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The Comovement between Monetary and Fiscal Policy Instruments during the Post-War Period in the U.S.

THE COMOVEMENT BETWEEN MONETARY AND FISCAL POLICY INSTRUMENTS DURING THE POST-WAR PERIOD IN THE U.S.*

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Abstract

This paper empirically studies the dynamic relationship between monetary and fiscal policies by analyzing the comovements between the Fed funds rate and the primary deficit/output ratio. Simple economic thinking establishes that a negative correlation between Fed rate and deficit arises whenever the two policy authorities share a common stabilization objective. However, when budget balancing concerns lead to a drastic deficit reduction the Fed may reduce the Fed rate in order to smooth the impact of fiscal policy, which results in a positive correlation between these two policy instruments. The empirical results show (i) a significant negative comovement between Fed rate and deficit and (ii) that deficit and output gap Granger-cause the Fed funds rate during the post-Volcker era, but the opposite is not true.

Key words: Fed rate, deficit, comovement, switching regimes
JEL classification numbers: C32, E52, E62

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1 INTRODUCTION

Some economists may have the perception that the Federal Reserve tends to counteract aggregate demand variations caused by deficit changes (see, for instance, DeLong, 2003 p.384) as a way of smoothing the impact of fiscal policy. For instance, President Reagan's tax cut was followed by a restrictive monetary policy. In this scenario, one would expect a positive correlation between the Fed funds rate (the monetary policy instrument) and the primary deficit-output ratio (the fiscal instrument). However, it is not hard to imagine other scenarios where the two economic policy authorities share a common stabilization objective and thus the Fed rate and the primary deficit show a negative correlation. This would be the case in a recession (expansion) where the monetary authority may coordinate with the fiscal authority for a fall (rise) of the Fed rate with an increase (decrease) of the primary deficit-output ratio (which we will refer to hereafter as "the deficit"). A similar argument can be established when the two authorities fight inflationary pressures together.

At the heart of the dynamic relationship between the two policy instruments are the causes leading to the shifts in both monetary and fiscal policies during the post-war period in the U.S. Many macroeconomists believe that U.S. monetary policy changed to a strong anti-inflationary regime when Paul Volcker became Fed chairman in late 1979.[1] Similarly, as documented by Davig, Leeper and Chung (2004), fiscal policy has exhibited pendulum swings where periods characterized by tight fiscal policy aiming at budget balancing (i.e. a "passive" fiscal policy) are followed by periods characterized by a countercyclical fiscal policy (i.e. an "active" stabilizing fiscal policy).[2]

This paper empirically investigates the dynamic relationship between Fed rate and deficit. This analysis will shed light on three related sets of questions: (i) Is there a significant comovement between Fed rate and deficit?

[1] Some economists believe that the switch in monetary policy went from a passive to an active monetary regime, using Leeper's (1991) taxonomy. Sargent (1999) and Cogley and Sargent (2005) share this view. Alternatively, Sims and Zha (2004) argue that the regime changes in the systematic component of the monetary policy reaction function have been rather modest compared to the large changes in the non-systematic component.

[2] Strictly speaking, we do not use the terms "active" and "passive" policy as defined by Leeper (1991). According to Leeper's taxonomy, an economic policy authority is passive when its policies are determined by the intertemporal budget constraint. But this policy stand does not preclude that the policy authority might follow an "active" countercyclical policy in the short-run even though its policy is determined by a "passive" budget balancing objective in the long-run. From now on, the term "active" policy stands for countercyclical policy whereas the term "passive" policy stands for a policy aimed at budget balancing.

Do monetary and fiscal instruments move together in pursuit of a common stabilization objective? (ii) Is the comovement between monetary and fiscal instruments stable over time? Does a "passive" fiscal policy last for long? (iii) Is there evidence of a causal relationship between Fed rate and deficit? Is the deficit Granger-causing the Fed rate? We believe that the answers to these questions are important because they can help to evaluate and design dynamic macroeconomic models for analyzing issues of monetary and fiscal policy coordination.

Some examples of recent literature concerned with related issues on coordination and switching of fiscal and monetary policies follow. Using a theoretical approach, Davig, Leeper and Chung (2004) study how the presence of switching-regimes in fiscal and monetary policies changes the effects of economic policy. At the empirical level, by using an augmented VAR specification, Favero and Monacelli (2003) show evidence of monetary and fiscal policy regime shifts in the U.S. and of how the analysis of a monetary-fiscal policy mix helps to explain U.S. inflation dynamics.

This paper follows three empirical approaches. First, we compute *rolling* measures of the unconditional correlation coefficient between Fed rate and deficit for three different amplitudes (five, ten and twenty year windows). Roughly speaking, as the window becomes wider (narrower) the rolling measure of the unconditional correlation coefficient gives more weight to the low (high) frequency components of the time series. The analysis of rolling correlation dynamics is a useful preliminary approach for studying the changing comovement between Fed funds rate and deficit. However, the Fed rate and deficit may be affected by other variables characterizing the state of the economy, such as inflation and the level of economic activity. For this reason, the two approaches below consider VAR processes that include the output gap and inflation in addition to the Fed rate and deficit.

Second, we use Den Haan's (2000) method to analyze the comovements between Fed rate and deficit. Den Haan proposes using the correlations of VAR forecast errors at different horizons. In this way one can take into account a full set of statistics characterizing comovement dynamics in an efficient manner. In particular, in order to analyze the comovement between Fed rate and deficit we estimate a four-variable VAR that includes four-quarter average inflation and output gap in addition to these variables.

The two approaches outlined above are useful for uncovering the dynamic correlation between fiscal and monetary policy instruments, but they can neither provide information on causality nor detect the presence of switching regimes. For this reason, we also study the dynamic relationship between Fed rate and deficit by estimating a two-state four-variable Markov switching VAR (MSVAR) model à la Hamilton. For the sake of simplicity, it is considered that the same two-state Markov switching process characterizes both the systematic part and the variance-covariance of the disturbances of the MSVAR. Following Pelletier (2006), we can further estimate in a quite straightforward manner the regime-switching dynamic correlations of the alternative variables of the model. This approach allows us to estimate the dates of regime switching without imposing them as occurs in the first two approaches considered.

[Insert FIGURE 1]

This paper uses U.S. quarterly data running from 1961:2 to 2003:4.[3] Figure 1 shows plots of the four time series studied. The empirical results from the first two approaches show a negative relationship between the Fed rate and the deficit for most periods. Particularly remarkable is the finding of a significant comovement between the Fed rate and the deficit using Den Haan's method during the post-war period in the U.S., a period characterized by several shifts in monetary and fiscal policies. Negative comovement shows up during the 60's, 70's and early 80's, characterized by outstanding shocks and economic fluctuations, as well as during the late 80's and the 90's, which are characterized by stability and economic growth. Therefore, the finding of a negative comovement between Fed rate and deficit at several forecast horizons can be considered as a robust stylized fact that can be used to evaluate the performance of dynamic stochastic general equilibrium models that aim to study monetary and fiscal coordination issues.

A negative comovement between Fed rate and deficit further suggests that monetary and fiscal policies work together in pursuit of a common stabilization objective. In other words, the effects of an "active" stabilizing fiscal policy seem to dominate the effects of a "passive" fiscal policy concerned with budget balancing over the post-war period.

The empirical results from the third approach provide additional support for the results found with the other two approaches. First, the post-Volcker period is characterized by a stable regime (say, state 1) featuring

[3] The Fed funds rate is taken from FRED (http://research/stlouisfed.org/fred2/). Output gap is calculated as the natural log of the ratio between real gross domestic product (GDPC96, seasonally adjusted) provided by the U.S. Department of Commerce, Bureau of Economic Analysis and real potential gross domestic product (GDPPOT) provided by the U.S. Congress: Congressional Budget Office. Four-quarter average inflation is computed from the gross domestic product implicit price deflator (GDPDEF) provided by the U.S. Department of Commerce, Bureau of Economic Analysis. Finally, the primary deficit-output ratio (seasonally adjusted) is taken from OECD statistics.

a significant negative correlation between Fed rate and deficit. Moreover, each variable exhibits a high degree of persistence and the effects of other variables are rather small under this regime. Second, the pre-Volcker period is characterized by frequent switches between the two states considered and the economy at the time of the two oil crises is in state 2, characterized by a positive but nonsignificant correlation between Fed rate and deficit. Finally, the empirical results suggest that output gap and deficit Granger-cause the Fed rate from 1984 to the end of the sample (that is, the post-Volcker era),[4] but the opposite is not true.

The rest of the paper is organized as follows. Section 2 analyzes the rolling correlation dynamics. Section 3 implements Den Haan's method to analyze the comovements between Fed rate and deficit. Section 4 introduces and estimates the two-state four-variable MSVAR model considered, which allows us to compute regime-switching dynamic correlations. Section 5 concludes.

2 DYNAMIC CORRELATIONS

In this section we compute the rolling unconditional correlation coefficient between pairs of variables for three window sizes: five years (twenty observations), ten years (forty observations) and twenty years (eighty observations). In addition to studying the dynamic correlation between Fed rate and deficit, we also analyze on the one hand the dynamic correlation between the Fed rate and a structural measure of deficit from which an automatic stabilizing component of the deficit has already been removed. More precisely, this structural measure is defined as the residual obtained from the least-squares projection of the primary deficit-output ratio on the output gap. By analyzing this alternative measure of fiscal policy we can further establish whether the discretionary component of fiscal policy is correlated with the Fed rate.

Figures 2-4 show the dynamic correlations between two pairs of variables using window sizes of five, ten and twenty years, respectively. The correlation coefficient between Fed rate and deficit changes substantially in the short-run (5-year window) and in the medium-run (10-year window). As expected, it changes more smoothly in the long-run (20-year window). Interestingly, the results for structural deficits and observed deficits are more similar

[4] We denote this period as the post-Volcker era because one can feel confident that the effects of Fed Chairman Volcker's monetary experiment on the Fed funds rate had vanished by 1984.

when a large window is considered. The rationale is that in the long-run analysis (that is, the 20-year window) the cyclical component of the deficit vanishes because GDP converges to potential GDP.[5] We also observe a negative correlation between Fed rate and deficit for most periods and a stronger negative correlation is found when the discretional measure of deficit is considered. These results thus show preliminary evidence that monetary and fiscal policies work together by sharing common stabilization objectives. However, the correlation coefficient is close to zero, especially for the observed measure of deficit, when analyzing long-run dynamics (that is, the 20-year window) during the post-Volcker era (after 1984). This latter result can be explained by the priority shift in fiscal policy toward long-run budget balancing as from the mid-eighties as documented by Davig, Leeper and Chung (2004).

The simple rolling correlation dynamics computed in this section provide information on the changing comovement between Fed funds rate and deficit. Are these comovement results robust to alternative specifications? In particular, the Fed rate and deficit may be affected by other variables, such as the state of the economy. The cyclical state of the economy is typically characterized by inflation and a measure of the level of economic activity such as the output gap. For this reason, the two approaches followed below consider VAR processes that include output gap and inflation in addition to the Fed rate and deficit.

[Insert FIGURE 2]

[Insert FIGURE 3]

[Insert FIGURE 4]

3 THE COMOVEMENT BETWEEN FED RATE AND DEFICIT

This section analyzes the comovement between Fed rate and deficit using the method suggested by Den Haan (2000).[6] This method calculates forecast errors at different horizons from an estimated *VAR* that includes at least

[5] I thank a referee for suggesting this intuition.

[6] Appendix 1 provides a brief description of Den Haan's method for readers unfamilar with this way of analyzing comovements.

the pair of variables whose comovement we are interested in studying. As mentioned above, we include four variables in the *VAR*: the Fed rate, inflation, output gap and deficit. The Akaike information criterion (AIC) is used to determine the number of lags. The number of lags chosen is six.

We do not consider any measure of structural deficit in the remaining sections of the paper for two reasons. First, the comovement analysis carried out in this section and the dynamic correlation analysis performed in the next section are based on the non-systematic component of the VAR (i.e. the forecast errors) and thus the deficit forecast error will be free from any systematic component of the deficit, and in particular from any automatic stabilizing component. Second, using structural deficit data generated from least-squares regression may result in the well-known generated regressor problem (Pagan, 1984).

Following Den Haan (2000), we estimate the correlation coefficients of *VAR* forecast errors by calculating the forecast errors for each horizon considered (from one quarter to 28 quarters) as the difference between the realizations and the corresponding forecasts and then calculating the correlations of these forecast errors for each horizon.[7] Since the estimated correlation coefficients are subject to sampling variation, confidence bands are constructed using bootstrap methods. More specifically, the estimated *VAR* and its bootstrapped errors are used to generate 2500 simulated data sets. Then, for each simulated data set the correlation coefficients at different horizons are estimated and standard confidence bands are calculated.[8]

[Insert FIGURE 5]

Figure 5 shows the estimated correlation coefficients between the forecast errors of the Fed rate and deficit (solid line) and the $10\% - 90\%$ (dots and dashes) and $5\% - 95\%$ confidence bands (dashed lines) constructed using bootstrap methods. Figure 5 shows a significant negative comovement between Fed rate and deficit at short-term forecast horizons up to four years (16 quarters) at standard significance levels.

[7] Den Haan and Sumner (2004) suggest an alternative method of estimating the correlation coefficients, which uses the covariance obtained from the *VAR* coefficients and the variance-covariance matrix of the white noise *VAR* disturbance process. They argue that using this method leads to efficiency gains especially in estimating the correlation coefficients associated with long-term forecast horizons. However, they also report that bias is larger with this second method.

[8] The programs for estimating the correlation coefficients and the confidence bands are adapted versions of programs written in RATS that were download from Den Haan's website.

Many papers (Clarida, Galí and Gertler 2000, McConnell and Pérez-Quirós 2000, Cogley and Sargent 2005, Primiceri 2005, Sims and Zha 2004, Valente 2003, and Vázquez 2004, among others), using different data sets and including real and/or nominal variables, have found that the post-Volcker era is characterized by a more stable regime than the pre-Volcker era. Most papers in this literature analyze whether it was bad monetary policy or bad luck that caused the volatile and rising inflation of the 70's. By fitting monetary policy rules for sub-periods, Clarida, Galí and Gertler (2000) find evidence of a systematic change of monetary policy in the pre-Volcker era. A similar conclusion is reached by Cogley and Sargent (2005) using a Bayesian VAR with drifting parameters and stochastic volatility. These findings have been disputed by Primiceri (2005) and Sims and Zha (2004) using structural VARs. For instance, Primiceri (2005) provides evidence of both systematic and non-systematic change in U.S. monetary policy. However, he also finds that the systematic changes in monetary policy have had a negligible effect on the rest of the economy. Moreover, Primiceri (2005) also finds that the role played by non-policy VAR innovations is more important than interest rate policy in explaining the high inflation and unemployment in the 70's and early 80's.

An alternative explanation for the decline in aggregate volatility is provided by McConnell and Pérez-Quirós (2000). By decomposing output growth by major product types (expenditure on goods, services and structures), they show evidence that the fall of aggregate volatility comes from a reduction in the volatility of durable goods.

In order to check whether there is a difference in the comovements between Fed rate and deficit in these two periods, we split the sample into two almost equal sub-samples. Figures 6-7 show the comovement between Fed rate and deficit for the sub-samples 1961:2-1983:4 and 1984:1-2003:4, respectively. As for the whole sample, the comovement is significantly negative for the two sub-samples up to two years whereas for the more recent sub-sample the comovement is still significantly negative at medium- and long-term forecast horizons (up to 7-year forecast horizons). The significant negative comovement between the Fed rate and deficit at short-term forecast horizons is then a robust stylized fact that survives the policy shifts and outstanding macroeconomic shocks that took place in the post-war period. Therefore, this negative correlation pattern describes a set of potentially good statistics for evaluating model performance.

At first sight, the empirical results based on contemporaneous correlation coefficients considered in the previous section are somewhat different from those found with Den Haan's method. In particular, the contemporaneous correlation between Fed rate and deficit has weakened in the post-Volcker era whereas there is still a significant negative comovement between the two policy instruments for this period, as shown in Figure 7.[9] However, a more careful examination shows that the correlation has weakened when considering long-term dynamics (that is, the 20-year window) whereas the short- and medium-term correlations described by the 5- and 10-year windows are negative for most dates. This evidence is consistent with the significant negative comovement shown in Figure 7 when analyzing the comovement at short- and medium-term forecast horizons (up to 7-years).

We have studied alternative measures of comovement between monetary and fiscal policies in the last two sections, but have not investigated any sort of causal relationship between Fed rate and deficit. Moreover, the analysis of comovement carried out in this section assumes that the VAR coefficients are stable over the whole period or, by considering two alternative sub-samples, exogenously establishes the date of a structural change. By estimating an MSVAR model, the next section overcomes these drawbacks and explores (i) whether the dynamic correlation between Fed rate and deficit exhibits regime-switching, (ii) whether there is a Granger-causal relationship between monetary and fiscal instruments, and (iii) whether any such relationship is stable over time.

[Insert FIGURE 6]

[Insert FIGURE 7]

4 THE MARKOV-SWITCHING VAR

In this section we estimate a two-state MSVAR model with four lags that includes the four variables considered in this paper. Formally,

$$Z_t = \Upsilon(s_t) + \sum_{i=1}^{4} B_i(s_t) Z_{t-i} + \Omega(s_t)^{1/2}\xi_t, \tag{1}$$

where $Z_t = (i_t, \overline{\pi}_t, \widetilde{y}_t, \overline{d}_t)'$ and $\xi_t \sim N(0, I)$. i_t is the Fed funds rate, $\overline{\pi}_t$ is four-quarter rate of inflation ($\overline{\pi}_t = \frac{1}{4}\sum_{i=0}^{3} \pi_{t-j}$, $\pi_t = 400(\ln P_t - \ln P_{t-1})$

[9] These results illustrate another example (Den Haan 2000, and Den Haan and Sumner, 2004, show other examples) in which by considering only contemporaneous correlation coefficients one may miss valuable dynamic information captured by the correlation coefficients between VAR forecast errors at different horizons.

and P_t is the implicit GDP price deflator), $\widetilde{y}_t$ is the output gap and $\overline{d}_t$ is the primary deficit-output ratio (in short, the deficit). The regime variable s_t is either 1 or 2 and follows a first-order two-state Markov process with $prob(s_t = 1|s_{t-1} = 1) = p$ and $prob(s_t = 2|s_{t-1} = 2) = q$.[10] We estimate the Cholesky decomposition $\Psi(s_t)$ of $\Omega(s_t)$ where $\Omega(s_t) = \Psi(s_t)\Psi(s_t)'$.

Closely following Pelletier (2006), the Markov switching covariance matrix $\Omega(s_t)$ can be decomposed into

$$\Omega(s_t) \equiv \Sigma(s_t)\Gamma(s_t)\Sigma(s_t),$$

where $\Sigma(s_t)$ is a diagonal matrix made up of the standard deviations and the matrix $\Gamma(s_t)$ contains the correlations.[11] Analysis of $\Gamma(s_t)$ allows us to study the regime-switching dynamic correlation between the alternative variables included in the MSVAR. The estimates of the dynamic correlations matrix (that is, $\Gamma(s_t)$) are straightforwardly obtained from the estimates of $\Psi(s_t)$. Formally,

$$\Gamma(s_t) = [\Sigma(s_t)]^{-1} \Psi(s_t)\Psi(s_t)' [\Sigma(s_t)]^{-1}.$$

Standard errors for the elements of $\Gamma(s_t)$ are obtained by applying the *Delta* method.[12]

The first equation of system (1) can be viewed as an augmented Taylor monetary rule whereas the fourth equation can be understood as a fiscal policy reaction function. We believe it is appropriate not to include contemporaneous variables as regressors in the Fed's reaction function or in the fiscal policy rule. Arguably, this allows for a closer match between the information set available to the researcher and the data used by the Fed and fiscal authorities at the time of implementing monetary and fiscal policies, respectively. Clarida, Galí and Gertler (2000) and Rudebusch (2002), among others, suggest and estimate empirical Taylor rule versions which are based only on lagged variables.

The maximum likelihood estimation of the MSVAR model follows the procedure suggested by Hamilton (1994, ch. 22). Appendix 2 briefly summarizes this procedure and displays the estimation results in Table A.1.

In order to compare the estimation results of system (1) easily for the two alternative regimes, we next display those results in regression format

[10] The two-regime MSVAR model with four lags considered may seem quite restrictive but it is the most the data can bear without extreme problems in estimation. Dealing with the two-regime MSVAR already implies the cumbersome task of estimating 158 coefficients.

[11] Pelletier (2006) assumes that the elements of Σ are modelled by a GARCH model in absolute innovations. By contrast, we assume that all time-varying parameters in the model including the elements of Σ are governed by the same regime-switching process.

[12] See, for instance, Greene (1993, p.297).

(standard errors in parentheses) by showing only the parameter estimates that are significant at standard significance levels:

Regime 1:

$$i_t = \underset{(0.0908)}{1.2327} i_{t-1} + \underset{(0.0559)}{0.1895} \widetilde{y}_{t-1} - \underset{(0.0733)}{0.2447} \overline{d}_{t-1} - \underset{(0.1307)}{0.5654} i_{t-2} + \underset{(0.1361)}{0.4534} i_{t-3},$$

$$\overline{d}_t = \underset{(0.1508)}{0.4650} \overline{\pi}_{t-1} + \underset{(0.0835)}{0.9078} \overline{d}_{t-1} + \underset{(0.1265)}{0.3433} \overline{d}_{t-2} - \underset{(0.0851)}{0.1706} \overline{d}_{t-4},$$

$$\widetilde{y}_t = \underset{(0.1522)}{0.3833} + \underset{(0.1065)}{1.1882} \widetilde{y}_{t-1} - \underset{(0.1080)}{0.2773} \widetilde{y}_{t-3} + \underset{(0.1209)}{0.2988} \overline{d}_{t-3},$$

$$\overline{\pi}_t = \underset{(0.0848)}{1.1577} \overline{\pi}_{t-1} + \underset{(0.0475)}{0.1108} \overline{d}_{t-4}.$$

Regime 2:

$$i_t = \underset{(0.6570)}{1.8915} \overline{\pi}_{t-1} - \underset{(0.2873)}{0.9239} \overline{d}_{t-1} + \underset{(0.2080)}{0.6036} i_{t-3},$$

$$\begin{aligned} \overline{d}_t = {} & \underset{(0.0310)}{0.2193} i_{t-1} - \underset{(0.1199)}{0.4011} \overline{\pi}_{t-1} + \underset{(0.0587)}{0.3924} \overline{d}_{t-1} + \underset{(0.0659)}{0.7027} \overline{d}_{t-2} + \underset{(0.1780)}{0.8767} \overline{\pi}_{t-3} \\ & - \underset{(0.0663)}{0.2314} \widetilde{y}_{t-3} - \underset{(0.1197)}{0.9127} \overline{d}_{t-3} + \underset{(0.1285)}{0.5580} \overline{\pi}_{t-4} + \underset{(0.0340)}{0.3285} \widetilde{y}_{t-4}, \end{aligned}$$

$$\begin{aligned} \widetilde{y}_t = {} & \underset{(0.5229)}{2.7232} - \underset{(0.0688)}{0.3536} i_{t-1} + \underset{(0.0990)}{0.5141} \widetilde{y}_{t-1} + \underset{(0.3923)}{0.9161} \overline{\pi}_{t-2} - \underset{(0.2122)}{0.5771} \overline{d}_{t-2} \\ & - \underset{(0.3321)}{2.0258} \overline{\pi}_{t-3} + \underset{(0.3082)}{1.1461} \overline{d}_{t-3} - \underset{(0.0629)}{0.2945} i_{t-4} + \underset{(0.2856)}{1.3452} \overline{\pi}_{t-4} - \underset{(0.1334)}{0.2724} \overline{d}_{t-3}, \end{aligned}$$

$$\overline{\pi}_t = \underset{(0.2912)}{1.3990} + \underset{(0.1643)}{1.4525} i_{t-1} - \underset{(0.0511)}{0.1018} \widetilde{y}_{t-1} - \underset{(0.0517)}{0.2003} \overline{d}_{t-1} - \underset{(0.2462)}{0.4164} \overline{\pi}_{t-2}.$$

The estimation results can be summarized as follows. First, state 1 exhibits simpler dynamics than state 2. In particular, each variable is described in regime 1 by its own lags and the effects of other variables are rather small. Second, state 1 perfectly fits the post-Volcker period whereas state 2 fits well with the two oil-crises corresponding to 1972-1974 and 1978-1981 as shown in Figure 9, where I have plotted the smoothed probabilities of being in state 1 at each point in time. Third, based on the estimates of the variance-covariance matrix $\Omega(s_t)$ $(= \Psi(s_t)\Psi(s_t)')$ displayed in Table A.1, we observe that regime 1 (2) is characterized by low (high) volatility of interest rate innovations and high (low) volatility of deficit innovations. Fourth, Figure 9 also shows that the number of observations attributed to regime 2 by the estimation procedure is small. Therefore, it is difficult to make any serious statement about how fiscal and monetary policies are determined in regime 2. Fifth, looking at the correlation between the Fed rate and the deficit, Γ_{14}, in Table 1 and the smoothed probabilities displayed in Figure 9, we see that the correlations between the fiscal and monetary instruments appear to be dynamic in the pre-Volcker era, but they have remained static during the post-Volcker era.

From the estimation results it is hard to establish what is the main feature that distinguishes state 1 from state 2. State 2 is characterized by high volatility of interest rate innovations and low volatility of deficit innovations. These two features could be understood as the equilibrium outcome characterized by a passive (accommodating) monetary policy where the fiscal authority is dominating the monetary authority. But this interpretation is likely to be partially biased because the estimation results are likely to be capturing that regime 2 fits well with the two oil-crises (supply shocks) that result in high inflation rates and these effects are hard to distinguish from the inflationary effects of an accommodating monetary policy.

The estimation results also suggest the existence of two different periods: the pre-Volcker era (up to 1984) and the post-Volcker era. The first period is characterized by frequent regime switches whereas the post-Volcker era is characterized by a single regime, state 1. Moreover, the split between the two periods is consistent with the pre-determined structural break assumed in Section 3.

Focusing on the post-Volcker era, when regime 1 fits well, we observe that (i) the correlation between Fed rate and deficit (Γ_{14}) is significantly negative, as shown in Table 1; (ii) the Fed's policy reaction function shows great persistence (that is, lagged Fed rates up to three lags are found to be significant); (iii) the Fed rate reacts positively to the output gap and negatively to the deficit; and (iv) interestingly, the Fed rate does not react to inflation.

Result (i) supports the view stated in the Introduction that the fiscal and monetary authorities share a common stabilization objective. The highly persistent Fed reaction function, result (ii), is consistent with the empirical evidence found in the relevant literature (see, for instance, Clarida, Galí and Gertler, 2000). There are several arguments suggesting that the significant role of lagged interest rate may reflect the existence of an optimal policy inertia. These arguments range from the traditional concern of central banks for the stability of financial markets (see Goodfriend, 1991 and Sack, 1997) to the more psychological argument posed by Lowe and Ellis (1997) that there might be a political incentive for smoothing whenever policymakers are likely to be embarrassed by reversals in the direction of interest-rate changes if they believe that the public may interpret them as repudiations of previous actions. By contrast, a series of interest-rate changes in the same direction looks like a well-designed programme, and that may give rise to the sluggish behavior of the intervention interest rate.

Result (iii) is partially consistent with the existence of a monetary Taylor rule which establishes that the interest rate responds positively to the output gap. However, the estimation result (iv) also suggests that the Fed does not respond to inflation, in contrast to the predictions of a standard Taylor rule. One possible explanation for the latter result is that inflation and interest rates are highly correlated. Therefore, it is difficult to distinguish the effect of lagged inflation from the effect of lagged interest rate on the current Fed rate.

Result (iii) also establishes a negative response of the Fed rate to lagged deficit, which is consistent with the view that the two economic authorities share a common stabilization objective and that monetary policy shows policy inertia. For instance, the deficit is expected to increase during a recession, but the interest rate decreases in small-steps due to policy inertia, which leads to a negative correlation between current interest rates and lagged deficits.

Looking at the fiscal policy reaction function in the first regime, we observe that the deficit shows a great deal of persistence, but less than that observed for the interest rate. Moreover, fiscal policy reacts positively to lagged inflation. The latter result is somewhat surprising because one would expect the opposite: the deficit decreases (increases) during expansions (recessions) where inflation usually increases (decreases). This result is probably reflecting the fact that some behavioral parameters are difficult to identify from reduced-form coefficient estimates because these are cumbersome functions of structural and policy parameters.

[Insert TABLE 1]

Note: Recall that the order of variables in the MSVAR is: Fed rate, inflation, output gap and deficit. Therefore, Γ_{14} denotes the correlation coefficient between the 1-period ahead forecast errors associated with Fed rate and deficit equations in the VAR.

More generally, we carry out Granger-causality tests based on a likelihood ratio (LR) test. The LR statistic for the hypothesis that the deficit does not Granger cause the Fed rate in the first regime is 24.08. The LR statistic for the hypothesis that the output gap does not Granger cause the Fed rate in the first regime is 31.61. The LR statistics for the hypotheses that the Fed funds rate does not Granger cause the deficit and the output gap in the first regime are 5.72 and 4.70, respectively. These LR statistic tests are all distributed as a $\chi^2(4)$. The 5% (1%) critical value is 9.49 (13.3). These tests thus show that deficit and output gap Granger-cause Fed rate at all standard confidence levels in the first regime, but the opposite is not true.

[Insert FIGURE 8]

5 CONCLUSIONS

Some economists have the perception that the Federal Reserve counteracts aggregate demand variations caused by deficit changes. In this case, one would expect a positive correlation between the Fed funds rate and the primary deficit-output ratio. However, it is also plausible for monetary and fiscal authorities to hold common stabilization objectives and thus the Fed rate and the primary deficit would show a negative correlation. This paper studies empirically which is the dominant effect.

Using quarterly U.S. data over the post-war period, the empirical results show a negative comovement between the two policy instruments most of the time. This result provides empirical evidence that monetary and fiscal authorities hold a common stabilization objective that sometimes breaks down when fast-growing Federal government debt, including its associated interest payments, shifts fiscal policy priorities to budget balancing. Moreover, the empirical results also show that deficit-output ratio and output gap Granger-cause the Fed funds rate during the post-Volcker era, but the opposite is not true.

APPENDIX 1

For the sake of illustration, this appendix describes the method suggested by Den Haan (2000) for measuring error correlations at different forecast horizons.

Let us consider an N-vector of random variables X_t. The vector X_t may include any combination of stationary processes and integrated processes of arbitrary order. In order to characterize the comovement between two variables, say the Fed funds rate, i_t, and the primary deficit-output ratio, $\overline{d}_t$, X_t must contain at least i_t and $\overline{d}_t$. Consider the following VAR

$$X_t = \alpha + \beta t + \gamma t^2 + \sum_{l=1}^{L} A_l X_{t-l} + U_t,$$

where α, β, and γ denote fixed N-vectors of constants, A_l are fixed N x N coefficient matrices. U_t is an N-dimensional white noise process, that is, $E(U_t) = 0$, $E(U_t U_t') = \Omega_u$ and $E(U_t U_s') = 0$ for $s \neq t$. L is the total number of lags included. The K-period ahead forecast and the K-period ahead forecast error of the random variable i_t are denoted by $E_t i_{t+K}$ and $i^{ue}_{t+K,t}$, respectively. Similarly, we can define $E_t \overline{d}_{t+K}$ and $\overline{d}^{ue}_{t+K,t}$. Let us denote the correlation coefficients between $i^{ue}_{t+K,t}$ and $\overline{d}^{ue}_{t+K,t}$ by $COR(K)$.

As pointed out by Den Haan (2000), if all time series included in X_t are stationary, then the correlation coefficient of the forecast errors will converge to the unconditional correlation coefficient between i_t and $\overline{d}_t$ as K goes to infinity. If X_t includes integrated processes, then the correlation coefficients may not converge but they can be estimated consistently for fixed K.

Moreover, Den Haan (2000) shows the relationship between correlation coefficients and impulse response functions. Let us denote the covariance between $i^{ue}_{t+K,t}$ and $\overline{d}^{ue}_{t+K,t}$ by $COV(K)$ and, without loss of generality, let us assume that there are M structural shocks driving the Fed rate and deficit. Den Haan (2000) shows that

$$COV(K) = \sum_{k=1}^{K} COV^{\Delta}(k)$$

and

$$COV^{\Delta}(k) = \sum_{m=1}^{M} i_k^{imp,m} \overline{d}_k^{imp,m},$$

where $z_k^{imp,m}$ is the k-th period impulse response of variable z to a one-standard deviation disturbance of the m-th shock. Therefore, the covariance between Fed rate and deficit is simply the average of the product of the Fed rate and deficit impulses across the different structural shocks.

APPENDIX 2

This appendix briefly summarizes the recursive algorithm implemented in the maximum likelihood estimation procedure. We focus on the four-variable two-state MSVAR model considered in this paper. Let θ denote the vector of parameters. Let $\widehat{\xi}_{t/t}$ denote the 2×1 vector containing the researcher inference about the values of s_t $(= 1, 2)$ based on data obtained through date t and conditional on a given value for θ. Finally, let $\widehat{\xi}_{t+1/t}$ denote the 2×1 vector containing the one-period forecast of the values of s_{t+1} $(= 1, 2)$ based on data obtained through date t. Hamilton (1994, Ch. 22) shows that the optimal inference and the one-period forecast can be solved recursively from the following two equations:

$$\widehat{\xi}_{t/t} = \frac{\widehat{\xi}_{t/t-1} \odot \eta_t}{\mathbf{1}'(\widehat{\xi}_{t/t-1} \odot \eta_t)},$$

$$\widehat{\xi}_{t+1/t} = P\widehat{\xi}_{t/t}$$

where the symbol $\odot$ denotes element-by-element multiplication, $\mathbf{1}$ denotes a 2×1 vector of 1s, P is the 2×2 transition probability matrix and η_t is a 2×1 vector containing the two conditional densities, one for each state. For the MSVAR (1),

$$\eta_t = \begin{bmatrix} \eta_t(1) \\ \eta_t(2) \end{bmatrix}$$

where each element of η_t is given by the probability density function of the multivariate normal distribution

$$\begin{aligned} \eta_t(s_t) &= \frac{1}{(2\pi)^2 \left|\Omega(s_t)\right|^{1/2}} \exp\{-\frac{1}{2}\left[Z_t - \Upsilon(s_t) - B(s_t)Z_{t-1}\right]' \\ &\quad \left[\Omega(s_t)\right]^{-1}\left[Z_t - \Upsilon(s_t) - B(s_t)Z_{t-1}\right]\}, \end{aligned}$$

for $s_t = 1, 2$.

The log likelihood function $\pounds(\theta)$ for the data set evaluated at a value of θ can be computed as a by-product of the above recursive algorithm from the following expression

$$\pounds(\theta) = \sum_{t=1}^{T} \log\left[\mathbf{1}'\left(\widehat{\xi}_{t/t-1} \odot \eta_t\right)\right].$$

The value of θ that maximizes $\pounds(\theta)$ is found using the maximum likelihood routine programmed in GAUSS. The Newton-Raphson numerical method is used to update the Hessian at each iteration of the maximization routine.

[Insert TABLE A.1.]

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Table 1. Estimation results for the correlation matrix

	Γ_{12}	Γ_{13}	Γ_{14}	Γ_{23}	Γ_{24}	Γ_{34}
Regime 1	0.2163	-0.1236	-0.1926	-0.2429	-0.1371	-0.1790
	(0.085)	(0.088)	(0.082)	(0.090)	(0.099)	(0.082)
Regime 2	-0.0704	0.0018	0.1772	0.3005	-0.2882	-0.5854
	(0.163)	(0.196)	(0.223)	(0.149)	(0.140)	(0.223)

Table A.1. Estimation results for the two-state four-variable MSVAR model (1).

Parameter	Estimate	Stand. error	Parameter	Estimate	Stand. error
$\gamma_1(1)$	0.1200	0.0899	$b_{31}^2(1)$	0.0816	0.1692
$\gamma_2(1)$	0.0758	0.0611	$b_{32}^2(1)$	−0.3430	0.3589
$\gamma_3(1)$	0.3833	0.1522	$b_{33}^2(1)$	−0.0311	0.1222
$\gamma_4(1)$	−0.1364	0.1179	$b_{34}^2(1)$	−0.0760	0.1604
$\gamma_1(2)$	−1.8072	1.2372	$b_{41}^2(1)$	0.1520	0.1402
$\gamma_2(2)$	1.3990	0.2912	$b_{42}^2(1)$	−0.2000	0.2899
$\gamma_3(2)$	2.7233	0.5229	$b_{43}^2(1)$	−0.0652	0.1091
$\gamma_4(2)$	0.3605	0.1855	$b_{44}^2(1)$	0.3433	0.1265
$b_{11}^1(1)$	1.2317	0.0908	$b_{11}^3(1)$	0.4534	0.1361
$b_{12}^1(1)$	0.2150	0.1307	$b_{12}^3(1)$	−0.2768	0.2176
$b_{13}^1(1)$	0.1895	0.0559	$b_{13}^3(1)$	0.1582	0.0888
$b_{14}^1(1)$	−0.2447	0.0733	$b_{14}^3(1)$	0.1518	0.0829
$b_{21}^1(1)$	−0.0374	0.0605	$b_{21}^3(1)$	−0.0818	0.0649
$b_{22}^1(1)$	1.1577	0.0848	$b_{22}^3(1)$	−0.1923	0.1677
$b_{23}^1(1)$	0.0303	0.0410	$b_{23}^3(1)$	−0.0618	0.0525
$b_{24}^1(1)$	−0.0112	0.0421	$b_{24}^3(1)$	−0.0676	0.0518
$b_{31}^1(1)$	−0.1184	0.1191	$b_{31}^3(1)$	0.1069	0.1456
$b_{32}^1(1)$	0.2893	0.2151	$b_{32}^3(1)$	−0.1658	0.3435
$b_{33}^1(1)$	1.1882	0.1065	$b_{33}^3(1)$	−0.2773	0.1080
$b_{34}^1(1)$	−0.1267	0.1170	$b_{34}^3(1)$	0.2988	0.1209
$b_{41}^1(1)$	−0.1244	0.1075	$b_{41}^3(1)$	0.0088	0.1051
$b_{42}^1(1)$	0.4650	0.1508	$b_{42}^3(1)$	−0.2986	0.3137
$b_{43}^1(1)$	−0.0633	0.0867	$b_{43}^3(1)$	0.0145	0.1215
$b_{44}^1(1)$	0.9078	0.0835	$b_{44}^3(1)$	−0.1213	0.0767
$b_{11}^2(1)$	−0.5654	0.1307	$b_{11}^4(1)$	−0.1467	0.0840
$b_{12}^2(1)$	0.0308	0.2128	$b_{12}^4(1)$	0.0116	0.1398
$b_{13}^2(1)$	0.0893	0.0961	$b_{13}^4(1)$	−0.0617	0.0562
$b_{14}^2(1)$	0.0749	0.1128	$b_{14}^4(1)$	0.0724	0.0755
$b_{21}^2(1)$	0.1075	0.0840	$b_{21}^4(1)$	0.0080	0.0381
$b_{22}^2(1)$	−0.0129	0.1447	$b_{22}^4(1)$	0.0154	0.1094
$b_{23}^2(1)$	0.0253	0.0605	$b_{23}^4(1)$	0.0407	0.0425
$b_{24}^2(1)$	−0.0061	0.0563	$b_{24}^4(1)$	0.1081	0.0475

Table A.1. (Continued)

Parameter	Estimate	Stand. error	Parameter	Estimate	Stand. error
$b^4_{31}(1)$	−0.0931	0.0903	$b^2_{33}(2)$	0.2268	0.1233
$b^4_{32}(1)$	0.1526	0.2391	$b^2_{34}(2)$	−0.5771	0.2122
$b^4_{33}(1)$	0.0522	0.0909	$b^2_{41}(2)$	−0.0528	0.0303
$b^4_{34}(1)$	−0.0755	0.1055	$b^2_{42}(2)$	−0.1925	0.2252
$b^4_{41}(1)$	−0.0013	0.0714	$b^2_{43}(2)$	−0.0987	0.0544
$b^4_{42}(1)$	0.0444	0.1929	$b^2_{44}(2)$	0.7027	0.0659
$b^4_{43}(1)$	0.0779	0.0890	$b^3_{11}(2)$	0.6036	0.2080
$b^4_{44}(1)$	−0.1706	0.0851	$b^3_{12}(2)$	−0.7797	1.0088
$b^1_{11}(2)$	0.0286	0.2310	$b^3_{13}(2)$	−0.2272	0.3784
$b^1_{12}(2)$	1.8915	0.6570	$b^3_{14}(2)$	0.3773	0.6037
$b^1_{13}(2)$	0.2518	0.2584	$b^3_{21}(2)$	−0.0226	0.0308
$b^1_{14}(2)$	−0.9239	0.2873	$b^3_{22}(2)$	0.1746	0.2255
$b^1_{21}(2)$	−0.0541	0.0390	$b^3_{23}(2)$	0.0531	0.0922
$b^1_{22}(2)$	1.4525	0.1643	$b^3_{24}(2)$	0.0693	0.1505
$b^1_{23}(2)$	−0.1018	0.0511	$b^3_{31}(2)$	0.0916	0.0576
$b^1_{24}(2)$	−0.2003	0.0517	$b^3_{32}(2)$	2.0258	0.3321
$b^1_{31}(2)$	0.3536	0.0688	$b^3_{33}(2)$	−0.1135	0.1677
$b^1_{32}(2)$	0.0568	0.2390	$b^3_{34}(2)$	1.1461	0.3082
$b^1_{33}(2)$	0.5141	0.0990	$b^3_{41}(2)$	−0.0496	0.0271
$b^1_{34}(2)$	−0.1506	0.1272	$b^3_{42}(2)$	0.8767	0.1780
$b^1_{41}(2)$	0.2193	0.0310	$b^3_{43}(2)$	0.2314	0.0663
$b^1_{42}(2)$	−0.4011	0.1199	$b^3_{44}(2)$	0.9127	0.1197
$b^1_{43}(2)$	−0.0529	0.0437	$b^4_{11}(2)$	0.1062	0.1991
$b^1_{44}(2)$	0.3924	0.0587	$b^4_{12}(2)$	0.2535	0.5745
$b^2_{11}(2)$	0.2017	0.2199	$b^4_{13}(2)$	−0.3078	0.1956
$b^2_{12}(2)$	−0.8170	1.2893	$b^4_{14}(2)$	0.3127	0.2244
$b^2_{13}(2)$	0.3079	0.4239	$b^4_{21}(2)$	−0.0334	0.0360
$b^2_{14}(2)$	−0.0312	0.3294	$b^4_{22}(2)$	0.0735	0.1512
$b^2_{21}(2)$	0.0160	0.0427	$b^4_{23}(2)$	0.0186	0.0564
$b^2_{22}(2)$	−0.4164	0.2462	$b^4_{24}(2)$	−0.1284	0.0711
$b^2_{23}(2)$	−0.0713	0.0705	$b^4_{31}(2)$	−0.2945	0.0629
$b^2_{24}(2)$	−0.0617	0.0964	$b^4_{32}(2)$	1.3452	0.2856
$b^2_{31}(2)$	0.0488	0.0754	$b^4_{33}(2)$	−0.1203	0.0881
$b^2_{32}(2)$	0.9161	0.3923	$b^4_{34}(2)$	−0.2724	0.1334

Table A.1. (Continued)

Parameter	Estimate	Stand. error	Parameter	Estimate	Stand. error
$b^4_{41}(2)$	0.0098	0.0257	$\psi_{12}(2)$	−0.0181	0.0424
$b^4_{42}(2)$	−0.5580	0.1285	$\psi_{13}(2)$	0.0009	0.1014
$b^4_{43}(2)$	0.3285	0.0340	$\psi_{14}(2)$	0.0350	0.0464
$b^4_{44}(2)$	0.1001	0.0527	$\psi_{22}(2)$	0.2564	0.0239
$\psi_{11}(1)$	0.3631	0.0239	$\psi_{23}(2)$	0.1539	0.0845
$\psi_{12}(1)$	0.0530	0.0212	$\psi_{24}(2)$	−0.0547	0.0280
$\psi_{13}(1)$	−0.0685	0.0489	$\psi_{33}(2)$	0.4870	0.0494
$\psi_{14}(1)$	−0.0924	0.0431	$\psi_{34}(2)$	−0.1042	0.0271
$\psi_{22}(1)$	0.2393	0.0152	$\psi_{44}(2)$	0.1550	0.0196
$\psi_{23}(1)$	−0.1226	0.0531	p	0.9793	0.0052
$\psi_{24}(1)$	−0.0469	0.0463	q	0.9993	0.0025
$\psi_{33}(1)$	0.5358	0.0322			
$\psi_{34}(1)$	−0.1113	0.0464			
$\psi_{44}(1)$	0.4550	0.0300	log		
$\psi_{11}(2)$	1.2033	0.1874	likelihood	−1.8560	

Notes: $\gamma_i(s_t)$ denotes a generic element of vector $\Upsilon(s_t)$, $b^i_{jh}(s_t)$ denotes a generic element of matrix $B_i(s_t)$ and $\psi_{jh}(s_t)$ denotes a generic element of matrix $\Psi(s_t)'$.

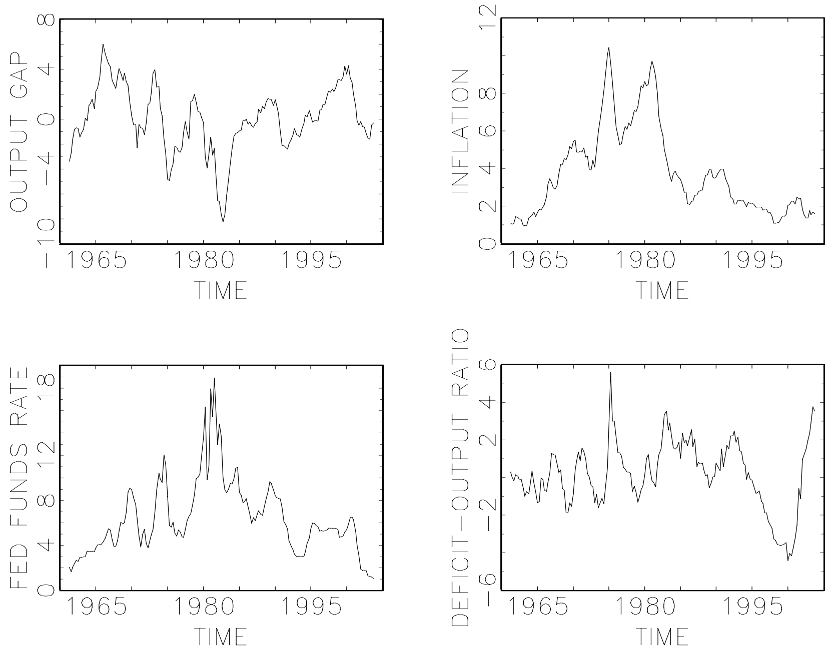

Figure 1: Data set time series

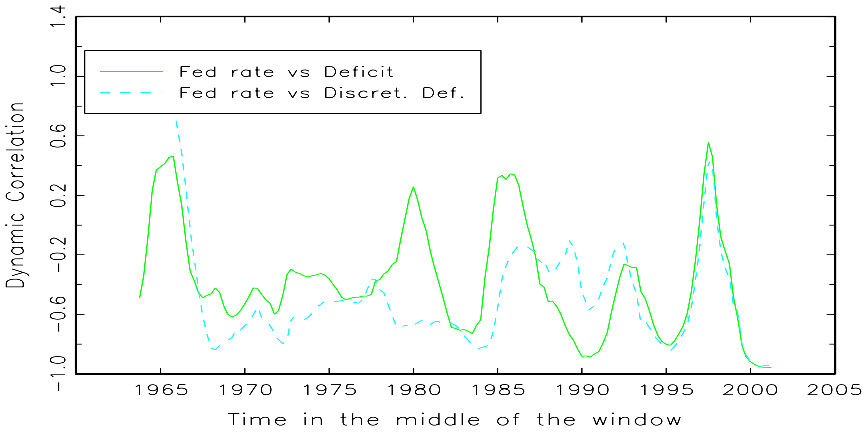

Figure 2: Dynamic correlations (5-year window)

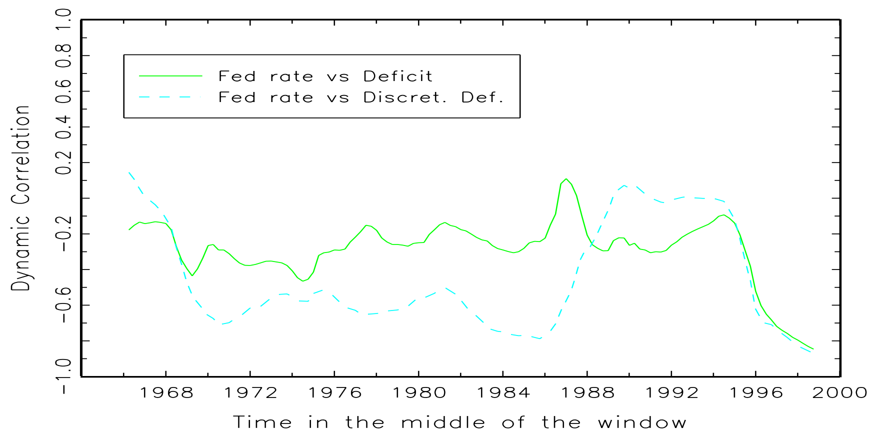

Figure 3: Dynamic correlations (10-year window)

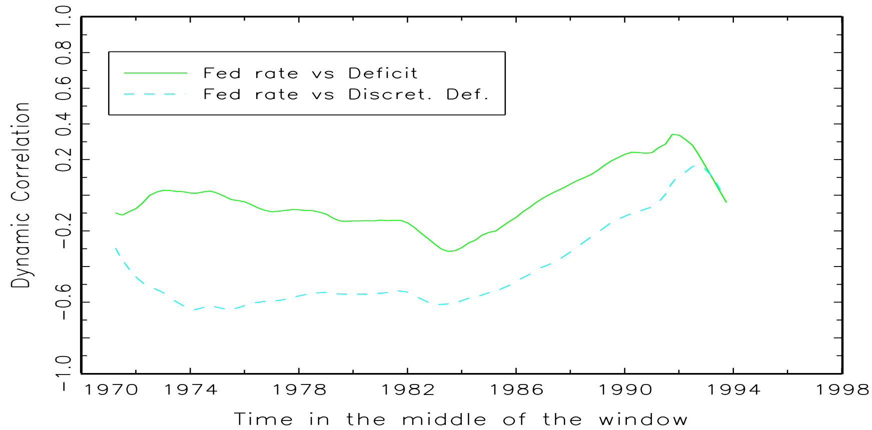

Figure 4: Dynamic correlations (20-year window)

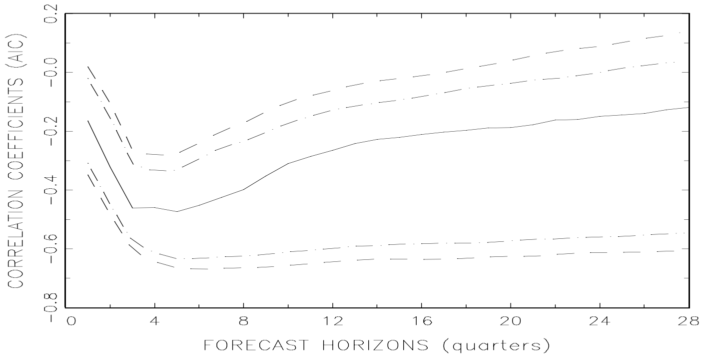

Figure 5: Fed rate and deficit forecast errors (1961-2003)

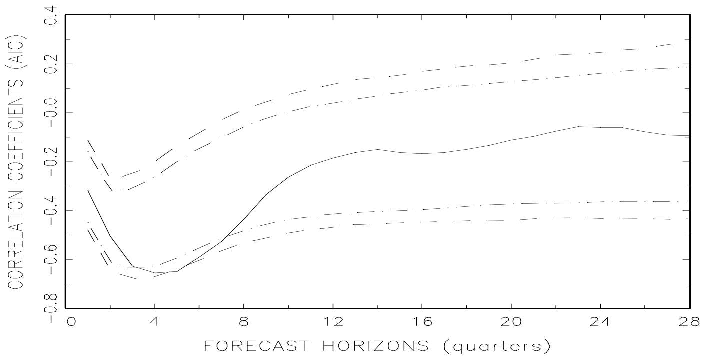

Figure 6: Fed rate and deficit forecast errors (1961-1983)

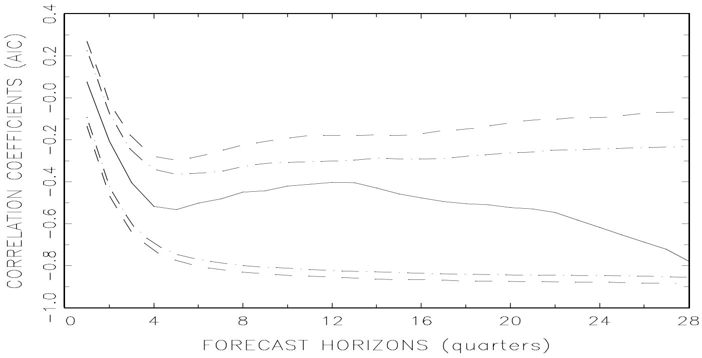

Figure 7: Fed rate and deficit forecast errors (1984-2003)

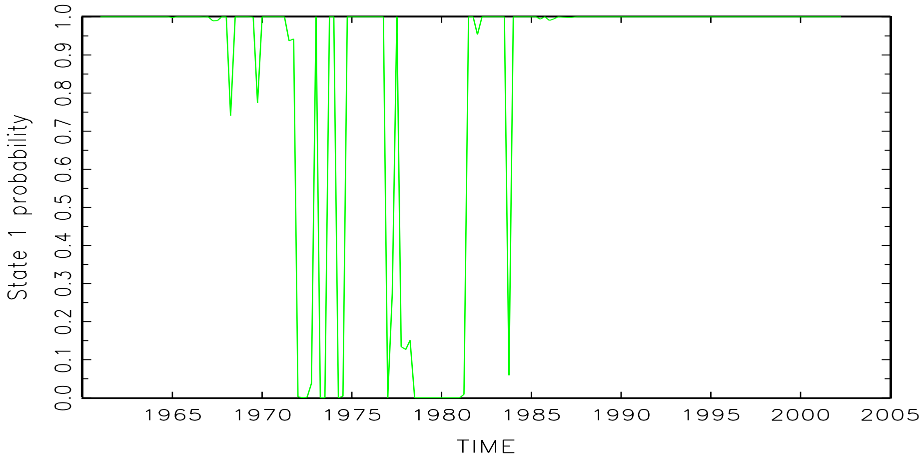

Figure 8: Smoothed probabilities from the MSVAR