The Anguish of Central Banking: Another Look at the Great US Inflation and its Aftermath

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1 Introduction

The great inflation under Burns/Miller and its aftermath under Volcker are some of the most traumatic event of US economic history during the second half of the twenthieth century. Many explanations have been offered for the rise and fall of that inflation. Among those are initially faulty models of the economy, political pressures and limiteds independence of the Fed, direct inflationary impacts of the two oil shocks, large and persistent underestimation of potential output by policymakers at the Fed and overexpansionary fiscal policy leading to deficits and a higher Federal debt.

Although different economists may may differ on the relative importance of these factors there is, I believe, broad consensus regarding the following statements. First, some appropriate

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mix of those explanations goes a long way towards explaining the rise and stabilization of the great inflation. Second, long run structural changes in the Fed's objectives and policy rule were important factors both in the rise and fall of the great inflation. Third, the evolution of inflationary expectations played an important role in the propagation of the great inflation and their behavior under Volcker was an important reason for the pain and time required to restore the price stability of the fivties and the early sixties.

The objectives of this paper are: 1. To provide direct empirical evidence on the implicit policy rule followed during the Burns/Miller great inflation and to compare it to the the implicit rules followed during Volcker's disinflation and under Greenspan and Martin tenures as chairs.[1] 2. To examine how monetary policy during the seventies would have differed if conducted by means of these alternative policy rules. 3. To provide evidence on unexpected inflation and on the impact of inflation uncertainty on evaluation of the real monetary policy stance by the Fed's staff during the great inflation and its aftermath. 4. To provide direct empirical evidence on the factors that affected the behavior of Fed's staff inflation forecasts as well as those of private sector forecasters with particular emphasis on the impact of recent past inflationary developments. 5. To examine how the process of expectation formation has changed, if at all, between the period encompassing the great inflation and its stabilization with their formation during the relatively tranquil Greenspan era.

Section 2 utilizes nonlinear interest rate rules for the Burns/Miller, Volcker, Greenspan and Martin chairmanships (estimated in Cukierman and Muscatelli (2008)) to examine how monetary policy during the seventies would have differed if conducted by means of each of those alternative policy rules. With a new Keynesian economy a concave rule is indicative of dominant recession avoidance preferences (RAP) at the Fed and a convex rule is indicative of dominant

[1] Such counterfactuals shed further light on the particular role of the implicit policy rule followed in the seventies in the propagation of the great inflation.

inflation aversion preferences (IAP).[2] The main results are: 1. If policy during the seventies had been conducted by means of Volcker's rule policy it would have been more restrictive during most of that decade. 2. If it had been conducted in Greenspan's style, it would have been less restrictive for most of the decade. 3. If conducted by a "Martin" FOMC it would have been substantially more persistently restrictive after the first oil shock and similar during the remainder of the seventies. In a series of papers Orphanides convincingly argues that Fed's perceptions of the output gap were substantially biased downward during the seventies (An example is Orphanides (2001)). It is therefore possible that the RAP detected in Cukierman and Muscatelli for the Burns/Miller era is due to the fact that they had used retrospective, rather than real time, data to measure the output gap. To examine the robustness of the results to this potential problem the counterfactuals above have been repeated with linear interest rules estimated with real time data for the Burns/Miller, Volcker and Greenspan periods. The main conclusion is that results 1 and 2 above stand and are even amplified.

Using data on Fed's Greenbook inflation forecasts and on private sector inflationary expectations from the survey of Professional Forecasters and the Livingston Survey, Section 2 shows that, for the most part, inflation was universally underestimated during the seventies and overestimated during the credibility rebuilding period under Volcker. In particular, underestimation of inflation during the Burns/Miller period implies that the Fed's monetary policy stance as derived from the Greenbook forecasts must have systematically considered the policy stance of the Fed to be more restrictive than what it turned out to be with hindsight. Or, in different words, exante real interest rates were largely considered by the Fed's staff to be higher than their realized expost counterparts. This raises the possibility that some of the great inflation of the seventies was re-einforced by the Fed's overestimation of real interest rates. The section also

[2]RAP means that policymakers are more averse to negative than to positive output gaps. IAP means that they are more averse to positive than to negative inflation gaps. Here, the inflation gap is defined as the deviation of inflation from it implicit target. Details appear in Cukierman and Muscatelli (2008).

demonstrates that inflation uncertainty, which was abnormally high by long term US standards under Burns/Miller and Volcker, decreased substantially during Greenspan's term in office. The last part of section 2 examines the impact of past inflation and other variables on the formation of inflationary expectations and compares their formation during the Burns/Miller and Volcker combined terms with their formation during Greenspan's relatively stabler era.[3] This is followed by concluding reflections.

2 How would have interest rate decisions in the seventies differed if taken by Volcker, Greenspan and Martin?

In retrospection, it is generally felt that one of the reasons for the magnitude and persistence of the great inflation was that monetary policy during the Burns/Miller era was too loose. One way to evaluate whether this is the case, and if so, how strong was this inclination towards monetary permissiveness is to compare the path of the policy rate, and the closely related federal funds rate, under Burns and Miller to the paths that these rates would have followed had policy been conducted in the styles of other Fed chairs. As is well known, Burns and Miller were succeeded by a relatively restrictive monetary policy under Volcker which ultimately brought inflation down. By the time Greenspan replaced Volcker in the last quarter of 1987 CPI inflation had come down from a double digit range at the beginning of Volcker's term into the vicinity of four percent. Under Greespan inflation went down even further. It is therefore interesting to examine how monetary policy during the seventies would have differed, had it been conducted in the styles of Volcker and Greenspan. For completness I also examine how policy during the seventies would

[3]The Burns/Miller and Volcker periods are lumped together because, in terms of both inflation and inflation uncertainty, Volcker's period is more similar to that of Burns/Miller than to that of Greenspan. But the qualitative nature of the conclusions in section 2 is similar if one compares only the Burns/Miller period with that of Greenspan.

have differed if it had been conducted in the style of Martin who preceded Burns as chair. Most of Martin's term was characterized by inflation rates which are commonly considered as price stability. But during his last several years in office, between 1966 and 1969, inflation accelerated reaching a peak at the begining of 1970 when his term as chair ran out.

2.1 Counterfactuals based on nonlinear Taylor rules

To conduct counterfactual experiments of the type descibed above it is necessary to have in hand operational characterizations of different policymaking "styles". Here we use Taylor rules estimated in Cukierman and Muscatelli (2008) (CM in the sequel) for each of the following periods at the Fed; Martin, Burns/Miller, Volcker and Greenspan to precisely characterize the policy style under each chair.[4] The estimated rules relate, as in Clarida, Gali and Gertler (2000) (CGG-00), the federal funds rate (FFR) to policymakers' expectation of upcoming values of the inflation and output gaps and to the lagged value of the policy rate with one important difference. The specification used allows for potential nonlinearities in the reaction functions by using hyperbolic tangent smooth transition regressions (HTSTR). It conveniently maps the convexity or concavity properties of the reaction function with respect to the output and inflation gaps into two parameters denoted by β_2 and γ_2 respectively. In particular, it implie that, depending on whether β_2 is positive or negative, the reaction function is convex or concave with respect to the inflation gap, and depending on whether γ_2 is positive or negative the reaction function is concave or convex with respect to the output gap. When $\beta_2 = \gamma_2 = 0$ the Taylor rule is linear and reduces to the specification in CGG-00. The linear coefficients of the inflation gap, the output gap, the lagged interest rate and the regression constant are denoted by β_1, γ_1, ρ and α respectively.

[4]Burns and Miller are lumped into a single period since the term of the latter was rather short and he did not havemuch time to develop a style of his own.

Table 1 shows that the curvature properties of the reaction function has varied across different chairs. In particular, during the Burns/Miller and Greenspan periods reaction functions are mostly concave while under Volcker the Taylor rule is linear and under Martin it is convex. In general, nonlinear Taylor rules imply that the underlying loss function of policymakers are not quadratic in either the inflation gap or in the output gap, or in both. CM show that, given a New Keynesian economy of the type presented in Clarida, Gali and Gertler (1999) (CGG-99 in the sequel), concavity of the reaction function indicates that policymakers' preferences are dominated by stronger aversion to negative than to positive output gaps and convexity of the reaction function indicates that their preferences are dominated by stronger aversion to positive than to negative inflation gaps (proposition 1). Using their terminology I refer to these two types of asymmetry as recession avoidance preferences (RAP) and inflation avoidance preferences (IAP) respectively.[5] Thus, given a CGG-99 New Keynesian framework, the results in Table 1 are consistent with the view that RAP dominated under Burns/Miller and Greenspan, IAP dominated under Martin and that under Volcker the more prevalent recession avoidance of the Fed was offset by inflation avoidance.

The notion that losses from the output and inflation gaps are subject to asymmetries actually goes back to the seventies. At the time, the staff of the Fed used the following loss function to evaluate the impact of alternative policy choices by means of various large scale econometric models including the MPS model (Craine, Havenner and Berry (1978), equation (1))

$$L = \sum_{i=1}^{h} \left\{ 2(u_i > 4.8)^2 + (\pi_i > 2.5)^2 + 5(\mid \Delta r_i^{TB} \mid > 1.5)^2 + 0.00001 LM1G \right\} \qquad (1)$$

[5] In the presence of RAP only theory implies that the reaction function is concave and in the presence of IAP only it is convex. When both asymmetries are present the reaction function may still be linear since each of RAP and IAP push the benchmark Taylor rule away from linearity in opposite directions.

Table 1

Reaction Functions by Board Chairs: US, 1960:1 - 2005:4

Period	**Estimated Coefficients**							**Stats**
	$\widehat{\widehat{\alpha}}$ or $\widehat{\widehat{\alpha}}$	$\widehat{\beta}_1$	$\widehat{\beta}_2$	$\widehat{\gamma}_1$	$\widehat{\gamma}_2$	$\widehat{\rho}$	π^*	
Martin 1960:1 1970:1	5.76** (1.52)	-1.80* (0.98)	3.21** (0.63)	0.34** (0.17)	0.09** (0.04)	0.76** (0.08)	1.3	σ=0.42 J_{15}=11.6
Burns/ Miller 1970:2 1979:3	1.42** (0.72)	0.86** (0.09)	0.08 (0.72)	0.55** (0.19)	-0.90** (0.45)	0.42** (0.13)	3.2	σ=0.85 J_{15}=14.0
Volcker 1982:4 1987:3	0.16 (1.31)	1.52** (0.29)	-	0.80** (0.40)	-	0.89** (0.03)	-	σ=0.84 J_{17}=11.6
Green- span 1987:4 2005:4	2.35 (1.08)	1.01** (0.36)	-0.92 (0.85)	0.88** (0.12)	-0.84** (0.14)	0.81** (0.03)	2.9	σ=0.38 J_{15}=13.4

Source: Cukierman and Muscatelli (2008), Table 2.

Notes: Numbers in parentheses indicate standard errors; σ indicates the standard error of the estimate; J_n is Hansen's test of the model's overidentifying restrictions, which is distributed as a $\chi^2(n+1)$ variate under the null hypothesis of valid overidentifying restrictions. Two stars designate a coefficient/statistic that is significant at the 5% level, and one star indicates significance at the 10% level. The interest rate, the output gap, inflation, the inflation target, π^*, and σ are all measured in percentages.

where u_i, π_i are the rate of unemployment and the rate of inflation in quarter i in the future and Δr_i^{TB} is the change in the treasury bill rate between period i and period $i-1$.[6] The target values for inflation (2.5 percent) and unemployment (4.8 percent) were chosen based on the Nixon administration announced 1973 inflation and unemployment objectives in conjunction with the long rate of unemployment implied by the MPS model. As is well known forecasts derived from the MPS model were rather poor. But this fact is orthogonal to the features of the loss function in (1) which is the main focus of the following argument. In particular, this loss function only penalizes **positive** deviations of unemployment from its natural level and **positive** deviations of inflation the 2.5 percent target. In other words it builds in both RAP and IAP. This loss function was used by the staff of the Fed when presenting the consequences of alternative policy decisions to the Board. Although there is no evidence that the Board officially endorsed this loss function it is reasonable to presume that the staff would not have proposed it, if it had not been in the ball-park of the implicit objectives of the Board and the FOMC at the time. It is also noteworthy that the weight on deviations of unemployment from the target is twice the size of the weight on deviations of inflation from its target. This in conjunction with the concavity of the Taylor rule under Burns in Table 1 above is consistent with the view that, to the extent that decisionmaking under Burns had been subject to IAP, the reaction function was dominated by recession avoidance.

The graphs in Figures 1a through 1c show what would have been the paths of the federal funds rate (FFR) during the period corresponding to the Burns/Miller tenure (essentially the seventies) had policy been conducted in line with the non linear policy rules estimated in Table 1 for each of the other chairs. In each case the value of the federal fund rate predicted by Burns' nonlinear rule in table 1 (FFR_B) is presented for comparison purposes with the paths simulated by using the Taylor rules of Volcker (FFR_V), Greenspan (FFR_G) and Martin (FFR_M). This

[6] $LM1G$ is a quadratic in the rate of change in the rate of growth of narrow money from a 5.1 percent benchmark.

is shown in the first panel of each figure. The simulations are all dynamic in the sense that they take into consideration the slow adjustment of the policy rate. In all cases the initial value of the federal funds rate for starting the simulations is equal to its actual value in the quarter immediatly preceding the beginning of Burns' term in office (70:1). The second panel in each Figure shows the difference between the value of the federal funds rate predicted by using the counterfactuals (FFR_V, FFR_G or FFR_M) and between .the rate predicted by the Taylor rule under Burns.

Figures 1a, 1b, 1c about here

The main lessons from the counterfactuals follow. Not surprisingly, if policy during the seventies had been conducted by a Volcker type the path of the federal funds rate would have been uniformly higher. This is particularly striking after the first oil shock and to a lesser extent during the first three years of Burns' tenure as chair (Figure 1a). More surprisingly, policy under a Greenspan type policy would have been more expansionary than under Burns during most of the seventies (Figure 1b). This is particularly in evidence during the two oil shocks. Those findings are consistent with the view that reaction functions adapt to the economic environment. Volcker who inherited a highly inflationary environment strongly tightened rates in response to rising inflation. On the other hand under Greenspan, whose term started after most of the high inflation of the seventies had been conquered, recession avoidance became sufficiently important to make his policy, given similar circumstances, even looser than that of Burns. Finally, although during most of the seventies a Martin type would have exerted a level of thightness similar to that of Burns, he would have responded substantially more aggressively than Burns to the first oil shock. This is consistent with a recent account by Wood (2005, p. 256) who notes that after the 1957-58 recession, in response to criticism of insufficient ease before the House Ways and Means Committee, he said: "I do want to point out that in eight years of experience in the Federal Reserve System, I am convinced that our bias, if anything, has been on the side of too much money rather than too little"

The Volcker and Greenspan counterfactuals are consistent with the view that at least part of the inflation of the seventies and its persistence were due to the relatively soft policy stance adopted under Burns. This begs the question of whether this was due to incompetence or to lack of independence from political authorities. Leaving the competence issue aside for the time, there is evidence that political pressures were definitely part of the story. Vivid illustrations of such pressures appear in a summary of conversations between Nixon and Burns in recently released Nixon tapes. For example, following Burns' warning about excessive liquidity during an October 1971 conversation in the Oval Office, Nixon responds by stating that the liquidity problem is "just bullshit" (Abrams, 2006, P. 180). To resist such pressures Burns and the FOMC would have needed stronger professional convictions and backing about the urgency of restrictive policies than those they could hold in light of the state of academic economics of the time. As is well known the decade of the seventies was characterized by violent conceptual and policy differences between Keynesians and the monetarists. Burns and the FOMC were often critisized for opposing reasons by those two camps. In his memoirs Burns succinctly summarizes the innaction this injected into policymaking at the Fed by recalling that when one camp critisized the Fed's policy for not going sufficiently in a particular direction while critics in the other camp assailed him for doing too much of it, he safely ducked in the middle. Chapter 4 of Meltzer (Forthcoming, 2008) contains a detailed discussion of these and related issues.

2.2 Counterfactuals based on real time data and linear reaction functions

In a series of papers Orphanides convincingly argues that part of the inflation of the seventies was due to substantial and persistent overestimation of potential output (Two reprentative articles are Orphanides (2001, 2004)). Since the counterfactual experiments in the previous subsection are based on regressions estimated with retrospective, rather than with real time data, it is

desirable to reproduce them with real time data for reasons of robustness. To this end I tried to reestimate the non linear regressions in Table 1 with real time data from Orphanides (2004). This data includes, to my knowledge, the best existing proxies for the perceptions policymakers held about the outlook for inflation and the output gap when making policy decisions. To this point the NLLS used to pinpoint the parameters of the nonlinear version did not yield sufficiently tight estimates. On the other hand the corresponding linear reaction functions were estimated with a relatively high degree of accuracy. These estimators are summarized in table 2. The estimators are parallel those presented in Table 1 of Orphanides (2004) for the case of a one period forecast horizon for inflation. But rather than spliting the sample in the second quarter of 1979 as he does, I split it into subperiods by Fed chairs. Since the real time data is available only during 66:1 - 95:4 Greenspan's term is not fully covered and Martin's period is excluded. The Taylor rule for Volcker's period is estimated twice. Once with and once without the first three years of his tenure when the Fed was targeting a nominal stock rather than the federal funds rate (Volcker L and Volcker S in Table 2 respectively).

Figures 2a through 2c show counterfactual dynamic simulations structured as those in Figures 1a through 1c for the paths of the federal funds rate (FFR). As before there are two panels in each figure. The first panel shows the counterfactual path for either Volcker or Greenspan along with the path implied by The Burns/Miller reaction function. The second panel shows the difference between the paths of Volcker's or Greenspan counterfactuals and that of Burns/Miller.

Figures 2a, 2b, 2c about here

A quick look at the figures confirms that the main two messages of the previous subsection are robust to the use of real time rather than retrospective data. Even with real time missperceptions, had policy in the seventies been conducted in Volcker's style it would have been tighter than the one implied by Burns/Miller policy rule. Had policy been conducted in the style followed by Greenspan during his first eight years as chair, it would have been uniformly

Table 2

Real Time Linear Reaction Functions: Burns, Volcker and Greenspan

Period	Estimated Coefficients				
	$\widehat{\alpha}$	$\widehat{\beta}_1$	$\widehat{\gamma}_1$	$\widehat{\rho}$	$\overline{R^2}$
Burns/Miller (70:2-79:3)	3.20*	1.40***	0.55***	0.62	0.88
	(1.54)	(0.26)	(0.14)	0.09***	
Volcker L (79:4-87:3)	4.56	1.50***	0.18	0.60	0.81
	(2.46)	(0.35)	(0.31)	0.13***	
Volcker S (82:4-87:3)	3.82	1.17	-0.10	0.62	0.77
	(2.31)	(0.77)	(0.19)	0.20**	
Greenspan (87:4-95:4)	3.81**	1.11**	1.15***	0.73***	0.98
	(1.10)	0.31	(0.16)	(0.04)	

Notes: Numbers in parentheses indicate standard errors.

* indicates significance at the 0.05 level,

** indicates significance at the 0.01 level,

*** indicates significance at the 0.001 level

looser than the one implied by the Burns/Miller rule. Although this does not rehabilitate the actual policy process during the seventies, the comparison with Greenspan provides a somewhat less sanguine perspective on the policy errors of the seventies.

3 Inflationary expectations and the great inflation

Led by its New Keynesian reincarnation, the current theory of monetary policy assigns a central role to inflationary expectations in the propagation of inflation. Although polictmaker in the seventies were not blind to shifting inflationary expectations, some of their policy errors might have been due to insufficient attention to the effects of policy on these expectations. In addition,

to the extent that they underestimated future inflation, policymakers might have been led to believe that they were setting higher real rates than what turned out to be the case with the benefits of hindsight. This section empirically explores those two hypotheses by using inflation forecasts from the Fed's Greenbook to proxy for real time inflationary perceptions of policymakers and data on survey expectations from the Survey of Professional Forecasters (SPF) and the Livingston Survey (LS) to proxy for the public's expectations.[7]

Survey based inflationary expectations do not possess the shining internal consistency of rational expectations and may be subject to various measurement errors. On the other hand the fact that they do not impose the model consistency assumption required by rational expectations may be an advantage. When the economic model is oversimplistic or if the information set postulated by the model for individuals is not realistic the requirement of model consistency may lead to serious errors in the measurement of inflationary expectations.

3.1 The impact of inflation uncertainty on the difference between exante and expost indicators of real policy rates

An important cost of inflation is related to the rise in inflation uncertainty associated with a rise in inflation. Within the private sector, this uncertainty leads to arbitrary redistributions of wealth and to deviations between actual and desirable production. It also injects uncertainty into monetary policy choices. Since monetary policy affects the economy through real rates, policymakers must evaluate the real impact of their **nominal** rate decisions exante before they know the realization of inflation. This subsection examines how often the FOMC in the seventies was led to believe exante that its policy actions led to **real** interest rates that were biased upward in comparison to what these rates turned out to be with the benefit of hindsight. To the extent

[7]The Greenbook Forecasts have been used in Orphanides (2004) and the SPF and the LS are maitained by the Philadelphia Fed.

that, during the seventies, upward errors in evaluation of real rates were more frequent than errors in the opposite direction part of the inflationary bulge of the time may be traced to overestimation of these real rates.

Two proxies for exante real rates as perceived by the FOMC in real time are used. The first is the effective federal funds rate (F_t) minus the one quarter ahead forecast of GNP inflation from the Greenbook in quarter t ($\pi^{GF}_{t,t+1}$).[8] The second is the one year treasury bill rate (T_t) minus the one year ahead forecast of GNP inflation from the Greenbook in quarter t ($\pi^{GF}_{t,t+4}$). The superscript GF stands for "Greenbook forecast". The data for $F_t, \pi^{GF}_{t,t+1}, \pi^{GF}_{t,t+4}$ is taken from the data set underlying Orphanides (2004) and data for T_t is from the Federal Reserve Bank of St Louis data set. For future reference it is convenient to define

$$\begin{aligned} F^r_t &\equiv F_t - \pi^{GF}_{t,t+1} \\ T^r_t &\equiv T_t - \pi^{GF}_{t,t+4}. \end{aligned} \tag{2}$$

Here F^r_t and T^r_t are proxies for the exante real content of the federal funds rate and the exante real one year treasury bill rate as perceived by the Greenbook forecasters given the information available to them in quarter t. Let

$$\begin{aligned} F^{ra}_t &\equiv F_t - \pi_{t,t+1} \\ T^{ra}_t &\equiv T_t - \pi_{t,t+4}. \end{aligned} \tag{3}$$

be the expost realizations of F^r_t and of T^r_t. Here $\pi_{t,t+j}$ denotes actual inflation measured by the rate of change in the GNP implicit price deflator between quarter t and quarter $t+1$. The difference $F^{ra}_t - F^r_t$ is a proxy for the extent to which Greenbook forecasts of the real content of

[8] The headline implicit deflator during the seventies was based on GNP rather than on GDP measures of aggregate productive activity.

the federal funds rate exceeded its realized value. Similarly, $T_t^r - T_t^{ra}$ is a measure of the extent to which Greenbook forecasts of one year treasury bill rates exceeded the actually realized value of those rates. Figures 3a and 3b show the paths of those two differences between 1967 and 1995.

Figures 3a, 3b about here

Figure 3a suggests that policymakers' perceptions of the real time tightness of monetary policy over the upcoming quarter were generally biased upward. During most of the period under consideration the bias was bounded from above by half a percent tending towards this bound from below in the early seventies. This bound was exceeded twice during the period. Once after the first oil shock, when the bias rose to one pecent and during the early phase of Volcker's disinflation when it climbed to an all time maximum of two percent.

It is widely believed that the impact of monetary policy on the real economy is transmitted mainly through the effects it has on longer term rates.[9] Figure 3b examines whether similar differences arise between exante and expost real one year treasury rates. Over the entire period between 1973 and 1995 the Figure suggests that over and under predictions of tightness balance each other out rather well. Interestingly, the distribution of over and under predictions is strongly serially correlated. In particular, most of the seventies are characterized by over predictions of the real treasury rate, while the first three years of Volcker's tenure are characterized by under predictions. Another striking feature is that the standard deviation of the forecast error of $T_t^r - T_t^{ra}$ is substantially lower under Greenspan's tenure than before. It is 1.062 before 87:3 and only 0.392 during the first nine years of Greenspan Chairmanship.[10] As discussed later, this is one of the long term benefits of Volcker's disinflation. In particular, the nominal stability

[9] For the one year treasury bill rate this belief is backed by the finding that the correlation between F_t and T_t over the sample period is 0.967. The corresponding correlation between the expost real counterparts of F_t and of T_t is 0.925.

[10] Greenspan's period is cut in the middle since the data on the one year ahead Greenbook inflation forecdasts ends in 95:4.

inherited by Greenspan led policymakers at the Fed to more accurate evaluations of the stance of monetary policy.

3.2 A direct look at the behavior of unexpected inflation during the great inflation and its aftermath

This section provides evidence on inflation forecast errors during the great inflation and its aftermath. Data on inflationary expectations or forecasts is obtained from three different sources. The Survey of Professional Forecasters (SPF), the Livingston Survey (LS) and the Fed's Greenbook forecasts (GB). The first two surveys are currently maintained by the Federal Reserve Bank of Philadelphia and are aimed at capturing the expectations of individuals in the financial and business community. The Greenbook forecasts come from the data set underlying Orphanides (2004) and reflect the real time forecasts of the staff of the Federal Reserve. The time periods covered differ across surveys. All three sources provide forecasts for a one year ahead forecast horizon, as well as for other horizons. The SPF and GB series provide forecasts for the GDP (or prior to the early nineties) GNP deflator and the LS provides forecasts of CPI inflation.

Figures 4a, 4b and 4c show the paths of the one year ahead inflation forecast errors implied by data from the SPF, the LS and the GB respectively. The main lessons from the figures follow. First, except for a relatively short time interval during the mid seventies, the magnitude of inflation was systematically underestimated during the seventies. This statement applies to private sector forcasters as well as to the predictions made by the staff of the Fed as reflected in the Greenbook forecasts. Second, during Volcker's disinflation forecast errors tend to be negative. This is particularly in evidence for the private forecasts and to a lesser extent for the Greenbook forecasts. Third, inflation uncertainty as characterized by the standard deviation of forecast errors is substantilly lower since the start of Greenspan Chairmanship than during the great inflation and its stabilization. For example, the standard deviation of the one year ahead

forecast error of Greenbook forecasts goes down from 1.371 prior to 87:4 to 0.575 thereafter. Those findings are robust across different forecast sources, as well as across forecast horizons.

Figures 4a, 4b, 4c about here

3.3 The impact of inflationary experience on expectation formation

Although Burns and his predecessors were not unaware of the role of inflationary expectations, the inflationary experience of the seventies led policymakers to realize their prime role in the transmission and perpetuation of the inflationary process. For example in a testimony to a Congressional committee Volcker states; "Anticipations of of higher prices themselves help speed the inflationary process..." (Volcker (1980), pp. 2,3). This view is currently firmly enshrined in all modern macroeconomic models.

However, relatively less attention has been paid to the factors that affect the behavior of inflationary expectations over time. Obviously, full understanding of the interplay between inflation and inflationary expectations also requires a good understanding of the factors that shape inflationary expectations. In particular, understanding of the channels through which monetary policy might affect expectations is essential for their efficient management.

The findings in the previous subsection show that when inflation accelerated during the seventies it was generally underestimated and when it deccelerated during the first half of the eighties it was generally overestimated. This suggests that expectations formation tends to be adaptive in the sense that they appear to rely on the past inflationary environment. During the early stages of the rational expectations revolution adaptive expectations have been discredited on the ground that they are not rational. But it became apparent after a while that this early critisism was based on oversimplistic assumptions about the information sets possessed by individuals. In particular (as originally shown by Muth (1960) and subsequently applied to the process of monetary policy by Cukierman and Meltzer (1986) and others) when forecasters are

uncertain about the extent to which a given inflationary bulge is persistent or transitory, optimal statistical forecasts of future inflation take the form of distributed lags on past actual rates of inflation. Since the main real life inference problem of forecasters is to disentangle persistent from short term movements in inflation it is interesting to examine the relationship between each of the various forecasts and the actual behavior of past inflation. This is implemented by estimating the following set of OLS regressions

$$\pi^e_{jt} = c + \sum_{i=1}^{10} \alpha_{ji}\pi_{t-i} + \delta_1 d_1 + \delta_2 d_2 \tag{4}$$

where π^e_{jt} is inflation forcast of type j in quarter t, π_{t-i} is actual inflation in quarter $t-i$, d_1 and d_2 are oil shocks dummies for the first and second oil shock respectively. These dummies are added to account for possible extraordinary impacts of the inflationary bulges created by the first and second oil shock on the process of expectation formation. All other symbols are parameters to be estimated. All regressions feature a constant, c, that is taken to reflect maintained beliefs about the very long run underlying inflation process.

The estimated equations for seven alternative expectations series are summarized in Table 3a. The table shows regressions of each type of expectation on past actual quarterly rates of inflation measured per year. The maximum lag allowed is ten quarters but the final lag lenghts presented in the table are shorter due to application of the following recursive lag elimination procedure. When the coefficient at the tail of the lag distribution is not significant the tenth lag is dropped and the distributed lag is reestimated with only nine lagged inflation terms. The hypothesis that the last two tail coefficient are jointly zero is then tested. When this hypothsis is rejected the number of lags is taken to be nine. When it is accepted the equation is reestimated with only eight lags and the hypothesis that the last three lag coefficients are jointly zero is tested, and so on. As a consequence the number of lags within the zero to ten lag quarters range is determined endogenously.

The first four columns in the table show regression equations for the one, two, three and four quarters ahead GDP (or GDP) inflation forecasts from the Greenbook. The fifth column shows the median SPF one year ahead forecast for the same variable. The last two columns show equations for the six months and one year ahead LS forecasts for CPI inflation. Numbers under the coefficients show standard errors. One, two and three stars designate significance at the 0.05, 0.01 and 0.001 levels of significance respectively.

Table 3a about here

3.3.1 Full sample results

The main findings in table 3a are summarized in what follows. 1. The sum of lag coefficients varies between a minimum of 0.65 for the one year ahead Greenbook forecast and a maximum of 0.94 for the six months ahead CPI inflation from the Livingston survey. The sums of lag coefficients of the Fed's staff Greenbook forecast equations are generally smaller than those of private sector forecasters. 2. The distributed lags of the Fed's staff forecast equations are generally shorter than the distributed lags in the equations for private sector inflationary expectations. 3. The lag coefficients of Greenbook forecast equations are all significant. By contrast the lag coefficients in private sector forecast equations are significant for the first several lags and the last one or two lags only. 4. The lenght of the lag in Greenbook forecasts equations tends to go down with the forecast horizon. 5. The first oil shock dummy is negative in all equations but not always significant while the second oil shock dummy is positive and significant in all equations. These findings are consistent with the view that at least some of the forecasters interpreted the inflationary bulge during the first oil shock as a transitory phenomenon whereas all of them interpreted the bulge associated with the second oil shock as a persistent one. 6. The estimated constant is positive and highly significant in all equations showing that the expected long run rate of inflation varies between a minimum of 0.81 for the one year ahead SPF expectation and

a maximum of 1.38 for the one year ahead Greenbook inflation forecast equation.

3.3.2 Expectation formation under Burns/Miller and Volcker - A comparison to their formation under GreRenspan

An important question is whether the expectation formation process has changed when long run price stability reappeared under Greenspan and, to the extent it did, in what ways. To answer this question the various samples underlying the regressions in Table 3a are split into two subperiods the first of which corresponds to the tenures of Burns, Miller and Volcker and the second to Greenspan's tenure. The last quarter of the first subperiod is therefore 87:3. The reason for starting the second subperiod only at the end of Volcker's term is that, in spite of the fact that with hindsight it became clear that he had managed to stabilize most of the high inflation, this was not necessarily clear in real time. This view is supported by the negative inflation forecast errors documented in Figures 4a, 4b and 4c and by the fact that CPI inflation was normally six percent almost till the end of 1982. Even in latter years during Volcker's tenure the rate of inflation often was in the vicinity of four percent.

Tables 3b and 3c repeat the regressions in Table 3a for the first and second subperiods respectively. The first subperiod basically covers the era of the great inflation and its stabilization. The second starts after most of the high inflation has been stabilized and a reasonable measure of credibility attained. Comparison of findings across the two tables support the following conclusions. 1. The Greenbook and SPF long run underlying core expected rates of inflation as measured by the regression constants is higher under Greenspan. By contrast it is lower during the Greenspan era for the Livingston survey.[11] 2. The distributed lags of private inflation forecasts equations become substantially shorter while those of the Fed's staff tend

[11] In interpreting those results one should keep in mind that the sample period for the Livingston survey is about ten years longer than that of the Greenbook forecasts and that the latter refers to GDP deflator inflation and the former to CPI inflation.

to display some mild lenghtening. 3 The sums of lag coefficients of Greenbook forecast equations are higher under Greenspan while the sums of lag coefficients of regressions CPI inflation forecasts from Livingston are somewhat lower. Those results are robust to reestimation of the Livingston equations with two versions of zero constraints on the insignificant lag coefficients.[12]

Figures 3b, 3c about here

3.3.3 Two robustness checks

This subsection reports two robustness checks. In the first the expectation formation processes in Tables 3a, 3b and 3c are reestimated with a proxy for a measure of the perceived unemployment gap suggested by Orphanides and Williams (2005). This gap is measured as the rate of unemployment for the the current quarter as perceived in that quarter (from the SPF) minus a retrospective measure of the natural rate of unemployment. This variable is taken as a proxy for perceived excess demand pressures and is added in order to examine the extent to which inflationary expectations respond to the perceived phase of the business cycle. The main result (not shown) is that the the unemployment gap has a positive effect on expectations during the first subperiod and a negative one under Greenspan. This finding is consistent with the following interpretation. During the period of the great inflation, recessionary perceptions led the public to believe that monetary policy will be accomodative to an extent that will dominate the direct downward pull of a perceived recession on prices. By contrast, under Greenspan the public expected that the second effect will dominate the first because the anti inflationary stance of the Fed had previously been convincingly reestablished under Volcker. A subsidiary result is that the addition of the unemployment gap tends to shorten the distributed lags on past inflation in the private sector regressions.

The second robustness check involves reestimation of the Livingston expectation equation

[12] In one experiment all coefficients from the third one and on are constrained to zero. In the other only the lag coefficients from the third through the eight are constrained to zero.

under zero restrictions on the longish insignificant lag coefficients in Tables 3 (and alternatively, under a zero restriction on all lag coefficients higher than or equal to the third one). This did not lead to appreciable changes in the sum of lag coefficients, nor in the other findings discussed above.

4 Concluding reflections

Two main findings of the paper are; 1. had monetary policy during the seventies and the eighties been conducted in the Volcker's style, it would have been more restrictive than unders Burns/Miller; 2. had policy during this period been conducted in Greenspan's style it would have been less restrictive than under Burns/Miller. Should we conclude from these findings that if either Volcker or Greenspan had been appointed as chair of the Fed at the beginning of the seventies and had faced the same external circumstances as Burns did, they would necessarily stick to their respective policy rules? I believe not. Rather, the policy rules of both Volcker and Greenspan arose as endogenous reactions to the main problem monetary policy had to tackle when they were appointed. Volcker was appointed when, inflation came to be considered the number one economic problem of the day. So he developed a rather conservative rule of conduct. Greenspan, on the other hand, came into office after inflation had been largely stabilized under Volcker. He could therefore deploy more policy efforts to the employment objective in the Fed's dual policy mandate. The broader conclusion is that policy rules adapt so as to respond to the main economic problem of the day.

A third finding is that inflation uncertainty was substantially lower under Greenspan than under either Burns/Miller or Volcker. The second finding might appear surprising at first blush. However, when one recognizes that the process of rebuilding credibility after high inflation has taken hold is normally clouded with uncertainties, a slow rather than a quick decline in inflation uncertainty is to be expected. For the same reason, the major reduction in inflation uncertainty

between Volcker and Greenspan tenure is largely attrbutable to the policies deployed under the former. Greenspan's contribution was that he did not spoil the hard earned stability under Volcker and utilised it to devote more of the policy effort to stabilzation of real economic activity without endangering price stability.

Meltzer (2005) argues that a major reason for the emergence of the great inflation in the early seventies was Burns' inability to stand up to political pressures. On the other hand Romer and Romer (2004), Sargent (1999) and others argue that the main reason is that, during the seventies, the Fed believed in faulty models of the economy. My feeling is that there were strong interactions between those two explanations under Burns tenure. In particular, Burns ability to resist political pressures would, most likely, have been much enhanced had there been a consensus about the right model of the economy and the consequent policy recommendations within the economic profession. Unfortunately for him and for his ability to resist political pressures this was not the case. Although a broad consensus emerged later, the decade of the seventies was characterized by strong policy disagreements between monetarists and Keynesians. Burns alludes to the impact of this controversy in his memoirs by recalling that when monetarists critisized the Fed's policy for not sufficiently deploying policy in one direction while Keynesians assailed him for going too much in that direction, he would safely duck in the middle.

The finding that the Fed's staff underestimated inflation quite often during the seventies makes it likely that Burn's FOMC did not sufficiently appreciate the importance of inflationary expectations in the propagation of inflation. It is also likely that they were not sufficiently aware of the fact (observed during other high inflation episodes) that the speed of adjustment of nominal prices and wages goes up when a higher rate of inflation becomes sufficiently persistent. Phrased in terms of the new classical synthesis they might have largely overlooked the fact that the Calvo parameter rises with inflation, leading them to underestimate the additional inflationary momentum generated by this factor.

I close this article with a little bit of evidence on potential fiscal origins of the great

inflation. Figures 5a and 5b show the behavior of the deficit/GNP and the Debt/GDP ratios between 1960 and 2000. A glance at both ratios reveals that both ratios were smaller during the great inflation of the seventies than during its stabilization in the eighties. This implies that any fiscal view of the great inflation and of its stabilization better address these inverse correlations between inflation and the deficit and debt ratios.

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Fig. 1a: Counterfactual based on nonlinear Taylor rule - Volcker

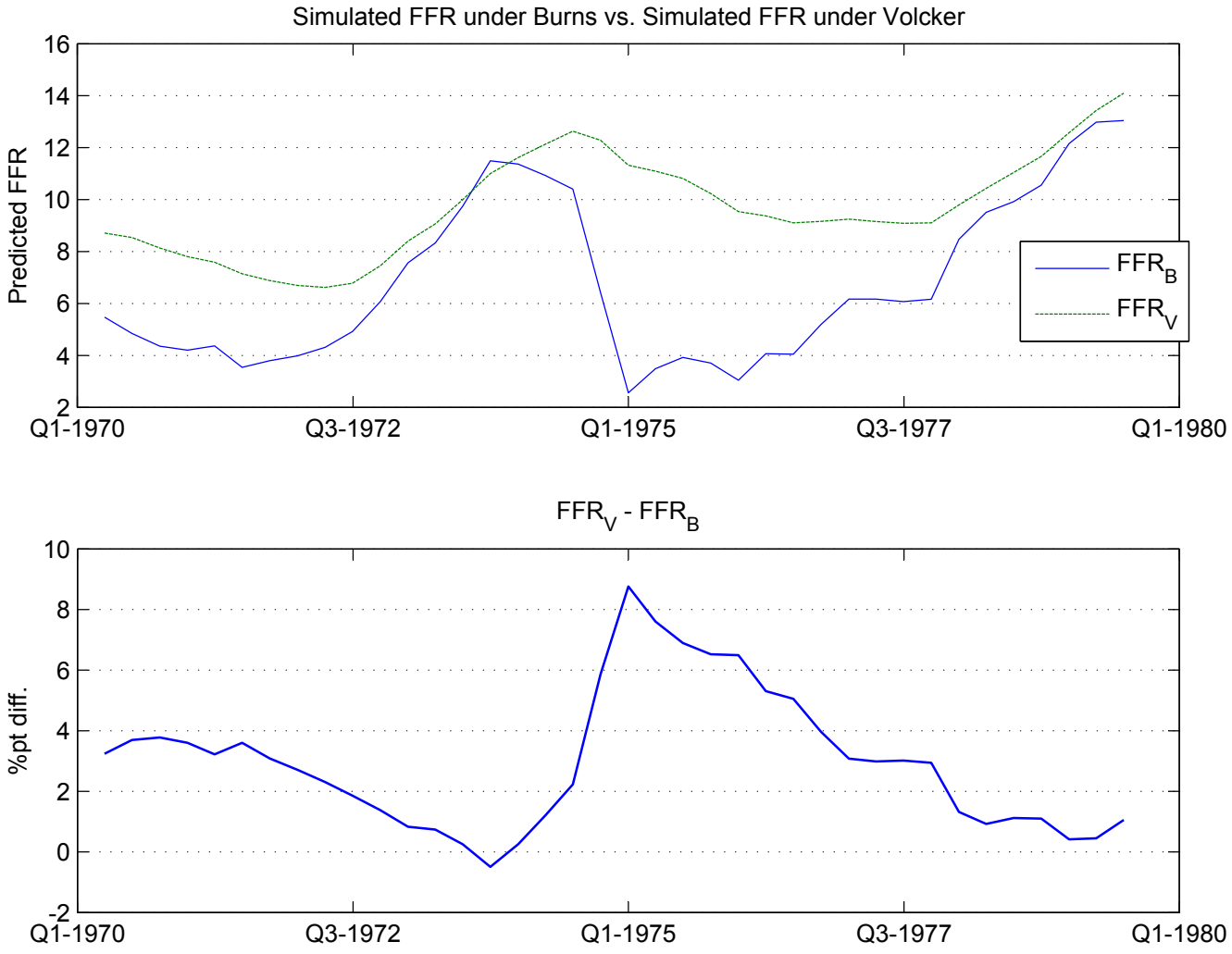

Fig. 1b: Counterfactual based on nonlinear Taylor rule - Greenspan

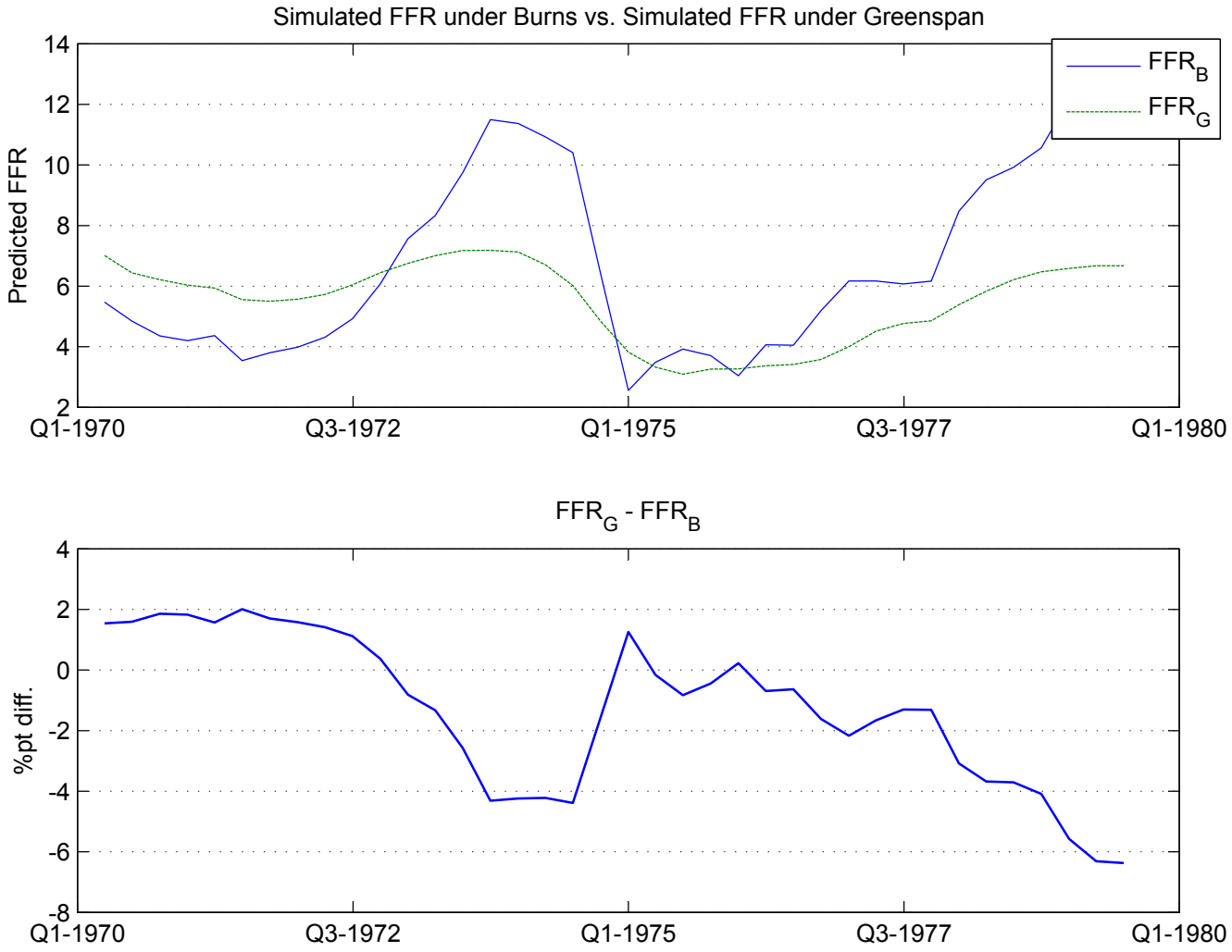

Fig. 1c: Counterfactual based on nonlinear Taylor rule - Martin

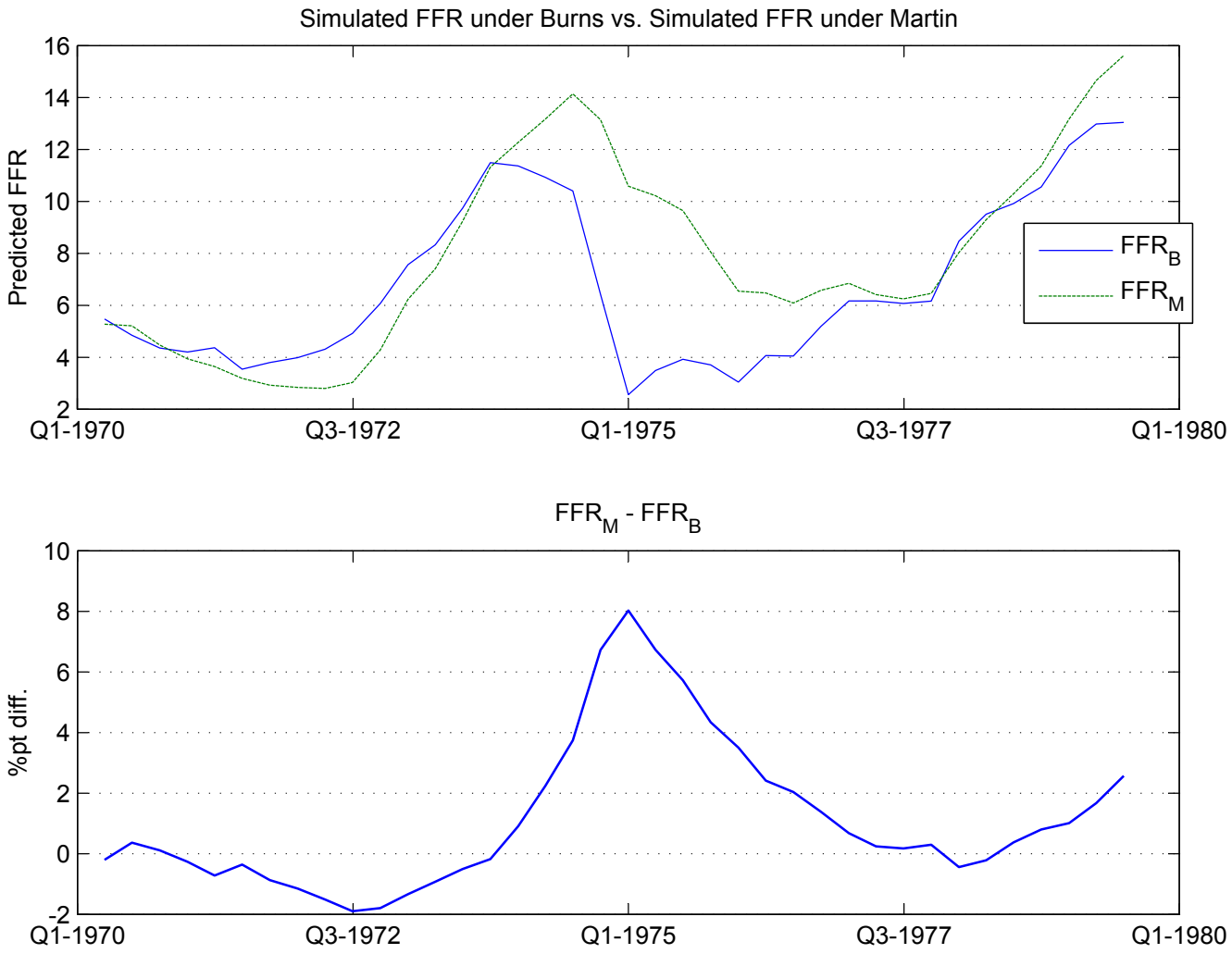

Fig. 2a: Counterfactual based on linear Taylor rule estimated with real time data - Volcker (long)

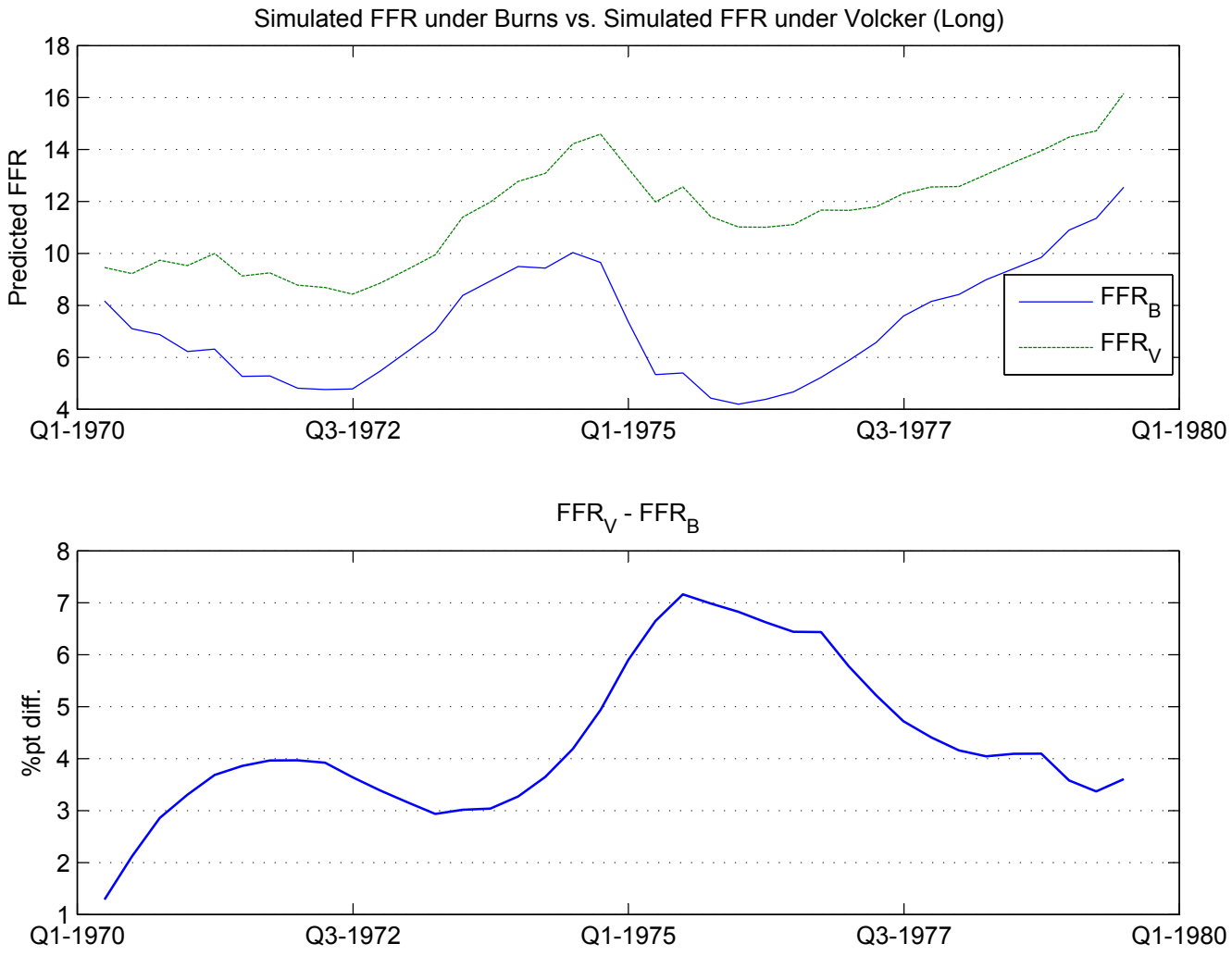

Fig. 2b: Counterfactual based on linear Taylor rule estimated with real time data - Volcker (short)

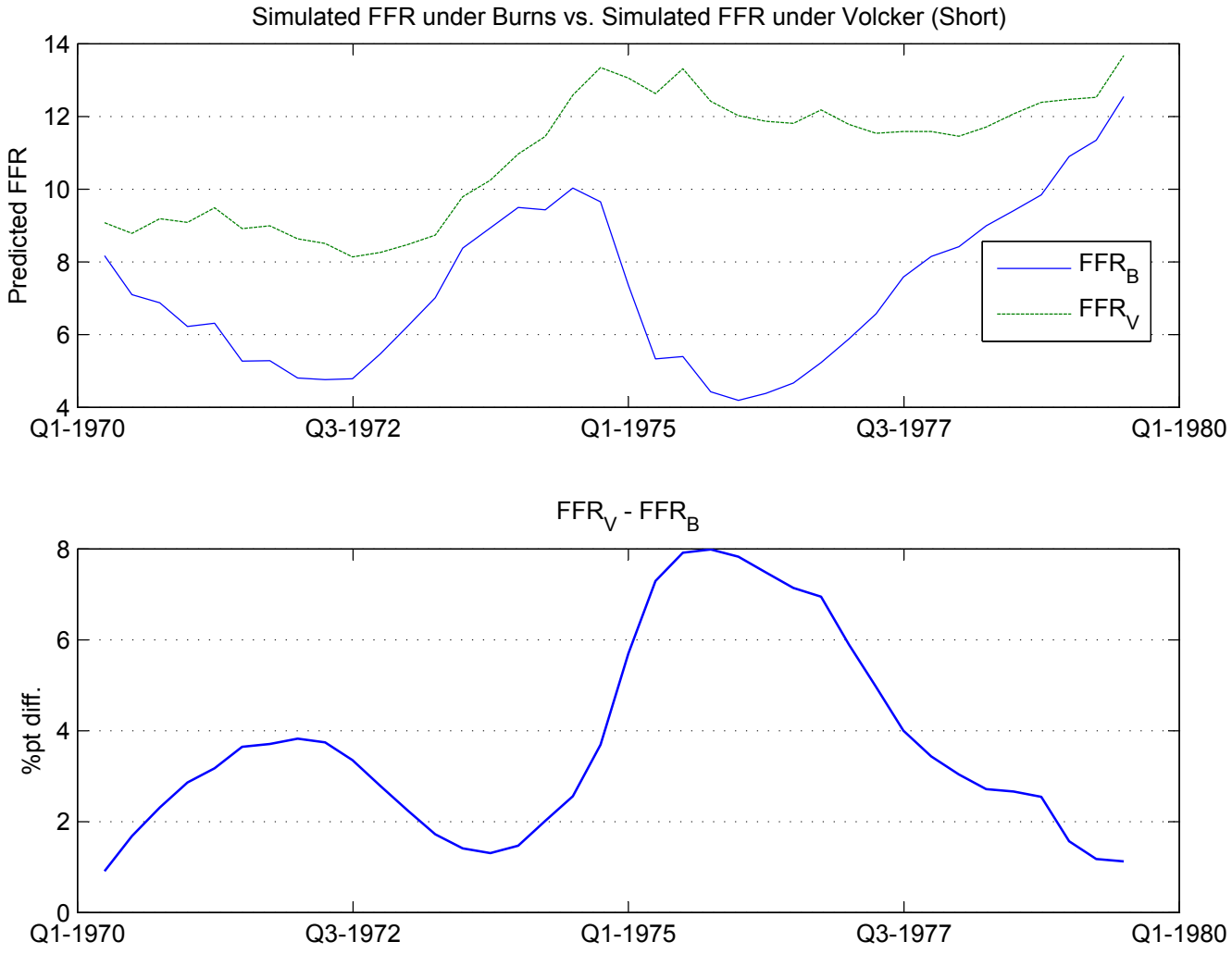

Fig. 2c: Counterfactual based on linear Taylor rule estimated with real time data - Greenspan

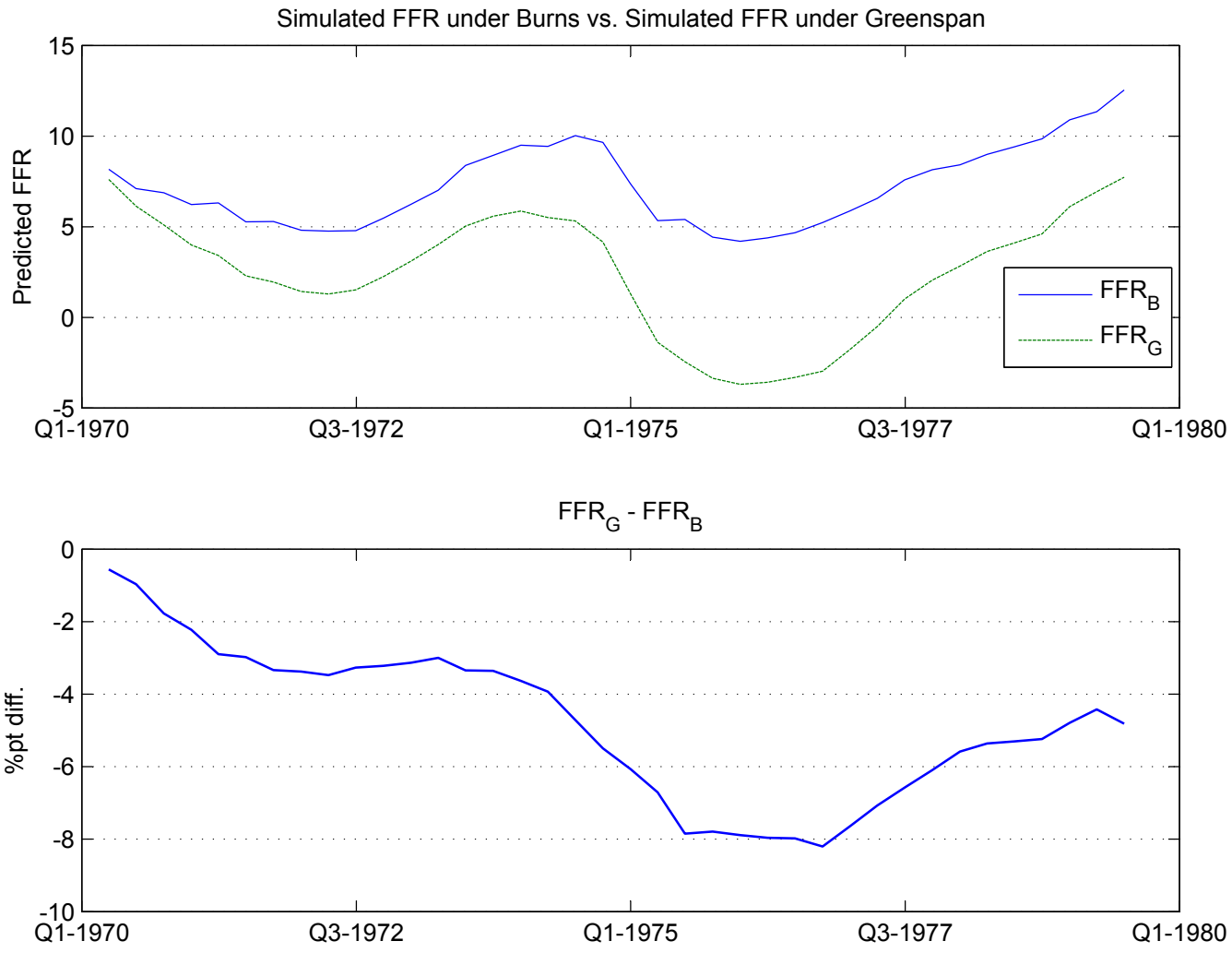

Figure 3a: Difference between the exante and expost real contents of the federal funds rate, %

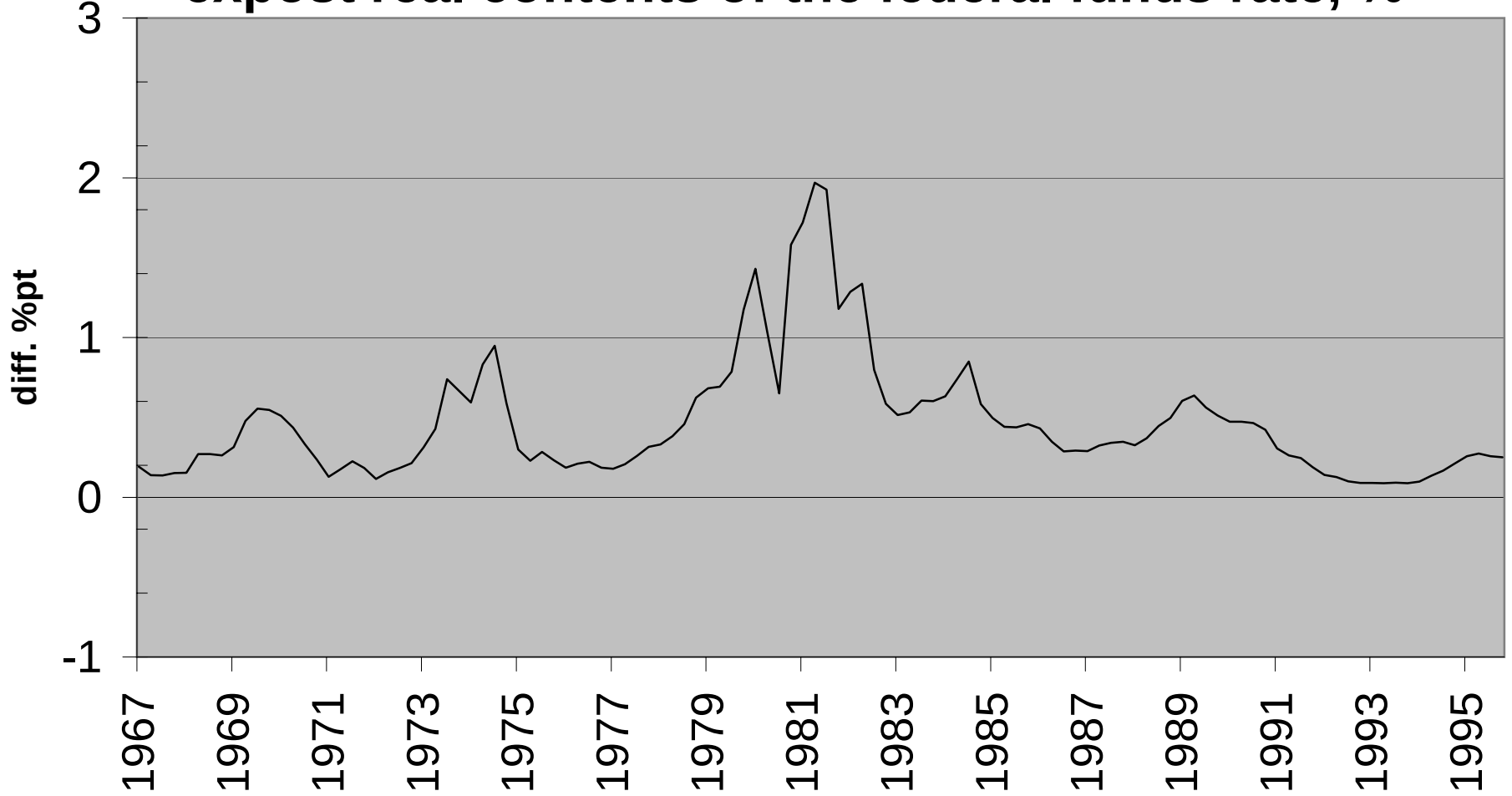

Figure 3b: Difference between exante and expost real 1 year treasury bill rates, %

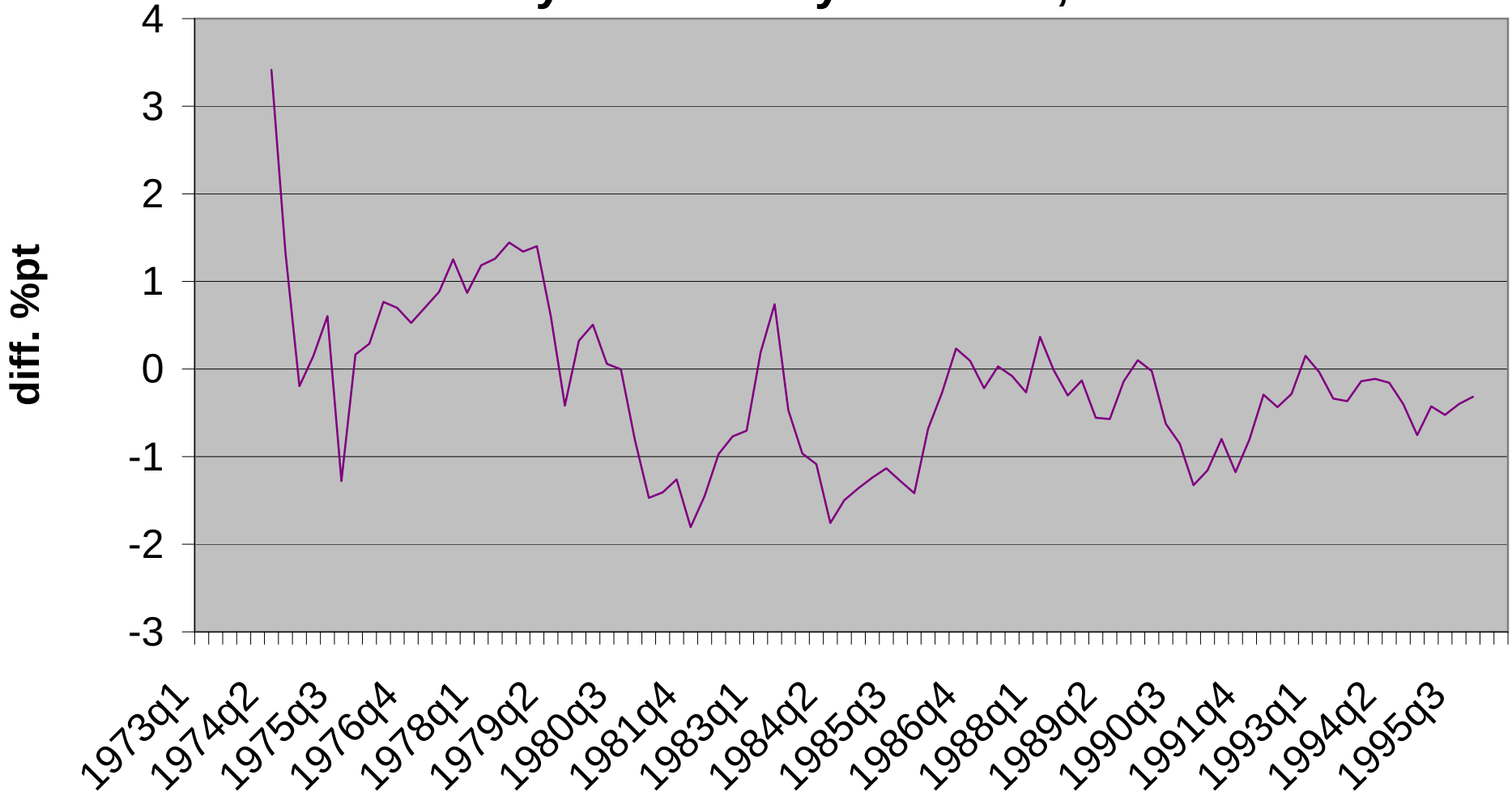

Figure 4a: Actual minus Forecasted Inflation

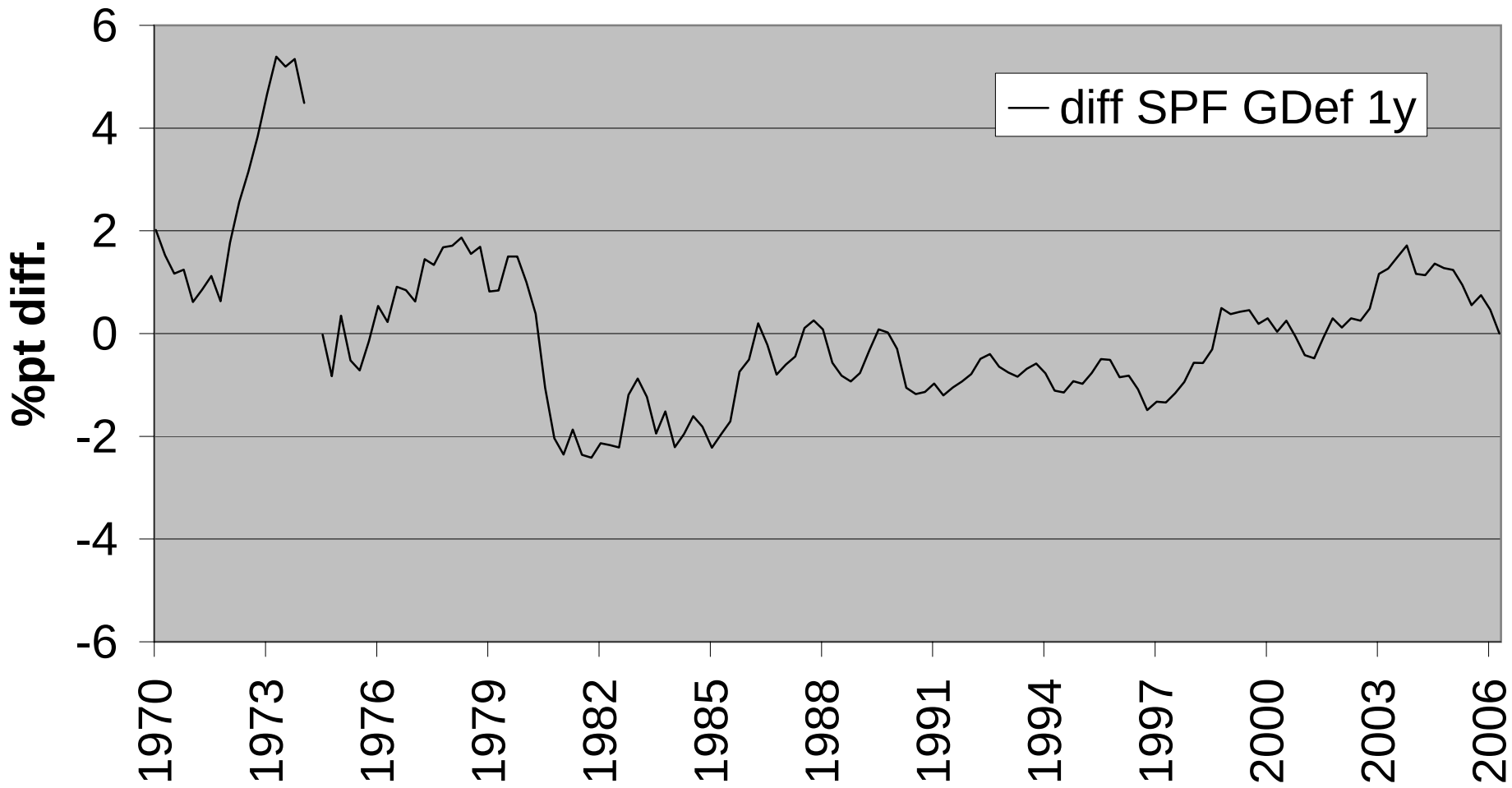

Figure 4b: Actual minus Forecasted Inflation

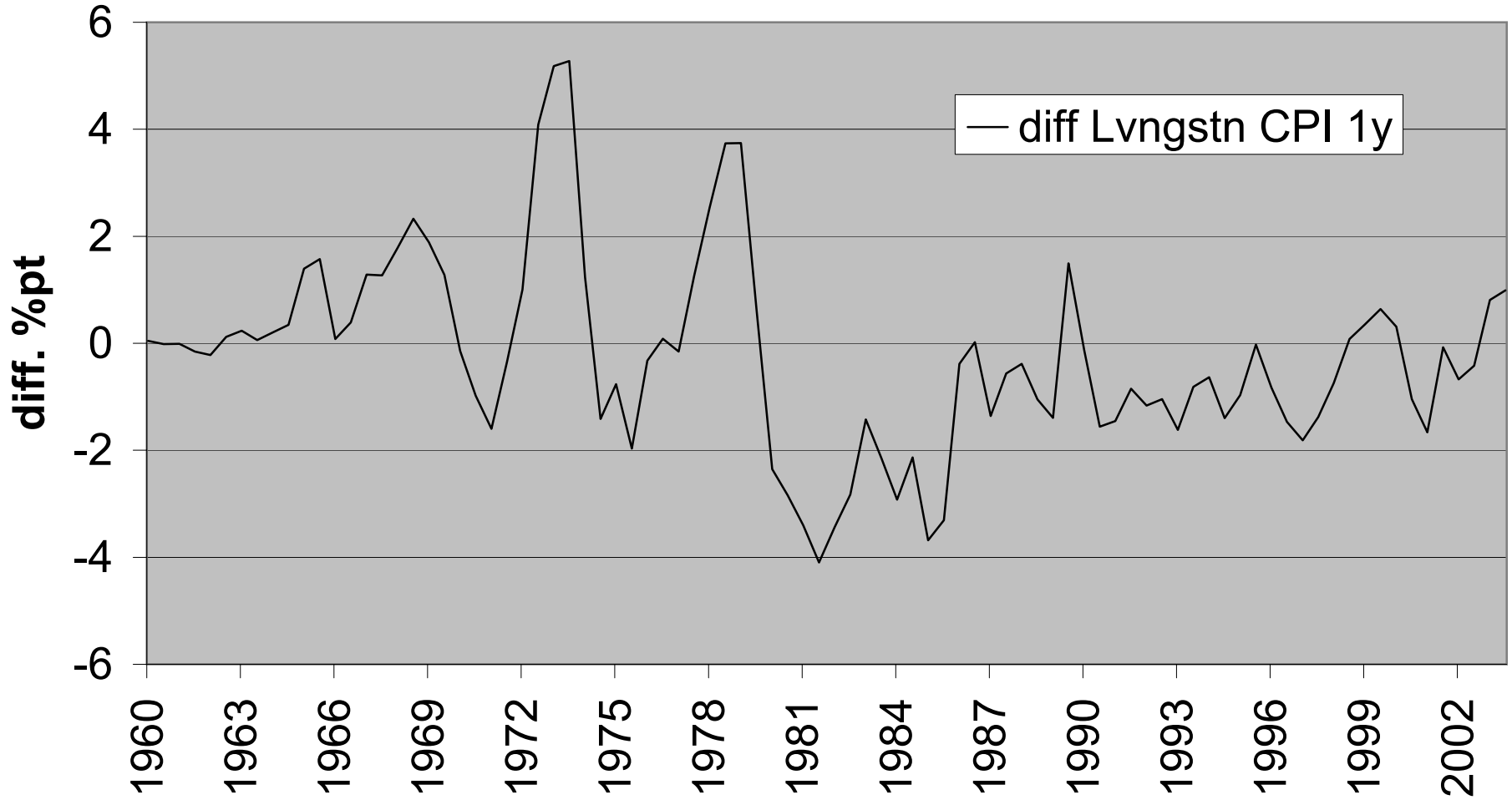

Figure 4c: Actual minus Forecasted Inflation

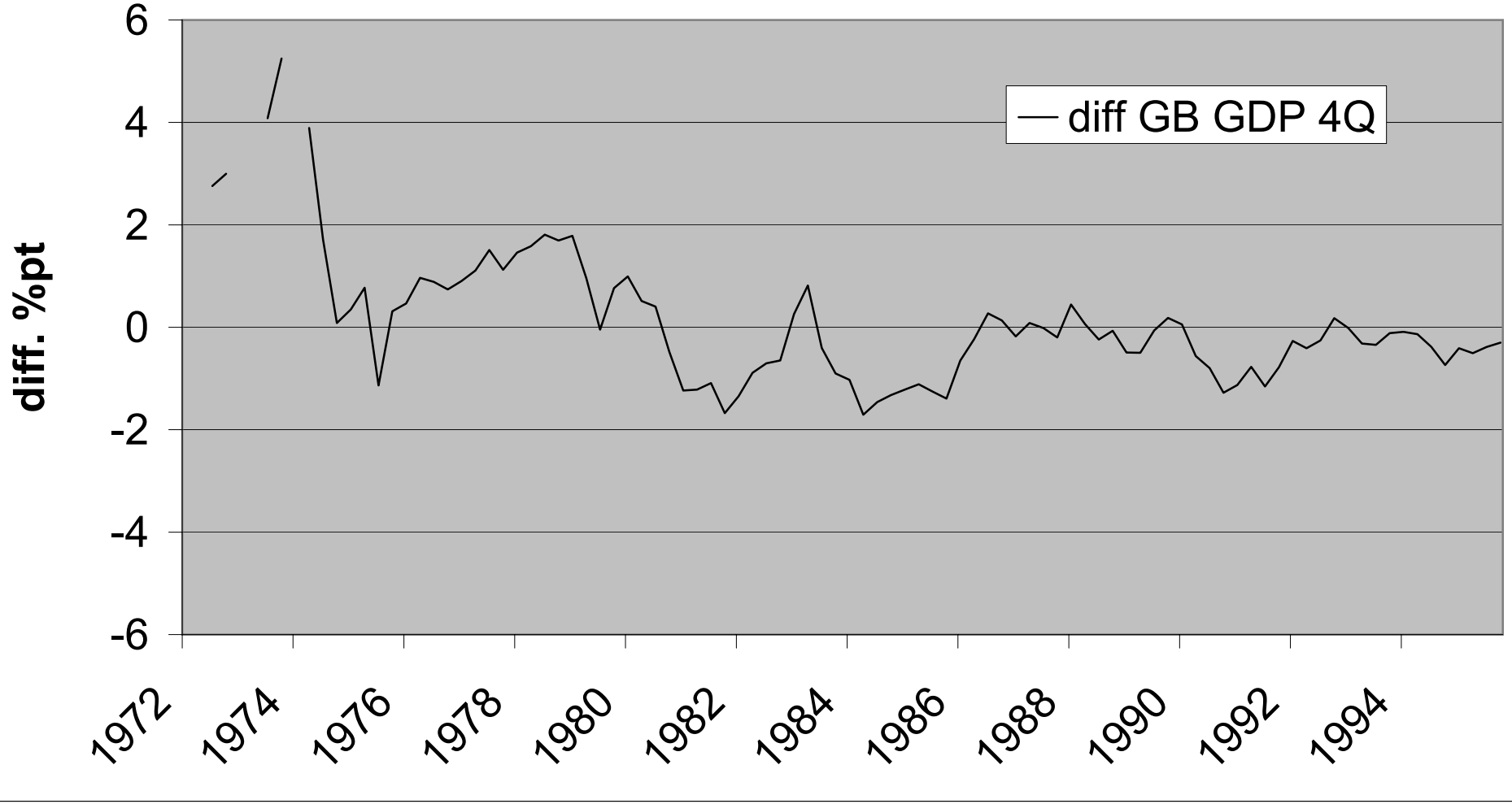

Table 3a: Expectation formation processes - full sample

	rate of change of GNP or GDP deflator					rate of change of CPI	
Series	GB1Q	GB2Q	GB3Q	GB4Q	SPF4Q	LIV2Q	LIV4Q
Range	66:1-95:4	67:4-95:4	69:1-95:4	69:4-95:4	70:2-07:2	60:2-04:1	60:3-04:1
Constant	**0.96**	**1.14**	**1.24**	**1.38**	**0.81**	**0.90**	**1.06**
	0.18	0.17	0.16	0.15	0.13	0.24	0.21
	***	***	***	***	***	***	***
1st oil shock dummy (73:4-74:4)	**-0.24**	**-0.47**	**-0.80**	**-1.47**	**-0.31**	**0.13**	**0.05**
	0.42	0.38	0.36	0.37	0.44	0.77	0.69
			*	***			
2nd oil shock dummy (79:1-80:2)	**1.40**	**1.62**	**1.68**	**1.49**	**1.33**	**2.38**	**1.72**
	0.36	0.33	0.32	0.30	0.34	0.79	0.71
	***	***	***	***	***	**	*
Sum of lag coefficients	0.73	0.68	0.66	0.65	0.75	0.94	0.81
Lag 1	**0.34**	**0.31**	**0.31**	**0.42**	**0.19**	**0.29**	**0.24**
	0.06	0.05	0.05	0.05	0.06	0.09	0.08
	***	***	***	***	***	**	**
Lag 2	**0.13**	**0.16**	**0.19**	**0.24**	**0.16**	**0.23**	**0.17**
	0.07	0.06	0.06	0.05	0.06	0.10	0.09
		*	**	***	**	*	*
Lag 3	**0.08**	**0.22**	**0.16**		**0.13**	**0.14**	**0.13**
	0.06	0.05	0.05		0.06	0.09	0.08
		***	**		*		
Lag 4	**0.18**				**0.02**	**-0.02**	**-0.02**
	0.06				0.06	0.11	0.10
	**						
Lag 5					**-0.02**	**0.15**	**0.14**
					0.06	0.10	0.09
Lag 6					**0.03**	**-0.09**	**-0.10**
					0.06	0.11	0.10
Lag 7					**0.02**	**0.19**	**0.17**
					0.06	0.10	0.09
							*
Lag 8					**0.12**	**-0.19**	**-0.16**
					0.06	0.10	0.09
					*		
Lag 9					**0.10**	**0.23**	**0.23**
					0.05	0.08	0.07
						**	**
R^2	0.86	0.87	0.88	0.90	0.87	0.90	0.88
N	118	110	102	94	149	83	83

GB1Q - 1 quarter ahead Green Book forecast
GB2Q - 2 quarters ahead Green Book forecast
GB3Q - 3 quarters ahead Green Book forecast
GB1Q - 4 quarters ahead Green Book forecast

SPF4Q - 1 year ahead survey of professional forecasters expectation
LIV2Q - Livingston 2 quarters ahead expectation
LIV4Q - Livingston 1 year ahead expectation

Table 3b: Expectation formation processes - from start of data till end of Volcker's era

	Rate of change of GNP or GDP deflator					Rate of change of CPI	
Series	GB1Q	GB2Q	GB3Q	GB4Q	SPF4Q	LIV2Q	LIV4Q
Range	66:1-87:3	67:4-87:3	69:1-87:3	69:4-87:3	70:2-87:3	60:2-87:3	60:2-87:3
Constant	**0.75**	**1.08**	**1.46**	**1.92**	**1.62**	**0.92**	**0.99**
	0.27	0.27	0.27	0.25	0.33	0.36	0.34
	**	***	***	***	***	*	**
1st oil shock dummy (73:4-74:4)	**-0.37**	**-0.50**	**-0.95**	**-1.45**	**-0.74**	**-0.45**	**0.02**
	0.48	0.44	0.44	0.46	0.56	0.95	0.90
			*	**			
2nd oil shock dummy (79:1-80:2)	**1.35**	**1.62**	**1.69**	**1.63**	**1.20**	**1.66**	**1.69**
	0.41	0.38	0.38	0.36	0.44	1.01	0.93
	**	***	***	***	**		
Sum of lag coefficients	0.76	0.69	0.63	0.57	0.64	0.94	0.82
Lag 1	**0.38**	**0.33**	**0.36**	**0.57**	**0.22**	**0.39**	**0.29**
	0.07	0.07	0.07	0.04	0.08	0.12	0.11
	***	***	***	***	*	**	*
Lag 2	**0.13**	**0.15**	**0.27**		**0.13**	**0.09**	**0.11**
	0.08	0.07	0.07		0.09	0.14	0.13
		*	***				
Lag 3	**0.07**	**0.21**			**0.10**	**0.30**	**0.21**
	0.08	0.06			0.09	0.12	0.13
		**				*	
Lag 4	**0.17**				**0.02**	**-0.07**	**-0.11**
	0.07				0.09	0.14	0.14
	*						
Lag 5					**0.03**	**0.23**	**0.19**
					0.09	0.11	0.14
						*	
Lag 6					**0.14**		**-0.14**
					0.08		0.16
Lag 7							**0.18**
							0.13
Lag 8							**-0.14**
							0.14
Lag 9							**0.23**
							0.10
							*
R^2	0.84	0.84	0.83	0.84	0.77	0.88	0.89
N	85	77	69	61	69	52	50

GB1Q - 1 quarter ahead Green Book forecast
GB2Q - 2 quarters ahead Green Book forecast
GB3Q - 3 quarters ahead Green Book forecast
GB1Q - 4 quarters ahead Green Book forecast
SPF4Q - 1 year ahead survey of professional forecasters expectation
LIV2Q - Livingston 2 quarters ahead expectation
LIV4Q - Livingston 1 year ahead expectation

Table 3c: Expectation formation processes - Greenspan's era

	Rate of change of GNP or GDP deflator					Rate of change of CPI	
Series	GB1Q	GB2Q	GB3Q	GB4Q	SPF4Q	LIV2Q	LIV4Q
Range	87:4-95:4	87:4-95:4	87:4-95:4	87:4-95:4	87:4-05:4	87:4-04:1	87:4-04:1
Constant	**0.66**	**0.51**	**0.38**	**0.53**	**1.04**	**1.77**	**1.73**
	0.28	0.22	0.22	0.22	0.22	0.38	0.35
	*	*		*	***	***	***
Sum of lag coefficients	0.87	0.91	0.95	0.89	0.64	0.70	0.61
Lag 1	**0.11**	**0.15**	**0.18**	**0.31**	**0.16**	**0.28**	**0.25**
	0.09	0.07	0.07	0.08	0.08	0.11	0.10
		*	*	***		*	*
Lag 2	**0.13**	**0.20**	**0.30**	**0.30**	**0.20**	**0.42**	**0.36**
	0.09	0.08	0.07	0.08	0.09	0.11	0.10
		*	***	***	*	***	***
Lag 3	**0.22**	**0.30**	**0.25**	**0.28**	**0.28**		
	0.09	0.07	0.07	0.08	0.08		
	*	***	**	**	**		
Lag 4	**0.41**	**0.26**	**0.22**				
	0.09	0.07	0.07				
	***	**	**				
R^2	0.77	0.85	0.87	0.84	0.41	0.55	0.53
N	33	33	33	33	80	33	33

GB1Q - 1 quarter ahead Green Book forecast
GB2Q - 2 quarters ahead Green Book forecast
GB3Q - 3 quarters ahead Green Book forecast
GB1Q - 4 quarters ahead Green Book forecast
SPF4Q - 1 year ahead survey of professional forecasters expectation
LIV2Q - Livingston 2 quarters ahead expectation
LIV4Q - Livingston 1 year ahead expectation

Figure 5a: Federal deficit as a fraction of GNP

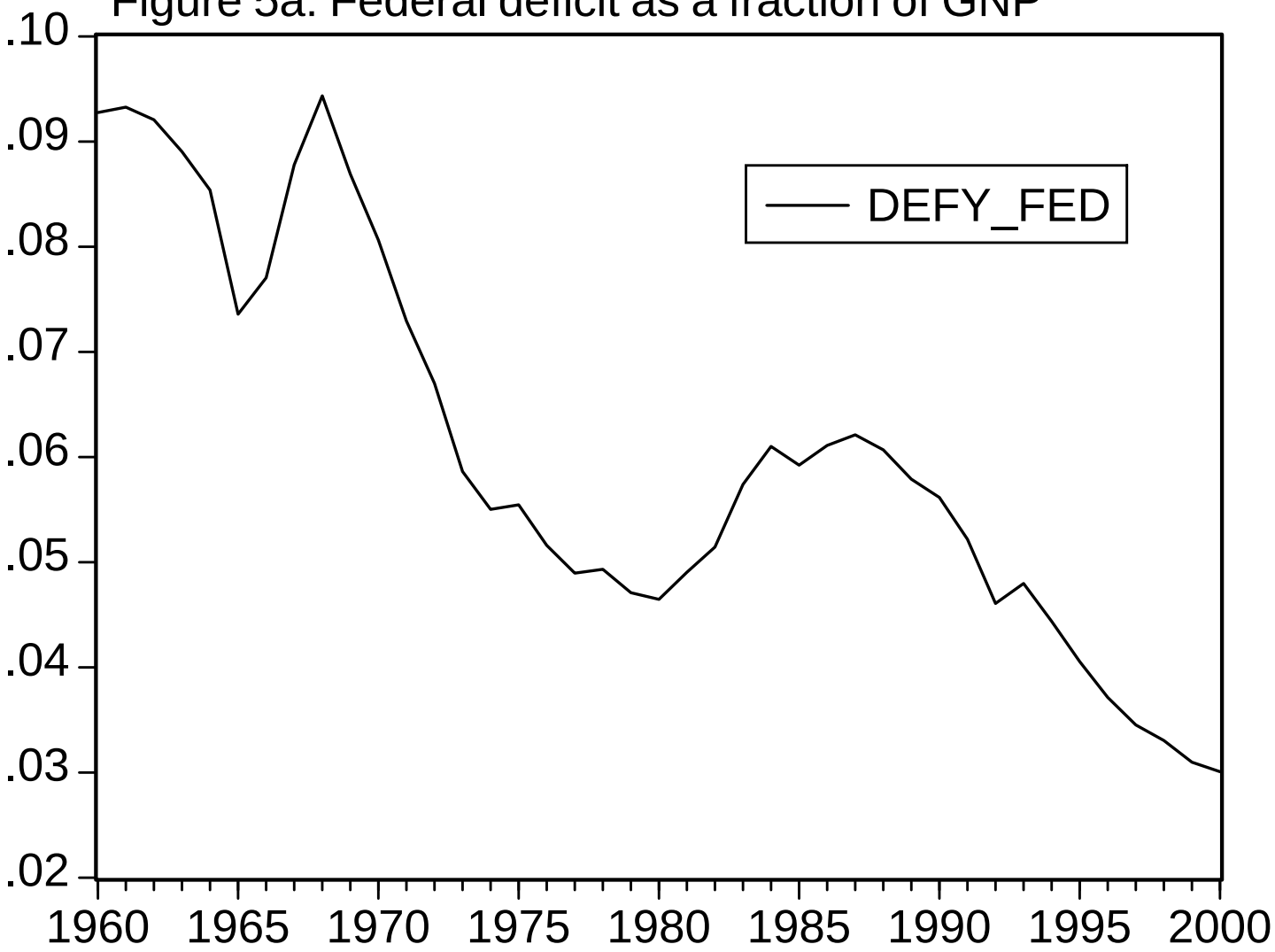

Figure 5b: Federal debt as a fraction of GNP