy. McCallum and Nelson (1999), derive their IS curve from microfoundations. Agents maximize their lifetime utility by choosing a mix between consumption and the stock of real money balances.

We modify McCallum and Nelson's (1999) IS specification in terms of the output gap level rather than the actual output level:

$$y_t = -\beta \left(r_t - E_t \pi_{t+1} - r^* \right) + u_{2t}, \tag{4}$$

where r_t is nominal interest rate, r^* is the target real interest rate, and $\beta > 0$. If the real interest rate, $r_t - E_t\pi_{t+1}$, is below the targeted real interest rate $[(r_t - E_t\pi_{t+1}) - r^* < 0]$, then citizens increase their consumption and also raise the output level $((y_t)$ in $(3))$ above the natural level, $(y_t > 0)$. The opposite occurs when the real interest rate is above the target.

2.3 The Taylor Interest Rate Policy Rule

The contingency plan or policy rule that policymakers follow is the Taylor Rule $(1993, 1994, 1999)$:

$$r_t = \pi_t + \alpha_\pi \left(\pi_t - \pi^* \right) + \alpha_y y_t + r^*. \tag{5}$$

Taylor (1999) argues that his interest rate rule is related to the quantity theory of money. He further asserts that his policy rule accurately describes different historical time periods when there were different policy regimes.

Clarida, Gali, and Gertler (2000) argue that a non-aggressive monetary policy rule is a policy rule which accommodates inflationary pressure by reducing the real interest rate. This reduction in the real interest rate stimulates an increase in aggregate demand and inflation from equations $((3), (4))$. Clarida, Gali, and Gertler (2000) define an aggressive policy as policymakers using this policy rule to raise (lower) the real interest rate when inflationary (deflationary) pressures exist in the economy.

Equation (5) can be categorized as aggressive only if both α_π and α_y are positive (Taylor 1993,1994). Positive values of α_π and α_y indicate a willingness to raise (lower) real interest in response to the positive (negative) derivations from either the target inflation rate $(\pi_t - \pi^*)$ and the output gap (y_t).

For clarity we define an aggressive policy tack in the following way:

Definition 1 *An aggressive policy rule is one where both α_π and α_y are positive in equation* (5).

3 Stability Analysis

The next step is to determine if the learning dynamics allow citizens to reach the (REE) when they start from a point of reference that contains nonequilibrium values. The stability analysis proceeds in the following way.

3.1 The Stationary Equilibrium Inflation Rate

The reduced form for the inflation rate is found by substituting equation (5) into equation (4). First solve for y_t and then put that result into equation (3). The expression for inflation (π_t) becomes:

$$\pi_t = \Omega_0 + \Omega_1 \pi_{t-1} + \Omega_2 E_t \pi_{t+1} + \xi_t, \tag{6}$$

where $\Omega_0 = \frac{\gamma\beta\alpha_\pi \pi^*}{1+\beta\alpha_y+\gamma\beta(1+\alpha_\pi)}$, $\Omega_1 = \frac{1+\beta\alpha_y}{2[1+\beta\alpha_y+\gamma\beta(1+\alpha_\pi)]}$, $\Omega_2 = \frac{1+\beta\alpha_y+2\gamma\beta}{2[1+\beta\alpha_y+\gamma\beta(1+\alpha_\pi)]}$ and $\xi_t = \frac{\gamma u_{2t}+(1+\beta\alpha_y)u_{1t}}{1+\beta\alpha_y+\gamma\beta(1+\alpha_\pi)}$. Equation (6) shows that current inflation depends on the first-order lag of inflation and also expected future inflation.

We now solve for the REE by taking the conditional expectations at time $t+1$ of equation (6), and substituting this result into equation (6). The result is:

$$\pi_t = A + B\pi_{t-1} + \xi_t', \tag{7}$$

where $A = \frac{\Omega_0}{1-\Omega_2 B-\Omega_2}$ and $B = \frac{1\pm\sqrt{1-4\Omega_1\Omega_2}}{2\Omega_2}$.

Equation (7) is the *minimum state variable* (MSV) solution of inflation — which depends solely on the lagged inflation rate. The coefficient of the lagged inflation, B, is a quadratic since we are taking contemporaneous expectations. The two values are defined as: $B^+ = \frac{1+\sqrt{1-4\Omega_1\Omega_2}}{2\Omega_2}$ and $B^- = \frac{1-\sqrt{1-4\Omega_1\Omega_2}}{2\Omega_2}$.

We consider whether the model is determinate. Since B takes two values: B^+ and B^-, we show that B^- is a unique stationary solution only if $\alpha_\pi \geq 0$. Policymakers stabilize inflation (the economy) if they respond to deviations from their inflation target in an aggressive manner.

Proposition 2 *For the reduced form* (7), *there exists a unique stationary REE only if* $\alpha_\pi \geq 0$.

Proof. We need to show that only B^- is less than 1 when $a_\pi \geq 0$. We consider all values of α_π by separating it into 3 intervals: $\alpha_\pi < 0$, $\alpha_\pi = 0$, and $\alpha_\pi > 0$. For $\alpha_\pi < 0$, we can assign a numerical value of $\alpha_\pi < 0$ such that both B^+ and B^- are inside the unit circle. This implies that multiple equilibria exist when $\alpha_\pi < 0$. When $\alpha_\pi = 0$, we have $B^+ = 1$ and $B^- = 1 - \frac{2\beta\gamma}{1+2\beta\gamma+\beta\alpha_y} < 1$. For the case of $\alpha_\pi > 1$, B^+ is a strictly increasing function with respect to $\alpha_\pi > 0$. Taking derivative of B^+ with respect to α_π, we have:

$$\frac{\partial B^+}{\partial \alpha_\pi} = \frac{\beta\gamma(1+\Phi)}{(1+2\beta\gamma+\beta\alpha_y)\Phi} > 0 \quad \forall \alpha_\pi > 0$$

where $\Phi = \sqrt{1 - \frac{(1+\beta\alpha_y)(1+2\beta\gamma+\beta\alpha_y)}{(1+\beta\gamma(1+\alpha_\pi)+\beta\alpha_y)^2}}$. In addition, B^- is a decreasing function with respect to $\alpha_\pi > 0$ and asymptotically converges to 0. The derivative of B^- is

$$\begin{aligned} \frac{\partial B^-}{\partial \alpha_\pi} &= \frac{\beta\gamma(-1+\Phi)}{(1+2\beta\gamma+\beta\alpha_y)\Phi} < 0 & for\ 0 \leq \alpha_\pi < \infty \\ &= 0 & for\ a_\pi \to \infty \end{aligned}$$

and the limiting value of B^- as $\alpha_\pi \to \infty$ is $0:$

$$\lim_{\alpha_\pi \to \infty} B^- = 0$$

■

3.2 Expectational Stability

We assume citizens learn in an adaptive manner and form expectations as new data becomes available over time. Evans and Honkapohja (2001) present the general specification of equation (6) in the context of an adaptive learning model. They first assume that citizens are able to obtain the current value of the inflation rate π_t at time t. If we assume that citizens learn (and update) in a manner consistent with recursive least squares, then the stability of equation (7) can be summarized in the following proposition:

Proposition 3 *For equation* (6), *the E-stability conditions for the MSV solutions are* $\Omega_1\Omega_2(1-\Omega_2 B)^{-2} < 1$ *and* $\Omega_2(1-\Omega_2 B)^{-1} < 1$. *If an MSV solution is stationary and E-stable, then it is locally stable under recursive least squares* (*RLS*) *learning (Evans and Honkapohja 2000: 201-204).*

Evans and Honkapohja (2001) also demonstrate the existence of the observable current value of the inflation rate π_t — at the time of expectations formation — can create a simultaneity problem. To avoid this problem, they relax this assumption and instead assume that citizens observe the lagged inflation rate π_{t-1} only. This assumption alters the E-stability conditions: B^+ is always unstable whereas B^- is E-stable with the form:

$$-\sqrt{1-4\Omega_1\Omega_2} < 1 - 2\Omega_2. \tag{8}$$

Equation (8) is a necessary condition of E-stability. In particular, if $\Omega_2 < \frac{1}{2}$, the MSV solution is sufficient for E-stability.

The E-stability condition is the basis for the policy implications of this model. In equation (6), Ω_2 is less than $\frac{1}{2}$ only if $\alpha_\pi > 1$. This implies that citizens are better able to learn the inflation equilibrium if policymakers are aggressive enough in fighting inflation. The link between policymaker aggressiveness, agent learning, and inflation persistence is demonstrated by the necessary conditions for E-stability with respect to α_π.

Proposition 4 *For equation* (6), *assuming that citizens do not observe the current value of the inflation rate* π_t *at the time of expectations formation, the MSV solution* (7) *is E-stable if* $\alpha_\pi > 0$.

Proof. For convenience, we first define that the left hand side and right hand side in equation (8) as $LHS = -\sqrt{1-4\Omega_1\Omega_2}$ and $RHS = 1-2\Omega_2$. Since Ω_1 and Ω_2 are a function of α_y and α_π from equation (6) ,we substitute the expressions of Ω_1 and Ω_2 into equation (8). It follows that $LHS = RHS$ only if $\alpha_\pi = 0$. LHS is nonlinear and decreasing over α_π, while RHS is nonlinear and increasing over α_π^2. We conclude that the condition in equation (8) holds if $\alpha_\pi > 0$. Figure 1 plots[5] the values of LHS and RHS against α_π. The two curves intersect at $\alpha_\pi = 0$ and $LHS < RHS$ when $\alpha_\pi > 0$. ■

<<**Figure 1 about here**>>

4 Aggressive Policy and Inflation

4.1 Inflation Persistence

The policy rule now affects the inflation persistence in this model. Equation (7) represents the AR(1) process of the inflation rate. It shows that an increase in α_π raises the persistence of inflation for B^+ but reduces the persistence for B^-.

Proposition 5 *Provided that the model is determinate and E-stable, the persistence of inflation is reduced as policymakers aggressively respond to the deviation of the inflation rate from its target.*

Proof. We extend proposition 1. With the fact the B^+ is not E-stable and the proof of proposition 1, we show that B^- decreases as α_π increases and B^- converges to 0 as α_π approaches to ∞. ■
These results are presented on the left and right panels of Figure 2.

<<**Figure 2 about here**>>

4.2 Inflation Variance

There is also strong evidence that the mean and variance of inflation have a positive relationship (Owyang 2001). As a result, the linkage between the policy aggressiveness α_π should follow as well. We summarize this relationship in the following proposition.

Proposition 6 *Provided that the model is determinate and E-stable, the variance of inflation is reduced as policymakers aggressively respond to the deviation of the inflation rate from its target.*

Proof. From equation (7), one can solve the variance of inflation σ_π^2 :

$$\sigma_\pi^2 = \frac{\sigma_{\xi'}^2}{1 - (B^-)^2}, \tag{9}$$

[5] The underlying parameters are: $\beta = 1$, $\alpha_y = 0.5$, and $\gamma = 0.5$. Also, when $\alpha_\pi = 0$, we have $LHS = RHS = \frac{-\gamma\beta}{1+\beta\alpha_y+\gamma\beta} = -0.25$.

where $\sigma^2_{\xi'} = \frac{\sigma^2_{\xi}}{1-\Omega_2 B^-}$. Solving the expression (9), we have:

$$\sigma^2_{\pi} = \frac{2\left[\gamma^2 \sigma^2_{u_2} + (1+\beta\alpha_y)^2 \sigma^2_{u_1}\right]}{\left[1+\beta\alpha_y + \gamma\beta(1+\alpha_\pi)\right]^2 (1+\Phi)}, \tag{10}$$

where $\Phi = \sqrt{1 - \frac{(1+\beta\alpha_y)(1+2\beta\gamma+\beta\alpha_y)}{(1+\beta\gamma(1+\alpha_\pi)+\beta\alpha_y)^2}}$. From Proposition 1, we show that $\frac{\beta\gamma}{1+\beta\gamma+\beta\alpha_y} < \Phi < 1 \quad for \quad \alpha_\pi \in [0,\infty)$. Therefore, we can see that σ^2_π is non-linear decreasing function with respect to α_π and asymptotically converges to 0 as $\alpha_\pi \to \infty$. ■ These results are presented in Figure 3.

<<**Figure 3 about here**>>

Since observed current inflation is not possible in this model, B^- is the only valid result. It implies that an aggressive policy tack helps citizens learn the REE for inflation. The result is that an aggressive policy to achieve and maintain price stability reduces inflation persistence and, by extension, inflation volatility.

5 Empirical Findings

Clarida, Gali, and Gertler (2000) estimate a forward-looking Taylor Rule for the period 1960:I-1996:IV. They use Paul Volcker's appointment as Fed Chairman in August, 1979 (1979:III) as a regime shift to a more aggressive anti-inflation policy stance.[6] Their results show that the policy rule is significantly more aggressive (see Definition 1) in the post-1979 period (hereafter Volcker-Greenspan) than in the pre-Volcker period.

According to our theory, inflation persistence should also be reduced significantly under an aggressive anti-inflation policy rule. From our reduced form in (7) we estimate a first-order autoregressive process [AR(1)] of the United States inflation rate. We expect that the inflation persistence parameter (B_t) in the Volcker-Greenspan period (1979:III-2000:III) to be smaller relative to the pre-Volcker period (1960:I-1979:II).

5.1 Descriptive Statistics

The analysis is based on quarterly observations of the inflation rate in the post-war United States (1960:I–2000:III). Figure 4 depicts the annual rate of inflation in the United States consumer price index (CPI) from 1960:II–2000:III. Inflation was low during the early 1960's, then trended upward between the late 1960's and late 1970's. After 1980 (i.e., after the Volcker appointment) the inflation rate was lower and relatively stable.

[6] The policy shift to more strict monetary aggregate control was announced in early October, 1979 (1979:4). This policy focus ended in October, 1982. During this period, there was considerable volatility in short-term interest rates (Federal Funds Rate). There was also volatility in monetary aggregates as they followed a downward (restrictive) trend.

<<**Figure 4 about here**>>

Table 1 presents the summary statistics. For the period, the mean inflation rate equals 4.38 percent. The maximum level is about 15.51 percent (1980:I) and the minimum level is -0.86 percent (1986:II).

<<**Table 1 about here**>>

5.2 Estimates of Inflation Persistence

We use ordinary least squares (OLS) to estimate the persistence parameter (B_t) in (7). The first column in Table 2 reports the value of the persistence parameter over the full sample period. Columns 2 and 3 depict the pre-Volcker (1960:II–1979:II) and Volcker-Greenspan (1979:III–2000:III) eras respectively. Using the full sample, the persistence parameter (B_t) equals 0.82 with a standard error of 0.06. The persistence parameter in the pre-Volcker period equals 0.91 with a standard of 0.07. In contrast, the persistence parameter in the Volcker-Greenspan era equals 0.7452 with a standard error of 0.10.

The inflation rate has less persistence after Volcker is appointed as Fed Chairman in 1979. To test whether inflation persistence is significantly reduced during the Volcker-Greenspan era, we use a Chow's test and find that the break point period of 1979:III is, however, not significant even at the 10 percent level.

<<**Table 2 about here**>>

5.2.1 The Appropriate Structural Break

The results indicate that a simple appointment or announced policy shift that signals an aggressive policy is not sufficient for citizens to learn the REE. There is simply no data at that time for citizens to use and the past behavior of policymakers creates a credibility problem (Baxter 1985; Granato 1996). This further delays the transition to the REE.

If 1979:III is not a significant break point of inflation persistence, then when did one occur — if it occurred at all? Contemporaneous and historical accounts of this time suggest that Volcker was not able to adopt an aggressive monetary policy until Ronald Reagan became president. This places the date for sustained and effective implementation of an aggressive policy to 1981 or 1982 (Clarida, Gali, and Gertler 2000; Granato 1996; Greider 1987; Kettl 1986).

Figure 5 provides point estimates of inflation persistence (B_t) for a 10-year rolling sample since 1960:II. Most of the regressions show that inflation was highly persistent over the periods from 1960–1970 and 1980–1990. After 1990, inflation persistence starts falling. In addition to the rolling sample of the point estimates we also plot the t-statistics (Figure 6) and find the inflation persistence parameters from 1981–1991 and 1983–1993 are not significantly different from zero.

<<**Figure 5 about here**>>

<<Figure 6 about here>>

We also formulate a switching regression model to estimate the break point for the full sample period (Quandt 1958; Goldfeld and Quandt 1973; Hinkley 1971; McGee and Carlton 1970). Assuming the error variances to be equal for both regimes, we estimate two regime models by moving the different break point periods from 1965:I to 1995:III (i.e., different partitions of the full sample period). We then examine the respective residual sums of squares and choose that break point for which this sum is the minimum.

Figure 7 plots the residual sum of squares over the break point periods. The minimum residual sum of squares exists in the range of 1981:I–1982:IV. This coincides with contemporaneous and historical accounts (Kettl 1986; Greider 1987). Andrews (1993) also develops a technique to test parameter instability and structural change with and unknown change point in the model (see also Piehl, Cooper, Braga, and Kennedy 1999). Estimating (7) we find (see Figure 8) that the largest structural break exists in 1982:IV (sup Wald value = 32.35 (5 percent critical value = 7.93)).

We then reestimate the AR(1) model of inflation using the break point of 1982:IV. In Table 3, the persistence parameter (B_t) of period 1960:II–1982:III equals 0.85 with a standard error of 0.07. However, for the period 1982:IV–2000:III persistence falls to 0.34 with a standard error equal to 0.14. Chow's structural break test shows that 1982:IV is significant at the 1 percent level ($F = 8.82$).

In sum, after 1982:IV, inflation persistence drops significantly and this coincides with the aggressive and sustained monetary policy that takes affect in late 1982.[7]

<<Figure 7 about here>>
<<Table 3 about here>>
<<Figure 8 about here>>

5.3 The Variance of Inflation and Inflation Persistence

5.3.1 Autoregressive Conditional Heteroskedasticity (ARCH) Model Results

Clarida, Gali, and Gertler (2000) and Granato and Wong (2001b) examine how monetary policy – as represented by an interest rate rule – stabilizes the business cycle. The consensus is that an aggressive policy tack reduces both inflation and output volatility. In this section, we link both the variation and persistence of inflation together.

Using an Autoregressive Conditional Heteroskedasticity (ARCH) model, we test whether an aggressive policy reduces the variance of inflation (Owyang

[7] The R-squared of the second regression drops in Table 3 ($R^2 = 0.13$). This implies that the lagged inflation rate does not have enough relative power in the regression model after 1982:4.

2001). Figure 9 shows a positive relationship between the persistence of inflation and its variance.

<<Figure 9 about here>>

The ARCH representation is estimated as follows:

$$\pi_t = A + B\pi_{t-1} + C\sigma^2_{u,t} + u_t, \quad (11)$$

$$\sigma^2_{u,t} = \gamma + \phi u^2_{t-1} + \lambda BP_t, \quad (12)$$

where BP_t is a dummy variable of switching regimes, $\sigma^2_{u,t}$ is a conditional variance of u_t. $\sigma^2_{u,t}$ is a conditional variance of inflation given the value of lagged inflation π_{t-1}. We treat this term as the proxy for the inflation rate variance and predict that the aggressive monetary policy tack reduces the variance of inflation $\sigma^2_{u,t}$ over time.

Table 4 shows the results of the ARCH model with different break points. The first column represents the baseline model without a dummy variable. The coefficient of the inflation variance in equation (11) is (C) equals 0.36 with an standard error equal to 0.18. The persistence parameter is (B) equals 0.75 with a standard error equal to 0.06.

The variance of the inflation rate is positively related to its level. Comparing the ARCH results with the OLS estimation of the full sample in Table 2, shows that the persistence parameter in the ARCH model is smaller after the inflation variance is included. However, it is still significantly different from zero at the 1 percent significance level.

The second column in Table 4 presents the results with a dummy variable for the Volcker and Volcker-Greenspan periods. The dummy variable equals zero and one for the pre-Volcker and the Volcker-Greenspan periods respectively. Most parameters in (12) are significant at the 5 percent significance level or less, except the parameter of the dummy variable (λ).

This latter finding on the dummy variable implies that there is no significant change in the inflation variance as of 1979:III. We then estimate the model with the break point of 1982:I. The results reported in the last column indicate that that all coefficients are significant at the least 5 percent level. The change in regime during 1982 does have a negative effect on the variance of inflation and it is large ($\lambda = -1.38$ with standard error equal to 0.62).

<<Table 4 about here>>

We also estimate the effect of regime changes on the persistence of inflation:

$$\pi_t = A' + B'\pi_{t-1} + C'\sigma^2_{u,t} + D'BP_t + E'(BP_t * \pi_{t-1}) + u'_t, \quad (13)$$

$$\sigma^2_{u',t} = \gamma' + \phi' u'^2_{t-1} + \lambda' BP_t. \quad (14)$$

The results of the ARCH model with the pre-Volcker break point dummy variable are presented in the first column of Table 5. Coefficients of B' and E' show the effect of regime switches on the inflation persistence in the ARCH model. The persistence of inflation is reduced significantly during the Volcker and Greenspan era ($E' = -0.31$ with standard error equal to 0.10.). There is a positive effect of the variance of inflation on the inflation level ($C = 0.20$ with standard error equal to 0.07).

We also estimate the ARCH model with a 1982:I break point. The second column of Table 5 shows that most of the coefficients are significant at the 5 percent significance level. The coefficient of the inflation variance C' is very close to the 5 percent level (p = 0.0552). The coefficient of the break point in equation (14) , is negative and significant ($\lambda' = -1.48$ with standard error equal to 0.66). This again shows that a significant reduction in the inflation variance occurred starting in 1982:I.

<<**Table 5 about here**>>

6 Conclusion

This paper considers the effect of an aggressive monetary policy tack on inflation persistence. We first derive a small scale macroeconomic model of inflation that follows from Fuhrer (1995), Fuhrer and Moore (1995), and Taylor (1993, 1994, 1999). We further assume that citizens learn about inflation in an adaptive manner (Evans and Honkapohja 2001).

Under specific stability conditions, citizens are able to learn the REE of inflation only if the policy rule stabilizes prices aggressively. This result shows that aggressive anti-inflation policies lower inflation persistence.

Using the postwar data in the United States for the period 1960:I and 2000:III, we find inflation persistence decreases over the sample period. We then test for specific policy interventions that were in an aggressive direction. The first reflects the work of Clarida, Gali, and Gertler (2000) who estimate a forward looking policy rule before and after the appointment of Volcker as the chairman of the Fed. They find substantial differences in the estimated rule across periods, with the post-Volcker period being the most aggressive. However, this particular break point is not significant in our model.

One reason for this non-finding is that the period of inflation control started in late 1981 or 1982 after policymakers could credibly implement such politically difficult policies (Granato 1996; Kettl 1986). The intuitive argument is that there are some political constraints which worked against earlier attempts to control inflation. Our results show that the persistence of inflation drops significantly starting in either late 1981 or late 1982 and continues for the remainder of the sample. We also find that there is a substantial decrease in the variance of inflation starting in roughly the same period.

As a final thought our model and results provide an alternative viewpoint on how policymakers behave. Traditional model's of policymaker behavior tend to show that policymakers try to fool citizens about the future course of policy. This temporary citizen confusion has the effect of lowering unemployment or raising output in the near term. We turn that logic around and show that aggressive policy that hits targets can have a salutary effect on citizen expectations and, thereby, contribute to superior macroeconomic outcomes.

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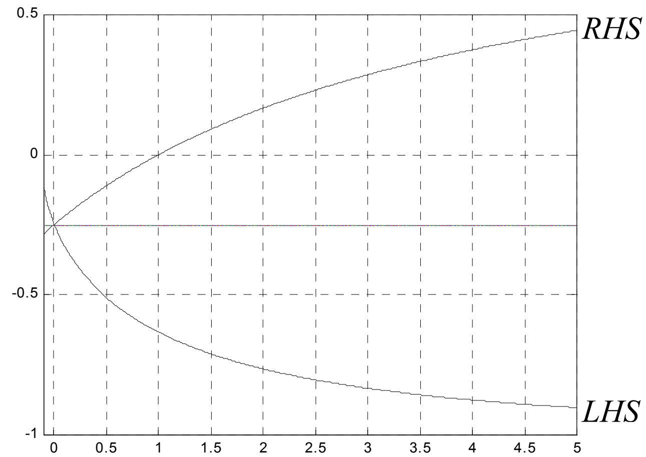
Figure 1: The Necessary Condition for E-Stability



The Value of α_π

Figure 2: The Relationship between the Inflation Persistence coefficients and the Policy Rule Parameter

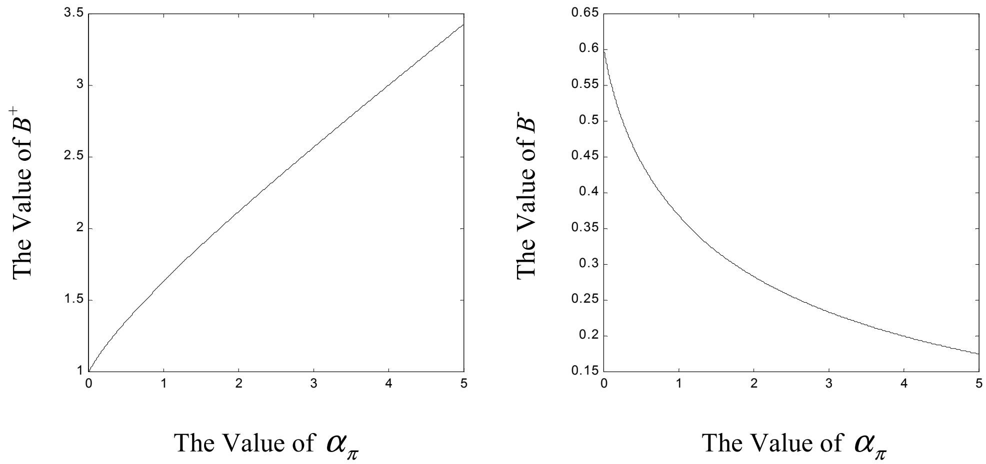


Figure 3: The Variance of Inflation and the Policy Rule Parameter

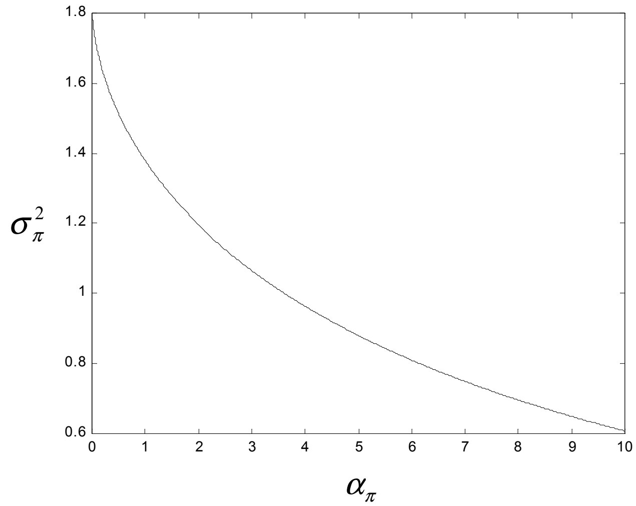


Figure 4: The Inflation Rate of the United States between 1960:II and 2000:III

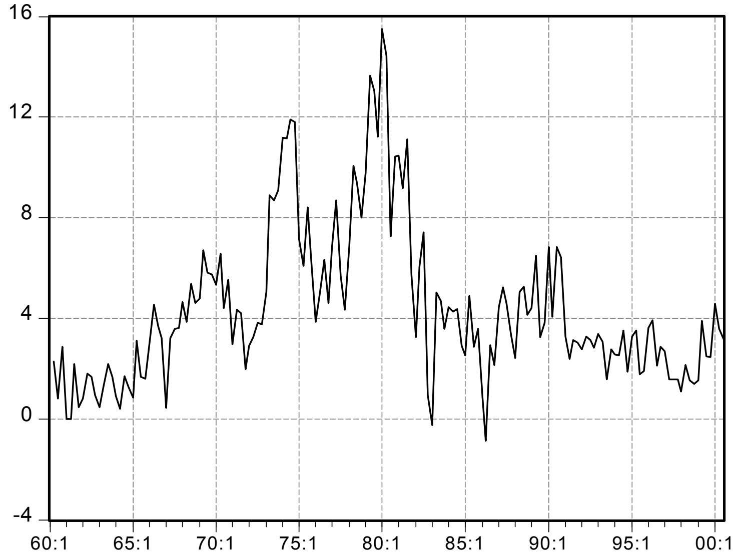


Table 1: The Descriptive Statistics of the United States Inflation Rate

	Full Sample	Pre-Volcker	Volcker-Greenspan
Mean	4.3805	4.6206	4.1630
Median	3.5918	4.2090	3.2842
Maximum	15.5092	13.6489	15.5092
Minimum	-0.8565	0.0000	-0.8565
Standard Deviation	3.1252	3.2307	3.0292

Table 2: The Estimation of Inflation Persistence

	Full Sample	Pre-Volcker	Volcker-Greenspan
Persistence Parameter, B_t	0.8202**	0.9070**	0.7452**
	(0.0629)	(0.0706)	(0.0988)
Chow Test F-statistic		2.2227 (p-value = 0.1117)	
R^2	0.67	0.74	0.62
No. of Observations	161	76	85

Standard errors are reported in parentheses. * and ** indicate that the parameter is significant at the 5% or 1% level respectively.

Figure 5: Inflation Persistence Over Time
(10-Year Windows Rolling Regression)

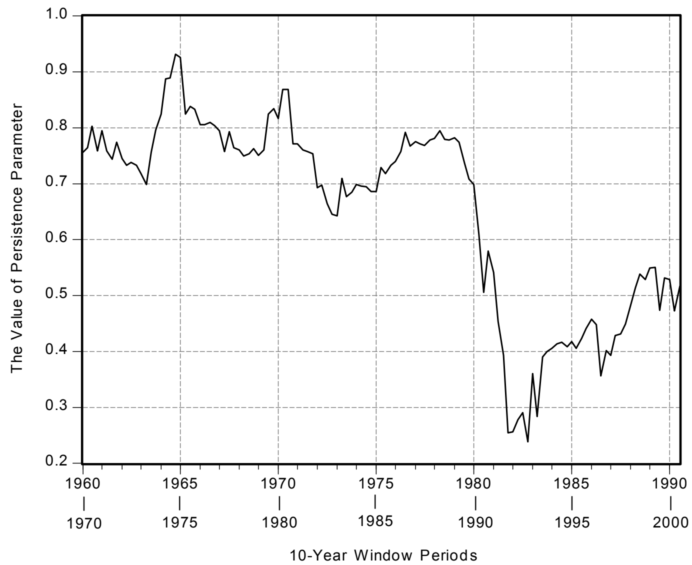


Figure 6: The t-statistic Values of Inflation Persistence Over time (10-Year Windows Rolling Regression)

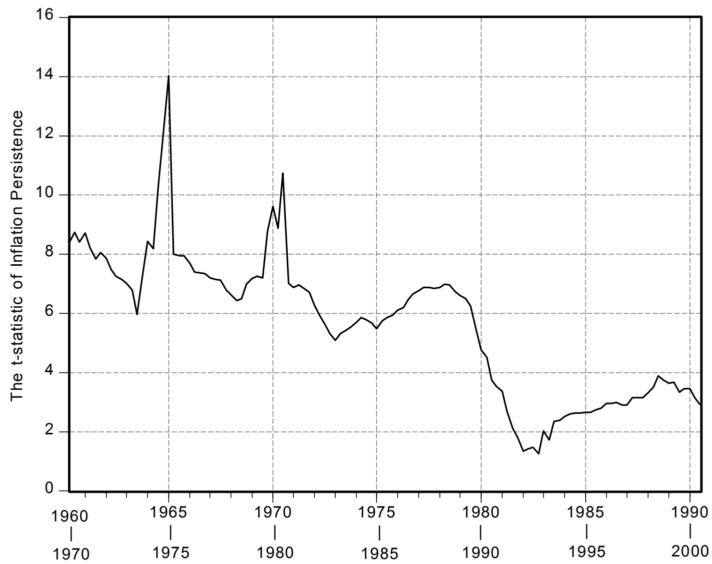


Figure 7: The Residual Sums of Squares

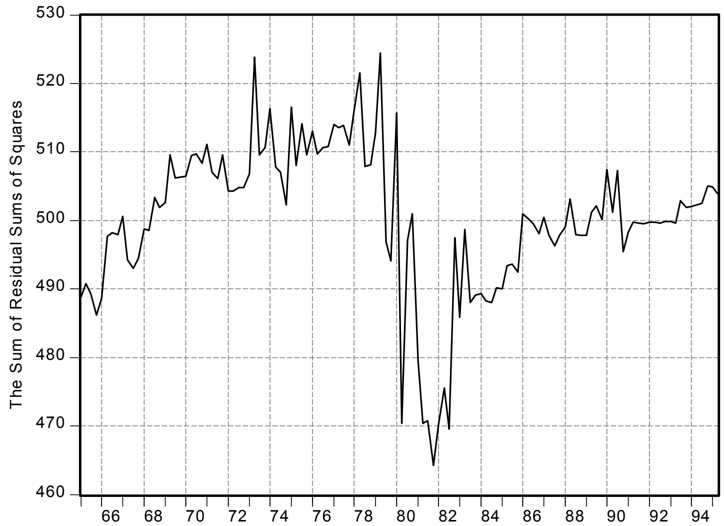


Figure 8: Rolling Wald Statistics

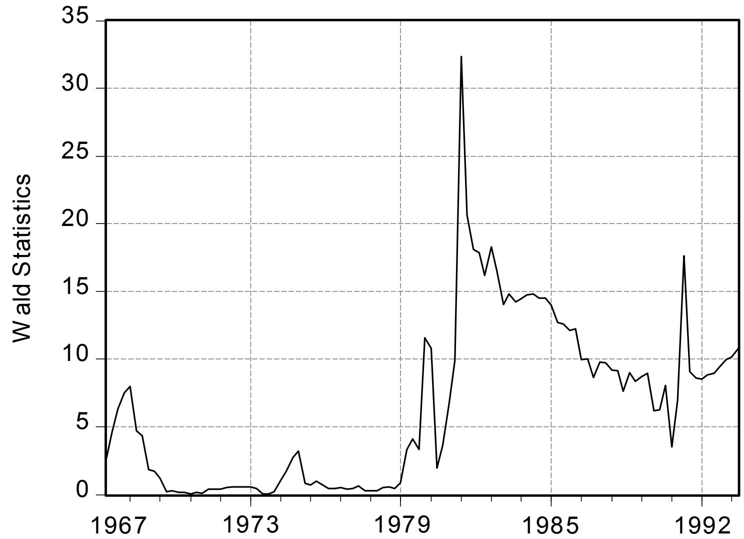


Table 3: The Estimation of Inflation Persistence with the Break Point of 1982:IV

	1960:II – 1982:III	1982:IV – 2000:III
Persistence Parameter, B_t	0.8456**	0.3417**
	(0.0690)	(0.1435)
Chow Test F-statistic	8.8206 **	
R^2	0.71	0.13
No. of Observations	90	72

Standard errors are reported in parentheses. * and ** indicate that the parameter is significant at the 5% or 1% level respectively.

Figure 9: Inflation Persistence and Inflation Variance

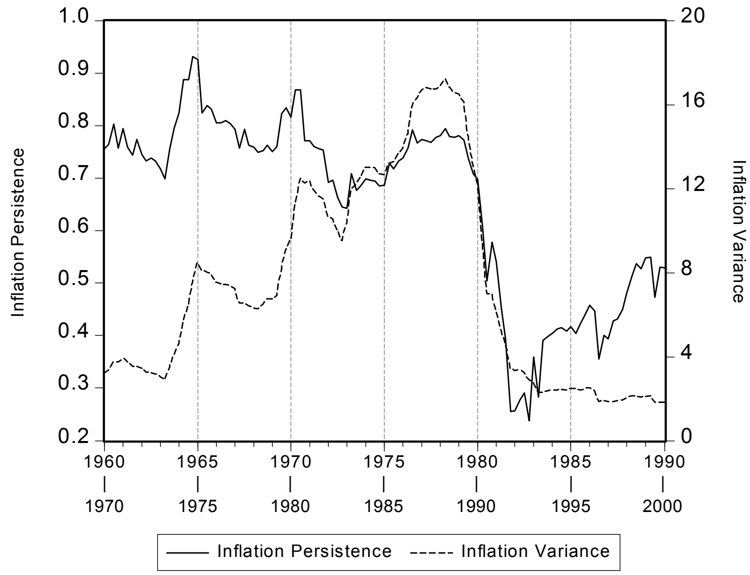


Table 4: The Estimation of the ARCH Model – Equations (8) and (9)

Parameter	Baseline Model	Pre- / Post- Volcker	1982:IV Break Point
B	0.7520**	0.7419**	0.6852**
	(0.0577)	(0.0560)	(0.0563)
C	0.3608*	0.3649*	0.3069**
	(0.1790)	(0.1744)	(0.0958)
ϕ	0.2706*	0.2723*	0.3109**
	(0.1224)	(0.1181)	(0.0898)
λ	----	-0.1159	-1.3230*
		(0.5548)	(0.6099)

Standard errors are reported in parentheses. * and ** indicate that the parameter is significant at the 5% or 1% level respectively.

Table 5: The Estimation of the ARCH Model – Equations (10) and (11)

Parameter	Pre- / Post- Volcker	1982:IV Break Point
B'	0.8347**	0.8581**
	(0.0686)	(0.0829)
C'	0.2046**	0.3191^{+}
	(0.0663)	(0.1910)
D'	0.9655**	1.7746**
	(0.3768)	(0.6273)
E'	-0.3055**	-0.4828**
	(0.0982)	(0.1668)
ϕ'	0.6259**	0.2599**
	(0.2118)	(0.1176)
λ'	-0.3911	-1.5307*
	(0.5156)	(0.7118)

Standard errors are reported in parentheses. * and ** indicate that the parameter is significant at the 5% or 1% level respectively. + represents the p-value of C' of 0.0947.