IV.Module 4: EITM and Persistence

The Role of Expectations and Learning

Example 1: Persistence in Party Identification (“Macropartisanship”)

- The behavioral assumptions are primitive, but the model does have the potential to be enriched by further theoretical (formal) revisions that would incorporate findings in, for example, economics, cognitive psychology, communications, and political science.

- The more general point is to show that **persistence -- autocorrelation** -- can be identified at its source, and researchers can use theory to assist in differentiating between various types of persistence (i.e., near-integrated versus fractionally integrated processes) that may characterize an empirical realization of a time series of interest.

- In our model we assume that political campaign advertisments influence the public.

- We argue that the persistence of rival political parties political advisors to target and influence (through the use of political advertisement resources) rival party voters, reduces the well known persistence in macropartisanship.
- As a consequence, shocks to macropartisanship can either be amplified or die out quickly depending on rival political advisor behavior.

Example 2: Policy and Inflation Targeting

- We use a relative-real-wage contracting model in combination with a Taylor interest rate rule (Fuhrer (1995), Fuhrer and Moore (1995a,b), Taylor (1993a, 1994, 1999a,b)).

- The second component is that we assume adaptive learning on the part of agents with respect to policymaker actions. The model has a unique and stable equilibrium (expectationally stable (Evans and Honkapohja (2001)).

- The E-stability conditions have the following implication for policymakers and inflation persistence: when policy is aggressive inflation persistence decreases.

- Agents Learn Adaptively: update their expectations as new data becomes available

- Can achieve *Rational Expectations forecasts* of Inflation

    - Their forecasts are correct on average

    - They take advantage of all available relevant information (in the model)

    - Inflation will persist less in this equilibrium (in this model)

- Non-aggressive behavior coincides with the rise of inflation and stagflation of the late 1960s and 1970

- Non-aggressive behavior linked to volatile boom-bust cycles

Module 4

Example 1: Persistence in Party Identification

The Model

- A Rival Political Strategist can use campaign advertisements to influence aggregate persistence in party identification.
- Our model comprises three equations. Each citizen (i) is subject to an event (j) at time (t).
- We aggregate across individuals and events so the notation will only have the subscript t.

Macropartisanship:

$$M_t = a_1 M_{t-1} + a_2 E_{t-1} M_t + a_3 F_t + u_{1t}. \quad (1)$$

- The first equation (1) specifies what influences aggregate party identification (M_t).
- The variable M_{t-1} accounts for the possibility of persistence.
- Citizens also have an expectation of what portion of the population will identify with the party $(E_{t-1} M_t)$.

- We assume that, in forming their expectations, citizens use all available and relevant information (up to time t-1) as specified in this model (rational expectations).

- We further assume that party identification depends on how favorably a citizen views the national party (F_t).

- Finally, party identification can be subject to unanticipated stochastic shocks (reallignments) (u_{1t}) where $u_{1t} \sim N\left(0, \sigma^2_{u_{1t}}\right)$.

- We assume the relations are positive — $a_1, a_2, a_3 \geq 0$.

Favorability:

$$F_t = b_1 F_{t-1} + b_2 A_t + u_{2t}. \qquad (2)$$

- Equation (2) represents citizens' impression ("favorability") of a political party (F_t).
- In this model, favorability is a linear function of the lag of favorability (F_{t-1}) and an advertising resource variable (A_t).
- There are many ways to measure political advertising resources. u_{2t} is a stochastic shock that represents unanticipated events (uncertainty), where $u_{2t} \sim N\left(0, \sigma^2_{u_{2t}}\right)$.
- The parameter $b_1 \geq 0$, while $b_2 \gtreqless 0$ depending on the tone and content of the advertisement.

Rival Political Advisor:

$$A_t = c_1 A_{t-1} + c_2 (M_t - M^*) + c_3 F_{t-1}. \tag{3}$$

- Equation (3) presents the contingency plan or rule that (rival) political advisors use.
- We argue that political advisors track their previous period's advertising resource expenditures (A_{t-1}) and react to that period's favorability rating for the (rival) national party (F_{t-1}).
- Political advisors also base their current expenditure of advertisement resources on the degree to which macropartisanship (M_t) approximates a prespecified and desired target (M^*).
- Ideally, political advisors want $(M_t - M^*) = 0$.
- We assume that the parameters c_1 and c_3 are positive.
- The parameter c_2 is countercyclical $(-1 \leq c_2 \leq 0)$. This reflects political advisors willingness to increase or conserve their advertising resources depending on whether macropartisanship is above (decrease advertising) or below (increase advertising) the target.

The Reduced Form

- To get the reduced form for macropartisanship, substitute (3) into (2):

$$
\begin{aligned}
F_t &= b_1 F_{t-1} + \\
&\quad b_2 \left[c_1 A_{t-1} + c_2 \left(M_t - M^* \right) + c_3 F_{t-1} \right] + u_{2t},
\end{aligned} \tag{4}
$$

and

$$
\begin{aligned}
F_t &= \left(b_1 + b_2 c_3 \right) F_{t-1} + b_2 c_1 A_{t-1} + \\
&\quad b_2 c_2 \left(M_t - M^* \right) + u_{2t}.
\end{aligned} \tag{5}
$$

- Now substitute (5) into (1):

$$
\begin{aligned}
M_t &= a_1 M_{t-1} + a_2 E_{t-1} M_t + \left(b_1 + b_2 c_3 \right) F_{t-1} + \\
&\quad b_2 c_1 A_{t-1} + b_2 c_2 \left(M_t - M^* \right) + \\
&\quad u_{2t} + u_{1t}.
\end{aligned} \tag{6}
$$

- Collect terms and divide through by $(1 - b_2 c_2)$:

$$
\begin{aligned}
M_t &= \frac{a_1}{(1 - b_2 c_2)} M_{t-1} + \frac{a_2}{(1 - b_2 c_2)} E_{t-1} M_t + \\
&\quad \frac{b_2 c_1}{(1 - b_2 c_2)} A_{t-1} + \frac{(b_1 + b_2 c_3)}{(1 - b_2 c_2)} F_{t-1} - \\
&\quad \frac{b_2 c_1}{(1 - b_2 c_2)} M^* + \frac{u_{2t} + u_{1t}}{(1 - b_2 c_2)}.
\end{aligned} \tag{7}
$$

- Simplifying the notation we find that there is an autoregressive component in the reduced form for macropartisanship:

$$M_t = \Theta_0 + \Theta_1 M_{t-1} + \Theta_2 E_{t-1} M_t + \Theta_3 A_{t-1} + \Theta_4 F_{t-1} + \varepsilon_t^*, \qquad (8)$$

where:

$\Theta_0 = \frac{b_2 c_1 Y^*}{(1-b_2 c_2)}$, $\Theta_1 = \frac{a_1}{(1-b_2 c_2)}$, $\Theta_2 = \frac{a_2}{(1-b_2 c_2)}$, $\Theta_3 = \frac{b_2 c_1}{(1-b_2 c_2)}$, $\Theta_4 = \frac{(b_1+b_2 c_3)}{(1-b_2 c_2)}$,
and $\varepsilon_t^* = \frac{u_{2t}+u_{1t}}{(1-b_2 c_2)}$.

- The system is now simplified to a model of macropartisanship that depends on lagged macropartisanship and also the conditional expectation at time $t-1$ of current macropartisanship.
- The prior values of advertising and favorability may also have an effect.

The MSV

- To close the model the rational expectations equilibrium (REE) can be solved by taking the conditional expectation at time $t-1$ of equation (8) and then substiting this result back into equation (8):

$$M_t = \Pi_1 + \Pi_2 M_{t-1} + \Pi_3 A_{t-2} + \Pi_4 F_{t-2} + \xi_t', \qquad (9)$$

where:

$$\begin{aligned}
\Pi_1 &= \left(\frac{\Theta_0}{1-\Theta_2} - \left[\frac{\Theta_3}{1-\Theta_2} - \frac{\Theta_4}{1-\Theta_2}b_2\right] c_2 Y^*\right), \\
\Pi_2 &= \left(\frac{\Theta_1}{1-\Theta_2} + \left[\frac{\Theta_3}{1-\Theta_2} + \frac{\Theta_4}{1-\Theta_2}b_2\right] c_2\right), \\
\Pi_3 &= \left(\left[\frac{\Theta_3}{1-\Theta_2} + \frac{\Theta_4}{1-\Theta_2}b_2\right] c_1\right), \\
\Pi_4 &= \left(\frac{\Theta_3}{1-\Theta_2}c_3 + \frac{\Theta_4}{1-\Theta_2}\left[b_1 + b_2 c_3\right]\right), \\
\text{and } \xi_t' &= \left(\frac{\Theta_4}{1-\Theta_2}u_{2t} + \varepsilon_t^*\right).
\end{aligned}$$

- Equation (9) is the minimum state variable (MSV) solution (McCallum, 1983) for macropartisanship.
- Macropartisanship (M_t) depends, in part, on the lag of macropartisanship (M_{t-1}).
- More importantly, the persistence of macropartisanship (Π_2) is now shown to depend on the persistence and willingness of rival political advisors to maintain a rival macropartisanship target (c_2).
- This can be shown by examining the reduced form AR(1) coefficient expression Π_2:

$$\Pi_2 = \frac{a_1 + b_2 c_2 \left(c_1 + b_1 + b_2 c_3\right)}{1 - b_2 c_2 - a_2}. \tag{10}$$

- We take the derivative of (10) with respect to (c_2)

and get the following relationship:

$$\frac{\partial \Pi_2}{\partial c_2} = \frac{b_2 \left(a_1(-1+a_2)\left(b_1+c_1+b_2c_3\right)\right)}{\left(-1+a_2+b_2c_2\right)^2} \tag{11}$$

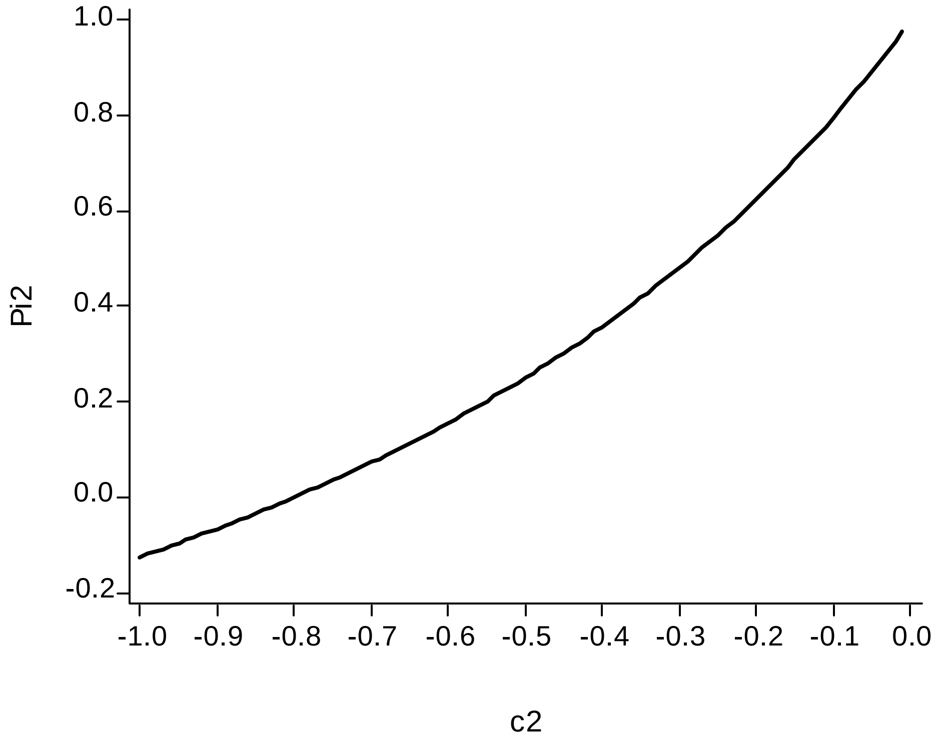
- Given the assumptions about the signs of the coefficients in the model, the numerator is positive as long as $a_2 < 1$.
- Therefore, under these conditions, we know that the relationship is positive $\left(\frac{\partial \Pi_2}{\partial c_2} > 0\right)$.
- The final step is to find if the model reaches an equilibrium when it starts from a point of reference that contains nonequilibrium values.
- For our model, since it has an first-order autoregressive component, the result is straightforward.
- We summarize the stability condition in the following proposition:

PROPOSITION 1. *Equation* (9) *is a uniquely stationary minimum state variable (MSV) solution if* $|\Pi_2| < 1$.

- The relationship between c_2 and Π_2 is demonstrated in Figure 4.
- We use the following values: $a_1 = a_2 = b_1 = b_2 = c_1 = c_3 = 0.5$.

- The parameter c_2 ranges from 0.0 to -1.0.
- As we vary the value of c_2 between 0.0 and -1.0, we find that the persistence (autocorrelation) in macropartisanship (Π_2) — all things equal — is zero when $c_2 = -0.8$.
- On the other hand, macropartisanship becomes highly autoregressive $(\Pi_2 \rightarrow 1.0)$ when rival political advisors fail to react $(c_2 \rightarrow 0.0)$ to deviations from their prespecified target.
- The conclusion from this model is that negative advertisements from rival political parties can influence the persistence of their opponents national party identification.

Figure 4. The Relationship Between Pi2 and c2



Module 4

Example 2: Policy and Inflation Targeting

The Model

- 3 Equation System
- Behavioral implications: policy induces public expecations substitute inflation target for past inflation

Price Level Adjustment

- 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:

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

where p_t is the logged price level, and x_t is the log wage level at period t.

- In addition, agents are concerned with their real wages over the lifetime of the contract:

$$x_t - p_t = \frac{1}{2}\left[x_{t-1} - p_{t-1} + E_t(x_{t+1} - p_{t+1})\right] + a_2 z_t, \tag{2}$$

where $z_t = (y_t - y_t^n)$ is the excess demand for labor at time t and $E_t(x_{t+1} - p_{t+1})$ 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:

$$\pi_t = \frac{1}{2}\left(\pi_{t-1} + E_t\pi_{t+1}\right) + a_2 z_t + u_{3t}. \tag{3}$$

  where $E_t\pi_{t+1}$ is the expected inflation rate over the next period and $u_{3t} \sim iid\left(0, \sigma_{u_3}^2\right)$.
- Equation (3) captures the main characteristic of inflation persistence.
- Since agents make plans 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 level.

The IS Specification

- Equation (4) represents a standard IS curve where the quantity demanded on output relative to natural output (z_t) is negatively associated with the changes in real interest rates:

$$z_t = -b_2 \left(i_t - E_t \pi_{t+1} - r^* \right) + u_{4t}, \tag{4}$$

  where i_t is nominal interest rate, r^* is the target real interest rate, $u_{4t} \sim iid\left(0, \sigma_{u_4}^2\right)$, and $b_2 > 0$.

- If the real interest rate, $i_t - E_t \pi_{t+1}$, is below the targeted real interest rate $[(i_t - E_t \pi_{t+1}) - r^* < 0]$, then agents increase their consumption and also raise output level above the natural level, $(z_t > 0)$.

The Taylor Rule

$$i_t = \pi_t + \alpha_y z_t + \alpha_\pi (\pi_t - \pi^*) + r^*. \quad (5)$$

- Positive values of α_π and α_y indicate a willingness to raise (lower) real interest in response to the positive (negative) deviations from either the target inflation rate $(\pi_t - \pi^*)$ or the output gap (z_t) or both.

Stability Analysis

The Equilibrium Inflation Rate

- The reduced form for the inflation rate is found by substituting equation (5) into equation (4).
- Now solve for z_t and then put that result into equation (3).
- If we solve that expression for π_t:

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

where

$\Omega_0 = \frac{a_2 b_2 \alpha_\pi \pi^*}{1+b_2\alpha_y+a_2b_2(1+\alpha_\pi)}$,

$\Omega_1 = \frac{1+b_2\alpha_y}{2[1+b_2\alpha_y+a_2b_2(1+\alpha_\pi)]}$,

$\Omega_2 = \frac{1+b_2\alpha_y+2a_2b_2}{2[1+b_2\alpha_y+a_2b_2(1+\alpha_\pi)]}$ and

$\xi_t = \frac{a_2u_{4t}+(1+b_2\alpha_y)u_{3t}}{1+b_2\alpha_y+a_2b_2(1+\alpha_\pi)}$.

- Equation (6) shows that current inflation depends on the first-order lag of inflation and also expected future inflation.

The MSV

- 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 $B^- = \frac{1-\sqrt{1-4\Omega_1\Omega_2}}{2\Omega_2}$.

Proposition 1 *For the reduced form in equation* (7), B^- *is a locally unique stationary solution for all* $\alpha_\pi \geq 0$.

Proof. To show that only B^- is less than one when $\alpha_\pi \geq 0$, we consider the values of α_π by separating it into two intervals: $\alpha_\pi = 0$, and $\alpha_\pi > 0$. When $\alpha_\pi = 0$, we have $B^+ = 1$ and $B^- = 1 - \frac{2b_2a_2}{1+2b_2a_2+b_2\alpha_y} < 1$. For the case of $\alpha_\pi > 0$, B^+ is a strictly increasing function. This is shown by taking the derivative of B^+ with respect to α_π:

$$\frac{\partial B^+}{\partial \alpha_\pi} = \frac{b_2a_2\left(1+\Phi_{\alpha_\pi}\right)}{\left(1+2b_2a_2+b_2\alpha_y\right)\Phi_{\alpha_\pi}} > 0 \quad \forall \alpha_\pi > 0,$$

where $\Phi_{\alpha_\pi} = \sqrt{1 - \frac{(1+b_2\alpha_y)(1+2b_2a_2+b_2\alpha_y)}{(1+b_2a_2(1+\alpha_\pi)+b_2\alpha_y)^2}}$.

On the other hand, B^- is a decreasing function when $\alpha_\pi > 0$ and asymptotically converges to zero.

To see this take the derivative of B^- with respect to α_π:

$$\begin{aligned}\frac{\partial B^-}{\partial \alpha_\pi} &= \frac{b_2 a_2 \left(-1+\Phi_{\alpha_\pi}\right)}{\left(1+2b_2 a_2+b_2\alpha_y\right)\Phi_{\alpha_\pi}} < 0 \qquad for\ 0 \leq \alpha_\pi < \infty \\ &= 0 \qquad\qquad\qquad\qquad\qquad\quad for\ \alpha_\pi \to \infty,\end{aligned}$$

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

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

■

Determinacy and Expectational Stability

- We consider whether the model is determinate and its solution is a (locally) unique stationary equilibrium.
- Since B takes two values, B^{+} and B^{-}, Proposition 2 shows that B^{-} is a unique stationary solution if $\alpha_{\pi} \geq 0$.
- Evans and Honkapohja (2001) present the general specification of equation (6) in the context of an adaptive learning model.
- They first assume that agents are able to obtain the current value of the inflation rate π_t at time t.
- If we assume that agents learn in a manner consistent with recursive least squares, then the stability of equation (7) can be summarized in the following proposition:

Proposition 2 *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 (2001)).*

- Note that the existence of the observable current value of the inflation rate π_t (at the time of expectations formation) creates a simultaneity problem (see Evans and Honkapohja (2001)).
- To avoid this problem, we relax this assumption and instead assume that agents observe only the lagged inflation rate π_{t-1}.

- This new assumption alters the E-stability conditions: B^+ is always unstable, but B^- is E-stable with the form:

$$-\sqrt{1-4\Omega_1\Omega_2} < 1-2\Omega_2. \quad (8)$$

- Equation (8) is a necessary and sufficient condition for E-stability.
- In particular, if $\Omega_2 < \frac{1}{2}$, the MSV solution is sufficient for E-stability.
- The necessary and sufficient conditions for E-stability demonstrate the link between policymaker aggressiveness (α_π), agent learning, and inflation persistence.
- In equation (6), Ω_2 is less than half if $\alpha_\pi > 1$.
- This sufficient condition implies that agents are better able to learn the inflation equilibrium if policymakers aggressively stabilize inflation.
- On the other hand, the necessary condition suggests a less vigorous response $(\alpha_\pi > 0)$.

Proposition 3 *For equation* (6), *assuming that agents 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. This is demonstrated by showing the inequality in (8) holds. We first define that the left-hand and right-hand sides in equation (8) as $LHS = -\sqrt{1-4\Omega_1\Omega_2}$ and $RHS = 1-2\Omega_2$. Since we see that from equation (6) that Ω_1 and Ω_2 are a function of α_y and α_π, we substitute the expressions of Ω_1 and Ω_2 into equation (8). It follows that $LHS = RHS$ when

$\alpha_\pi = 0$. LHS is nonlinear and decreasing over α_π, while RHS is nonlinear and increasing over α_π. We conclude that the condition in equation (8) holds if $\alpha_\pi > 0$. ■

- Figure 6.1 plots the values of LHS and RHS against α_π.
- The two curves intersect at $\alpha_\pi = 0$ and $LHS < RHS$ when $\alpha_\pi > 0$.
- Following Woodford (1999) the underlying parameters are $b_2 = 6.37, \quad \alpha_y = 0.5,$ and $a_2 = 0.024$.
- When $\alpha_\pi = 0, \ LHS = RHS = \frac{-a_2 b_2}{1+b_2\alpha_y+a_2 b_2} = -0.035243$.

Aggressive Policy and Inflation

Inflation Persistence

- Equation (7) represents the AR(1) process of the inflation rate.
- The empirical implications of our model as represented in equation (7) shows that an increase in α_π raises inflation persistence under B^+ but reduces the persistence under B^-.

Proposition 4 *Provided that the model is determinate and E-stable, the persistence of inflation is reduced as policymakers respond aggressively* $(\alpha_\pi > 0)$ *to the deviation of the inflation rate from its target.*

Proof. We extend proposition 2. Given that B^+ is not E-stable, we know that under the proof of proposition 2, B^- decreases as α_π increases and B^- converges to 0 as α_π approaches ∞. ■

- These results are presented in the left and right panels of Figure 6.2.

Estimates of Inflation Persistence

- We base our analysis on quarterly observations of the inflation rate in the postwar United States (1960:I to 2000:III).
- We use ordinary least squares (OLS) to estimate the persistence parameter (B_t) in equation (7).
- The first column in Table 6.1 reports the value of the persistence parameter over the full sample period.
- Columns 2 and 3 depict the pre-Volcker (1960:II to 1979:II) and Volcker-Greenspan (1979:III to 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 is less persistent after Volcker is appointed as Fed chairman in August 1979.
- Figure 6.4 presents the rolling regression results.

Figure 6.1: The Necessary Condition for E-Stability

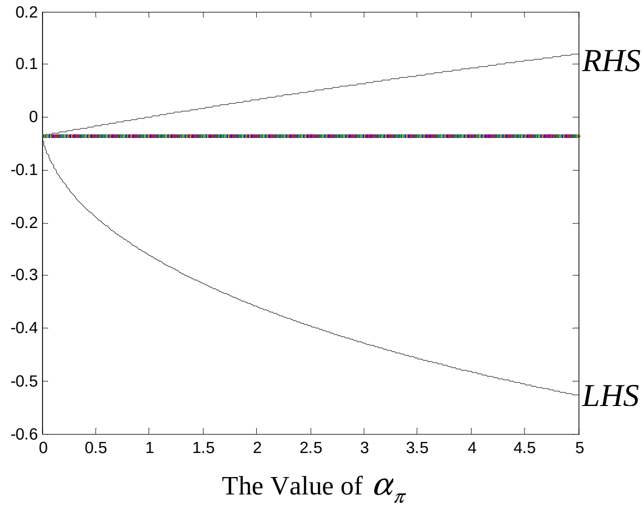


Figure 6.2: The Relationship Between the Inflation Persistence and Policy Rule Parameters

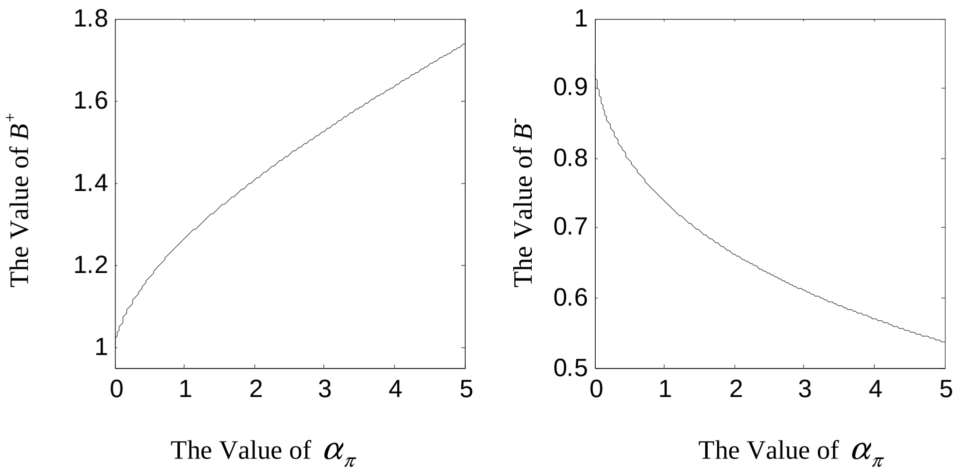


Figure 6.4: Inflation Persistence Over Time
(10-Year Windows Rolling Regression)

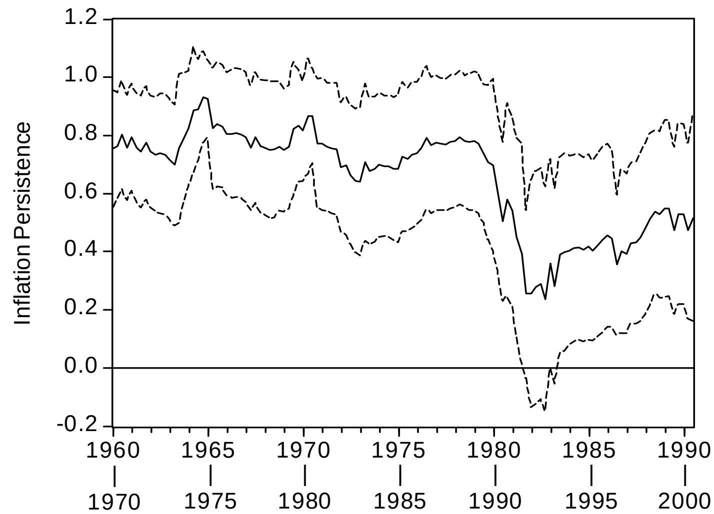


Table 6.1: The Estimation of Inflation Persistence

	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 ** indicates that the parameter is significant at the 5% and 1% level respectively.

Table 6.2: The Estimation of Inflation Persistence with the Break Point of 1981:IV

	1960:II – 1981:III	1981:IV – 2000:III
Persistence Parameter, B_t	0.8830**	0.3631**
	(0.0687)	(0.1089)
Chow Test F-statistic	12.2096 **	
R^2	0.76	0.17
No. of Observations	85	76

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