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IN SEARCH OF THE LIQUIDITY EFFECT

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ABSTRACT

A short-run negative relationship between monetary aggregates and interest rates – the "liquidity effect" – is central to popular, political, and academic discussions of monetary policy. This paper searches for this empirical relationship. We use monthly U.S. data since 1954 to ask if the characterization of the liquidity effect is sensitive to: (i) changes in sample period; (ii) conditioning the correlations on additional variables; (iii) assuming money growth is exogenous, and (iv) treating monetary changes as anticipated or unanticipated.

The correlations change significantly with each of the four variations. We conclude that a successful search for the liquidity effect requires careful identification of private and policy behavior.

JEL Classifications: E40, E41, E50.

In Search of the Liquidity Effect

Eric M. Leeper and David B. Gordon*

1. Introduction

A short-run negative response of interest rates to an increase in the money supply, often dubbed the "liquidity effect," is central to popular, political, and academic discussions of monetary policy. The liquidity effect is the first step of the transmission mechanism of monetary policy in many analyses. It is a structural element in traditional Keynesian models [based on Tobin (1947)] and in the monetarist approaches of Friedman (1968) and Cagan (1972). Recent neoclassical models [Lucas (1990), Fuerst (1990), Christiano (1991), and Christiano and Eichenbaum (1991)] have included this feature to remedy the apparent deficiency of earlier theoretical models in which monetary shocks tend, if anything, to raise nominal interest rates.[1] In addition, the liquidity effect seems to have achieved the status of a criterion of acceptability in the specification, estimation, and simulation of structural models and aggregate money demand relationships.[2]

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[1]Grossman and Weiss (1983) and Rotemberg (1984) are exceptions among the earlier theoretical models. In their models, open market operations lower real interest rates, and in the case of Grossman and Weiss, they also lower nominal interest rates.

[2]Christiano (1991, p. 3) labels the negative short-run response of interest rates to a surprise monetary expansion "a basic premise guiding the implementation of monetary policy," which is an "important characteristic for a good model to have." Bryant, et. al. (1988) report that all but one of the dozen econometric models they study produces declines

(continued...)

In this paper we present a largely atheoretical characterization of the relationship between the federal funds rate and monetary aggregates over the 1954-1990 period. In addition, we consider the stability of the relationship over four sub-periods that are commonly viewed as reflecting different policy environments. By estimating traditional distributed lag regressions of the interest rate on current and past money growth rates, we replicate the pattern of correlations that has traditionally been interpreted as evidence of the liquidity effect. However, this pattern of correlations is sensitive to dynamic specification. When lagged interest rates, consumer prices, and industrial production are included in the regressions as conditioning variables, all evidence of the liquidity effect disappears: The correlation between unanticipated money growth and interest rates is zero or positive.[3] Modern versions of the traditional analysis emphasize that unanticipated shifts in the money supply should produce stronger liquidity effects, while anticipated monetary expansions primarily result in higher expected inflation. In contrast, we find that the correlation between anticipated money growth and anticipated interest rates is often significantly negative, and the correlation between anticipated changes in money growth and anticipated changes in interest rates is

[2](...continued)
in short-term nominal interest rates following a U.S. monetary expansion. Laidler (1985, p. 124) writes: "Of the literally hundreds of studies of the demand for money . . . I am aware of only three that have failed to find a significant negative relationship between the rate of interest and the demand for money." After conducting a specification search of empirical money demand, Cooley and LeRoy (1981, p. 843) conclude that "the negative interest elasticity of money demand reported in the literature represents prior beliefs much more that sample information."

[3]Similar results already exist. Mishkin (1983) fails to uncover a negative relationship between unanticipated money and interest rates. Sims (1980,1986) and Litterman and Weiss (1985) report that money supply innovations in unrestricted vector autoregressions do not produce sizeable short-run declines in interest rates.

always significantly negative or zero. Finally, we find that the relationships change sign and vary in statistical significance across the four sub-periods that we consider.[4]

These results lead us to one of two possible conclusions: Either the widespread belief in the liquidity effect is incorrect or the observed short-run correlations between money growth and interest rates do not primarily reflect the liquidity effect. We are inclined toward the latter conclusion: The correlations arise in large part from the endogenous responses of interest rates and money growth to other variables. We believe these results underscore the need to identify money supply and money demand processes when estimating and interpreting structural models and/or aggregate money demand relations. We hope that the characterization of the data presented here provides a useful background for that effort.

The next section of the paper discusses the traditional analysis of the liquidity effect, how the analysis is used to interpret data, and the money growth-interest rate correlations that the analysis implies. Section 3 describes the data set we use to characterize the liquidity effect. The estimation techniques and empirical results are reported in section 4. The paper ends with a summary and conclusions.

2. Overview

The standard analysis of the liquidity effect, as presented in Friedman (1968) or Cagan (1972), is firmly rooted in the comparative statics of money demand: An increase in the rate of growth of the money supply, holding output and prices constant, causes the nominal

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[4]Our work parallels Cooley and LeRoy's (1981) extreme value analysis of the interest elasticity of money demand. Both papers are in the spirit of Leamer's (1978) specification search methodology, however, we focus on patterns of correlations rather than on an individual coefficient of interest.

interest rate to fall. As long as prices and output do not respond "too quickly," the partial equilibrium analysis carries over to the general equilibrium: After an increase in money growth there will be a period over which the interest rate is depressed. Eventually, (expected) inflation will adjust to the new growth rate in money and the long-run correlation between the interest rate and money growth is positive. The long-run tendency for changes in money growth to be reflected in expected inflation and thus, nominal interest rates, is referred to as the "expected inflation effect." The negative interest elasticity of money demand produces the liquidity effect, but ultimately the expected inflation effect dominates the liquidity effect.[5] We shall refer to this analysis as the Friedman-Cagan analysis.

In recent extensions of the Friedman-Cagan analysis, the sooner people come to expect a monetary expansion, the milder and briefer will be the decline in the interest rate. The modern models associated with Lucas (1990), Fuerst (1990), Christiano (1991), and Christiano and Eichenbaum (1991) employ an extreme version of this logic: Only unanticipated increases in the money supply can lower interest rates. Anticipated money growth produces only the expected inflation effect.

There are two traditional empirical approaches to isolating the relation between money and interest rates: calculating reduced-form correlations between the variables and estimating money demand. The former approach, which is associated with Cagan (1966,1972), Cagan and Gandolfi (1969), Gibson (1970a,1970b), Melvin (1983), and Cochrane (1989), among others, regresses interest rates against current and past monetary aggregates. The aggregate

[5]We are omitting the short-run output adjustment to monetary expansions [that is, Friedman's (1968, p. 6) "income" effect and Cagan's (1972, p. 3) "credit effect"]. The duration and the degree of sensitivity of these effects continue to be controversial.

money demand tradition, from Meltzer (1963) to Goldfeld (1973) and extensive recent work, estimates the interest elasticity that underlies the liquidity effect by conditioning on a broader set of variables and imposing more restrictive assumptions on dynamics than does the reduced-form work.

The Friedman-Cagan characterization of short-run dynamics is routinely applied to interpret the empirical literature cited above. This interpretation *presumes* that money supply shocks are the dominant source of the observed correlations in the data. Christiano and Eichenbaum (1991, pp. 2-3) explicitly assert this: ". . . we interpret the observed correlation between the nominal federal funds rate with the growth rate of money and real GNP as reflecting the liquidity effects associated with unanticipated shocks to monetary policy."

The use of the Friedman-Cagan analysis to interpret the traditional empirical results implicitly requires the maintained assumption that the money supply is an exogenous process. Specifically, the money supply must be independent of variables that influence the interest rate. When the money supply is not exogenous, the traditional empirical results do not distinguish how much of the money-interest rate correlation is due to the interest elasticity of money demand and how much of the correlation arises from the dependence of money supply and interest rates on other variables.[6] Failure to address this identification problem precludes isolating the private behavior thought to underlie the monetary transmission mechanism. It is then impossible to evaluate the relevance of the models developed by Friedman, Cagan, and

[6]For example, if monetary policy were countercyclical, then recessions might be associated with high money growth and relatively lower interest rates, even if money demand is perfectly interest inelastic.

modern authors: We are left unsure what empirical regularities theories of the liquidity effect should capture, and what regularities are products of endogenous monetary policy.

The dangers of maintaining the assumption that the money supply is exogenous when drawing inferences about policy effects were pointed out long ago by Kareken and Solow (1963) and Tobin (1970). To address this problem, a sizeable literature attempts to identify the endogenous response of the money supply. One line of attack estimates policy reaction functions [see Fair (1978,1984) and the references in Khoury (1990) and Bryant (1991)], a second line tries to isolate monetary policy shocks using aggregate data [Sims (1986,1988), Bernanke and Blinder (1990), and Gali (1990)], and a third line draws on non-traditional data sources or employs pronouncements by policy makers to identify "exogenous" monetary policy events [Cook and Hahn (1989) and Romer and Romer (1989)].[7] This work suggests that identifying the money supply "shocks" that trigger the liquidity effect is a non-trivial task.

Few economists disagree with the assertion that some version of the Friedman-Cagan analysis correctly characterizes the economy's short-run response to an exogenous monetary shock.[8] There is considerably less agreement on how to empirically identify such shocks. If it is appropriate to use the analysis to interpret the observed correlations between money growth and interest rates, we would expect:

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[7]Using time series methods, Sargent (1976) and Sims (1980) find that the data reject the assumption that the money supply is exogenous.

[8]Simulations from King's (1990) model contrast with those from the models in Christiano (1991) and Christiano and Eichenbaum (1991). In King's setup, an unanticipated expansion of the money supply increases interest rates immediately because there is a strong investment multiplier that offsets the liquidity effect.

(1) the sign pattern of those correlations – negative in the short run and positive in the long run – to be stable over time and robust to conditioning the correlations on price and output variables, and

(2) the negative correlation to be strongest between innovations in money growth and interest rates, while the correlation between anticipated money growth and anticipated interest rates should be more positive, reflecting the expected inflation effect.

3. Data Considerations

The bulk of the traditional estimates of the liquidity effect and of money demand focus on monetary aggregates such as M1 and M2 and on interest rates such as three-month Treasury bills or six-month commercial paper rates.[9] We concentrate on relationships between the monthly series for the monetary base and the federal funds rate.[10] The monetary base is more closely associated with the open market operations that underlie the liquidity effect than are the broader aggregates. As Bryant (1983) emphasizes, unlike M1 or M2, the base is something the Fed controls precisely, although it may choose to respond to interest rates or other variables. Goodfriend (1990) argues that throughout most of its history

[9]For example, Cagan (1966) and Melvin (1983) use old M2 and the three- to six-month commercial paper rate in their liquidity effect regressions. Gibson (1970a,1970b) uses old M1 and M2 with a variety of short- and long-term interest rates. Cochrane (1989) studies new M1 with three-month Treasury bills and long-term bond rates. Meltzer (1963) estimates money demand with old M1 and M2 and a long-term interest rate, while Goldfeld (1973) exhaustively studies old M1, old M2, and their components with interest rates on six different types of assets.

[10]A complete description and graphs of the data are in Appendix A. We estimated all the relationships using the three-month Treasury bill and six-month commercial paper rates, with no appreciable differences in results. We also note whenever using M1 or M2 in place of the monetary base alters the qualitative results.

the Fed has targeted the funds rate, either directly or indirectly, relying primarily on manipulating borrowed reserves to indirectly target the funds rate.

Since we are using monthly data, interest rates with maturity structures longer than one month should be converted to one-month holding period returns [see, for example, Mishkin (1983)]. By working with the funds rate, which is extremely short term, we should be able to separate liquidity effects from expected inflation effects without imposing a theory of the term structure and expected inflation.

To investigate the stability of correlations between money growth and the interest rate over the post-Korean War period, we sub-divide the sample into four non-overlapping periods: 1954:7 to 1972:12, 1973:1 to 1979:9, 1979:10 to 1982:11, and 1982:12 to 1990:12. For comparison with other empirical work, however, we also estimate relationships over the full 1954:7 to 1990:12 period. Several considerations guided the choice of sub-periods. Goodfriend (1990) lists the 1950s, 1960s, and the period since 1982 as times when the Fed indirectly targeted the funds rate, suggesting 54-72 and 82-90 as sub-periods. Melvin (1983) writes of the "vanishing liquidity effect" after 1972, when the United States moved to a flexible exchange rate system. The early 1970s also saw the Fed gradually shift to tightly targeting the funds rate [see Cook and Hahn (1989) and Goodfriend (1990)], leading to the choice of 73-79. Finally, Cochrane (1989) shows that the liquidity effect returns during the October 1979 to November 1982 period when the Fed targeted nonborrowed reserves.

Table 1 reports the means and standard deviations of the variables used in the study for the five sample periods. In the 1950s, 1960s, and the 82-90 period the funds rate and inflation exhibit low variability. From 73-79 the average levels of base growth, interest rates, and inflation increased. The variance of inflation doubled, but the variance of the funds rate rose by only 50 percent, loosely supporting the notion that the funds rate was not left to be determined entirely by market forces. In the 79-82 period, the funds rate, the monetary base, M1, and inflation exhibit greater volatility than in any other period.

In choosing lag lengths for the regressions we estimate, we faced the usual trade-off between including enough lags to exhaust the information in the data and overfitting the data. We also were faced with trying to make the regressions comparable across sub-periods of differing lengths. In the results reported in the paper, we varied the lag lengths across sub-periods, depending on the length of the sub-period. Appendix B reports results for a common lag length across sub-periods, for using M1 and M2 in place of the monetary base, and for alternative orderings of the vector autoregressions. We note in the text whenever these results are strikingly different from those reported.

4. Estimation and Empirical Results

4.1 Traditional Distributed Lag Regressions

The traditional empirical approach to measuring the liquidity effect, associated with Cagan and Gandolfi (1969) and others, estimates a distributed lag of the interest rate on current and past money growth:[11]

[11]Some studies regress the level of the interest rate against the level of the money stock [Gibson (1970b) and Stokes and Neuburger (1979)], some use the growth rate of money as the independent variable [Cagan (1966), Gibson (1970a), Reichenstein (1987), and Cochrane (1989)], and some regress the change in interest rates against the change in money growth [Cagan and Gandolfi (1969), Cagan (1972), Gibson (1970a), and Melvin (1983)]. This is not an exhaustive list of studies or functional forms of the regressions that have been estimated.

$$r_t = \alpha + \beta(L)\rho_t + \varepsilon_t, \quad where\ \beta(L) = \sum_{j=0}^{n} \beta_j L^j, \tag{1}$$

r is the level of the federal funds rate, ρ is the growth rate of the monetary base, and L is the lag operator, defined as $L^j x_t = x_{t-j}$.[12]

When the authors find that the cumulative coefficients from this regression are significantly negative over some relatively short horizon, they interpret this as evidence that the liquidity effect dominates the relationship between money growth and interest rates in the short run. Since these regressions condition only on money growth rates, to interpret the coefficients as reflecting the effects of monetary policy on interest rates, the authors must assume that money growth and interest rates do not have a strong tendency to respond jointly to other variables.

Figure 1 depicts the cumulative lag coefficients – the sum of the β_j's in equation (1) – on the growth rate of the base and of M1, along with two-standard-deviation significance bands. Looking down the first column of the figure, we see that the 54-72 period mimics Cagan and Gandolfi's (1969) traditional characterization of the liquidity effect: The cumulative coefficients are significantly negative for over a year before turning significantly positive. Melvin's (1983) "vanishing liquidity effect" is the difference in the pattern of coefficients between the 54-72 and 73-79 periods. In the 73-79 period the cumulative coefficients are zero or positive at all horizons. Melvin attributes this to enhanced inflation sensitivity that led the expected inflation effect of a monetary expansion to dominate the liquidity effect. As

[12]We use the following lag lengths: 1954:7 to 1972:12 (36 lags), 1973:1 to 1979:9 (18 lags), 1979:10 to 1982:11 (6 lags), 1982:12 to 1990:12 (18 lags), and 1954:7 to 1990:12 (36 lags). These lags lengths are consistent with those used in previous studies.

Cochrane (1989) discovered, the negative correlation reemerges during the 79-82 episode, at least for a few months.[13] The liquidity effect seems strongest in the 82-90 period when the cumulative coefficients are significantly negative throughout. The full sample closely matches the 54-72 period, but this clearly masks substantial differences in correlations across the sub-periods. The second column of the figure shows that the results for M1 differ from those for the monetary base most noticeably during 73-79. Melvin's vanishing liquidity effect disappears: The cumulative coefficients four to nine months in the past are significant and negative. In all other periods the cumulative coefficients on M1 growth are both smaller (in absolute value) and less significant than those on base growth.

Experimenting with different lag lengths for the distributed lag regressions produces few differences. The one exception is the 54-72 sub-period when lag lengths of 18 months or more are required to reproduce the general pattern of cumulative coefficients reported in Figure 1.[14]

These distributed lag regressions have been largely supplanted in recent work by estimates of the dynamic multipliers associated with *unanticipated* changes in money growth. To obtain the dynamic multipliers implied by traditional regressions, we append to the interest rate distributed lag regression an equation describing the evolution of money growth, which

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[13]Cochrane uses weekly data on M1 and the three-month Treasury bill rate and concludes that the negative individual coefficients on lagged money growth last for three weeks.

[14]For the 73-79 regression, lag lengths ranging from 12 to 36 months for the base and 18 to 36 months for M1 produce results similar to those in Figure 1. Lag lengths from 3 to 9 months give similar results for both the base and M1 in the 79-82 sub-period. For the 82-90 period, lag lengths ranging from 6 to 36 months produce cumulative coefficients like those in the figure. In general, results for M2 are closer to those for M1 than for the base (results in Appendix B).

allows the data to characterize money innovations. A money innovation is defined as a one-time change in the residual of the money equation and the two equations are used to trace out the paths of money growth and interest rates associated with a "typical" money innovation. To remain in the spirit of the interpretations that Cagan and others give to their regression results, we maintain the assumption that money growth is exogenous and estimate a univariate autoregressive process for it:[15]

$$\rho_t = \delta_0 + \delta(L)\rho_{t-1} + \eta_t, \quad \textit{where } \delta(L) = \sum_{i=1}^{n} \delta_i L^i. \tag{2}$$

Combining (1) and (2) yields the multipliers $\gamma(L)$ in[16]

$$\begin{aligned} r_t &= \alpha' + \gamma(L)\eta_t + \varepsilon_t, \quad \textit{where} \\ \alpha' &\equiv \alpha + \beta(L)[1-\delta(L)]^{-1}\delta_0 \quad \textit{and} \\ \gamma(L) &\equiv \beta(L)[1-\delta(L)]^{-1}. \end{aligned} \tag{3}$$

King (1990) reinterprets Friedman and Schwartz (1963b) by using (2) to obtain an estimated time series for unanticipated money growth, $\{\eta_t\}$, and then estimating a version of (3) for interest rates and a variety of other macroeconomic variables.[17] We estimate (1) and

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[15]Cochrane (1989) explicitly interprets his results in terms of an exogenous money supply process. Christiano (1991) and Christiano and Eichenbaum (1991) base their calibration exercises on an estimated exogenous autoregressive process for money growth.

[16]We estimated the same number of lags for the money growth process as in the interest rate distributed lag regression.

[17]Except for the assumption of exogenous money growth, King's procedure is identical to that used in Barro (1977,1978) and Barro and Rush (1980).

(2) separately to ensure that the uncertainty about the estimated $\{\eta_t\}$ series is incorporated into the calculations of the standard errors of the dynamic multipliers.[18]

The first column of Figure 2 depicts the path of the funds rate for 36 months following a one-percentage point innovation to the growth rate of the base (that is, we set $\eta_t = 1$ and $\eta_{t+k} = 0$ for $k > 0$, and graph the resulting path of r). The second column graphs the path of money growth following the money innovation.

Allowing money growth to evolve according to its own past does not appreciably alter the characterization drawn by the cumulative coefficients in the traditional regressions. In Figure 2, monetary base innovations are negatively correlated with the funds rate contemporaneously for all periods except 73-79. The path of interest rates during the 54-72 period closely matches Friedman's (1968) description of the effects of a monetary expansion: The point estimate shows that the funds rate declines at impact and stays below its initial level for nine months; three years after the innovation in the money growth rate, the funds rate is significantly above its initial level.

The interest rate response is persistently negative in the 82-90 period, as the cumulative coefficients in Figure 1 suggest, and sharply negative during the 79-82 period where an innovation in the base is associated with a 40-basis-point decline in the funds rate at impact. The response of money to its own innovation is roughly similar across sample periods,

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[18]Mishkin (1983) uses maximum likelihood methods to obtain the correct standard errors. The standard error bands for the dynamic multipliers reported throughout the paper are generated using the Monte Carlo procedure described in Doan (1990). We modified the algorithm for restricted VARs.

suggesting that the differences in interest rate paths are probably not due solely to differences in the serial correlation pattern of the money stock.[19]

The 73-79 period presents an interesting puzzle. As we will report more fully later, it is the only period for which the null hypothesis that money growth is exogenous *cannot* be rejected [see Table 2, Panel A]. This is also the only period in which a monetary expansion is never followed by lower interest rates (Figure 2): There is no liquidity effect when the maintained assumption that money growth is exogenous is statistically acceptable.

Figure 2 also underscores how misleading it may be to estimate relationships over the full post-war sample. Although the dynamic multipliers for the 54-90 period are close to those described by Friedman, these are averages of very disparate patterns of responses.

4.2 Traditional Distributed Lags with Endogenous Money Growth

The work of Sargent (1976) and Sims (1980) suggests that interest rates are good predictors of money [also see the results in Table 2]. To relax the restriction that the base is exogenous, we estimate a money growth process that depends on past money growth and interest rates. This redefines the money innovation in (2) and the dynamic multipliers in (3). This experiment differs from the previous one only in what we assume about the evolution of money growth; the interest rate equation is identical in the two cases. Figure 3 graphs the new multipliers and the new path of money growth after a money innovation.[20]

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[19]Altering the lag lengths in (1) and (2) has the same qualitative effects on the dynamic multipliers as it has on the cumulative coefficients.

[20]Because the money growth equation now includes lagged money growth and interest rates, the number of lags in both the interest rate and money growth equations has been shortened to 12 lags for 1954:7 to 1972:12, 6 lags for 1973:1 to 1979:9, 3 lags for 1979:10 to (continued...)

The response of the funds rate to the redefined monetary innovation no longer seems to match the Friedman-Cagan analysis. In all sub-periods the funds rate rises (although not significantly) upon impact. During the 54-72 period, which in earlier experiments produced the classic liquidity effect, interest rates never fall significantly and rise significantly within three months of the innovation in money growth. Except for the impact effect, the dynamic multipliers for 79-82 and 82-90 are similar to those with exogenous money (Figure 2), although in some sub-periods there is more uncertainty about the point estimates. Few of money growth's own responses in Figure 3 are significantly different from zero.

4.3 Vector Autoregressions

The interest rate distributed lag regressions implicitly assume that no other variables induce interest rates and money growth to move together to generate the correlations estimated in traditional regressions.[21] We explore this possibility by estimating a vector autoregression that includes money growth, interest rates, consumer prices, and industrial production.[22] Let $X_t = (\rho_t, r_t, p_t, y_t)'$ be the vector of four variables for which we estimate:

[20](...continued)
1982:11, 6 lags for 1982:12 to 1990:12, and 18 lags for 1954:7 to 1990:12. Reestimating the system using 6 lags in each sub-period does not alter the sign or the statistical significance of the short-run interest rate or money growth responses.

[21]This is the thrust of Tobin's (1970) classic critique of reduced-form evidence in favor of monetarism [see, for example, Friedman and Schwartz (1963a,1963b), Friedman and Meiselman (1963), and Anderson and Jordan (1968)].

[22]This system has been studied extensively by Sims (1980) and Litterman and Weiss (1985), among others.

$$X_t = A + B(L)X_{t-1} + u_t, \qquad u_t \sim N(0,\Sigma). \tag{4}$$

We consider two versions of this VAR. The first version maintains the traditional assumption that money growth is exogenous and leaves unrestricted the remaining three equations in the system. The second VAR is completely unrestricted, so past values of all four variables are permitted to predict money growth. In both cases we treat money growth as predetermined for interest rates, output, and prices. This allows the funds rate to depend on past funds rates, output, and prices, in addition to current and past money growth, but money growth depends only on lagged variables. We use the two systems to estimate the responses of interest rates associated with an unanticipated one-percent increase in money growth.[23]

Figure 4 reports the responses of the funds rate and the monetary base to a one-percent money growth innovation. The contemporaneous correlation between unanticipated monetary growth and the funds rate is never negative and is significantly positive in some sub-periods. In most sub-periods, the funds rate rises steadily following a money growth innovation. Surprisingly, in 79-82, when the strongest liquidity effect showed up in Figures 1 and 2, the funds rate response is positive. The only negative response of interest rates is in

[23]The lag lengths corresponding to the sample periods we study are: 1954:7 to 1990:12 (18 lags), 1954:7 to 1972:12 (12 lags), 1973:1 to 1979:9 (3 lags), 1979:10 to 1982:11 (3 lags), and 1982:12 to 1990:12 (3 lags). The system for the 1979:10 to 1982:11 period includes only past interest rates and money growth. The 18 lags for the full sample period were chosen using a likelihood ratio test. The resulting residuals were then tested for serial correlation using the Lagrange multiplier test proposed by Breusch (1978). The lag lengths for other sample periods were arbitrarily scaled down for the fewer observations. When 6 lags are used for each sub-period, we get no qualitative differences.

the 82-90 period after a lag of a few months, but this is not statistically significant. There seems to be no direct connection between the path of interest rates and the serial correlation pattern of money growth: In 73-79 the money growth response oscillates between significantly positive and significantly negative and the funds rate rises throughout; over the full sample money growth is persistently higher and the funds rates rises significantly.

Earlier we reported that the F-tests in Table 2 suggest including interest rates in the money growth equation. According to the table, the restriction that interest rates, prices, and output jointly do not help to predict money can be soundly rejected in all periods except 73-79; interest rates and output also tend to be important individually. The F-tests lead us to estimate a VAR that leaves the money growth equation unrestricted. Figure 5 reports the responses of the funds rate and base growth to a predetermined money innovation. Conditioning the money growth innovation on additional variables dampens the responses of interest rates, but unanticipated monetary expansions still fail to generate the liquidity effect. As the results indicate, given that we have imposed that the system is recursive, allowing other variables to predict money growth does not affect conclusions about the liquidity effect.[24] To us this suggests the need to move toward more careful identification of monetary policy and private behavior.[25]

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[24]Alternative recursive orderings of the variables – for example, making money innovations orthogonal to price and/or output innovations – do not alter the immediate response of the interest rate to a money innovation (results in Appendix B).

[25]Sims (1986) argues that recursive identification is not sufficient to separate money supply and money demand shocks. To identify these shocks he imposes zero restrictions on contemporaneous relationships among the VAR innovations. Sims (1986,1988) and Gali (1990) follow this procedure and find that identified unanticipated monetary expansions appear to depress interest rates.

4.4 *Correlations Between Anticipated Variables*

The traditional distributed lag regressions compute correlations between interest rates and realized money growth while the dynamic multipliers are correlations between interest rates and unanticipated changes in money. We complete the decomposition of money growth by computing correlations between anticipated interest rates and anticipated money growth. The traditional analysis and the modern monetary models discussed earlier suggest that the correlation between these anticipated series is likely to be more strongly influenced by the expected inflation effect than is the correlation between unanticipated money growth and interest rates. Thus, anticipated money growth and anticipated interest rates should be less negatively correlated than are unanticipated money growth and interest rates.

The anticipated money grwoth and interest rate series, $\hat{\rho}$ and $\hat{r}$, are the one-month-ahead forecasts from the unrestricted VAR in equation (4):

$$\begin{aligned} \hat{\rho}_t &= E[\rho_t | \Omega_{t-1}] = \hat{A}_1 + \hat{B}_1(L)X_{t-1} \\ \textit{and} \quad \hat{r}_t &= E[r_t | \Omega_{t-1}] = \hat{A}_2 + \hat{B}_2(L)X_{t-1}, \end{aligned} \tag{5}$$

where Ω_{t-1} is the information set formed by past X and $\hat{A}_i$ and $\hat{B}_i$ are the estimated coefficients in equation i. In (5) we used the fact that $E[u_t| \Omega_{t-1}] = 0$.

We calculate the contemporaneous correlation between $\hat{\rho}_t$ and $\hat{r}_t$ and between $\Delta\hat{\rho}_t = \hat{\rho}_t - \hat{\rho}_{t-1}$ and $\Delta\hat{r}_t = \hat{r}_t - \hat{r}_{t-1}$. To obtain an estimated distribution for the expected variables we take random draws from the estimated distribution of the VAR coefficients and use actual data for X to calculate new values for $\hat{\rho}$ and $\hat{r}$.

Figures 6 and 7 graph the histograms for 1000 draws of the correlations between the expected levels and the expected changes in the funds rate and money growth, where money is defined as the base, M1, or M2. The vertical lines in the graphs mark two-standard-deviation bands for the correlation coefficients. Table 3 summarizes the figures based on the confidence intervals.[26]

Across levels and changes in the three aggregates, 12 out of 24 of the correlations are significantly negative, 10 out of 24 are zero, and only two are significantly positive. Among the relationships between anticipated changes in money growth and anticipated changes in interest rates (Panel B of the table), M2 correlations are negative through 1982, M1 correlations are negative from 1973 to 1982, and base correlations are zero everywhere except 79-82. There are no positive correlations between anticipated changes in money growth and anticipated changes in the funds rate. Recall that positive innovations in money growth never lower the funds rate contemporaneously (Figure 5).[27] These are exactly opposite of the results predicted by the models developed by Lucas (1990), Fuerst (1990), Christiano (1991), and Christiano and Eichenbaum (1991) when the assumption that the money supply is exogenous is maintained.

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[26]When the VAR in each sub-period is estimated with 6 lags, we find virtually identical results to those in Figures 6 and 7 and Table 2 (see Appendix B).

We also applied McCallum's (1976) instrumental variables method to regress the anticipated funds rate on anticipated money growth. The results are consistent with those obtained with Monte Carlo methods.

[27]These results are reminiscent of Sims's (1982) finding that it is the predictable part of money that is strongly associated with future output (as long as interest rates are included in the information set).

Correlations computed using a VAR estimated over the full sample hide substantial differences across sub-periods. For example, all 1000 realizations of the correlation between anticipated levels of the base and the funds rate for 54-72, as shown in Figure 6, are positive. This also holds for the full period, 54-90. Both 79-82 and 82-90, however, yield strongly negative correlations. The correlations of anticipated changes in the base and anticipated changes in the funds rate (Figure 7) are zero in all sub-periods except 79-82 and the full sample: One sub-period, which accounts for nine percent of the data, dominates the entire sample!

4.5 *Estimating Responses to Funds Rate Innovations*

The final exercise follows up on Sims's (1982) and McCallum's (1983) suggestion that if monetary policy has targeted interest rates, then monetary policy actions may be more closely associated with interest rate innovations than with unanticipated changes in monetary aggregates. Bernanke and Blinder (1990, p. 6) argue this point forcefully, maintaining that it is "reasonable" to treat VAR innovations in the funds rate "as a measure of Federal Reserve policy which, though not statistically exogenous, is at least predetermined within the month." We look at the response to funds rate innovations for completeness, even though the fact that the Fed has targeted interest rates does not imply that exogenous monetary policy shocks will be identified with funds rate innovations.[28]

[28]Goodfriend (1990) points out that interest rate targeting is often indirect and relies on controlling borrowed reserves. Thus, the exact operating procedure of the Fed, rather than the Fed's target variable, will determine whether empirically a monetary policy shock is more closely associated with interest rate or money growth innovations.

Bernanke and Blinder identify unanticipated monetary contractions with positive realizations of the error term in the federal funds rate equation from a VAR. To mimic their procedure, we use the unrestricted VAR, reorder the variables so the funds rate is predetermined, and estimate the response of base growth associated with an innovation in the funds rate.[29] The F-tests reported in Panel B of Table 2 generally support leaving the interest rate equation unrestricted. Figure 8 graphs the responses of money and interest rates to a positive one percentage point innovation in the funds rate. As expected from Figure 5, the interest rate innovation is positively correlated with money growth initially.[30] With a one-month delay, money growth falls significantly in all periods except 73-79.[31] In the earliest period (the 54-72 period) money growth continues to fall for several months before returning to its initial level.

5. Summary and Conclusions

There is broad agreement that the negative interest elasticity of money demand is the partial equilibrium mechanism that produces the liquidity effect. There is also a widespread belief that the observed correlations between money growth and interest rates should be interpreted as the liquidity effect dominating the economy's short-run general equilibrium

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[29]We reestimated all the empirical relationships with the roles of money growth and interest rates reversed. The unrestricted VAR that we report provides the strongest support for treating funds rate innovations as monetary policy actions.

[30]This is expected because reordering the base and the funds rate does not change the contemporaneous correlation between their innovations.

[31]Table 2, Panel B, supports treating the funds rate as exogenous in 73-79. In this subperiod when the funds rate is treated as exogenous, a positive one percentage point innovation in the funds rate is associated with a contemporaneous *increase* in money growth of 1.8 annual percentage points (results not reported).

response to monetary policy shocks. Given this consensus, we were surprised to find that the data do not strongly support identifying money-interest rate correlations with the mechanism described by Friedman (1968) and Cagan (1972), and embedded in models developed by Lucas (1990) and others.

Our results can be briefly summarized:

1) The response of interest rates to a money growth innovation frequently becomes positive and is never negative when the correlations are conditioned on past interest rates, money growth, prices, and output.

2) The liquidity effect appears more strongly in the contemporaneous correlation between anticipated money growth and anticipated interest rates than in the correlation between unanticipated money growth and interest rates.

3) The signs and the patterns of correlations between money growth and interest rates are not robust across sub-periods of the 1954-1990 sample.

4) The assumption that money is exogenous, which is critical to the traditional interpretations of the data, is rejected statistically. In a bivariate system, the correlation between unanticipated money and the interest rate changes from significantly negative to significantly positive when monetary policy is allowed to respond to past interest rates in addition to past money growth. When prices and output are also included in the unrestricted VAR, the correlation is positive, independent of the assumption about the exogeneity of money.

To us, the results point toward the need to go beyond simple correlations when identifying monetary policy. Recent work separates money supply and money demand by identifying VAR models by placing zero restrictions on contemporaneous correlations among innovations, leaving the dynamics of the model unrestricted [Sims (1986,1988) and Gali (1990)]. Interestingly, this approach tends to find liquidity effects from identified money supply shocks.[32] This completes the circle: Severely restricted distributed lag regressions find a liquidity effect, unrestricted VARs do not, and weakly identified VARs appear to recover the liquidity effect.

The evidence in this paper raises questions about what economic behavior induces money and interest rates to move together. We are skeptical about analyses that attribute all of the observed correlation between money growth and interest rates to the trade-off between the liquidity effect and the expected inflation effect. The degree to which the liquidity effect should be relied upon to explain the money-interest rate relationship depends on the identification of unanticipated monetary policy actions. Work along the lines of Sims (1986,1988) and Gali (1990) appears to be a useful step toward identifying what empirical regularities theories of the liquidity effect should capture. We hope the characteristics of the data highlighted in this paper provide a useful background for future efforts in that vein.

[32]It is unclear to what extent Sims (1986) uses the liquidity effect as a criterion for identifying money supply shocks. In addition, Sims and Gali estimate their VARs over the entire post-World War II period, so we cannot tell if their results hold over the sub-periods we analyze.

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Table 1. Summary Statistics, Various Sub-Periods

Variable	Sub-Period 54 - 72 N=221	73 - 79 N=81	79 - 82 N=38	82 - 90 N=97	54 - 90 N=437
Base growth					
mean	4.0	7.9	6.5	7.3	5.7
std dev	4.3	3.2	4.4	3.8	4.4
M1 growth					
mean	3.6	6.3	6.8	6.9	5.1
std dev	4.1	4.3	9.5	6.7	5.6
M2 growth					
mean	6.9	9.0	8.5	6.7	7.4
std dev	7.1	3.7	4.1	4.7	5.9
Fed Funds					
mean	3.9	7.6	14.1	8.2	6.4
std dev	1.9	2.3	3.0	1.3	3.7
Inflation					
mean	2.5	8.3	8.7	3.9	4.4
std dev	2.5	3.6	4.9	2.6	3.9
Output growth					
mean	4.8	2.6	-2.1	3.6	3.5
std dev	13.6	12.4	12.0	7.7	12.3

Notes: Growth rates and inflation are monthly averages at annual rates. Fed Funds is in percentage points at annual rate. Inflation is measured by consumer prices and output is measured by industrial production. N = number of observations in each sub-period.

Table 2. F-Tests of Exclusion Restrictions in Money Growth and Funds Rate Equations

The table reports the marginal significance levels at which the null hypothesis that lagged coefficients are jointly zero can be rejected when ρ is defined as the Monetary Base / M1.

A: Tests of money growth equation based on the unrestricted OLS regression:

$$\rho_t = a + b(L)\rho_{t-1} + c(L)r_{t-1} + d(L)p_{t-1} + e(L)y_{t-1} + u_t$$

Sample Period	H_0: c(L) = 0	d(L) = 0	e(L) = 0	c(L)=d(L)= e(L)=0
54:7-72:12	.001/.160	.227/.170	.005/.087	.000/.004
73:1-79:9	.829/.062	.996/.564	.514/.008	.780/.013
79:10-82:11	.001/.006	–	–	.001/.006
82:12-90:12	.011/.004	.678/.214	.278/.247	.023/.000
54:7-90:12	.000/.000	.327/.057	.005/.159	.000/.000

B: Tests of interest rate equation based on the unrestricted OLS regression:

$$r_t = a + b(L)\rho_{t-1} + c(L)r_{t-1} + d(L)p_{t-1} + e(L)y_{t-1} + u_t$$

Sample Period	H_0: b(L) = 0	d(L) = 0	e(L) = 0	b(L)=d(L)= e(L)=0
54:7-72:12	.621/.135	.148/.296	.072/.654	.064/.013
73:1-79:9	.339/.004	.251/.234	.104/.069	.185/.007
79:10-82:11	.032/.011	–	–	.032/.011
82:12-90:12	.673/.269	.961/.879	.331/.605	.604/.368
54:7-90:12	.373/.001	.103/.087	.004/.032	.002/.000

Notes: Consumer prices, p, and industrial production, y, are logged. The system for the period 1979:10 to 1982:11 includes only money growth and interest rates. We included 12 lags for 54:7 to 72:12, 18 lags for 54:7 to 90:12, and 3 lags for the remaining three sub-periods.

Table 3. Correlations Between Anticipated Money Growth and the Funds Rate

	Monetary Aggregate					
	A: Levels			B: Changes		
Sub-Period	MB	M1	M2	MB	M1	M2
54-72	+ +	+ +	0	0	0	–
73-79	0	0	– –	0	–	– –
79-82	– –	– –	– –	– –	– –	– –
82-90	– –	– –	0	0	0	0
54-90	+ +	+ +	0	–	– –	– –

Notes: Results are based on Monte Carlo experiments with 1000 draws. Entries in the table indicate whether the two-standard-deviation band for the simulated contemporaneous correlations includes zero, is positive, or is negative. Double symbols mean that all 1000 realizations of the correlation were positive (+ +) or negative (– –). Panel A is the correlation between anticipated levels of money growth and anticipated levels of the funds rate, and Panel B is the correlation between anticipated changes in money growth and anticipated changes in the funds rate. The anticipated money growth and funds rate series are one-step-ahead forecasts from a VAR including money growth (the monetary base, M1, or M2), the funds rate, industrial production, and consumer prices. The 79-82 period uses a bivariate VAR in money and interest rates.

Figure 1. Cumulative OLS Distributed Lag Coefficients

Results from a regression of the funds rate on current and past money growth rates

Measured in basis points at each lag

(center line is the point estimate and outer lines are two-standard-error bands)

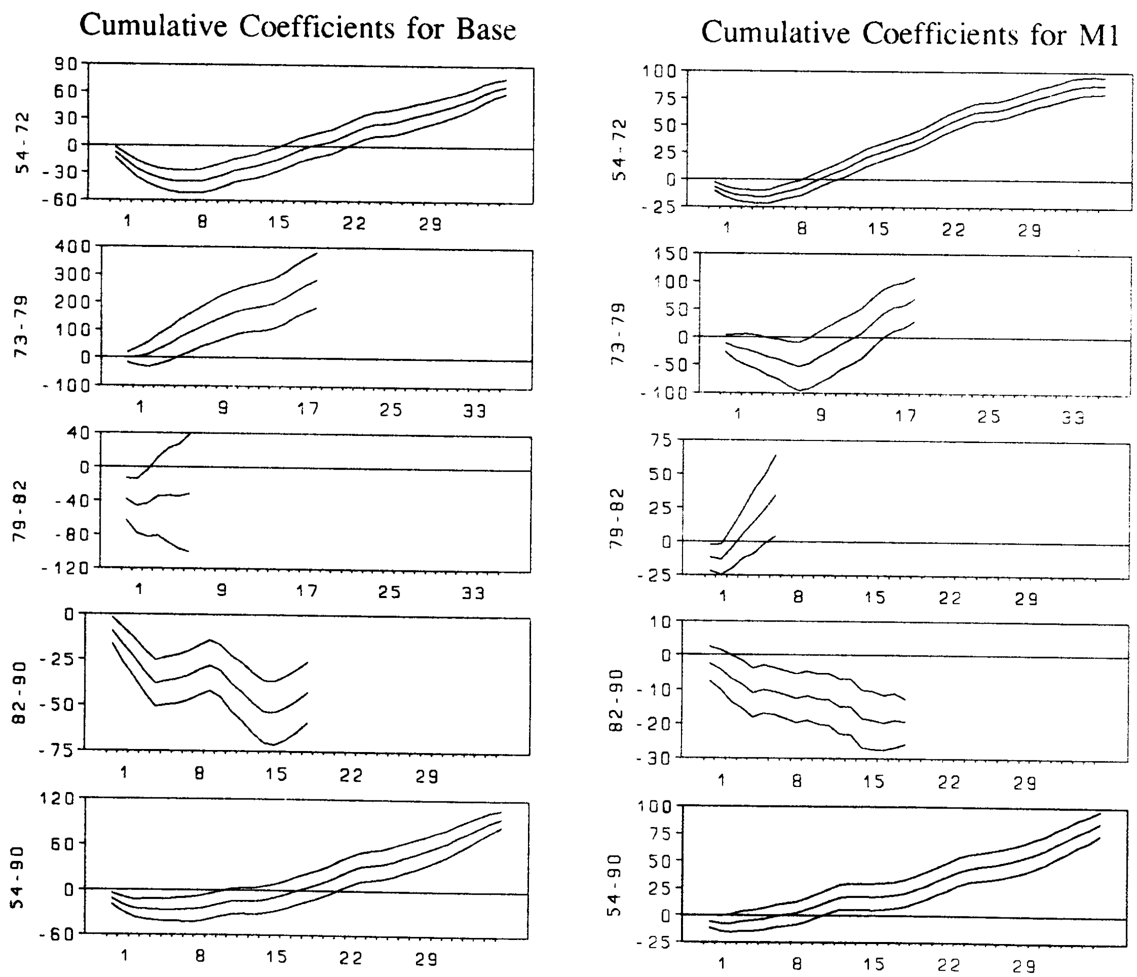
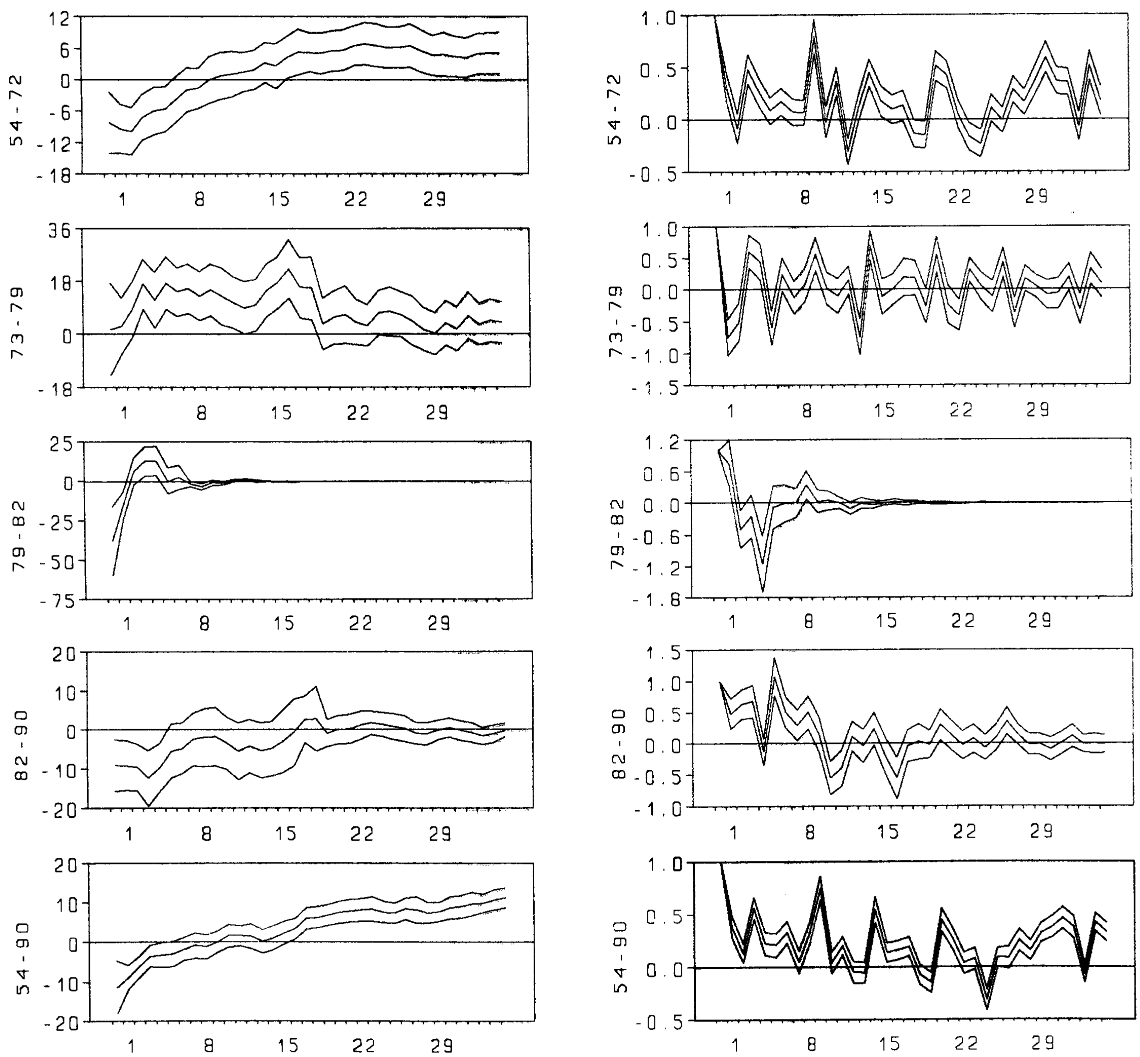


Figure 2. Interest Rate Dynamic Multipliers with Exogenous Money Growth

(center line is the point estimate and outer lines are two-standard-error bands)

Responses of Funds Rate to 1 %
Innovation in Base Growth
(basis points)

Responses of Base to 1 %
Innovation in Base Growth
(annual percentage points)



The interest rate distributed lag regression and the autoregressive process for money growth were estimated with the following lag lengths: 54-72 (36 lags), 73-79 (18 lags), 79-82 (6 lags), 82-90 (18 lags), and 54-90 (36 lags).

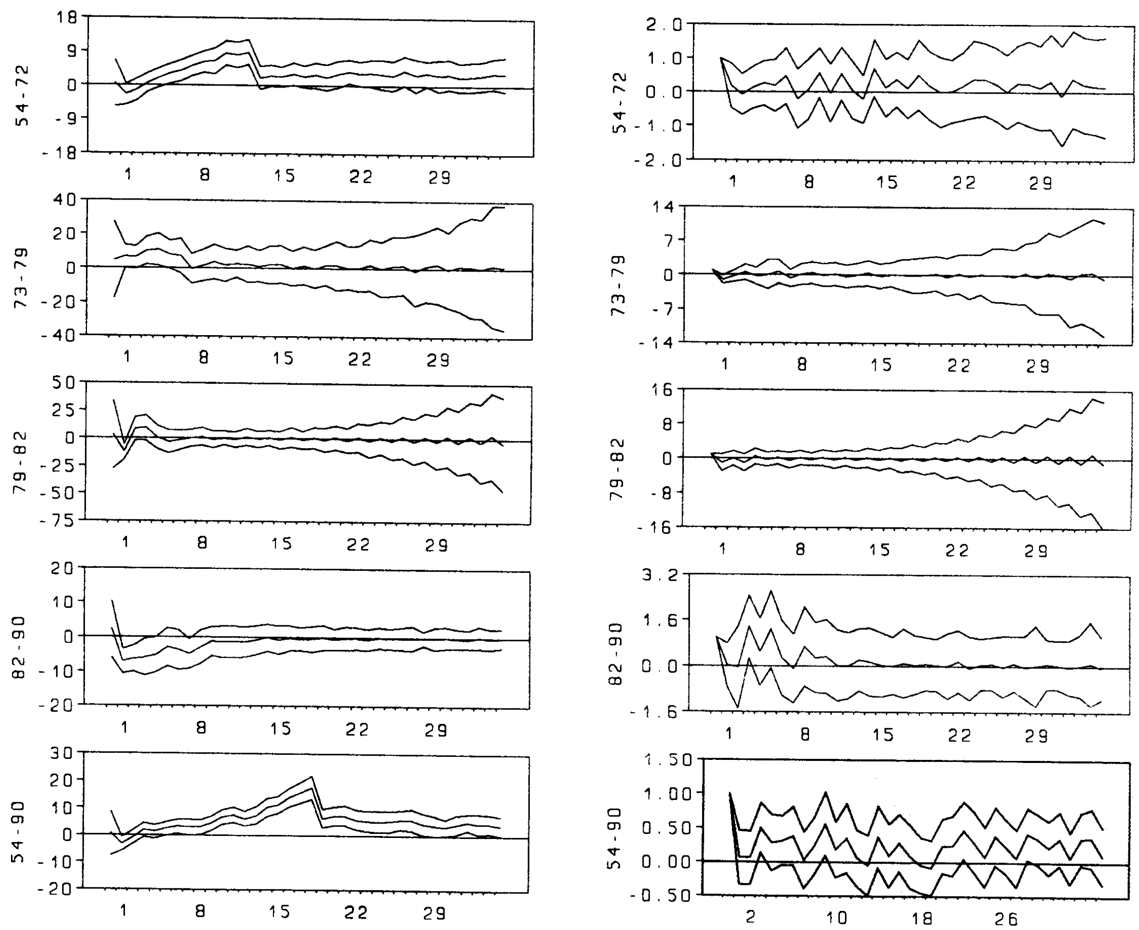
Figure 3. Interest Rate Dynamic Multipliers with Endogenous Money Growth

The money growth equation includes lagged money growth and funds rates

(center line is the point estimate and outer lines are two-standard-error bands)

Responses of Funds Rate to 1 % Innovation in Base Growth (basis points)

Responses of Base to 1 % Innovation in Base Growth (annual percentage points)



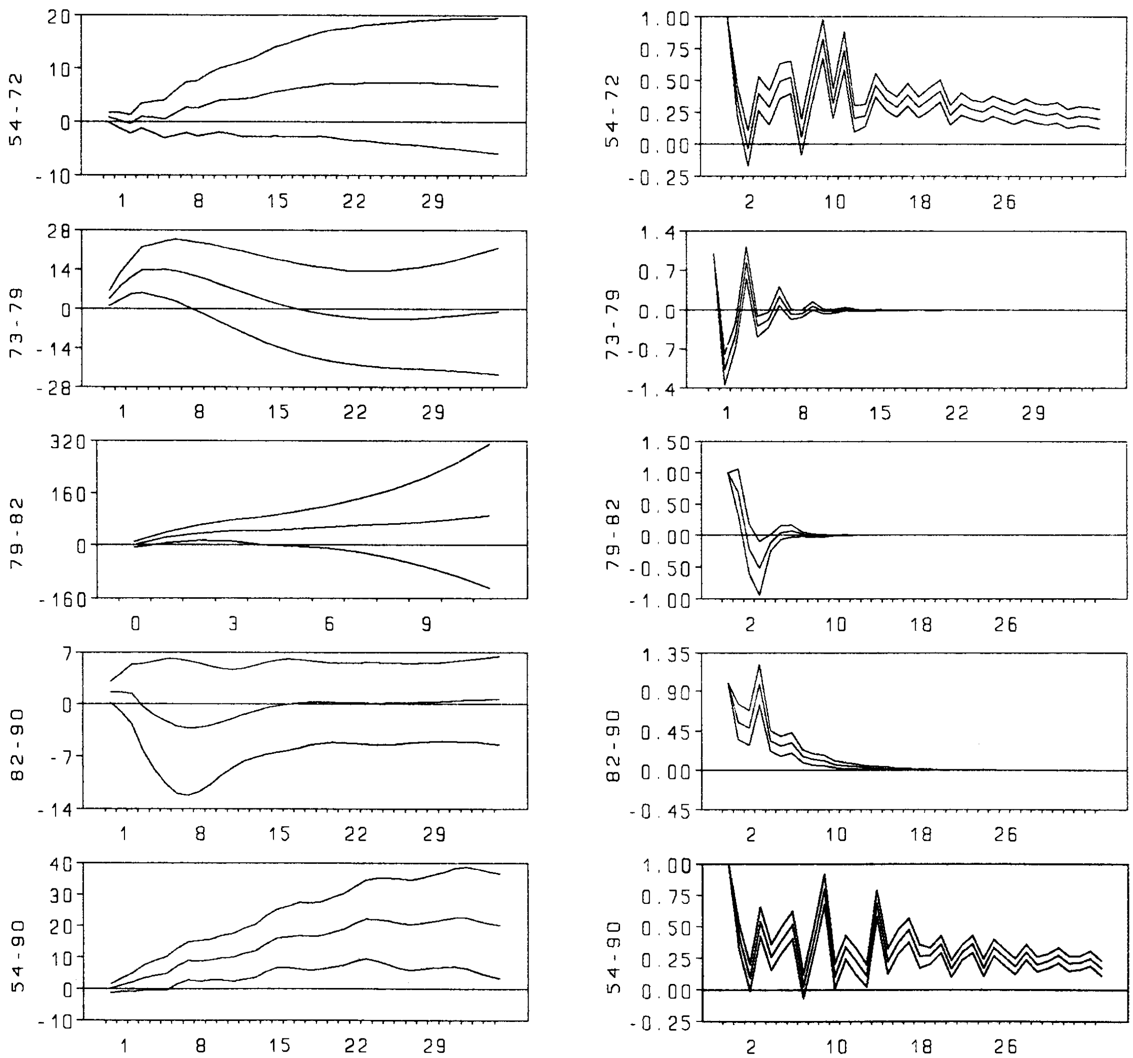
The interest rate distributed lag regression and the money growth process were estimated with the following lag lengths: 54-72 (12 lags), 73-79 (6 lags), 79-82 (3 lags), 82-90 (6 lags), and 54-90 (18 lags).

Figure 4. VAR with Exogenous Money Growth

(center line is the point estimate and outer lines are two-standard-error bands)

Responses of Funds Rate to 1 % Innovation in Base Growth (basis points)

Responses of Base to 1 % Innovation in Base Growth (annual percentage points)



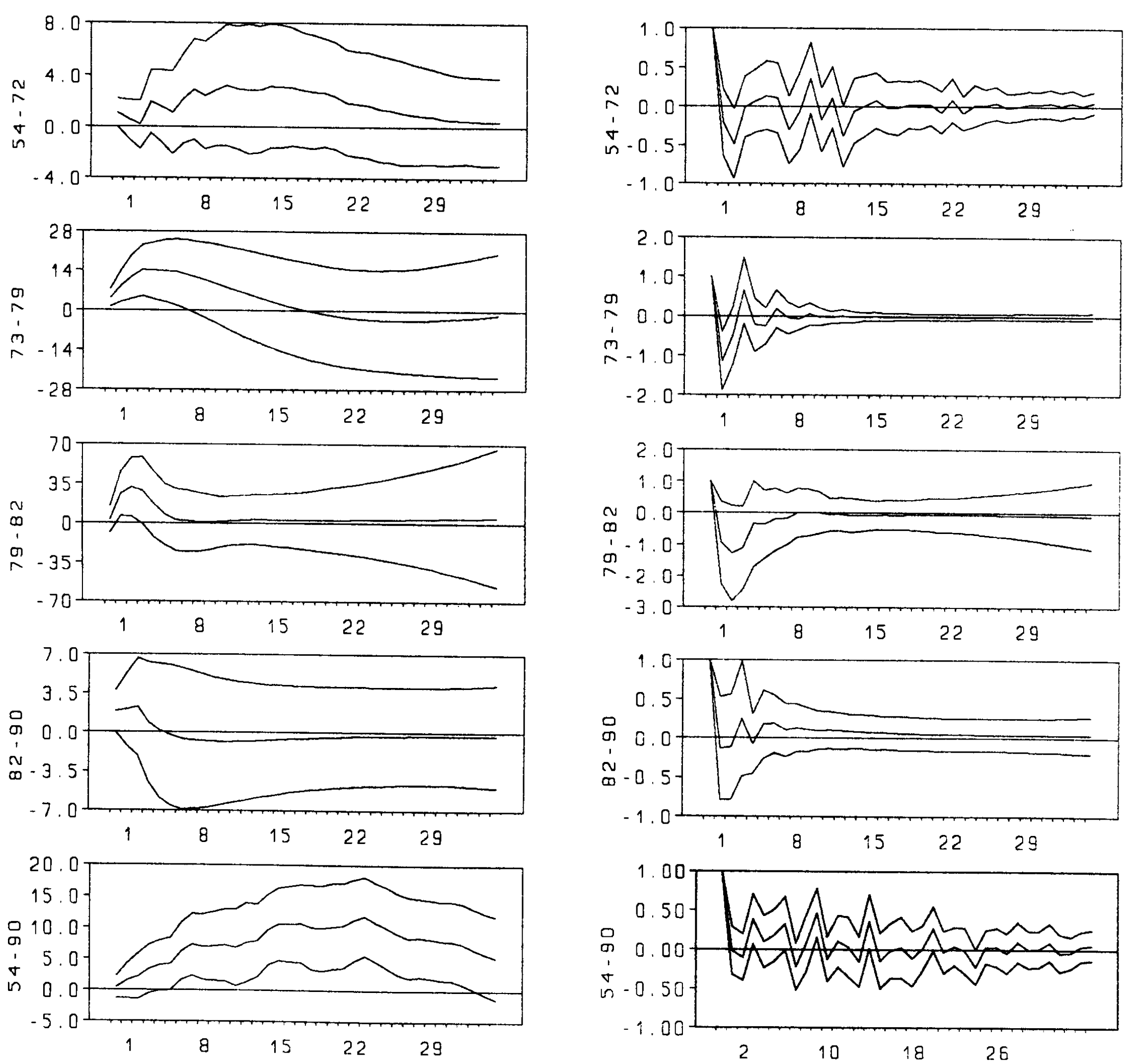
The VARs were estimated with the following lag lengths: 54-72 (12 lags), 73-79 (3 lags), 79-82 (3 lags), 82-90 (3 lags), and 54-90 (18 lags). The VAR for 79-82 includes only money growth and the funds rate. Note: The funds rate response in 79-82 is plotted over a 12-month horizon.

Figure 5. Unrestricted VAR with Money Innovation Predetermined

(center line is the point estimate and outer lines are two-standard-error bands)

Responses of Funds Rate to 1 % Innovation in Base Growth (basis points)

Responses of Base to 1 % Innovation in Base Growth (annual percentage points)



The VARs were estimated with the following lag lengths: 54-72 (12 lags), 73-79 (3 lags), 79-82 (3 lags), 82-90 (3 lags), and 54-90 (18 lags). The VAR for 79-82 includes only money growth and the funds rate.

Figure 6. Correlation of Anticipated Levels of Money Growth and the Funds Rate:

Empirical distributions based on 1000 draws from estimated VAR coefficients

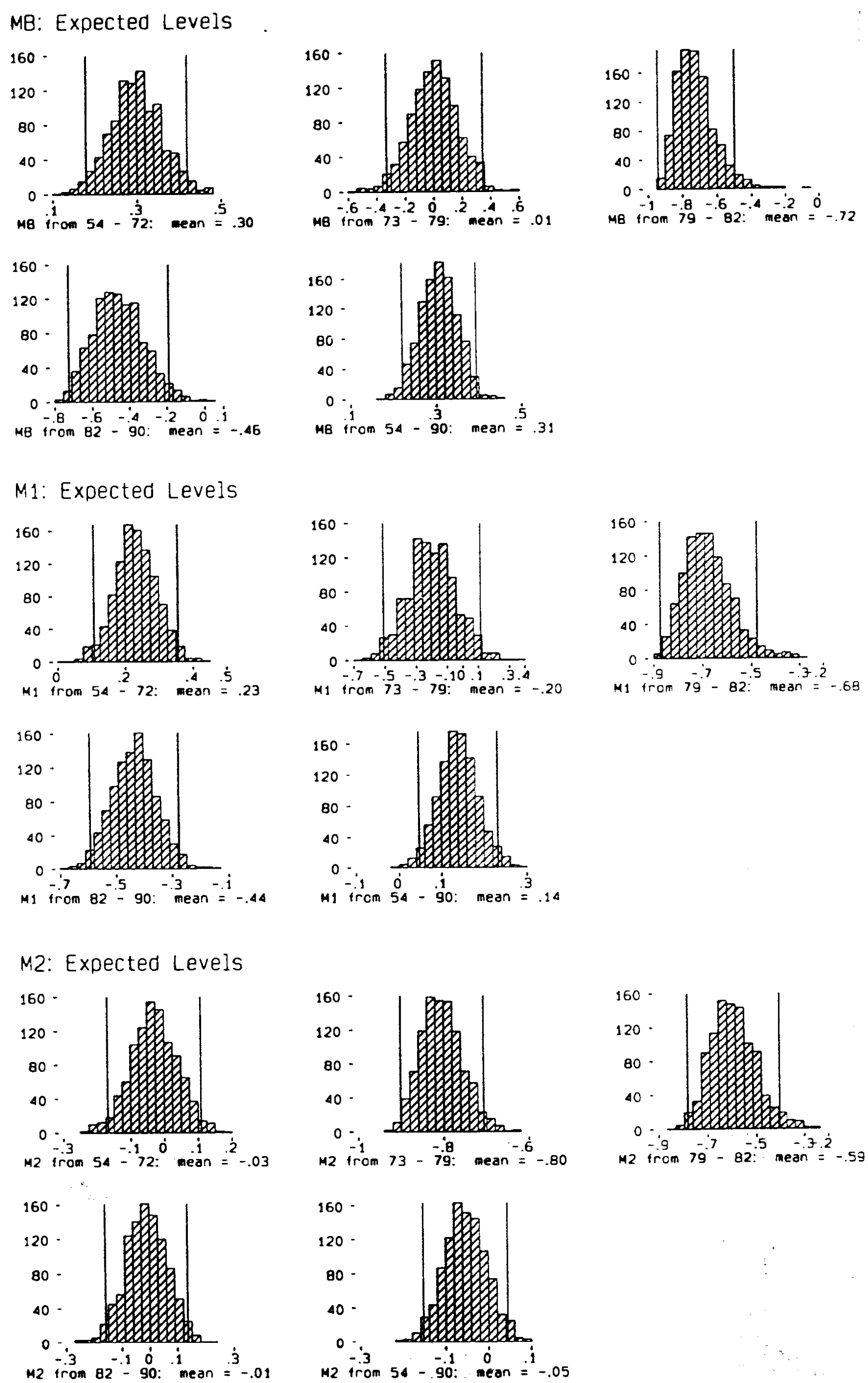


Figure 7. Correlation of Anticipated Changes in Money Growth and the Funds Rate:

Empirical distributions based on 1000 draws from estimated VAR coefficients

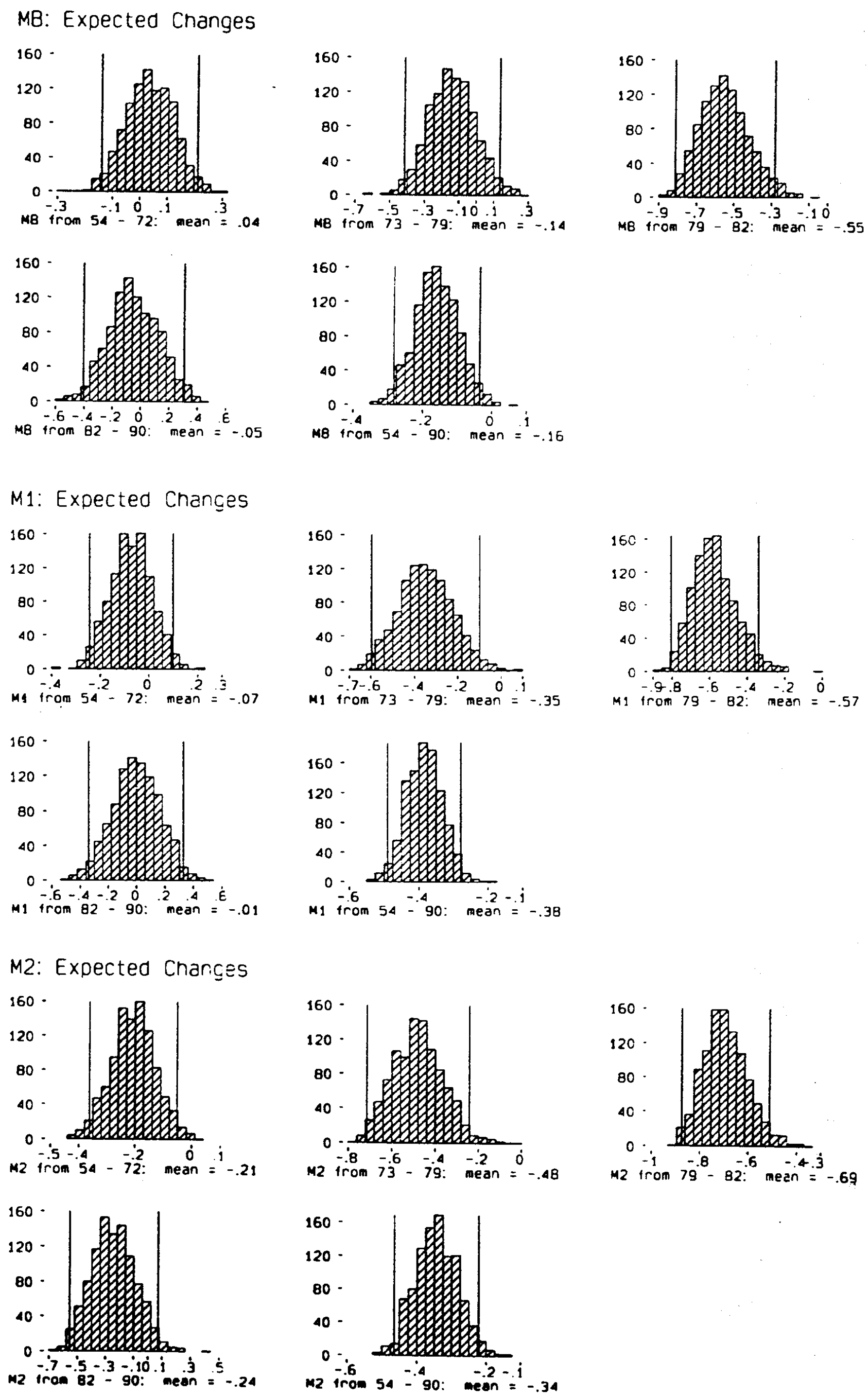
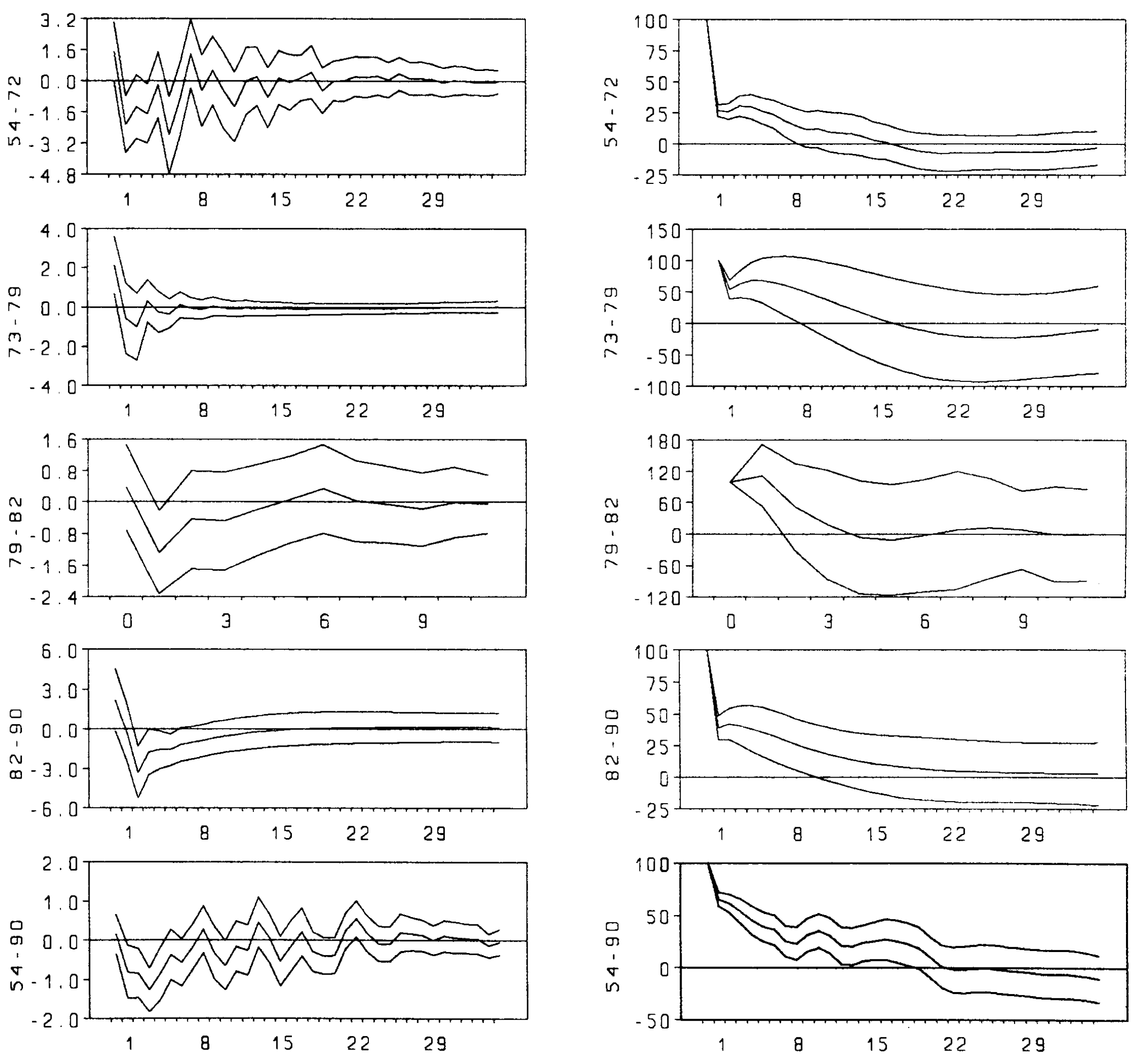


Figure 8. Unrestricted VAR with Funds Rate Innovation Predetermined

(center line is the point estimate and outer lines are two-standard-error bands)

Responses of Base to 100 Basis Point Innovation in Funds Rate (annual percentage points)

Responses of Funds Rate to 100 Basis Point Innovation in Funds Rate (basis points)



The VARs were estimated with the following lag lengths: 54-72 (12 lags), 73-79 (3 lags), 79-82 (3 lags), 82-90 (3 lags), and 54-90 (18 lags). The VAR for 79-82 includes only money growth and the funds rate.Note: The responses in 79-82 are plotted over a 12-month horizon.

Appendix A: The Data

The underlying data are monthly series from July 1954 to December 1990. The data are defined as:

MB = the nominal monetary base, seasonally adjusted, Federal Reserve Bank of St. Louis series, adjusted for reserve requirement changes, average of daily figures;

M1 = the nominal M1 monetary aggregate, seasonally adjusted, Federal Reserve Board for 1959 to 1990 and Rasche (1987) for 1954 to 1958;

M2 = the nominal M2 monetary aggregate, seasonally adjusted, Federal Reserve Board for 1959 to 1990 and Rasche (1990) for 1954 to 1958;

r = federal funds rate, average of business day figures, in percent per year, Federal Reserve Board;

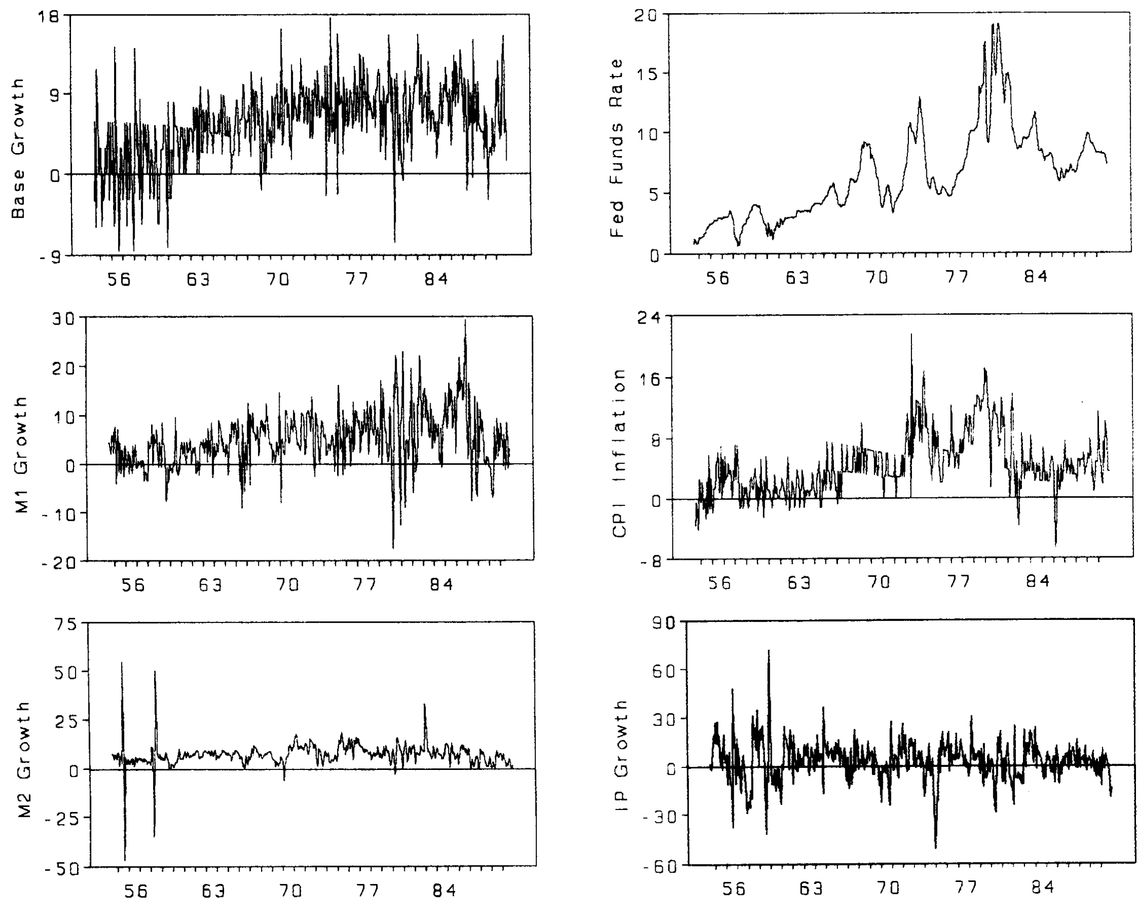
p = consumer price index for all urban consumers, seasonally adjusted;

y = total industrial production index, seasonally adjusted;

In the regressions we estimate, the money stock figure is converted to an annual percentage growth rate, $\rho_t = 1200*(\ln(M_t) - \ln(M_{t-1}))$.

Figure A.1. Data Series Used in Empirical Work

Plotted from July 1954 to December 1990



All growth rates are monthly averages at an annual rate and the federal funds rate is in percent per annum.

Appendix B: Additional Results

This appendix explores the sensitivity of the money growth-interest rate relationships estimated in the text to changing the lag lengths of the regressions, to using M1 or M2 in place of the monetary base, and to alternative orthogonalizations of the VAR. The appendix includes:

- Figures B.1A to B.1E – distributed lag regressions of the funds rate on the monetary base, M1, and M2 for a variety of lag lengths;
- Figure B.5A – unrestricted VARs using 6 lags in each sub-period;
- Figures B.5B to B.5D – unrestricted VARs with different orthogonalizations of the base;
- Figures B.5E and B.5F – unrestricted VARs with M1 and M2 predetermined;
- Figures B.6 and B.7 – histograms of the correlations between the anticipated level of base growth and the anticipated level of the funds rate and the correlations between the anticipated change in base growth and the anticipated change in the funds rate, where the anticipated variables come from VARs estimated with 6 lags in each sub-period; Table B.3 summarizes these figures;
- Figure B.8A – distributed lag regressions of base growth and M1 growth on current and past funds rates using 15 lags in each sub-period;
- Figure B.8B – unrestricted VARs using 6 lags in each sub-period, where the funds rate is predetermined;
- Figures B.8C and B.8D – unrestricted VARs with M1 and M2, where the funds rate is predetermined.

Figure B.1A. Cumulative OLS Distributed Lag Coefficients: 54-72 Various Lags

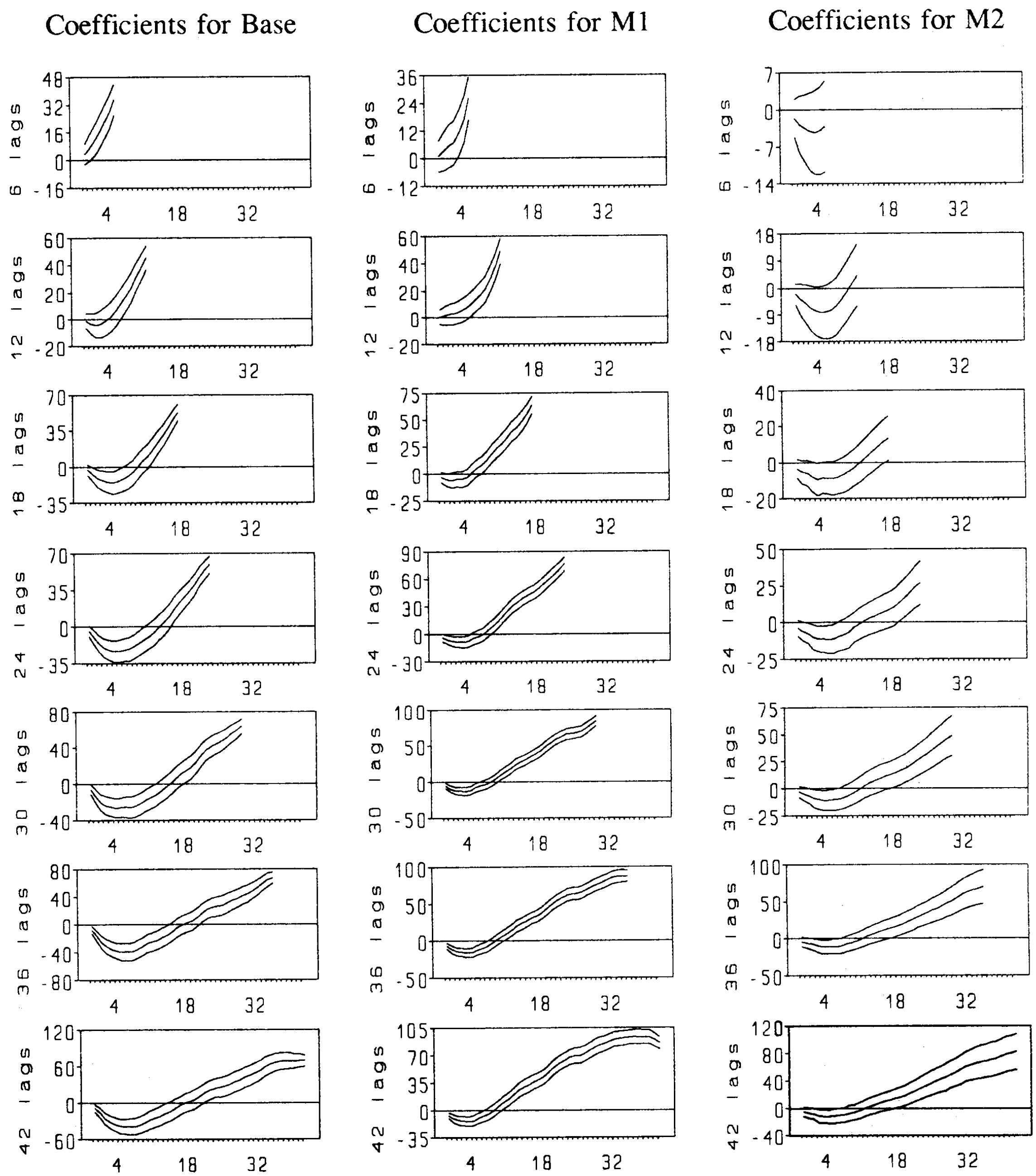


Figure B.1B. Cumulative OLS Distributed Lag Coefficients: 73-79 Various Lags

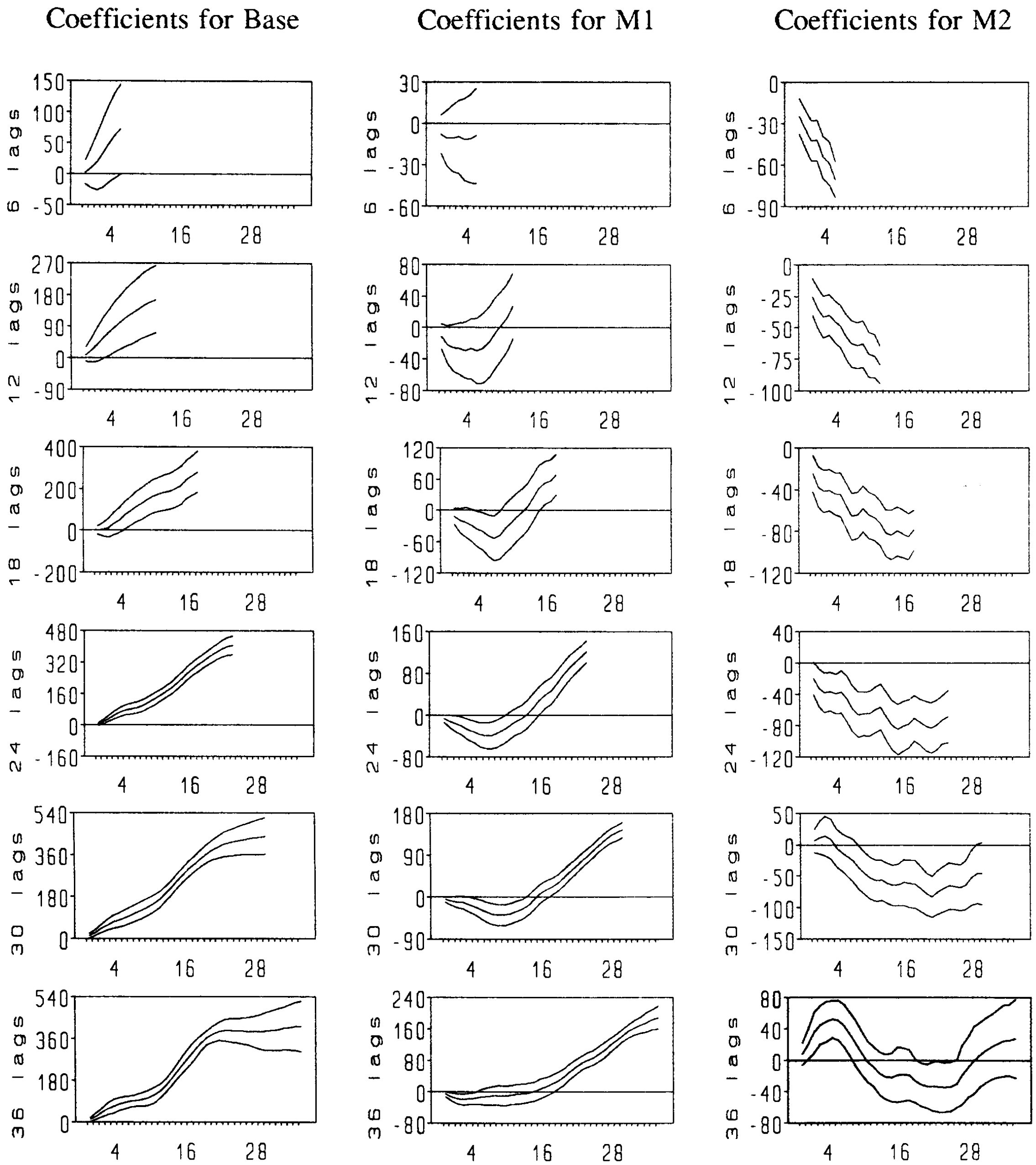


Figure B.1C. Cumulative OLS Distributed Lag Coefficients: 79-82 Various Lags

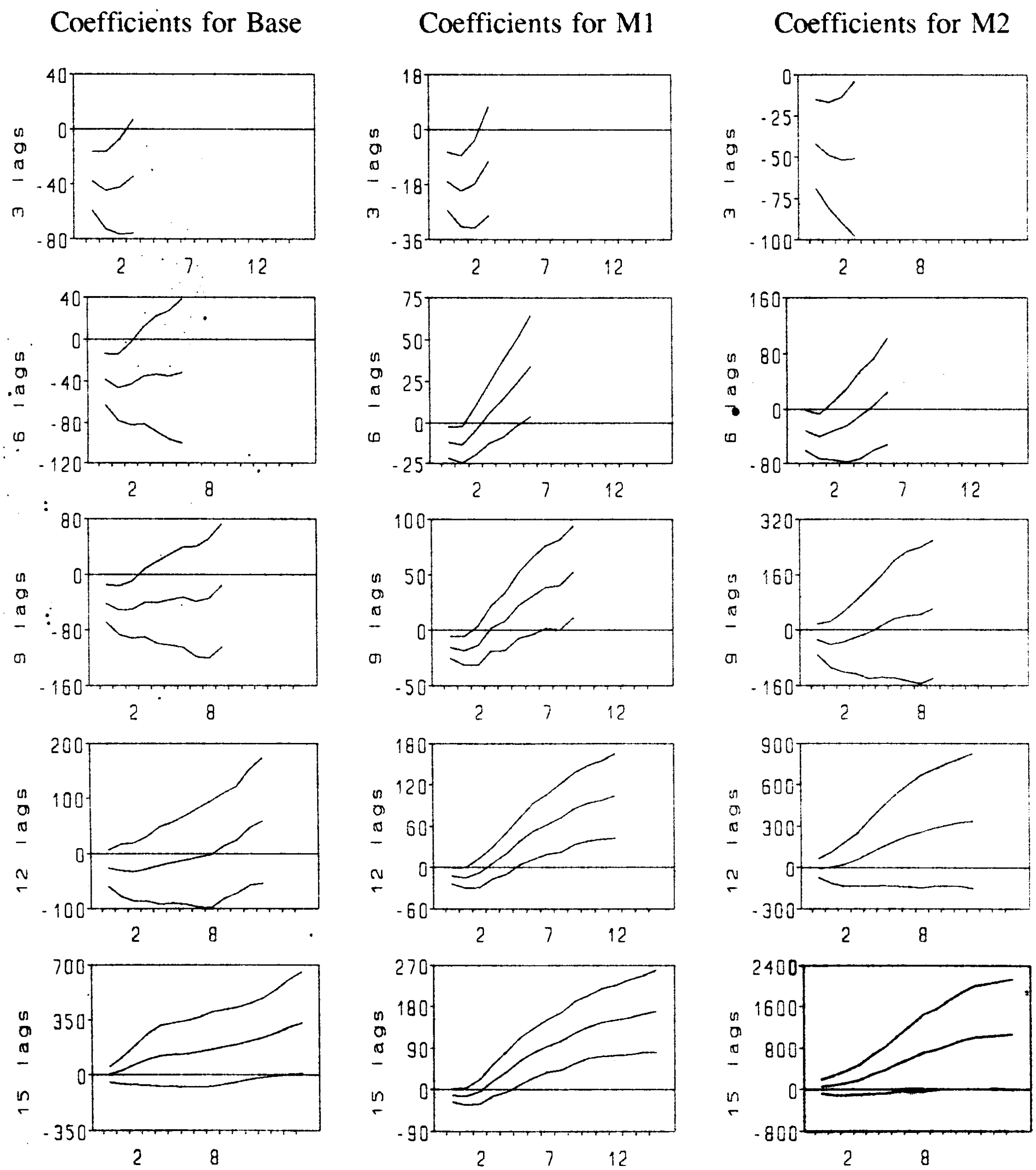


Figure B.1D. Cumulative OLS Distributed Lag Coefficients: 82-90 Various Lags

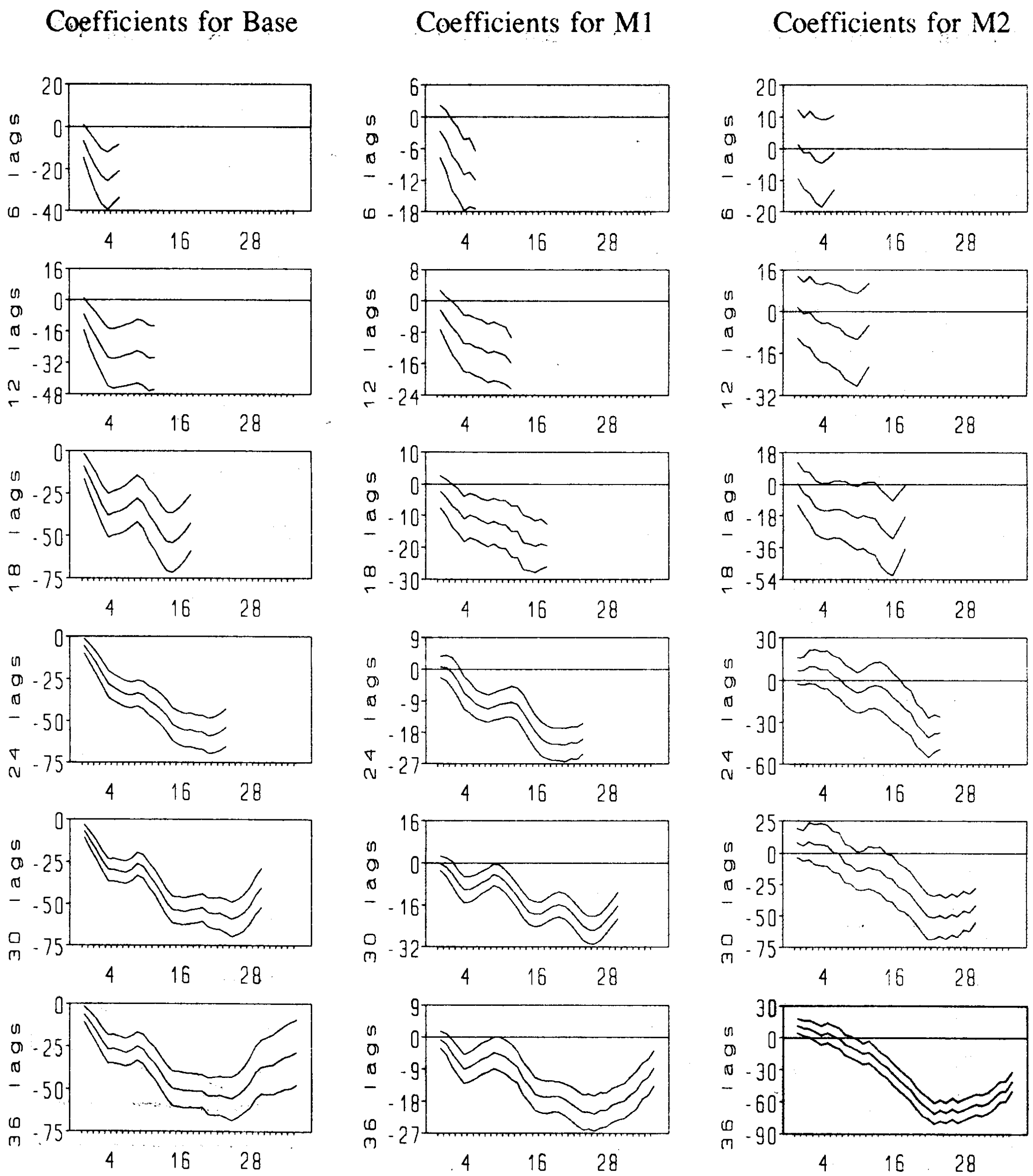


Figure B.1E. Cumulative OLS Distributed Lag Coefficients: 54-90 Various Lags

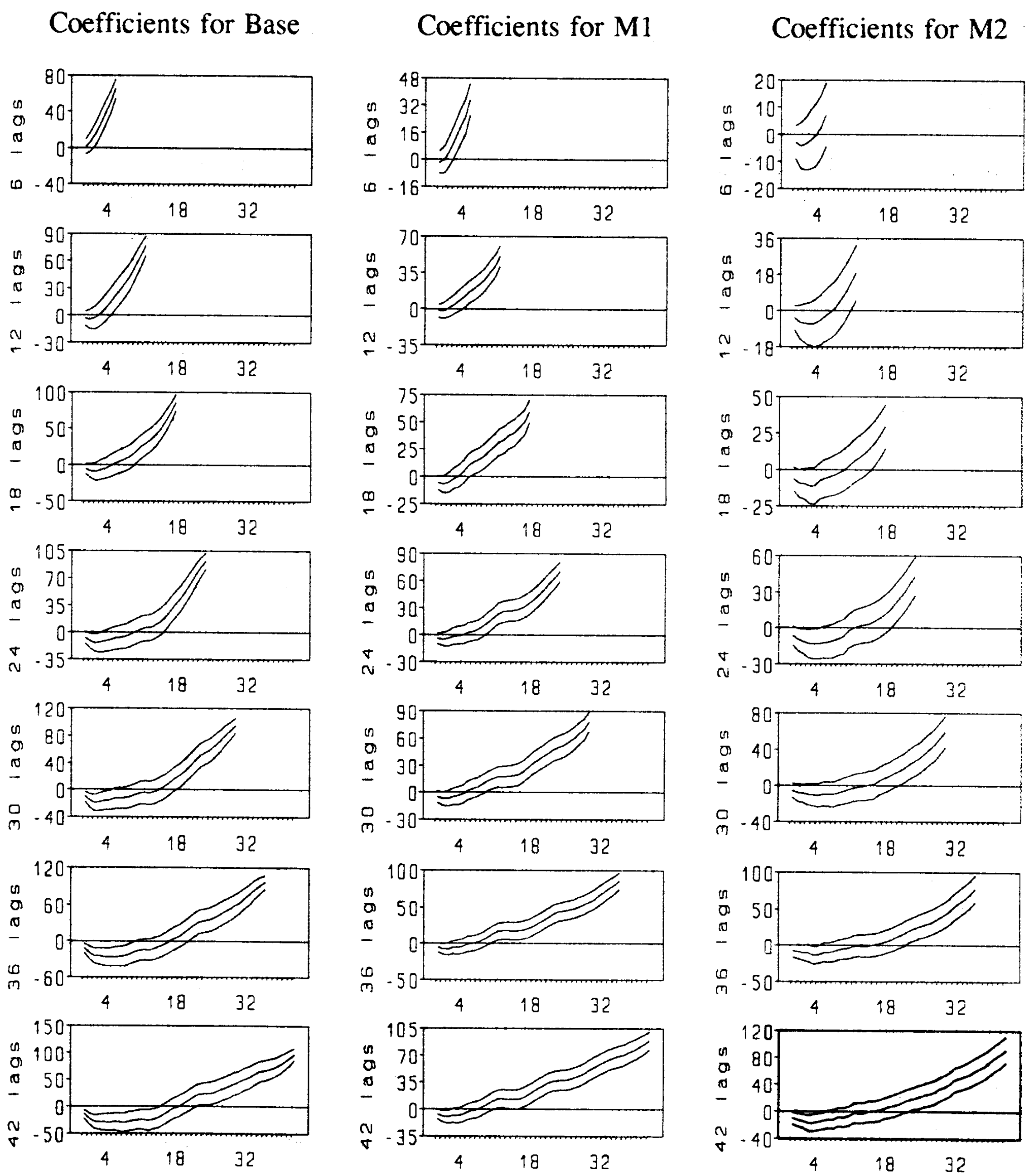
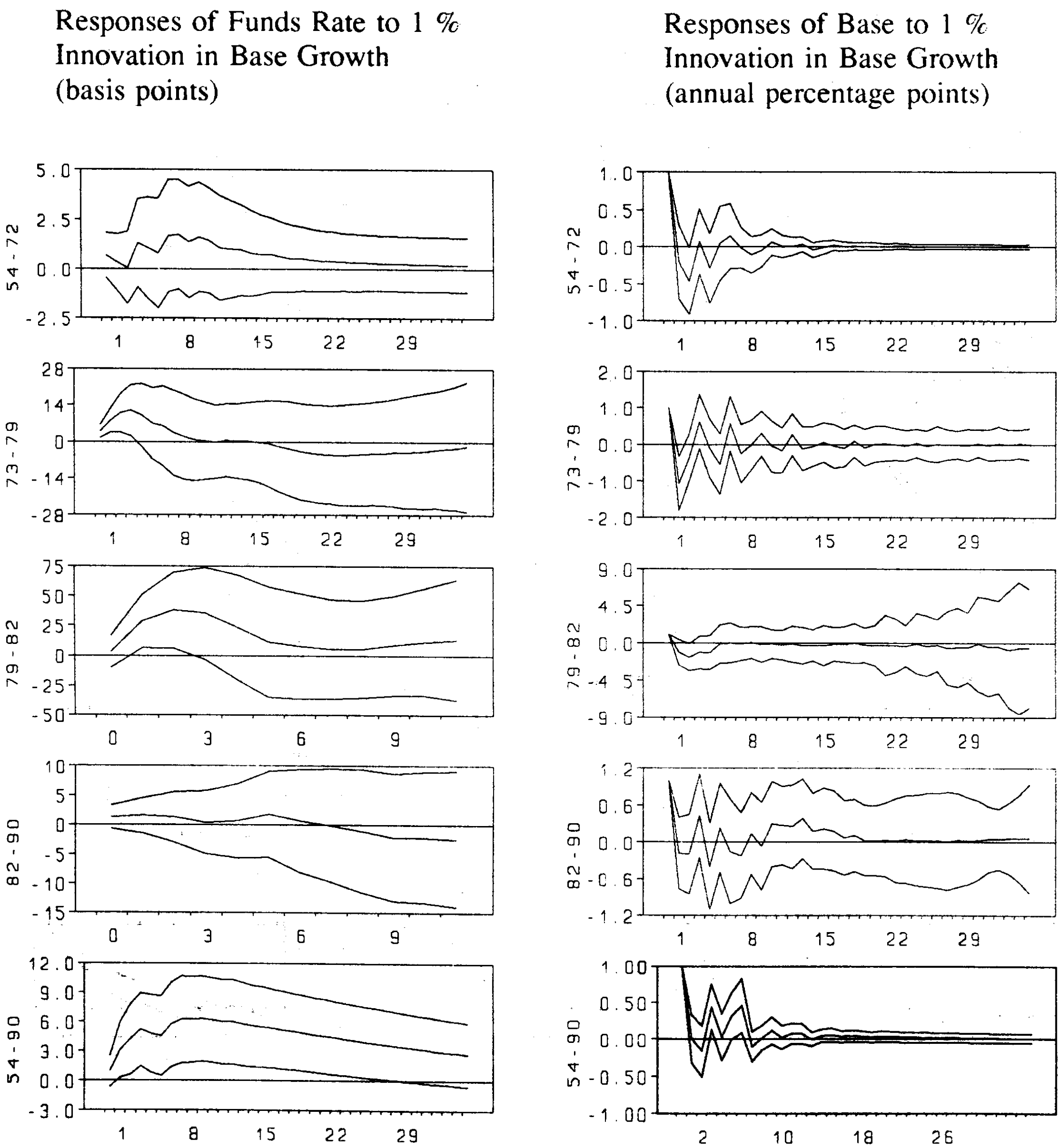


Figure B.5A. Unrestricted VAR with Money Innovation Predetermined: 6 Lags

(center line is the point estimate and outer lines are two-standard-error bands)



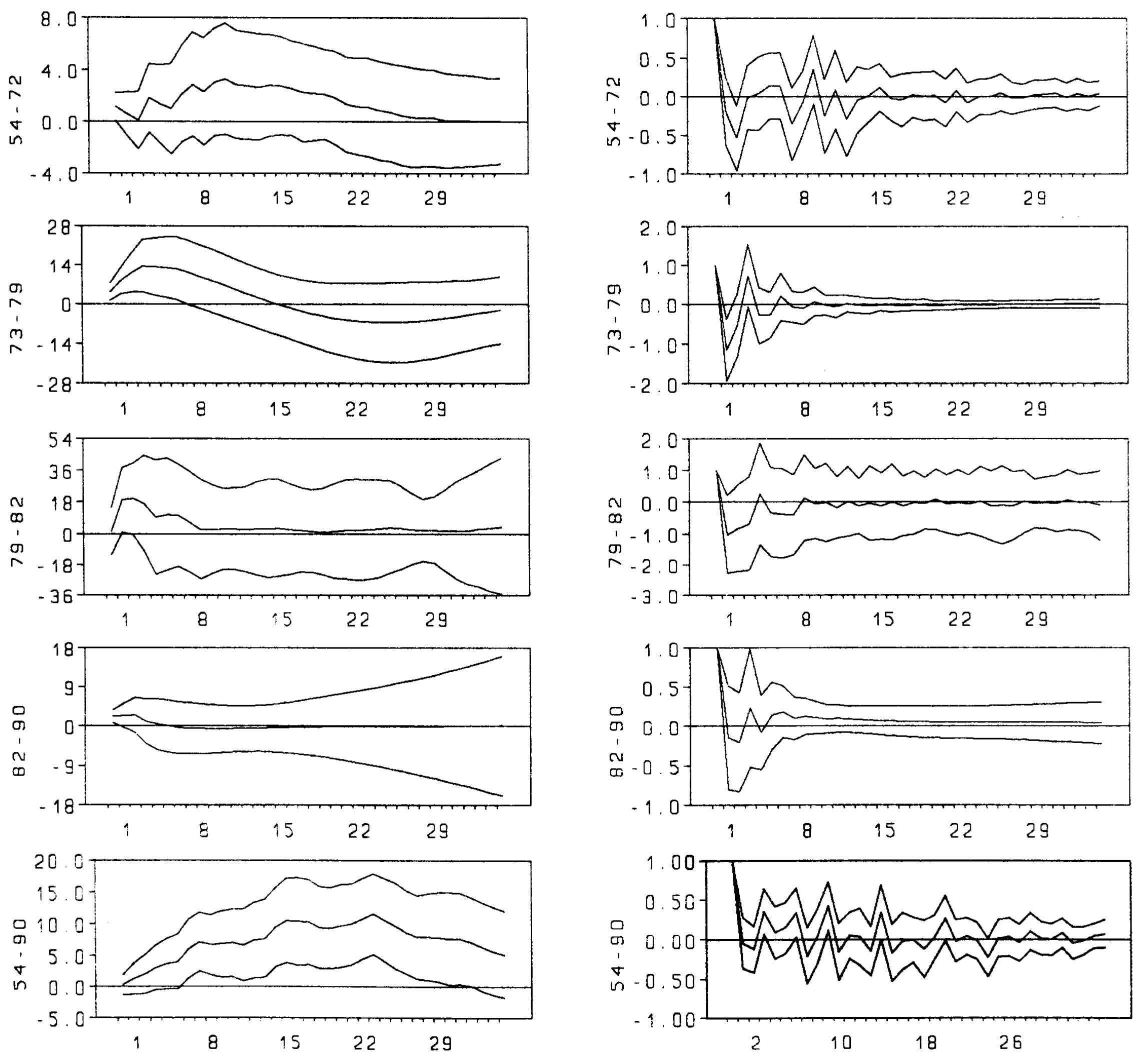
Note: The funds rate responses in 79-82 and 82-90 are plotted over a 12-month horizon.

Figure B.5B. Unrestricted VAR with Output Predetermined

(center line is the point estimate and outer lines are two-standard-error bands)

Responses of Funds Rate to 1 % Innovation in Base Growth (basis points)

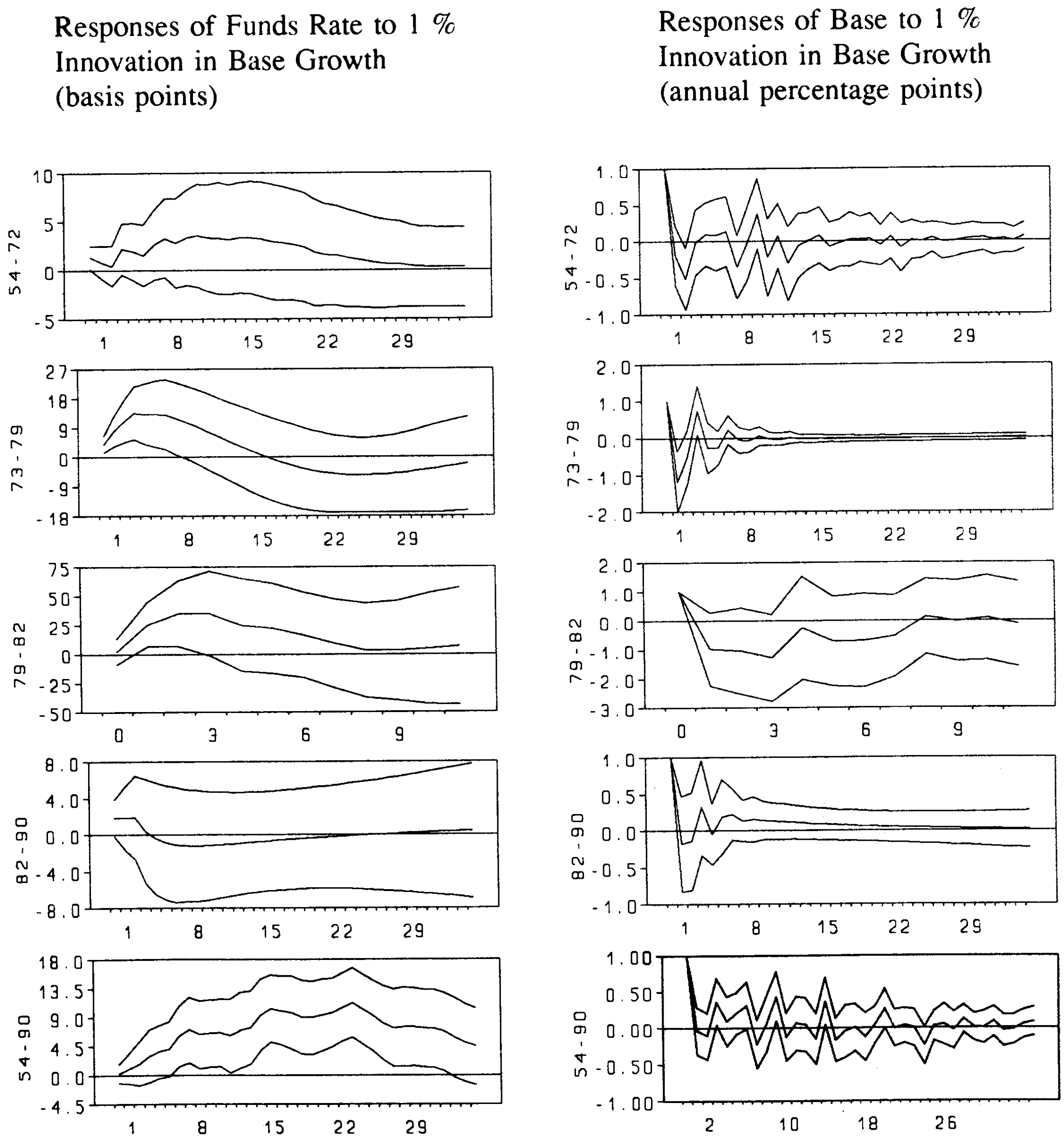
Responses of Base to 1 % Innovation in Base Growth (annual percentage points)



The VARs were estimated with following lag lengths: 54-72 (12 lags), 73-79 (3 lags), 79-82 (3 lags), 82-90 (3 lags), 54-90 (18 lags).

Figure B.5C. Unrestricted VAR with Prices Predetermined

(center line is the point estimate and outer lines are two-standard-error bands)



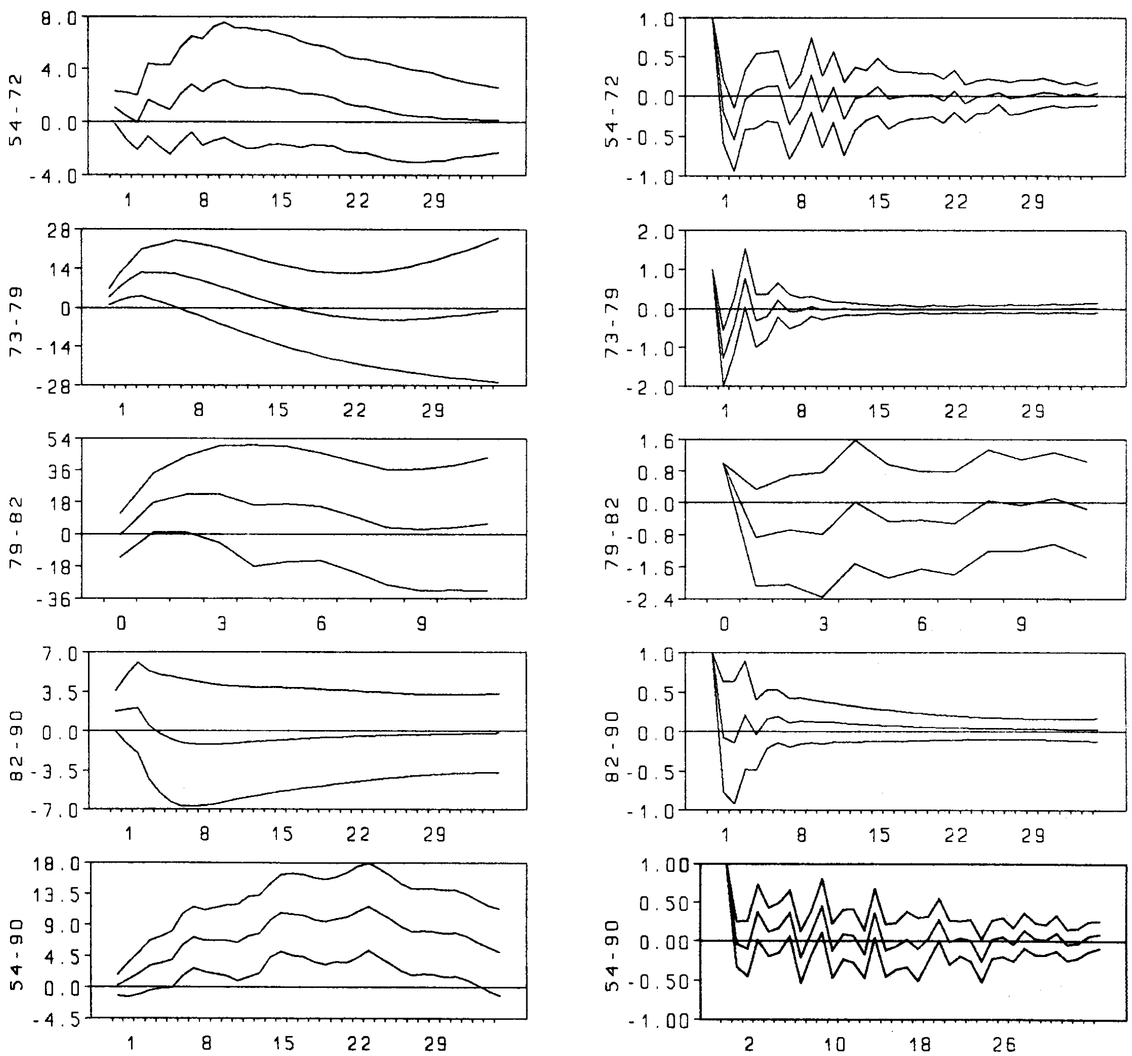
The VARs were estimated with following lag lengths: 54-72 (12 lags), 73-79 (3 lags), 79-82 (3 lags), 82-90 (3 lags), 54-90 (18 lags). Note: The responses in 79-82 are plotted over a 12-month horizon.

Figure B.5D. Unrestricted VAR with Output and Prices Predetermined

(center line is the point estimate and outer lines are two-standard-error bands)

Responses of Funds Rate to 1 % Innovation in Base Growth (basis points)

Responses of Base to 1 % Innovation in Base Growth (annual percentage points)



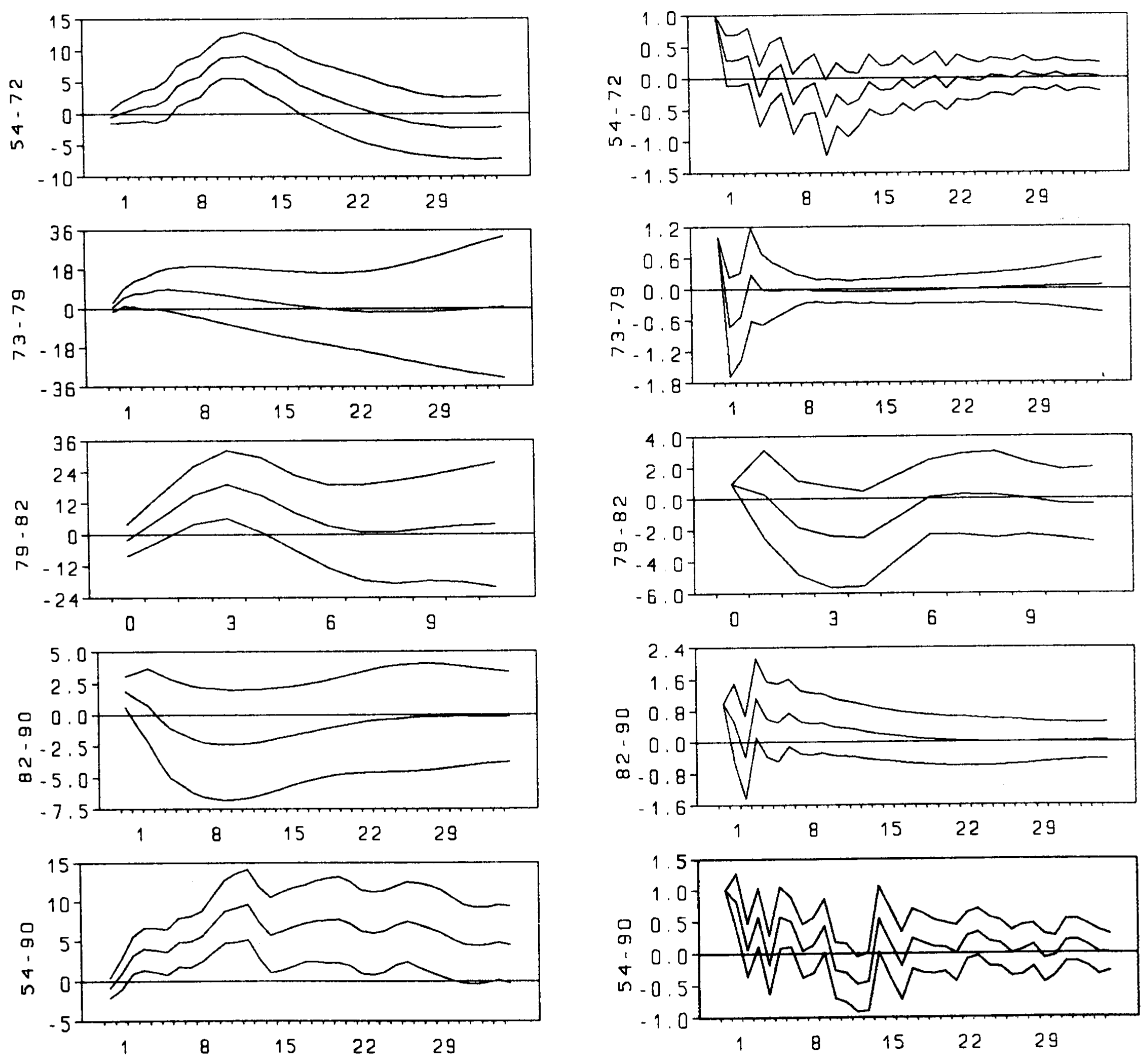
The VARs were estimated with following lag lengths: 54-72 (12 lags), 73-79 (3 lags), 79-82 (3 lags), 82-90 (3 lags), 54-90 (18 lags). Note: The responses in 79-82 are plotted over a 12-month horizon.

Figure B.5E. Unrestricted VAR with Money Innovation Predetermined: M1

(center line is the point estimate and outer lines are two-standard-error bands)

Responses of Funds Rate to 1 % Innovation in M1 Growth (basis points)

Responses of M1 to 1 % Innovation in M1 Growth (annual percentage points)



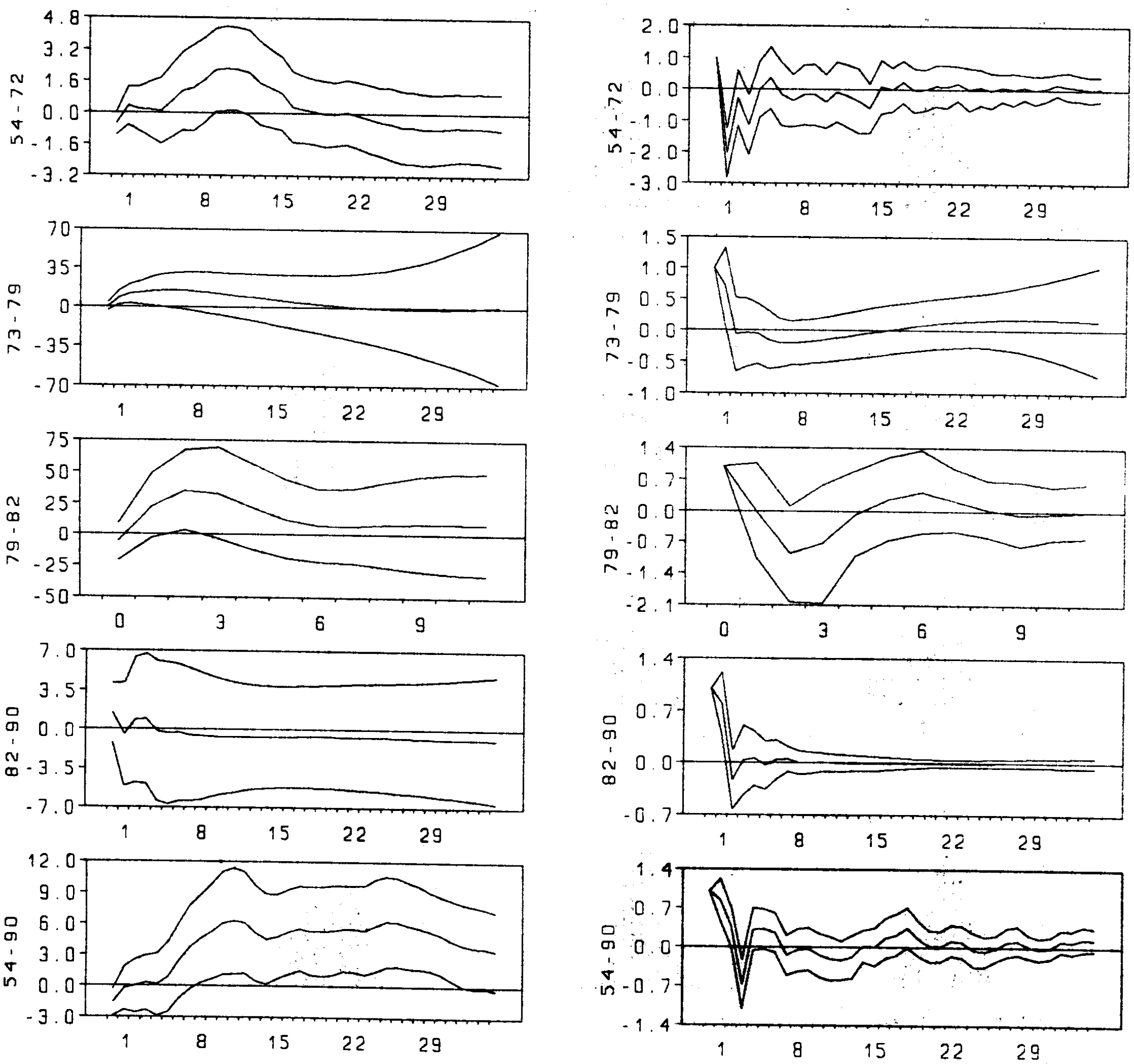
The VARs were estimated with following lag lengths: 54-72 (12 lags), 73-79 (3 lags), 79-82 (3 lags), 82-90 (3 lags), 54-90 (18 lags). Note: The responses in 79-82 are plotted over a 12-month horizon.

Figure B.5F. Unrestricted VAR with Money Innovation Predetermined: M2

(center line is the point estimate and outer lines are two-standard-error bands)

Responses of Funds Rate to 1 % Innovation in M2 Growth (basis points)

Responses of M2 to 1 % Innovation in M2 Growth (annual percentage points)



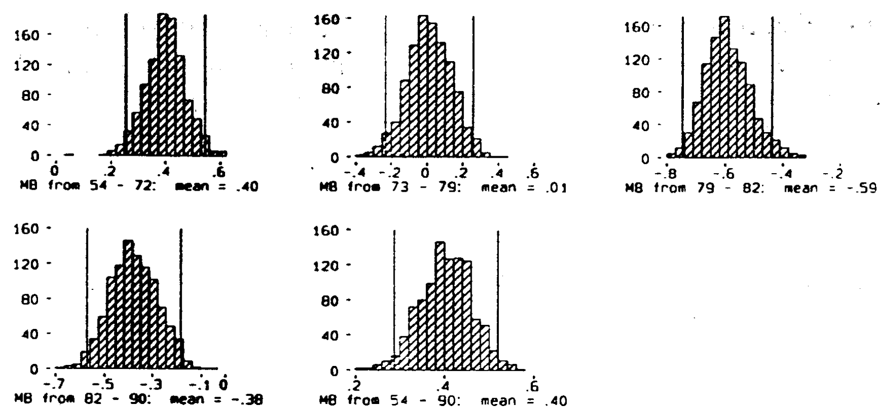
The VARs were estimated with following lag lengths: 54-72 (12 lags), 73-79 (3 lags), 79-82 (3 lags), 82-90 (3 lags), 54-90 (18 lags). Note: The responses in 79-82 are plotted over a 12-month horizon.

Figure B.6. Correlation of Anticipated Levels of Money Growth and the Funds Rate:

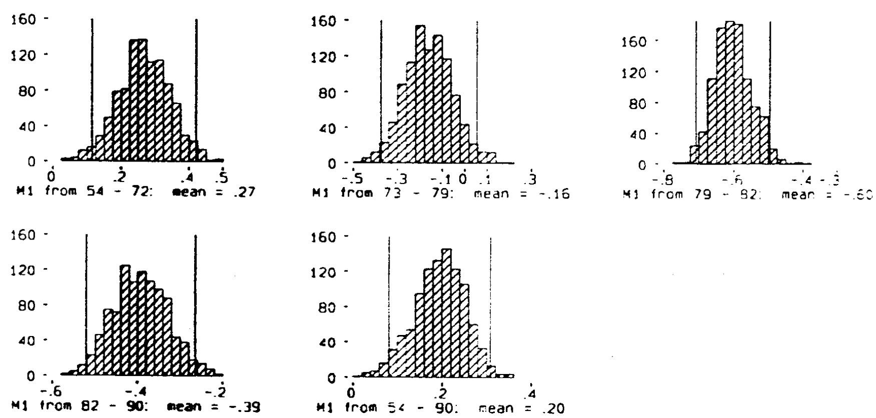
Using 6 Lags in all VARs

Empirical distributions based on 1000 draws from estimated VAR coefficients

MB: Expected Levels



M1: Expected Levels



M2: Expected Levels

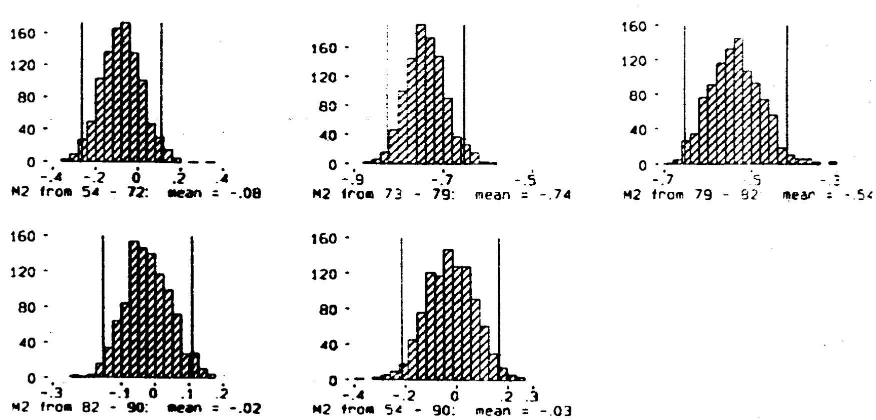


Figure B.7. Correlation of Anticipated Changes in Money Growth and the Funds Rate:

Using 6 Lags in all VARs

Empirical distributions based on 1000 draws from estimated VAR coefficients

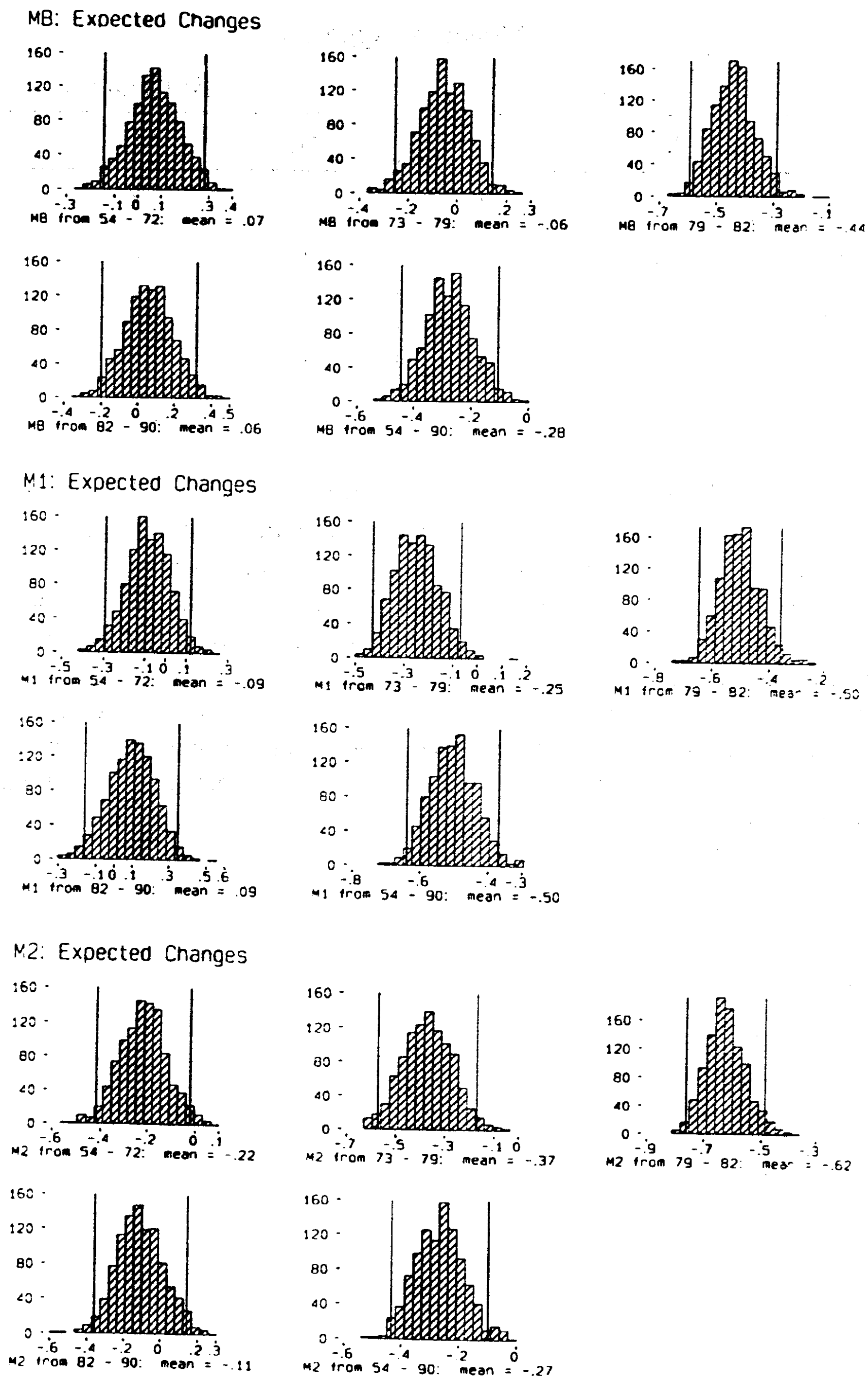


Table B.3. Correlations Between Anticipated Money Growth and the Funds Rate.

Using 6 Lags in all VARs

	Monetary Aggregate					
	A: Levels			B: Changes		
Sub-Period	MB	M1	M2	MB	M1	M2
54-72	+ +	+ +	0	0	0	–
73-79	0	0	– –	0	–	– –
79-82	– –	– –	– –	– –	– –	– –
82-90	– –	– –	0	0	0	0
54-90	+ +	+ +	0	– –	– –	– –

Notes: Results are based on Monte Carlo experiments with 1000 draws. Entries in the table indicate whether the two-standard-deviation band for the simulated contemporaneous correlations includes zero, is positive, or is negative. Double symbols mean that all 1000 realizations of the correlation were positive (+ +) or negative (– –). Panel A is the correlation between anticipated levels of money growth and anticipated levels of the funds rate, and Panel B is the correlation between anticipated changes in money growth and anticipated changes in the funds rate. The anticipated money growth and funds rate series are one-step-ahead forecasts from a VAR including money growth (the monetary base, M1, or M2), the funds rate, industrial production, and consumer prices. The 79-82 period uses a bivariate VAR in money and interest rates.

Figure B.8A. Cumulative OLS Distributed Lag Coefficients: 15 Lags

Results from a regression of money growth on current and past funds rates

(center line is the point estimate and outer lines are tw-standard-error bands)

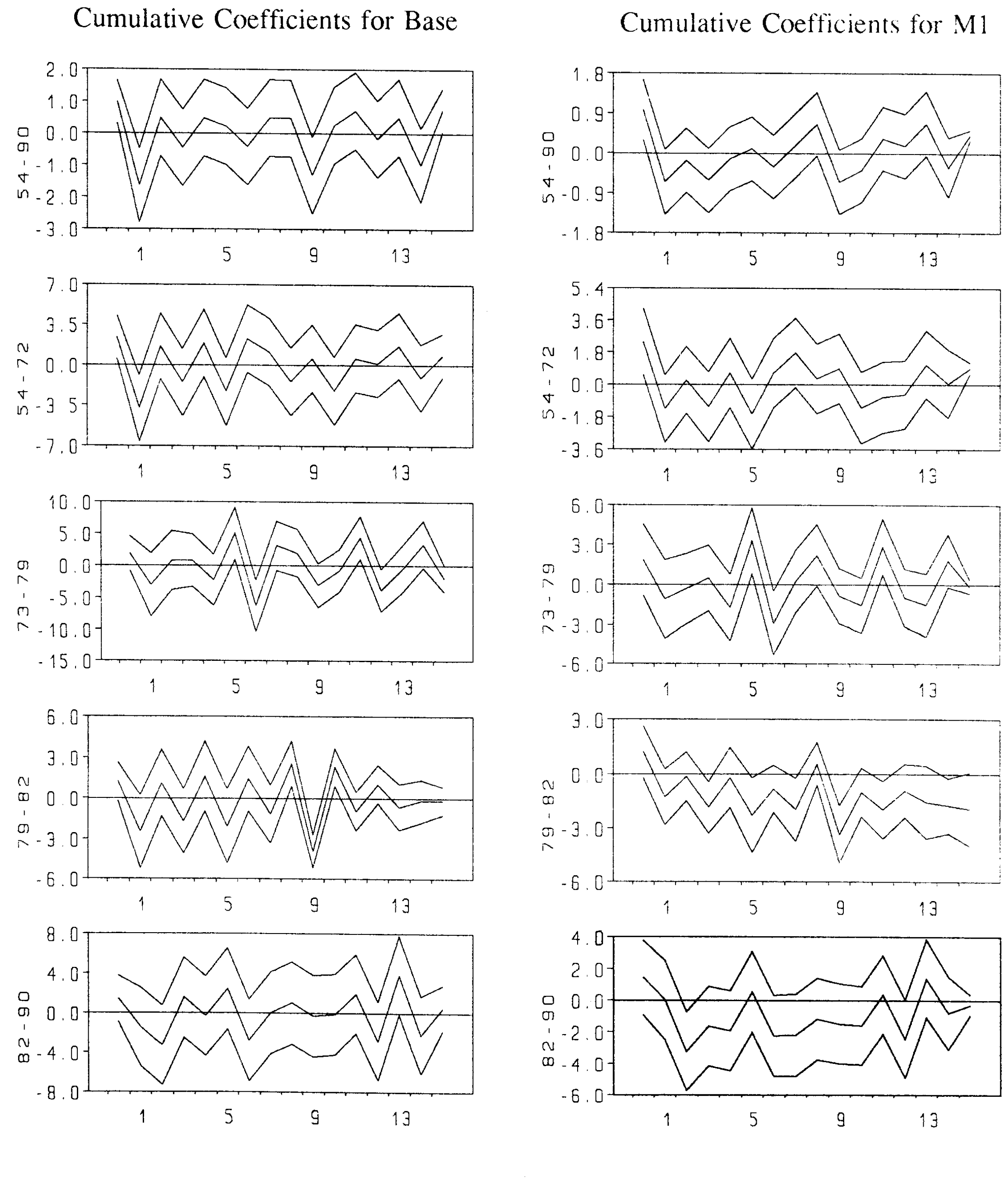
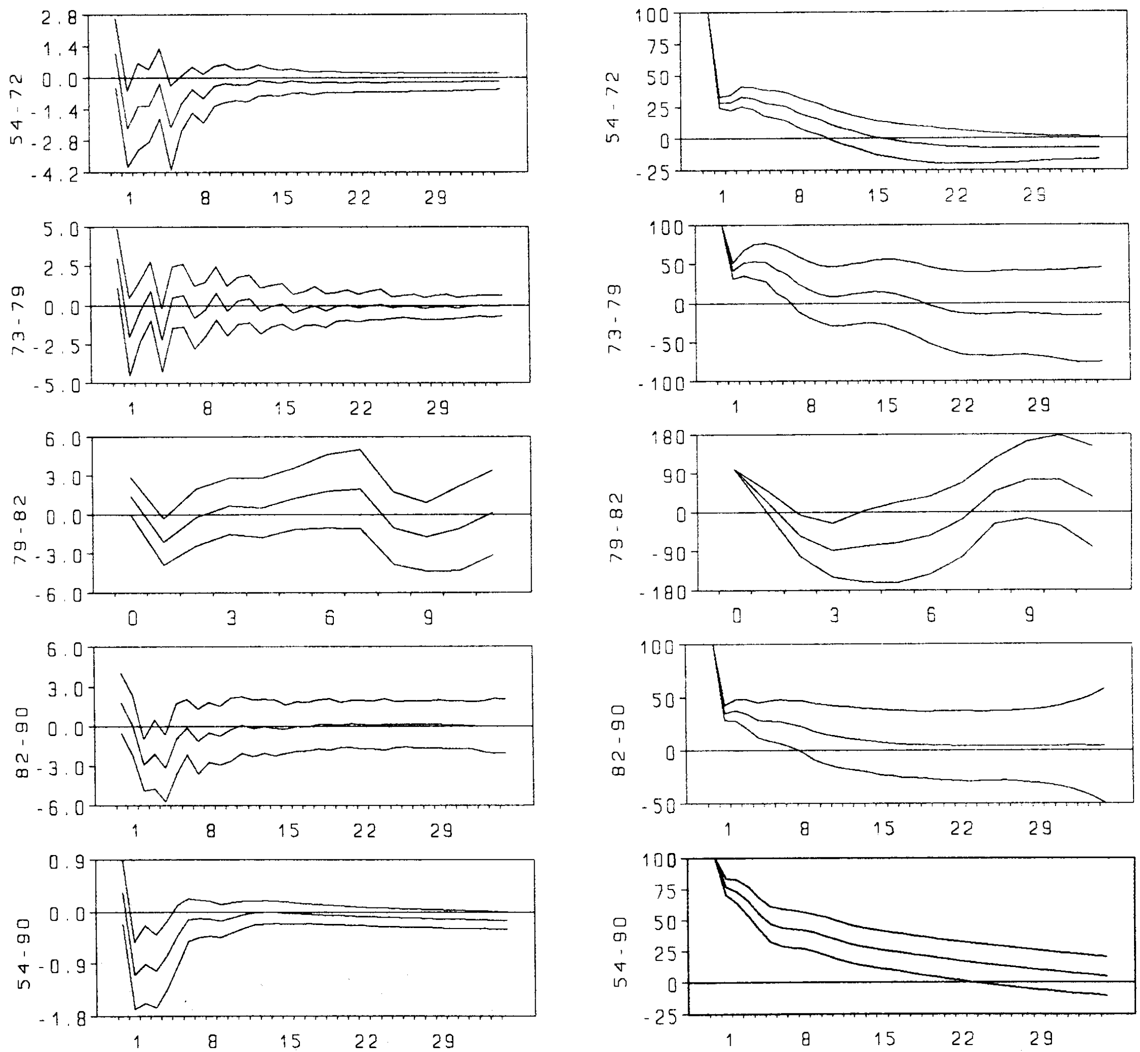


Figure B.8B. Unrestricted VAR with Funds Innovation Predetermined: MB with 6 Lags

(center line is the point estimate and outer lines are two-standard-error bands)

Responses of Base to 100 Basis Point Innovation in Funds Rate (annual percentage points)

Responses of Funds Rate to 100 Basis Point Innovation in Funds Rate (basis points)



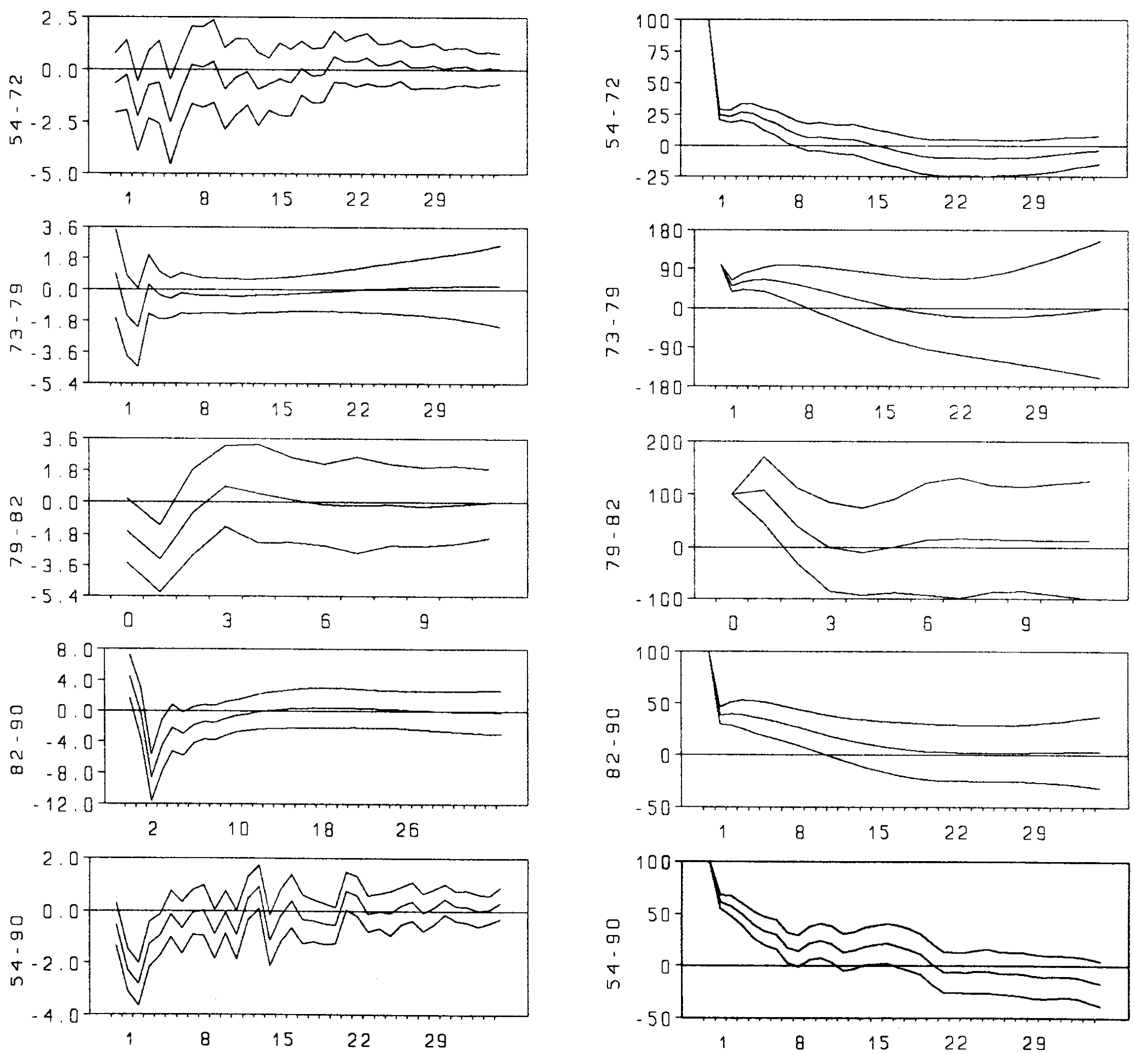
Note: The responses in 79-82 are plotted over a 12-month horizon.

Figure B.8C. Unrestricted VAR with Funds Innovation Predetermined: M1

(center line is the point estimate and outer lines are two-standard-error bands)

Responses of M1 to 100 Basis Point Innovation in Funds Rate (annual percentage points)

Responses of Funds Rate to 100 Basis Point Innovation in Funds Rate (basis points)



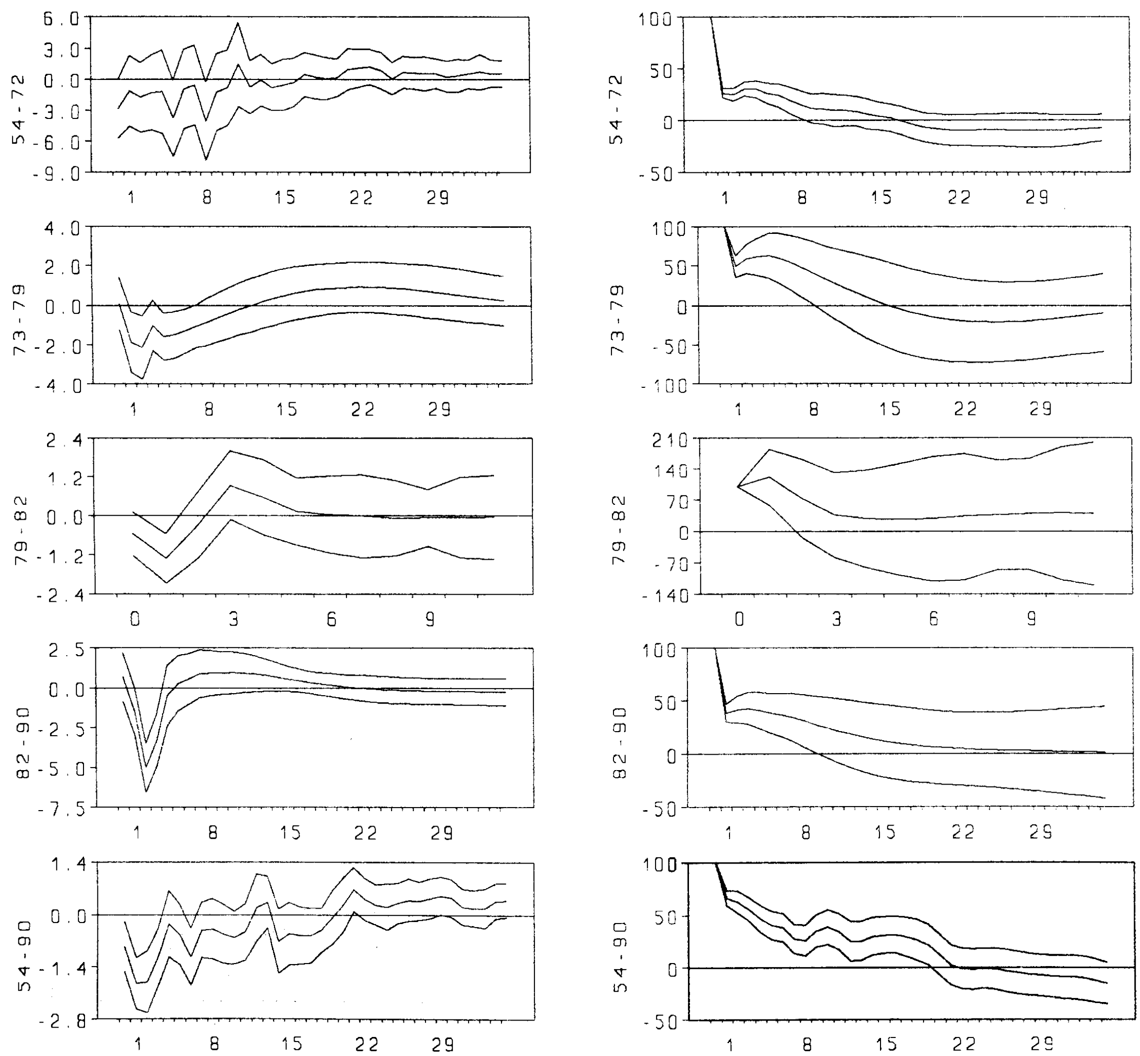
VARs were estimated with following lag lengths: 54-72 (12 lags), 73-79 (3 lags), 79-82 (3 lags), 82-90 (3 lags), 54-90 (18 lags). Note: The responses in 79-82 are plotted over a 12-month horizon.

Figure B.8D. Unrestricted VAR with Funds Innovation Predetermined: M2

(center line is the point estimate and outer lines are two-standard-error bands)

Responses of M2 to 100 Basis Point Innovation in Funds Rate (annual percentage points)

Responses of Funds Rate to 100 Basis Point Innovation in Funds Rate (basis points)



VARs were estimated with following lag lengths: 54-72 (12 lags), 73-79 (3 lags), 79-82 (3 lags), 82-90 (3 lags), 54-90 (18 lags). Note: The responses in 79-82 are plotted over a 12-month horizon.