FEDERAL RESERVE REACTION FUNCTIONS AND THE EFFECTIVENESS OF MONETARY POLICY

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Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
DOCTOR OF PHILOSOPHY
July, 1985

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MONETARY POLICY

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ACKNOWLEDGEMENTS

I wish to express my gratitude to Dr. Frank G. Steindl for his help, patient guidance, and deep understanding throughout the course of this study. I am also thankful to the members of my committee, Dr. John D. Rea, Dr. Michael R. Edgmand, and Dr. John A. Polonchek for their help, encouragement, and valuable suggestions.

I am grateful to Dr. Richard H. Leftwich, who has read this manuscript for me, and thankful to Dr. David G. Bivin for his valuable suggestions. I am also thankful to the Faculty of this department, from them I have learned as much as I can during my studying in Stillwater.

The financial support of an assistantship from the Department of Economics since August 1982 until now is also gratefully acknowledged. Finally, I am deeply grateful to my family for their encouragement all the time.

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CHAPTER I

INTRODUCTION

The money supply is affected by the interaction of the monetary authority, the banking system, and the public [Branson, 1979; Brunner and Meltzer, 1968; Burger and Rasche, 1977; Cagan, 1965; Friedman and Schwartz, 1963b; Steindl, 1982]. The Federal Reserve can control nonborrowed reserves directly through open market operations to affect the money supply. It is postulated that a causal relationship runs primarily from money to income and prices rather than in the opposite direction [Barro, 1981c; Cagan, 1965; Friedman and Schwartz, 1963a; Laidler, 1981]. It is also suggested that there is a predictable relationship between a change in money growth and a subsequent change in GNP growth [Brunner and Meltzer, 1983]. Monetarists have viewed that monetary impulses are a major factor determining variations in economic activity [Brunner, 1968; Laidler, 1981]. Accelerations or decelerations of the money supply are closely followed by accelerations or decelerations in economic activity. It is evident that the behavior of the Federal Reserve is related to basic economic goals: full employment, economic growth, price stability, and equilibrium in the balance of payments. Money market conditions are traditionally viewed by the Federal Reserve in pursuing its short-run objective of minimizing economic fluctuation [Havrilesky, Sapp, and Schweitzer, 1975; Teigen, 1969; Wood, 1967]. There exists a simultaneous relationship between Federal Reserve behavior and economic activity.

To monetarists, changes in the money stock result in short-run changes in both nominal and real magnitudes (such as output, employment, and real interest rates), while influencing only nominal magnitudes in the long run (such as total spending, prices, and market interest rates) [Friedman, Brunner, Meltzer, Tobin, Davidson, and Patinkin, 1974; Laidler, 1973 and 1981]. Under the rational expectations hypothesis, only the unanticipated money movements can have nonneutral effects on real variables because random movements in the money supply cannot be immediately distinguished from random movements in relative demand [Attfield and Duck, 1983; Barro, 1981a, 1981b, and 1981c; Griffiths and Wood, 1981]. The temporary trade-off between inflation and unemployment comes from the unanticipated inflation.

The purpose of this study is to test the policy ineffectiveness proposition--systematic policy cannot affect real variables in the short run and long run--empirically. In previous studies, the money supply has been generally used as the exogenous variable to test the effects of monetary actions on certain strategic economic variables [Andersen and Carlson, 1970; Beenstock and Dicks, 1983]. In the Fair model [1976], the value of government securities outstanding is used as a monetary policy variable controlled by the Federal Reserve. However, the money supply or the behavior of the Federal Reserve can have both exogenous and endogenous dimensions. In this study, the exogenous determinants of nonborrowed reserves are used as the policy-controlled parameters to test the neutrality of monetary policy in the long run. Within the target-instrument framework, a reaction function that relates Federal Reserve open market operations to policy goals is formed to explain both the endogenous and exogenous behavior of the monetary authority. Since the decision period of the Federal Reserve is much shorter, quarterly observations are able to capture only the average Federal Reserve response to economic events. Because of uncertainty about the detailed structure of the transmission mechanism and lags in the receipt of information about policy goal variables, intermediate targets are used by the monetary authority as an immediate operating guide in the money markets. Therefore, an alternative reaction function that explains how the Federal Reserve responds to intermediate targets is also estimated. These reaction functions are estimated by the instrumental-variables estimation technique. A money supply function that has the stock of money endogenously determined by the actions of the monetary authority, the banking system, and the public is then estimated. The money supply function is estimated by the instrumental-variables estimation technique, and the autoregressive procedure is used to correct the problem of serial correlation. A small dynamic macroeconometric model that treats the stock of money as endogenous and incorporates rational expectations is developed, estimated, and simulated. The model is estimated by the three-stage least-squares (3SLS) technique.

A survey of various theoretical studies is contained in chapter II. The process of monetary policy-making, the endogenous money supply, monetary institutions, and the effectiveness of monetary policy are discussed. The specification of reaction functions for the monetary authority, the money supply function, and a small macroeconometric model with rational expectations are presented in chapter III. The estimating techniques and data, the estimated models, and the econometric results are discussed in chapter IV. The equations and model are estimated using quarterly (seasonally adjusted) data for the United States over the 1953:1-1984:2 period.

CHAPTER II

THEORETICAL STUDIES

The Process of Monetary Policy Making

Targets, Instruments, and Indicators

The strategy for policy control includes policy goals, intermediate policy targets, and policy instruments [B. M. Friedman, 1975; Saving, 1967]. Targets are measures used to guide the adjustment of policy variables. Full employment, economic growth, price stability, and equilibrium in the balance of payments are the commonly cited policy goals--the ultimate targets--of monetary policy. Intermediate targets are short-run operating guides. They are treated by the central bank as though they are the ultimate targets of policy, the view being that the intermediate targets are "closely" linked to the ultimate targets. Two reasons why the monetary authority adopts intermediate targets are: (1) some degree of uncertainty about the detailed structure of the transmission mechanism, and (2) the (recognition) lag in the receipt of information about the policy goal variables by the central bank.

Monetary instruments are the tools of control directly manipulated by the monetary authority. The policy instruments of the Federal Reserve System include open market operations, the discount window, reserve requirements, Regulation Q, and moral suasion. The principal instrument of monetary management is open market operations. The Federal Open Market Committee (FOMC) of the Federal Reserve sets operating targets at each meeting and these decisions are intended to guide the open market trading desk at the Federal Reserve Bank of New York in planning security transactions. Adjustments in those instruments other than open market operations alter the relative rates of return either across banks or across different types of assets and liabilities [Kane, 1974].

Discount-rate policy can be viewed as a subsidy when the Federal Funds rate is above the discount rate. Changes in the difference between the Federal Funds rate and the discount rate are mainly influenced by the policy of the Federal Reserve.[1] That the Federal Funds rate is frequently above the discount rate since 1965 indicates nonprice rationing administered at the discount window [Goodfriend, 1983]. The Monetary Control Act of 1980 has made all depository institutions subject to the reserve requirements of the Federal Reserve since November 1980.

Regulation Q tends to distort the significance of movements in the broader monetary aggregates since the loss of interest induces the public to economize on funds held in these assets and place them in competing market securities.

The Depository Institutions Deregulation Act of 1980 required that Regulation Q be eliminated by April 1986. Without interest rate ceilings, more deposit liabilities pay explicit competitive rates of interest, and interest-bearing checkable deposits will be used for transactions purposes. Therefore, changes in interest rates can be expected to have a greater impact on consumption-saving decisions and a smaller effect on the growth of deposits as interest rate ceilings are removed.

Perryman [1983] indicates that there are three conceptions of what a monetary indicator should be. First, a policy indicator should measure the thrust of monetary actions, permitting the classification of policy as "easy" or "tight". In this sense it is used directly by the central bank, or it is used to provide information to other sectors of the economy to characterize the stance of current policy. Second, it is a monetary variable that should be closely correlated with economic activity, and beneficial to those participants in financial markets who desire a measure of the future path of economic activity. Third, the relevant measure should be independent of the business cycle reflecting only the need for countercyclical policy actions. The Federal Reserve used changes in short-term interest rates or free reserves as a monetary indicators in the 1950s and 1960s.[2] Since excessive monetary expansion raises interest rates through the price expectations effect, an increase in interest rates may either reflect a tight monetary policy or result from an expansionary policy. Empirically, low interest rates are a sign of tight policy and high interest rates are a sign of easy one. From a Keynesian view, if the demand function for money were predictably stable, the money supply could be a better indicator than interest rates, and movements in the monetary aggregates would change forecasts of output and prices [Foot, 1981]. Dewald [1969, p. 322] mentions that, "if an appropriately chosen indicator were available without lag, then policy makers could aim at a particular indicator value as a target of policy.... It is indeed a variable or class of variables that could be considered as indicators as well as targets." For comparative statements about policies, an appropriate ordinal scale -- an index or indicator function of policy variables, should be constructed for ranking policy actions meaningfully [Brunner and Meltzer, 1969]. An index function cannot be accurately computed because of the lack of certainty and perfect knowledge concerning the detail of economic structure; however, an optimal approximation could be determined through appropriate analysis.

In summary, full employment, economic growth, price stability, and equilibrium in the balance of payments are the ultimate targets of monetary policy. Intermediate targets are adopted by the monetary authority as short-run operating guides. Monetary instruments are the tools to achieve intermediate targets or policy goals. Open market operations are the principal instrument of monetary management. A monetary indicator is used to characterize the stance of current policy or to measure the future path of economy activity.

The Operational Methods for Controlling the Target Variables

General Comments

The Target Variable. It is indicated that strong political forces make the Federal Reserve smooth out short-term interest rates because of the political importance of the housing market and of the behavior of mortgage interest rates [Roos, 1981; Kane, 1980]. However, the monetary authority cannot peg the nominal rate for more than a very limited period [Friedman, 1968]. Controlling the money supply by pegging the Federal Funds rate is impossible because the Federal Reserve must make changes in the monetary base to maintain a given Federal Funds rate. A pegging of interest rates implies a loss of control over the money stock. Poole [1970] has shown that, to stabilize nominal income, the monetary authority should target interest rates if money markets were more subject to unanticipated shocks than were goods markets; while it should target on the money stock if the reverse is true. Based on certain assumptions, B. M. Friedman [1975] indicates that the choice of intermediate targets depends upon the structural coefficients and upon the joint distribution of the structural disturbance terms.[3]

Controllability is concerned with how the intermediate aggregate moves with the policy instruments. Predictability is concerned with how nominal GNP moves with the intermediate aggregate. Both are important in the choice of a monetary aggregate [Corden, 1981]. A monetary aggregate must be chosen for which there is a stable demand function. The predictability (or stability) of the money-GNP relationship depends on the predictability (or stability) of the growth rate of velocity.[4] Brunner and Meltzer [1983] suggest that quarterly changes in velocity are a moving average of random shocks and there is no significant evidence of a change in the trend growth of velocity over the period 1951:2-1981:3.[5] The link between M1 growth and GNP growth is strong up to 1982:4; there is no evidence to support the view that the M2-GNP relationship was relatively stronger than the M1-GNP relationship before 1982:4 [Batten, 1983]. The M1-GNP relationship became weaker during 1982-1983. Stabilizing the money supply would not perfectly stabilize nominal income if the real side, such as changes in saving propensities or the desire to invest, or external demand factors, were unstable [Corden, 1981]. It is argued by Rasche that focusing on one aggregate would not necessarily cause major problems because the actual behavior of all the aggregates tends to be similar in the long run [Meltzer, Rasche, Sternlight, and Axilrod, 1982].

<u>The Speed of Return to Target</u>. The greater short-term

interest rate volatility and market uncertainty, the greater the costs of getting better long-run monetary control. The aggressiveness of monetary control actions depends on (1) the size of the response in short-term interest rates; (2) the relative benefits provided to the economy by more stable short-term interest rates versus better monetary control; and (3) the nature of deviations of M1 from target [Judd, 1982]. Federal Reserve research suggests that temporary aberrations in money growth rates create few difficulties for the economy so long as the desired growth rates are effectively attained within two to four quarters [Wallich, 1978].

Monetary Institution. It is difficult for any government to pursue a purely discretionary monetary policy which is independent of either fixed exchange rates or monetary rules [Griffiths and Wood, 1981]. Under the gold exchange standard (up to 1914), the gold bullion standard (1925-1931), and the gold-dollar-sterling exchange standard (1946-1971), some degree of stability in domestic prices was assured by the resulting fixed exchange rates. Since 1971, the adoption of exchange rate flexibility replaced a balance of payments problem with a domestic inflation problem as an expansionary monetary policy was followed. Barro and Gordon [1983] assert that the presence or absence of precommitment is the most important distinction between rules and discretion. A simple rule can internalize the connection between monetary actions and inflationary expectations, but it ignores uncertainty about variables or about model structure. Discretion permits what may be regarded as some desirable flexibility of monetary growth, but the monetary authority cannot predict the actual course of monetary growth and inflation. Within a discretionary regime, inflationary expectations are treated as givens, the monetary growth rate is chosen to equate the marginal cost of actual inflation to the marginal benefit from additional revenue [Barro, 1983].[6] The trade-off between unemployment and inflation is central to the policymaker's decision. The optimal solution--a natural unemployment rate and zero inflation rate occurs only if the policymaker can predict future actions [Barro and Gordon, 1983].

Monetary rules for the growth of the monetary aggregates are proposed because of procyclical monetary growth. In principle, a flexible policy based on some form of optimal control is better than a rigid rule [Sargent and Wallace, 1976]. Persistent changes in the growth of productivity may change the growth of output and the rate of money growth consistent with a fixed inflation rate. Based on the evidence from Switzerland and Canada, it may be better to operate monetary targets with some degree of discretion rather than with rigid rules. However, due to the changing structure of the economy and a long (and variable) time lag in the dynamics of monetary processes, monetarists insist that monetary policy cannot be used to fine tune the economy. To monetarists, changes in the growth rate of the money stock are the dominant cause of fluctuations in money income [Andersen and Carlson, 1970]. Monetary policy should prevent money itself from being a major source of economic disturbance. If the rules of monetary policy change frequently, the forecast of the weekly money supply made by market participants may be biased and inefficient because of an imperfect knowledge of the structure of the economy. Any attempt to use activist stabilization policy is liable to make the economy less rather than more stable. It has been shown that a systematic activist policy has no ability to stabilize the economy within some models [Brunner and Meltzer, 1983; Kmenta and Smith, 1973; Sargent and Wallace, 1976]. The key argument of monetarists is to limit the scope of governmental influence over economic activity. A more predictable control procedure would result in a more stable financial market.

In summary, the choice of intermediate targets depends upon the structure of the economy. Controllability and predictability are important in the choice of a monetary aggregate. A pegging of nominal rates implies a loss of control over the money stock. However, greater short-term interest rate volatility and market uncertainty were to be the costs of better long-run monetary control. A monetary rule with some degree of discretion is desirable. To monetarists, monetary policy cannot be used to fine tune the economy and should prevent money itself from being a major source of economic disturbance.

A Short History of Post-War Federal Reserve Open Market Operations

A 1952 study of the U. S. government securities market concluded that the Federal Reserve's open market transactions had to represent only a relatively small share of total dealer transactions to be effective for defensive type operations [Wallich and Keir, 1978]. In early 1953, the Federal Reserve decided to focus its open market operations on short-term interest rates and the free reserves of member banks. The Federal Reserve influences the Federal Funds rate and other short-term interest rates via direct control over nonborrowed reserves. Free reserves respond to changes in short-term interest rates and the discount rate. Federal Reserve policy was associated with the business cycle and disregarded money supply behavior. During the 1960-61 recession, an easy monetary policy pushed down short-term interest rates encouraging capital outflows and resulting in increased balance-of payments deficits.

The FOMC has gradually shifted from controlling money market conditions to monetary aggregate targets since the early 1960s. Around the mid-1960s, the FOMC began to focus more than it had earlier on the linkages of the monetary process to policy goals. The FOMC started using bank credit as an intermediate target in the spring of 1966.[7] However, "money market conditions" continued to be the dominant operating target for open market operations during those years. In 1970, the short-run conduct of open market operations increased the emphasis on the monetary aggregates with about equal weight on bank credit and the money stock. Bank credit and the money stock were emphasized as primary targets and their average growth ranges were specified. Open market operations were directed at maintaining money-market conditions consistent with a modest growth in the monetary aggregates. The Federal Funds rate range was to be adjusted when the growth of monetary aggregates ranged outside the target ranges or when the monetary aggregates targets were changed. Since the information on the monetary aggregates growth was available only weekly, the FOMC set a reserve target in terms of reserves available to support private deposits (RPD) as an effective day-to-day operating guide in February 1972.[8] However, the RPD growth could not be controlled tightly in the short run because of lagged reserve accounting. The FOMC continued using "money market conditions" as its immediate operating target. There was still pressure on the Federal Reserve to soften the impact of chronic government deficits on interest rates in early 1970s.

In the 1970s, inflation became a dominant economic problem. Procyclical monetary growth accelerated inflation during expansion and increased unemployment during recession. The FOMC began to report publicly the short-run target ranges for the Federal Funds rate, M1, and M2 in January 1974.[9] Short-run flexibility in the money stock was thought to be needed to offset the impact of transitory shocks on the money market and the foreign exchange market. Trying to control inflation and to achieve greater stability in output growth, annual growth rates for the monetary aggregates (M1, M2, and M3) and one measure of bank credit began being announced quarterly in and since March 1975.[10] These long-run growth ranges, normally constructed from the general economic goals, are set within 2 to 3 percent annual rate range to give the central bank some degree of flexibility. Short-run growth ranges consistent with annual growth ranges were the primary focus of open market operations.

In October 1979, the Federal Reserve adopted a reserve-aggregates approach to monetary control. Open market operations were to be conducted to control nonborrowed reserves directly rather than to control the Federal Funds rate. The main reason for a nonborrowed reserve operating target, rather than a total reserves or total base target, is that it provides more time to permit fluctuations in the money supply to average itself out [Axilrod, 1983]. The Federal Reserve establishes a total reserves path, obtained by required reserves consistent with the short-run money growth targets and an estimate of excess reserves, as a general guide.[11] Nonborrowed reserves are calculated on the basis of forecasts of bank borrowings from the Federal

Reserve. The practical operative target is a weekly average of nonborrowed reserves over a three- to five-week interval. The translation from money supply targets to the desired reserve is reviewed each week and is adjusted if the assumed money multiplier were changed. In the short run, the banks' borrowing can be varied to offset the undesired effect on money from changes in the deposit to reserve multiplier [Meltzer et al., 1982].[12] The FOMC still indicates a range for the Federal Funds rate--4 to 7 percent--as a potential source of information on the availability of reserves. If the lagged reserve requirement rule is eliminated and the Federal Reserve discount rates are more flexible, the Federal Reserve could improve its control over the money supply by targeting the total reserves because the risk of error through unexpected multiplier variations would be reduced [Meltzer et al., 1982].

Financial innovation and deregulation in the early 1980s are alleged to have increased the substitutability between M1 and other financial assets. These financial innovations include the money market mutual funds, the nationwide NOW accounts (January 1, 1981), the tax-exempt all-savers certificates (October 1, 1981), the Garn-St Germain money market deposit accounts (December 14, 1982), and the super-NOW accounts (January 5, 1983). Interest-bearing NOW accounts permit holders to use negotiable orders of withdrawal very much as they would use checks. The absence of reserve requirements on money market deposit accounts enables depository institutions to pay interest rates above those on reservable checking deposits. The super-NOW accounts are free of interest rate ceilings but are still subject to reserve requirements. With the difficulty of interpreting the movements in M1, the FOMC reduced its emphasis on M1, increased the weight given M2, and set the short-run target on M3 during the fourth quarter of 1982. The Federal Reserve has adopted a procedure for targeting open market operations on average levels of reserves borrowed from Federal Reserve Banks since October 1982 [Gilbert, 1985]. The reason is that a large proportion of required reserves are against the deposit liabilities in M1 under the previous procedure of targeting nonborrowed reserves. At each meeting, the FOMC specifies a desired level of borrowed reserves over the intermeeting period. If the FOMC directive calls for an increase in reserve restraint, the Open Market Desk would increase its target for borrowed reserves as an increase in the estimate of total reserves. A change to contemporaneous reserve requirements (CRR) with a two-day lag, designed to strengthen the relationship between transaction deposit balances and the total reserves of depository institutions, was adopted in February, 1984 [Gilbert and Trebing, 1982].[13] Under CRR, required reserves are based on the average transaction deposit liabilities over 14 days ending two days before the end of the current reserve maintenance period (two weeks ending Wednesday) plus the average liabilities other than transaction deposits over 14 days ending 30 days before the current reserve maintenance period. This system is not exactly contemporaneous because the periods over which reserves are counted still lag.

In summary, short-term interest rates and free reserves were alternative operating guides used by the Federal Reserve in the 1950s and 1960s. The short-run conduct of open market operations increased the emphasis on the monetary aggregates in the 1970s. The FOMC began to announce the short-run and long-run target ranges for the monetary aggregates in 1974 and 1975, respectively. In October 1979, the Federal Reserve adopted a reserve-aggregates approach to monetary control. Nonborrowed reserves are the practical operative target. Financial innovation and deregulation in the early 1980s increase the substitutability between M1 and other financial assets. With the difficulty of interpreting the movements in M1, the FOMC increased its emphasis on M2 and M3 in 1982:4. Also, the Federal Reserve has adopted a procedure for targeting on borrowed reserves since October 1982.

International Experience

Evidence indicates that the central banks of Switzerland and Canada have had the ability to control a chosen monetary aggregate for several years [Freeman, 1981; Schiltknecht, 1981]. From 1975 to 1978, the Swiss National Bank chose the adjusted monetary base as an operating variable for achieving a money stock target. A band of 3 to 7 percent for the annual growth in the money stock was suggested for a stable growth economy at a zero inflation rate. Based on a money multiplier model, it was assumed that the money stock would only be adjusted to a deterministic change in the monetary base. Unless the multiplier were extraordinarily variable, maintaining the monetary base along the desired growth path would not lead to large swings in money growth. This policy practically achieved stable prices. The evidence from Canada indicates that a monetary growth target through the process of bank credit expansion has helped in controlling inflation. The authority chose M1 as the target and affected the public's demand for money via greater variation in interest rates.[14] The target ranges are defined as a band of uniform width with limits 2 percent above and 2 percent below the midpoints of the ranges.

The role of exchange fluctuations can be important for any open economy [Schiltknecht, 1981]. In 1979, the Swiss National Bank chose an exchange rate target to prevent a further rapid appreciation of the Swiss franc, pegging the exchange rate and temporarily allowing the money stock to rise. The money stock was expanded along a medium-term path designed to keep prices stable. It implies that a monetary policy aimed at price stability should take into account the monetary developments in other countries.

The Federal Reserve's Reaction Function

Wood [1967] was the first to develop and test a Federal Reserve reaction function, a behavioral equation measuring the response of policy instruments to movements in targets and exogenous forces. Government policy instruments, thus, are treated as endogenous. It is presumed that the Federal Reserve conducts open market operations to maximize an assumed utility function of the public subject to a given structure of the economy.

If society's desires are insatiable, a utility function relating the Federal Reserve's view of the public's welfare to policy goal variables can be written as

$$U_t = u(y_t, UN_t, P_t, BP_t) \tag{2.1}$$

where U = utility

y = real income

UN = unemployment

P = prices

BP = the balance of payments.

Current real income and employment are directly related to the utilities of the public during that same period. Since current price levels and the balance of payments affect real income and employment in future periods, they are included in the utility function.

Maximizing equation (2.1) subject to the Federal Reserve's view of the structure of the economy, a reaction function for the monetary authority may be written as

$$GS_t = u_1 + u_2\, Y_t + u_3\, UN_t - u_4\, P_t - u_5\, BP_t + u_6\, X_t + e_{2,t} \tag{2.2}$$

where GS = Federal Reserve's holdings of securities

X = other exogenous variables influencing those targets

$e_{2,t}$ = disturbance in period t which is assumed independently normally distributed with zero mean and finite variance.

The coefficients of the reaction function represent the combinations of structural and utility parameters. It is immaterial whether or not the Federal Reserve responds to the ultimate or intermediate targets because of the assumption that the monetary authority has full knowledge of the structure of the economic system. Empirical results of Wood [1967], Teigen [1969], Havrilesky, Sapp, and Schweitzer [1975] suggest strongly that the Federal Reserve responded systematically to variations in targets and predetermined variables during periods 1952-1963, 1953-1964, and 1964-1974, respectively.

The Endogenous Money Supply

The contemporary money-supply paradigm [Steindl, 1982], of which the Friedman-Cagan money supply model, the Brunner-Meltzer-St. Louis Federal Reserve Bank money supply model, and the Branson money supply model are variants, all show that the money supply is affected by interactions among the monetary authority, the banking system, and the public. These models are summarized as follows:

(1) The Friedman-Cagan Money Supply Model

$$M = \frac{1}{C/M + R/D - C/M \cdot R/D} \cdot H \qquad (2.3)$$

where M = the money stock, M2

C = the currency component of M

R = required reserves against deposits

D = deposits at commercial banks

H = high-powered money.

$\partial M/\partial H>0$, $\partial M/\partial(C/M)<0$, and $\partial M/\partial(R/D)<0$. Equation (2.3) can be derived from the definition of M and from the uses of high-powered money [Cagan, 1965; Friedman and Schwartz, 1963b].

(2) The Brunner-Meltzer-St. Louis Federal Reserve Bank Money Supply Model

$$M1 = \frac{1 + k}{r(1+d+t)+k} \cdot H \qquad (2.4)$$

where M1 = the narrow money stock

k = the ratio of currency held by the public to the demand deposits of the public, D_p

r = reserve requirement

d = the ratio of the demand deposits of U. S. Treasury to D_p

t = the ratio of time deposits to D_p

H = high-powered money.

$\partial M1/\partial H>0$, $\partial M1/\partial k<0$, $\partial M1/\partial r<0$, $\partial M1/\partial d<0$, and $\partial M1/\partial t<0$. Equation (2.4) can be derived from the definition of M1 and from the uses of high-powered money [Brunner and Meltzer, 1968; Burger and Rasche, 1977].

(3) The Branson Money Supply Model

$$M = \frac{NB - FR}{h + z(1 - h)} \qquad (2.5)$$

where M = the narrow money stock

NB = the nonborrowed base provided by the Federal Reserve mainly through open market operations[15]

FR = free reserves

h = the ratio of currency held by the public to the money stock

z = the reserve requirement of demand deposits.

$\partial M/\partial NB>0$, $\partial M/\partial FR<0$, $\partial M/\partial h<0$, and $\partial M/\partial z<0$. Equation (2.5) can be derived from the sources and uses of high-powered money [Branson, 1979]. FR is a function of market interest rate i and the discount rate i^d, $FR = f(i - i^d)$ where $\partial FR/\partial i<0$, $\partial FR/\partial i^d>0$, and $dFR/d(i - i^d)<0$.

The main impact of the Federal Reserve System is through changes in high-powered money. Federal Reserve credit outstanding (i.e., its monetary liabilities) accounts for the major changes in high-powered money. The effect on the money stock of high-powered money may be weak in short-run movements because of lags, but the effect has an important role in secular movements [Cagan, 1965]. The banking system responds to changes in market interest rates and the discount rate. Banks expand loans and deposits by reducing excess reserves and by borrowing additional reserves at the discount window during expansions, and vice versa during contractions [Branson, 1979; Rea, 1976]. The demand for currency in circulation depends not only on transactions but also on wealth holdings. The currency-money ratio represents the public's preference for currency, which depends on how the relevant demand factors affect currency and commercial bank deposits differently [Cagan, 1965]. Empirical test results have shown that the supply of money should be treated endogenously [Brunner and Meltzer, 1968; Gibson, 1972; Teigen, 1964 and 1976]. Teigen indicates that short-term interest rates link the supply function of money to the rest of the economy.

Rational Expectations and Policy Ineffectiveness

Theoretical Framework

Expectations play an important role in influencing agents' decisions. The strong rational expectations hypothesis implies that agents are assumed to have full information concerning all lagged variables in the model. The information set is I_t. Changes in a policy rule result in changes in the parameters of the model as the public takes actions to respond to the altered rule [Griffiths and Wood, 1981; Hafer, 1983; Lucas, 1975; McCallum, 1980]. Under rational expectations, individuals try to use all available information to anticipate the consequences of all events. However, information is both costly and imperfect; the future is unknown and no agent is perfectly informed as to the current state of the economy [Lucas, 1975]. The current shocks are not observable by either the monetary authority or individuals. It is customary to take the rational expectation of a variable as its conditional mathematical expectation.

Friedman's ideas have shaped a generation of monetarists. He asserts that changes in the money stock result in short-run changes in both nominal and real income; i.e., there exists a short-run Phillips relation [Friedman et al., 1974]. A monetary expansion lowers the nominal interest rate initially; prices then are raised through an income effect and price expectations are adjusted with a lag. Eventually, nominal interest rates rise above their initial level because of the Fisher effect. The transmission mechanism, connecting a change in the quantity of money with a change in total nominal income, operates through the changes in interest rates and the relative prices. Interest rates on financial assets not only affect the marginal cost of liability extension, but also influence the substitution between financial and real assets. This substitution changes the prices of real assets relative to their supply prices. The change in relative prices is a key element in the adjustment of economic activity. The price level is flexible, though not necessarily perfectly so, and is a joint outcome of the monetary forces and the real forces. The temporary trade-off between inflation and unemployment comes from the unanticipated inflation. An aggregate supply function rationalized by Lucas [Lucas, 1973; McCallum, 1980] can be written as

$$\ln y_t = q_1 + q_2 [\ln P_t - E(\ln P_t | I_t)] + q_3 \ln y_{t-1} + e_{6,t} \tag{2.6}$$

where y = real output

P = general price level

$E(\ln P_t | I_t)$ = the rational expectation of $\ln P_t$[16]

$e_{6,t}$ = disturbance in period t which is assumed to be independently normally distributed with zero mean and finite variance.

Agents' inflationary expectations are based on available information (I_t) and knowledge of the model's structure. They form inflationary expectations by forecasting the policymaker's best action. No systematic inflation surprises exist; however, surprises do occur because of the stochastic terms in the model. The unanticipated inflation rate equation can be derived from a specified model with a competitive equilibrium system, imperfect information, and rational expectations as [Barro, 1981a; Lucas, 1975; McCallum, 1980]

$$\ln P_t - E(\ln P_t|I_t) = n_1 [\ln M_t - E(\ln M_t|I_t)] + e_{7,t} \quad (2.7)$$

where M = nominal money stock

$e_{7,t}$ = disturbance in period t which is assumed independently normally distributed with zero mean and finite variance.

From equations (2.6) and (2.7), the output equation can be written as

$$\ln y_t = q_1 + n_1 q_2 [\ln M_t - E(\ln M_t|I_t)] + q_3 \ln y_{t-1} + e_{8,t} \quad (2.8)$$

where $e_{8,t} = e_{6,t} + q_2\, e_{7,t}$, disturbance in period t which is assumed independently normally distributed with zero mean and finite variance.

Only unanticipated money movements can have nonneutral effects on real variables because people do not possess perfect information [Barro, 1981a ; Lucas, 1975]. Any random movements in the money supply cannot be immediately distinguished from random movements in relative demand. An unanticipated increase in the money supply may confuse individual suppliers into believing that there has been an increase in relative demand for their firm's output and a random rise in its relative price; therefore, more output is supplied. The larger the variation in unanticipated money growth, the smaller the impact of unanticipated money growth on output since the less likely individual suppliers believe that it is their particular market that had a favorable relative demand shift [Attfield and Duck, 1983; Barro, 1981a; Lucas, 1973]. Unanticipated money movements may affect output with a lag because firms may respond immediately to the unanticipated movements in demand by adjusting inventories and later increase production to restore the desired inventories.

Rational expectations combined with a natural-rate-type view of the world means that a monetary fluctuation affects only the general level of prices in the long run, but has no effect on real output, i.e., there exists a vertical long-run Phillips relation [Andersen and Carlson, 1970; Barro, 1981a; Friedman et al., 1974; Griffiths and Wood, 1981]. The reduced form of output can be written as

$$\ln y_t = q_1 + q_3 \ln y_{t-1} + e_{9,t} \tag{2.9}$$

where $e_{9,t} = e_{6,t} + q_2\, e_{7,t} + n_1 q_2\, e_t^M$, disturbance in period t which is assumed independently normally distributed with zero mean and finite variance.

Activist stabilization policy is ineffective because the private sector discovers its systematic effect on output and employment and adapts to it. Rules with feedback can be worse than rules without if they increase the uncertainty of agents' information set.

In summary, under the rational expectations hypothesis, only the unanticipated money movements have nonneutral effects on real variables because random movements in the money supply cannot be immediately distinguished from random movements in relative demand. The temporary trade-off between inflation and unemployment comes from the unanticipated inflation. Systematic policy is ineffective in the short run and long run.

Empirical Results

The results of VanderHoff [1983] conclude that the rational expectations model best fits the U. S. quarterly data for the period 1951:4 to 1980:2. The models of Andersen and Carlson [1970], Beenstock and Dicks [1983] indicate that changes in the money stock can have an influence on real magnitudes in the short run, while influencing only nominal magnitudes in the long run. Fair [1976] also indicates that monetary policy is effective in the short run, if monetary policy is defined as a change in the value of government securities outstanding with other things being equal. The empirical tests of Attfield and Duck [1983] and Barro [1981b and 1981c] support the proposition that only unanticipated monetary growth affects real economic variables. The results of Attfield and Duck [1983] and Lucas [1973] indicate that the impact on output of unanticipated monetary growth declines the more unpredictable monetary growth becomes. The higher the variance in average prices, the less likely the individual supplier is to be confused into believing that his market has a relative increase in demand.

Endnotes

[1]The Federal Funds rate is the market interest rate on one-day loans of member-bank reserve balances on deposit at Federal Banks.

[2]Free reserves are defined as excess reserves minus borrowed reserves from the System.

[3]This argument is based on the following assumptions [B. M. Friedman, 1975]. First, the coefficients of structural equations are nonrandom and known with certainty. Second, this is a one-period model which does not analyze dynamic results. Third, the policy authorities may have some preferences about the intermediate target values per se, wholly appart from the impact of these variables on the ultimate target variables.

[4]Since $MV = Y$, $G_M + G_V = G_Y$ where G represents the annual growth rate.

[5]Gould and Nelson [1974] use an ARIMA technique. They also conclude that velocity is a random walk, i.e., changes in velocity are serially uncorrelated.

[6]The cost of inflation depends on the values for the unemployment rate and inflation. The benefits to positive inflation surprises include an unanticipated capital levy on holdings of the government's nominal liabilities (i.e., the revenue from money creation) and a lower real value of public debt.

[7]The FOMC uses daily-average statistics on total member bank deposits as a "bank credit proxy" because they are

compiled on a daily basis with a very short lag and the average deposit figures for a month are much less subject to the influence of single-date fluctuations than are the available month-end (the last Wednesday) data on total bank credit.

[8]RPD is defined as total member bank reserves minus reserves required on government and interbank deposits.

[9]Data on the broader M's and bank credit are available only after significantly longer time lags.

[10]Bank credit includes total bank loans and investments (measured on a monthly average basis) less interbank loans. The differences in the behavior of various M's are due to the regulatory constraints or the ability of the innovation in the financial system.

[11]Total reserves control is not a practical objective in the short run because it may lead to large fluctuations in financial markets.

[12]Borrowed reserves are provided when the Federal Reserve lends reserves to banks through its discount mechanism. Borrowed reserves rise only if the Federal Funds rate increases sufficiently above the discount rate to overcome banks' reluctance to borrow.

[13]Lagged reserve requirements (LRR) were changed from a one-day lag to a two-week lag in September 1968; the required reserves for a given week ending Wednesday are based on the average daily deposit liabilities in the 1-week computation period two weeks earlier. It is believed that

LRR are welcomed by small banks and may help to stop their departure from the Federal Reserve System.

[14]It is difficult to control the short-run growth rate of a broad aggregate through changes in short-term interest rates because those items included are close substitutes.

[15]The dominant sources of the nonborrowed base are the Federal Reserve's portfolio of government securities, gold certificates and foreign exchange held by the Federal Reserve.

[16]$[\ln P_t - E(\ln P_t | I_t)]$ is the unanticipated inflation rate since it equals $(\ln P_t - \ln P_{t-1}) - [E(\ln P_t | I_t) - \ln P_{t-1}]$.

CHAPTER III

MODEL SPECIFICATION

Reaction Functions

The Reaction Function Relating Federal Reserve Open Market Operations to Policy Goals

Under the assumption that the monetary authority sets policy to achieve policy goals, a reaction function of Federal Reserve open market operations can be specified as

$$\begin{aligned} \ln UR_t = {} & a_1 + a_2 (UN_t - UN_{t-1}) + a_3 (\ln y_t - \ln y_{t-1}) \\ & - a_4 (\ln P_t - \ln P_{t-1}) - a_5 BP_t + a_6 \ln UR_{t-1} \\ & + e_{1,t} \end{aligned} \qquad (3.1)$$

where UR = nonborrowed reserves

UN = unemployment rate

y = real GNP

P = GNP price deflator

BP = real balance on current account

$e_{1,t}$ = disturbance in period t which is assumed independently normally distributed with zero mean and finite variance.

The level of nonborrowed reserves is used to represent

Federal Reserve open market operations. The change in the unemployment rate, the growth rate of real income, the rate of inflation, and the real balance on current account are used as the variables relevant, respectively, to the ultimate targets of full employment, economic growth, price stability, and equilibrium in the balance of payments. For countercyclical purposes, the sign of the change in unemployment rate is expected to be positive, and those of the inflation rate and the real balance on current account are expected to be negative. A positive sign of the growth rate of real income explains that the Federal Reserve must provide reserves to accommodate short-term real income changes. The sign of the lagged dependent variable is expected to be positive reflecting the response of monetary policy to changes in the performance of the economy subject to a distributed lag. Federal Reserve behavior is endogenously determined by policy goals, it is also exogenously explained by the parameters of the constant term and lagged dependent variable. The coefficients: a_1 and a_6 are policy-controlled parameters.

The Reaction Function Relating Federal Reserve Open Market Operations to Intermediate Targets

An alternative reaction function that relates Federal Reserve open market operations to intermediate target variables can be specified as

$$\ln UR_t = b_1 - b_2 (i_t - i_{t-1}) - b_3 D1 \cdot (\ln M_t - \ln M_{t-1}) + b_4 \ln UR_{t-1} - b_5 D2 + e_{2,t} \quad (3.2)$$

where i = short-term nominal interest rate

$D1$ = dummy variable, takes the value of 1 after 1969:4 and zero otherwise

M = the nominal money stock (M1)[1]

$D2$ = dummy variable, takes the value of 1 after 1979:3 and zero otherwise

$e_{2,t}$ = random disturbance term which is assumed independently normally distributed with zero mean and finite variance.

Due to the uncertainties, money market conditions are traditionally chosen by the Federal Reserve as a short-run objective because information on these variables is available frequently and the market can respond quickly to policy operations.[2] Short-term interest rates and free reserves were alternative operating guides specified by the FOMC for the account management in the 1950s and 1960s; free reserves were changed to obtain the desired level of short-term interest rates. In the early 1970s, money market conditions were still used by the FOMC as its immediate operating target. The change in the short-term interest rate is used as a proxy variable measuring money market conditions. The sign of the change in the short-term interest rate is expected to be negative, which reflects defensive open market operations intended to protect the money market from disturbances.[3] The dummy variable, D1, is used to take into account the growing emphasis on the monetary aggregates in the 1970s. The short-run and long-run target ranges for the monetary aggregates have been announced since 1974 and 1975, respectively. The sign of the growth rate of the money stock is expected to be negative for countercyclical purpose. The dummy variable, D2, is used to take into account a reserve-aggregates approach to monetary control in October 1979. The sign of D2 is expected to be negative for a better monetary control. The coefficients: b_1, b_4, and b_5 are policy-controlled parameters.

The Money Supply Function

The money supply function can be specified as

$$\ln M_t = c_1 + c_2 \ln UR_t + c_3\, i_t - c_4\, i_t^d - c_5\, Z_t - c_6\, (H_t - H_{t-1}) + c_7\, D3 + e_{3,t} \qquad (3.3)$$

where i^d = the discount rate of the Federal Reserve Bank

Z = the reserve requirement for demand deposits

H = the ratio of currency held by the public to the money stock

$D3$ = dummy variable, takes the value of 1 after 1982:2 and zero otherwise

$e_{3,t}$ = random disturbance term which is assumed independently normally distributed with zero mean and finite variance.

It accounts both for the Federal Reserve policy influences and the market's responses in determining the stock of money. Nonborrowed reserves, the discount rate, and reserve requirements are controlled directly by the Federal Reserve. An increase in nonborrowed reserves, or a decrease in the discount rate, or reserve requirements increases banks' excess reserves, and then expands the money supply. The banking system responds to market interest rates and the discount rate. Banks expand loans and deposits as market interest rates increase. The currency-M1 ratio represents the public's preference for currency. When the public's money holdings increase, the stock of money is expected to be decreased. The dummy variable, D3, is used to take into account financial innovation and deregulation in the early 1980s. The sign of D3 is expected to be positive because travelers checks of nonbank issuers, interest-bearing NOW accounts, automatic transfer service accounts, and credit union share draft accounts are contained in M1.

A Small Macroeconometric Model With Rational Expectations

The structural equations are expressed in the IS-LM format using an aggregate supply function rationalized by Lucas. The aggregate price and quantity are determined by the intersection point of an aggregate demand curve and an aggregate supply curve. The money stock is treated as endogenous. A discretionary policy rule is included; it is assumed that the public understands the nature of the policymaker's optimization problem in each period. The exogenous determinants of nonborrowed reserves are used as policy-controlled parameters to test the policy ineffectiveness proposition. The model consists of the following set of equations:

$$\ln y_t = d_1 - d_2\, r_t^{**} - d_3\, r_{t-1}^{**} + d_4\, (\ln M_t - \ln P_t) + d_5 \ln G_t - d_6 \ln TAX_{t-1} + d_7\, t + d_8 \ln y_{t-1} + e_{4,t} \tag{3.4}$$

$$(\ln M_t - \ln P_t) = f_1 + f_2 \ln y_t - f_3\, i_t + f_4\, (\ln M_{t-1} - \ln P_{t-1}) + e_{5,t} \tag{3.5}$$

$$\ln M_t = g_1 + g_2 \ln UR_t + g_3\, i_t - g_4\, i_t^d - g_5\, Z_t - g_6\, (H_t - H_{t-1}) + g_7\, D3 + e_{3,t} \tag{3.3}$$

$$\ln UR_t = h_1 + h_2\, (UN_t - UN_{t-1}) + h_3\, (\ln y_t - \ln y_{t-1}) - h_4\, (\ln P_t - \ln P_{t-1}) - h_5\, BP_t + h_6 \ln UR_{t-1} + e_{1,t} \tag{3.1}$$

$$\ln y_t = j_1 + j_2\, [\ln P_t - E(\ln P_t | I_t)] + j_3 \ln y_{t-1} + e_{6,t} \tag{3.6}$$

$$i_t^{**} = k_1 + k_2\, i_t + k_3\, (i_t - i_{t-1}) + k_4\, i_{t-1}^{**} + e_{7,t} \tag{3.7}$$

$$r_t^{**} = i_t^{**} - [E(\ln P_t | I_t) - \ln P_{t-1}] \tag{3.8}$$

$$UN_t = s_1 - s_2 (\ln y_t - \ln y_{t-1}) - s_3 (\ln y_{t-1} - \ln y_{t-2})$$
$$- s_4 (\ln M_{t-1} - \ln P_{t-1}) + s_5\, t + s_6\, UN_{t-1} + e_{9,t} \quad (3.9)$$

where r^{**} = long-term real interest rate

G = real government purchases of goods and services

TAX = real net receipts of government

t = the time trend

$E(\ln P_t | I_t)$ = the expectation held in period t for $\ln P_t$

i^{**} = long-term nominal interest rate

$e_{4,t}$, $e_{5,t}$, $e_{3,t}$, $e_{1,t}$, $e_{6,t}$, $e_{7,t}$, and $e_{9,t}$ = disturbances in period t which are assumed independently normally distributed with zero mean and finite variance.

y, r^{**}, M, P, i, UR, i^{**}, and UN are endogenous variables, and all others are predetermined variables.

Equation (3.4) is the aggregate demand function for real income, which represents the output-price level relationship implicit in the IS-LM diagram. Aggregate demand is negatively related to real interest rates. The lagged long-term real interest rate reflects the lagged effect of the interest rate on investment spending because there is usually a significant lead time between an investment decision and an investment expenditure. (ln M - ln P) represents the real balance effect in logarithmic form. The time trend, t, accounts for technological change and the growth in capital stock and labor force. Lagged real income represents a persistent effect--an adjustment process for the goods market.

Equation (3.5) is the real money demand function. It is a direct relation to the conventional Goldfeld money demand equation. Real income is used to measure the volume of transactions in the economy. The interest rate measures the opportunity cost of money holdings. The lagged real balance implies that the actual real money holdings are adjusted to the desired level by a partial-adjustment mechanism, where $(1 - f_4)$ is the partial adjustment coefficient of real money demand.

Equation (3.3) is the money supply function specified above. Equation (3.1) is the Federal Reserve's reaction function specified above. The coefficients: h_1 and h_6 are policy-controlled parameters.

Equation (3.6) is the aggregate supply function. It embodies the natural rate notion that output supplied is affected only by the unanticipated inflation rate because individual suppliers cannot accurately distinguish general from relative price movements.[4] This equation is expressed in terms of a geometric distributed lag on the unanticipated inflation rates. In the steady state, real income is on its full-employment growth path and there is no expectational error in the inflation rate. The anticipated GNP price deflator can be expressed as

$$E(\ln P_t | I_t) = \vartheta_1 + \vartheta_2\, i_{t-1} + \vartheta_3\, i^{**}_{t-1} + \vartheta_4\, r^{**}_{t-1} + \vartheta_5 \ln UR_{t-1} + \vartheta_6 \ln M_{t-1} + \vartheta_7\, \hat{i}^d_t + \vartheta_8\, \hat{Z}_t + \vartheta_9\, \hat{H}_t + \vartheta_{10}\, H_{t-1} + \vartheta_{11} \ln P_{t-1} + \vartheta_{12} \ln y_{t-1} + \vartheta_{13} \ln y_{t-2} + \vartheta_{14}\, UN_{t-1} + \vartheta_{15}\, \hat{BP}_t + \vartheta_{16} \ln \hat{G}_t + \vartheta_{17} \ln TAX_{t-1} + \vartheta_{18}\, t \qquad (3.10)$$

where $\hat{i}^d_t$, $\hat{Z}_t$, $\hat{H}_t$, $\hat{BP}_t$, and $\ln \hat{G}_t$ are the expected values of the current exogenous variables i^d_t, Z_t, H_t, BP_t, and $\ln G_t$, respectively. The signs of ϑs may be negative. The details of equation (3.10) are explained in Appendix B.

Equation (3.7) is the term structure equation. The long-term interest rate responds to the short-term interest rate with a geometric distributed lag, and to the change in short-term interest rate. Equation (3.8) is the Fisher equation for real interest. Equation (3.9) is the unemployment equation. The unemployment rate is related to the current and lagged growth rate of real income, the lagged real money stock, and the time trend. The time trend, t, accounts for the growth in labor force.

The reduced form of real income is

$$\ln y_t = \gamma_1 + \gamma_2 \ln y_{t-1} + \gamma_3\, e^{i^d}_t + \gamma_4\, e^Z_t + \gamma_5\, e^H_t + \gamma_6\, e^{BP}_t + \gamma_7\, e^G_t + \gamma_8\, e_{4,t} + \gamma_9\, e_{5,t} + \gamma_{10}\, e_{3,t} + \gamma_{11}\, e_{1,t} + \gamma_{12}\, e_{6,t} + \gamma_{13}\, e_{7,t} + \gamma_{14}\, e_{9,t} \qquad (3.11)$$

where $\gamma_1 = j_1$

$\gamma_2 = j_3$

$$\gamma_3 = (-d_2g_4j_2k_2-d_2g_4j_2k_3)/DEN$$

$$\gamma_4 = (-d_2g_5j_2k_2-d_2g_5j_2k_3)/DEN$$

$$\gamma_5 = (-d_2g_6j_2k_2-d_2g_6j_2k_3)/DEN$$

$$\gamma_6 = (-d_2g_2h_5j_2k_2-d_2g_2h_5j_2k_3)/DEN$$

$$\gamma_7 = (d_5f_3j_2+d_5g_3j_2)/DEN$$

$$\gamma_8 = (f_3j_2+g_3j_2)/DEN$$

$$\gamma_9 = (-d_2j_2k_2-d_2j_2k_3)/DEN$$

$$\gamma_{10} = (d_2j_2k_2+d_2j_2k_3+d_4f_3j_2+d_4g_3j_2)/DEN$$

$$\gamma_{11} = (d_2g_2j_2k_2+d_2g_2j_2k_3)/DEN$$

$$\gamma_{12} = (d_2k_2+d_2k_3+d_4f_3+d_4g_3+d_2g_2h_4k_2+d_2g_2h_4k_3)/DEN$$

$$\gamma_{13} = (-d_2f_3j_2-d_2g_3j_2)/DEN$$

$$\gamma_{14} = (d_2g_2h_2j_2k_2+d_2g_2h_2j_2k_3)/DEN$$

$$\begin{aligned} DEN = {} & d_2k_2+d_2k_3+d_4f_3+d_4g_3+f_3j_2+g_3j_2+d_2f_2j_2k_2+d_2f_2j_2k_3 \\ & +d_2g_2h_4k_2+d_2g_2h_4k_3-d_2g_2h_3j_2k_2-d_2g_2h_3j_2k_3 \\ & +d_2g_2h_2j_2k_2s_2+d_2g_2h_2j_2k_3s_2 \end{aligned}$$

The details of the derivation of equation (3.11) are in Appendix A. The policy-controlled parameters h_1 and h_6 do not affect real income. The equation implies that no systematic short- or long-run effect because people will learn what the policy maker is doing. Monetary policy can only be effective in the short run affecting economic activity through the disturbance term $e_{1,t}$.

Endnotes

[1]The old M1 was redefined in February 1980. Adjustment was made for shifts to "other checkable deposits" from other assets to obtain a better measure of the underlying trend in M1. M1B was renamed M1 in January 1982.

[2]Money market conditions come from measures of many types of markets: the government securities market, the market for corporate bonds, and the market for bank reserves. Treasury bill rates, dealer financing and inventories, the Federal Funds rate, and the reserve positions of banks are the measures of money market conditions.

[3]There are at least four hypotheses used to explain the positive correlation between an unanticipated change in the money supply and interest rates [Cornell, 1983; Nichols, Small, and Webster, 1983]:

(a) The expected inflation hypothesis states that an unanticipated change in the money supply alters an agent's inflation expectation. Changes in long-term interest rates are less than those for short-term interest rates unless the change in expected inflation is permanent.

(b) The Keynesian hypothesis states that an unanticipated increase in the money supply causes higher short-term interest rates (via the liquidity effect with rigid prices) because an anticipated offsetting action is taken by the Federal Reserve. Under the reserve-aggregate approach, short-term interest rates may be expected to rise more.

(c) The real activity hypothesis states that an unanticipated increase in the money supply signals greater money demand and higher expected future output. Real interest rate must rise to clear the product market and the money market if the adjustment in prices were slow and if expansionary monetary policy were not taken; in turn, nominal interest rates increase.

(d) The risk premium hypothesis states that an unanticipated increase in the money supply reveals the rise in aggregate risk aversion and the riskiness of competing assets, leading to an increase in the risk premium.

[4]This aggregate supply function is also consistent with the ideas of Friedman, Sargent, Fischer, and others [McCallum, 1980].

CHAPTER IV

MODEL ESTIMATES

Introduction

In this chapter, the Federal Reserve's reaction functions, the money supply function, a small macroeconometric model, and the anticipated GNP price deflator equation are estimated. The estimating techniques are as follows.

(1) Reaction functions, the money supply function, and the anticipated price equation:

Since the lagged dependent variable is present in reaction functions--equations (4.1) and (4.2) below--and the anticipated price equation--equation (4.12)--the Durbin h statistic is used to test the null hypothesis of no first-order serial correlation against the alternative hypothesis that first-order serial correlation is present.[1] The Durbin h statistic is approximately normally distributed with zero mean and unit variance; the critical value of the standardized normal distribution is 1.645 for one-tailed test at the 5 percent significance level. For the money supply function, equation (4.3), the Durbin-Watson statistic (DW) is used to test for first-order serial correlation. If the DW statistic is less than 1.57, positive first-order serial correlation is present at the 5 percent significance level. The AUTOREG procedure, a generalized least-squares method, is also used to test for higher-order serial correlation [SAS, 1982]. The presence of serial correlation affects the efficiency of ordinary least-squares regression estimates; i.e., the variances of the estimated parameters are not the minimum variances.

The Goldfeld-Quandt test is used to test the null hypothesis of homoscedasticity against the alternative hypothesis that heteroscedasticity is present. The test statistic is the F statistic. The critical value with 43 degrees of freedom in the numerator and the denominator is 1.68 at the 5 percent significance level and 2.08 at the 1 percent significance level. When heteroscedasticity is present, ordinary least-squares parameter estimates are inefficient and the estimated variances of the estimated parameters are biased.

The correlation coefficients matrix of the independent variables is used to check for multicollinearity. If multicollinearity exists, ordinary least-squares parameter estimates are inefficient. However, multicollinearity does not cause problems if the standard errors of the estimated coefficients are low [Pindyck and Rubinfeld, 62, p. 90].

Since explanatory endogenous variables are included in equations (4.1), (4.2), and (4.3), the independent variables are correlated with the error term (i.e., they have a nonzero covariances). In this case, ordinary least-squares estimates of the regression parameters are biased and inconsistent. Therefore, these equations are estimated using instrumental-variables estimation to obtain consistent parameter estimates. The instrumental variable, which is both highly correlated with the endogenous explanatory variable and uncorrelated with the error term in the equation, replaces the endogenous explanatory variable. For equation (4.3), the AUTOREG procedure is also used to correct for serial correlation. The method used in AUTOREG is the two-step full transform method using the least-squares residuals to estimate the covariances across observations. Equation (4.12) is estimated using ordinary least-squares estimation.

(2) The macroeconometric model:

The model is estimated by the three-stage least-squares (3SLS) technique because (a) it is an overidentified case, (b) disturbances across equations are correlated, (c) the sample is large, and (d) 3SLS uses all available information. When explanatory endogenous variables are included and disturbances across equations are correlated, ordinary least-squares estimates are biased, inconsistent, and inefficient. Since serial correlation among disturbances of some equations exists and lagged endogenous variables are included, 2SLS estimates are biased, inconsistent and inefficient, but they are asymptotically efficient.[2] 3SLS is the full-information estimation, it estimates the entire simultaneous-equation system using all information available on each equation. In the first stage, ordinary least-squares procedure is performed to regress each explanatory endogenous variable on all predetermined variables in the model. In the second stage, ordinary least-squares procedure is used to regress each endogenous variable on the predicted values of the explanatory endogenous variables obtained from the first stage and the predetermined variables included in each equation. In the third stage, the generalized least-squares procedure is applied to 2SLS to improve efficiency. 3SLS is asymptotically more efficient than 2SLS. These estimates have the same asymptotic properties as estimates in a classical regression model. Although 3SLS is sensitive to both specification error and measurement error, most of the root-mean-square simulation errors of endogenous variables in the model using 3SLS are lower than those using 2SLS.

The corrected R^2 ($\bar{R}^2$) is used as a measure of goodness of fit to the regression. The F statistic is used to test the null hypothesis that none of the explanatory variables helps to explain the variation of the dependent variable about its mean. A high value of the F statistic implies that the null hypothesis is rejected. The t statistic (in parenthesis below the regression coefficient) is used to test the significance of the parameter estimates. The critical value of the t statistic with 120 degrees of freedom is 1.98 at the 5 percent significance level, or 1.658 at the 10 percent significance level. An ex post dynamic simulation over the 1953:3-1984:2 time period is performed to evaluate how well the model tracks each endogenous variable.[3]

The dynamic multipliers for each endogenous variable resulting from changes in the policy-controlled parameters are examined to test the effectiveness of monetary policy. The impact, interim, and total multipliers for each endogenous variable resulting from about a 0.1 increase in the parameter of the constant term, h_1, and a 0.1 decrease in the parameter of the lagged dependent variable, h_6, of the reaction function are calculated. For example, the dynamic multipliers of real income, $\ln y_t$ where $t = 1...T$, are calculated in the following way. The model is first dynamically simulated for the period 1953:3-1984:2. The predicted values of $\ln y_t$ from this simulation is $\ln \hat{y}_t$. Another simulation is then run for the same period using different values for the policy-controlled parameters (h_1 and h_6), respectively. The predicted values from the second simulation is $\ln \hat{y}^*_t$. These predicted values, $\ln \hat{y}_t$ and $\ln \hat{y}^*_t$, are compared to get the impact, interim, and total multipliers. The impact multipliers are obtained from $(\ln \hat{y}^*_1 - \ln \hat{y}_1)$. They measure the first period effects on real income of changes in the policy-controlled parameters. The interim multipliers are obtained from $[(\ln \hat{y}^*_t - \ln \hat{y}_t) - (\ln \hat{y}^*_{t-1} - \ln \hat{y}_{t-1})]$, and they measure the subsequent period by period effects on real income of changes in the policy-controlled parameters. The total multipliers are obtained from $(\ln \hat{y}^*_T - \ln \hat{y}_T)$. These are measures of the cumulative effects on real income of changes in the policy-controlled parameters (i.e., the sum of the interim multipliers).

The details of data sources are explained in Appendix C. All equations are estimated using quarterly (seasonally adjusted) data over the period, 1953:1-1984:2.

Estimated Results

Reaction Functions

The reaction function relating Federal Reserve open market operations to policy goals is estimated as

$$\begin{aligned} \ln UR_t = & - \underset{(-0.96)}{0.0640} + \underset{(3.09)}{0.1355}\,(UN_t - UN_{t-1}) \\ & + \underset{(0.25)}{0.0745}\,(\ln y_t - \ln y_{t-1}) \\ & - \underset{(-0.46)}{0.4236}\,(\ln P_t - \ln P_{t-1}) - \underset{(-0.32)}{0.0004}\,BP_t \\ & + \underset{(44.88)}{1.0208}\,\ln UR_{t-1} + e_{1,t} \qquad (4.1) \end{aligned}$$

$$F = 4211.62 \qquad \bar{R}^2 = 0.9942$$

Based on the Durbin h statistic (1.3979) and the statistics of the AUTOREG procedure--the t values of the parameters of previous error terms; no serial correlation exists at the 5 percent significance level. The Goldfeld-Quandt test statistic is 1.1340; homoscedasticity is present at the 5 percent significance level. Multicollinearity is present. There is high negative correlation between $(UN_t - UN_{t-1})$ and $(\ln y_t - \ln y_{t-1})$, their correlation coefficient is -0.7606. Also, there is high positive correlation between $(\ln P_t - \ln P_{t-1})$ and $\ln UR_{t-1}$, their correlation coefficient is 0.7733. This equation is estimated using instrumental-variables estimation.[4] The lagged unemployment rate, UN_{t-1}, is used as the instrumental variable for UN_t. Most predetermined variables in the model are used as a combination of instruments for $\ln y_t$ and $\ln P_t$, respectively.[5] The order of explanation ($\bar{R}^2$) is very high. All of the signs agree with expectations. The FOMC's response to the change in unemployment rate is highly significant.

An alternative reaction function relating Federal Reserve open market operations to intermediate target variables is estimated as

$$\begin{aligned} \ln UR_t = & - \underset{(-1.77)}{0.0597} - \underset{(-1.02)}{0.0033}\,(i_t - i_{t-1}) \\ & - \underset{(-1.42)}{0.3998}\, D1 \cdot (\ln M_t - \ln M_{t-1}) + \underset{(93.68)}{1.0217} \ln UR_{t-1} \\ & - \underset{(-2.95)}{0.0199}\, D2 + e_{2,t} \end{aligned} \tag{4.2}$$

$$F = 5456.33 \qquad \bar{R}^2 = 0.9944$$

The Durbin h statistic (0.1362) and the statistics of the AUTOREG procedure show that no serial correlation exists at the 5 percent significance level. The Goldfeld-Quandt test statistic is 1.7734; homoscedasticity is present at the 1 percent significance level. Multicollinearity is present. There is high positive correlation between $D1 \cdot (\ln M_t - \ln M_{t-1})$ and $\ln UR_{t-1}$, their correlation coefficient is 0.7308. This equation is estimated using instrumental-variables estimation. The discount rate, i_t^d, is used as the instrumental variable for i_t. Most predetermined variables in the model are used as a combination of instruments for $\ln M_t$.[6] The order of explanation ($\bar{R}^2$) is very high. All coefficients have the expected signs. The significant coefficient of D2 indicates that the Federal Reserve has had a better control over the money stock since 1979:4 because the nonborrowed reserves are less than before.

The Money Supply Function

The estimated money supply function is

$$\begin{aligned}\ln M_t = {} & \underset{(9.71)}{2.7272} + \underset{(16.00)}{1.0885} \ln UR_t + \underset{(1.78)}{0.0514}\, i_t - \underset{(-0.80)}{0.0273}\, i_t^d \\ & - \underset{(-4.92)}{0.0614}\, Z_t - \underset{(-2.40)}{3.8087}\, (H_t - H_{t-1}) + \underset{(8.07)}{0.2415}\, D3 \\ & + e_{3,t} \qquad (4.3)\end{aligned}$$

$$e_{3,t} = \underset{(10.71)}{0.6948}\, e_{t-1} + v_t$$

$$F = 1078.12 \qquad \bar{R}^2 = 0.9371$$

where v_t is the random disturbance term which is assumed independently normally distributed with zero mean and finite variance. Based on the DW statistic (0.5230) and the statistics of the AUTOREG procedure, positive first-order serial correlation is present at the 5 percent significance level. The Goldfeld-Quandt test statistic is 1.1792; homoscedasticity is present at the 5 percent significance level. Multicollinearity is present. The correlation coefficient for i_t and i_t^d is 0.9895. This equation is estimated using instrumental-variables estimation first. Most predetermined variables in the model are used as a combination of instruments for $\ln UR_t$.[7] $\ln UR_{t-1}$, $(\ln M_{t-1} - \ln P_{t-1})$, $\ln y_{t-1}$, UN_{t-1}, $\ln G_t$, and i_t^d are used as a combination of instruments for i_t. Then, the AUTOREG procedure is used to correct for serial correlation. The order of explanation ($\overline{R}^2$) is high. All signs of regression coefficients are consistent with expectations. All coefficients except that of the discount rate are significant at the 10 percent level.

The Small Macroeconometric Model with Rational Expectations

The notation for the model's variables is the following:

i = short-term nominal interest rate

i^{**} = long-term nominal interest rate

r^{**} = long-term real interest rate

i^d = the discount rate of the Federal Reserve Bank

UR = nonborrowed reserves

M = the nominal money stock

Z = the reserve requirement for demand deposits

H = the ratio of currency held by the public to the money stock

P = GNP price deflator

y = real GNP

UN = unemployment rate

BP = real balance on current account

G = real government purchases of goods and services

TAX = real net receipts of government

t = the time trend

D1 = dummy variable, takes the value of 1 after 1969:4 and zero otherwise

D2 = dummy variable, takes the value of 1 after 1979:3 and zero otherwise

D3 = dummy variable, takes the value of 1 after 1982:2 and zero otherwise

This model is estimated using 3SLS as follows:

$$\ln y_t = \underset{(3.53)}{0.4931} + \underset{(3.47)}{0.0067}\, r^{**}_t - \underset{(-1.83)}{0.0046}\, r^{**}_{t-1} - \underset{(-2.77)}{0.0042}\, r^{**}_{t-2}$$

$$+ \underset{(1.74)}{0.0299}\,(\ln M_t - \ln P_t) + \underset{(2.98)}{0.0332} \ln G_t$$

$$- \underset{(-2.44)}{0.0474} \ln TAX_{t-1} + \underset{(5.48)}{0.0010}\, t + \underset{(27.25)}{0.9321} \ln y_{t-1}$$

$$+ e_{4,t} \tag{4.4}$$

$$F = 18942.45 \qquad \bar{R}^2 = 0.9991$$

$$(\ln M_t - \ln P_t) = - \underset{(-4.04)}{0.1492} + \underset{(4.65)}{0.0337} \ln y_t + \underset{(0.27)}{0.0003}\, i_t$$

$$- \underset{(-2.23)}{0.0026}\, i_{t-1}$$

$$+ \underset{(37.25)}{0.9105} (\ln M_{t-1} - \ln P_{t-1}) + e_{5,t} \tag{4.5}$$

$F = 1041.87 \quad \bar{R}^2 = 0.9716$

$$\ln M_t = \underset{(15.49)}{2.5533} + \underset{(29.50)}{1.0905} \ln UR_t + \underset{(2.98)}{0.0426}\, i_t - \underset{(-1.26)}{0.0205}\, i_t^d$$

$$- \underset{(-6.31)}{0.0518} Z_t - \underset{(-0.70)}{1.8059} (H_t - H_{t-1}) + \underset{(17.44)}{0.4018} D3$$

$$+ e_{6,t} \tag{4.6}$$

$F = 1015.93 \quad \bar{R}^2 = 0.9803$

$$\ln UR_t = \underset{(2.46)}{0.1084} - \underset{(-1.80)}{0.0169} (UN_t - UN_{t-1})$$

$$- \underset{(-1.15)}{0.5164} (\ln y_t - \ln y_{t-1})$$

$$+ \underset{(1.96)}{1.3401} (\ln P_t - \ln P_{t-1}) - \underset{(-1.64)}{0.0018} BP_t$$

$$+ \underset{(62.19)}{0.9653} \ln UR_{t-1} + e_{7,t} \tag{4.7}$$

$F = 3633.62 \quad \bar{R}^2 = 0.9933$

$$\ln y_t = \underset{(0.70)}{0.0164} + \underset{(2.93)}{1.9320} [\ln P_t - E(\ln P_t | I_t)]$$

$$+ \underset{(295.18)}{0.9988} \ln y_{t-1} + e_{8,t} \tag{4.8}$$

$F = 43116.22 \quad \bar{R}^2 = 0.9986$

$$i_t^{**} = \underset{(1.30)}{0.0795} + \underset{(5.48)}{0.1150}\, i_t + \underset{(5.42)}{0.1890} (i_t - i_{t-1})$$

$$+ \underset{(37.22)}{0.8938}\, i_{t-1}^{**} + e \tag{4.9}$$

$F = 4581.90 \quad \bar{R}^2 = 0.9912$

$$r_t^{**} = i_t^{**} - [E(\ln P_t | I_t) - \ln P_{t-1}] \tag{4.10}$$

$$UN_t = \underset{(1.85)}{0.8623} - \underset{(-4.36)}{15.6317} (\ln y_t - \ln y_{t-1})$$

$$- \underset{(-7.22)}{16.9019} (\ln y_{t-1} - \ln y_{t-2})$$

$$- \underset{(-3.81)}{7.7290} (\ln y_{t-2} - \ln y_{t-3})$$

$$- \underset{(-0.76)}{0.4416} (\ln M_{t-1} - \ln P_{t-1}) + \underset{(0.55)}{0.0006}\, t$$

$$+ \underset{(49.88)}{0.9651}\, UN_{t-1} + e_{11,t} \qquad (4.11)$$

$$F = 1066.67 \qquad \bar{R}^2 = 0.9813$$

These values of F and $\bar{R}^2$ are from the results of 2SLS.

The anticipated GNP price deflator is estimated as

$$E(\ln P_t | I_t) = - \underset{(-1.09)}{0.5433} + \underset{(3.21)}{0.0019}\, i_{t-1} + \underset{(0.56)}{0.0545}\, i^{**}_{t-1}$$

$$- \underset{(-0.58)}{0.0562}\, r^{**}_{t-1} + \underset{(3.16)}{0.0284} \ln UR_{t-1}$$

$$+ \underset{(2.55)}{0.0770} \ln M_{t-1} + \underset{(2.24)}{0.2171}\, \hat{i}^d_t - \underset{(-1.46)}{0.0339}\, \hat{Z}_t$$

$$- \underset{(-0.53)}{0.2421}\, \hat{H}_t + \underset{(1.15)}{0.1353}\, H_{t-1} + \underset{(36.24)}{1.0073} \ln P_{t-1}$$

$$+ \underset{(0.10)}{0.0042} \ln y_{t-1} - \underset{(-1.43)}{0.0635} \ln y_{t-2}$$

$$- \underset{(-1.24)}{0.0015}\, UN_{t-1} - \underset{(-1.69)}{0.0005}\, \hat{BP}_t + \underset{(2.19)}{0.1618} \ln \hat{G}_t$$

$$- \underset{(-0.95)}{0.0154} \ln TAX_{t-1} - \underset{(-2.44)}{0.0189}\, t \qquad (4.12)$$

$$F = 99999.99 \qquad \bar{R}^2 = 0.9999$$

where $\hat{i}^d_t$, $\hat{Z}_t$, $\hat{H}_t$, $\hat{BP}_t$, and $\ln \hat{G}_t$ are the expected values of the current exogenous variables: i^d_t, Z_t, H_t, BP_t, and $\ln G_t$, respectively.[8] The Durbin h statistic is 0.7958; no positive first-order serial correlation exists at the 5 percent significance level. The Goldfeld-Quandt test statistic is 1.8825 which is less than the critical value $F_{40,40} = 2.11$ at the 1 percent significance level; homoscedasticity is present. This equation is estimated using ordinary least-squares.

In equation (4.4), all coefficients are significant at the 10 percent level. All signs of coefficients except that of the current long-term real interest rate are consistent with expectations. Empirically, aggregate demand is negatively related to the lagged long-term real interest rates. The positive sign of the current long-term real interest rate reflects the procyclical movements in real income and the long-term real interest rate.

In equation (4.5), all the parameter estimates (except that of the current short-term interest rate) have the same signs as those expected, and are significant at the 5 percent level. Empirically, real money demand is negatively related to the one lagged short-term interest rate, but not the current short-term interest rate. The adjustment coefficient of demand for real balance is 0.0895, which means that the adjustment between the desired and the actual demand for real balances is low.

All the parameter estimates of equation (4.6) have the same signs as those expected. The parameter estimates of equations (4.3) and (4.6) are different because different estimating techniques are used. Some coefficients of equation (4.7) do not have the same signs as those expected. The reason is that the instrumental variable for UN_t used in the first stage of 3SLS is a combination of all predetermined variables in the model, which is different from that used in equation (4.1). However, the one instrument--UN_{t-1} used in equation (4.1) has the highest correlation with UN_t. The policy-controlled parameters in equation (4.7) are significant at the 5 percent level.

In equation (4.8), all of the signs are consistent with expectations. The coefficient of the unanticipated inflation rate is significant at the 5 percent level. There exists a short-run trade off between unemployment and the unanticipated inflation rate. All the coefficients of equation (4.9) have the correct signs consistent with expectations, and are significant (except for the constant term) at the 5 percent level.

In equation (4.11), all of the signs agree with expectations. The unemployment rate is significantly negatively related to the current and the lagged growth rates of real income at the 5 percent level.

Based on the values of F and $\bar{R}^2$, each equation fits the data well. The weighted R^2 for the model is 0.9965, which corresponds to the approximate F test on all non-intercept parameters in the model [SAS, 1982]. The overall statistical fit of the model is good.

An ex post dynamic simulation over the 1953:3-1984:2 time period is performed. The statistics of fit of each endogenous variable are listed in Table I. The root-mean-square simulation error (rmse) measures the deviation of the simulated variable from its actual time path, or the estimate of the standard deviation of the error term. The rmse of each endogenous variable is compared with its mean. Real income, prices, the money stock, and nonborrowed reserves each has a small rmse. The historical simulation of each endogenous variable is shown on Figures 1-8. The estimated equations of real income, prices, and the money stock (Figures 1, 5, and 6) track the actual behavior quite well. Those equations of interest rates (Figures 2, 3, and 4) do not have good simulation fit; however, they generally duplicate the turning points in the historical data. The simulated series of nonborrowed reserves and unemployment rate (Figures 7 and 8) do reproduce the general long-run behavior of their actual series, although some turning points are missed and the short-run fluctuations in the actual series are not reproduced well.

TABLE I

GOODNESS-OF-FIT STATISTICS

variable	mean	rmse
ln y	6.9172	0.0635
r**	6.0159	1.9207
i**	6.0012	1.9220
i	5.3470	2.0296
ln p	4.5679	0.0036
ln M	5.3664	0.0569
ln UR	3.2559	0.1210
UN	5.7619	1.7859

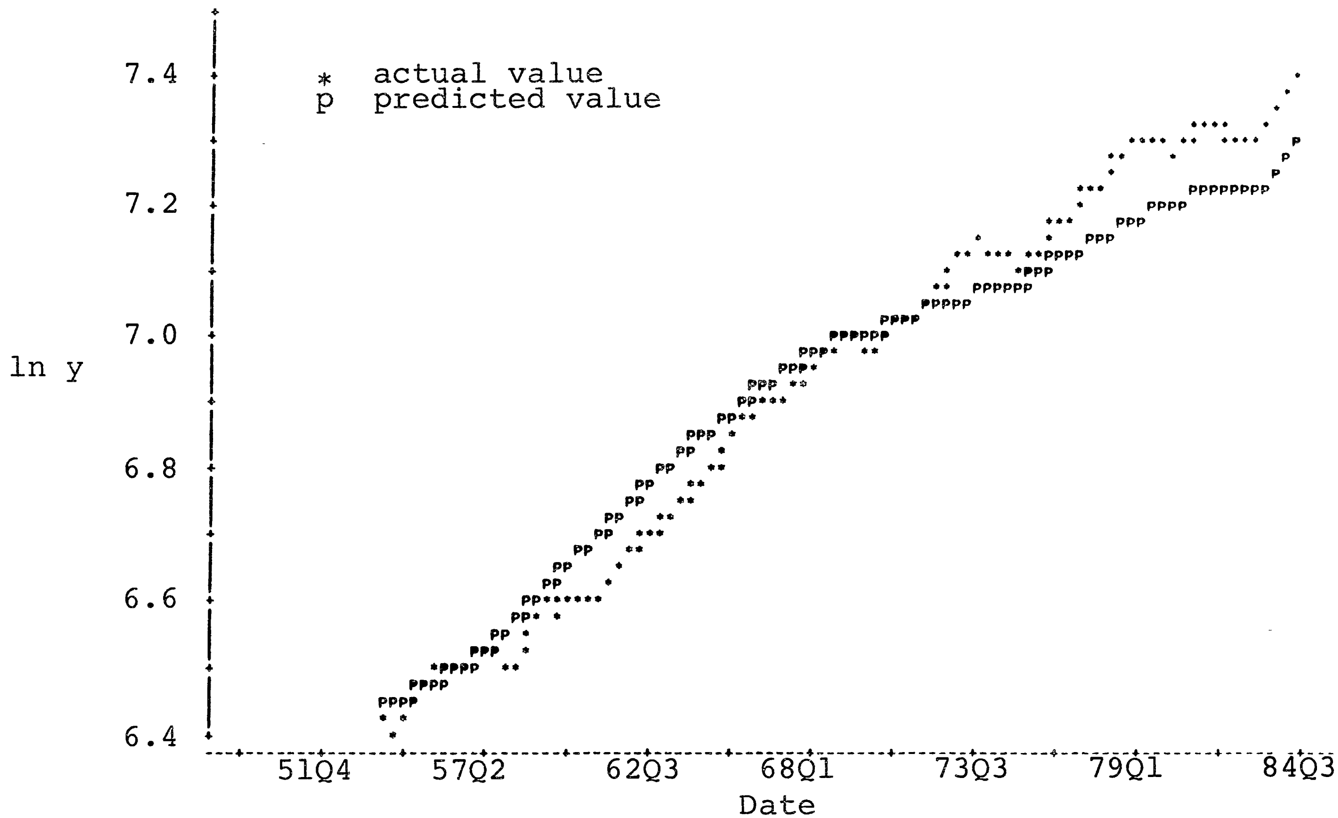

Figure 1. Real GNP, ln y (Billions of 1972 Dollars)

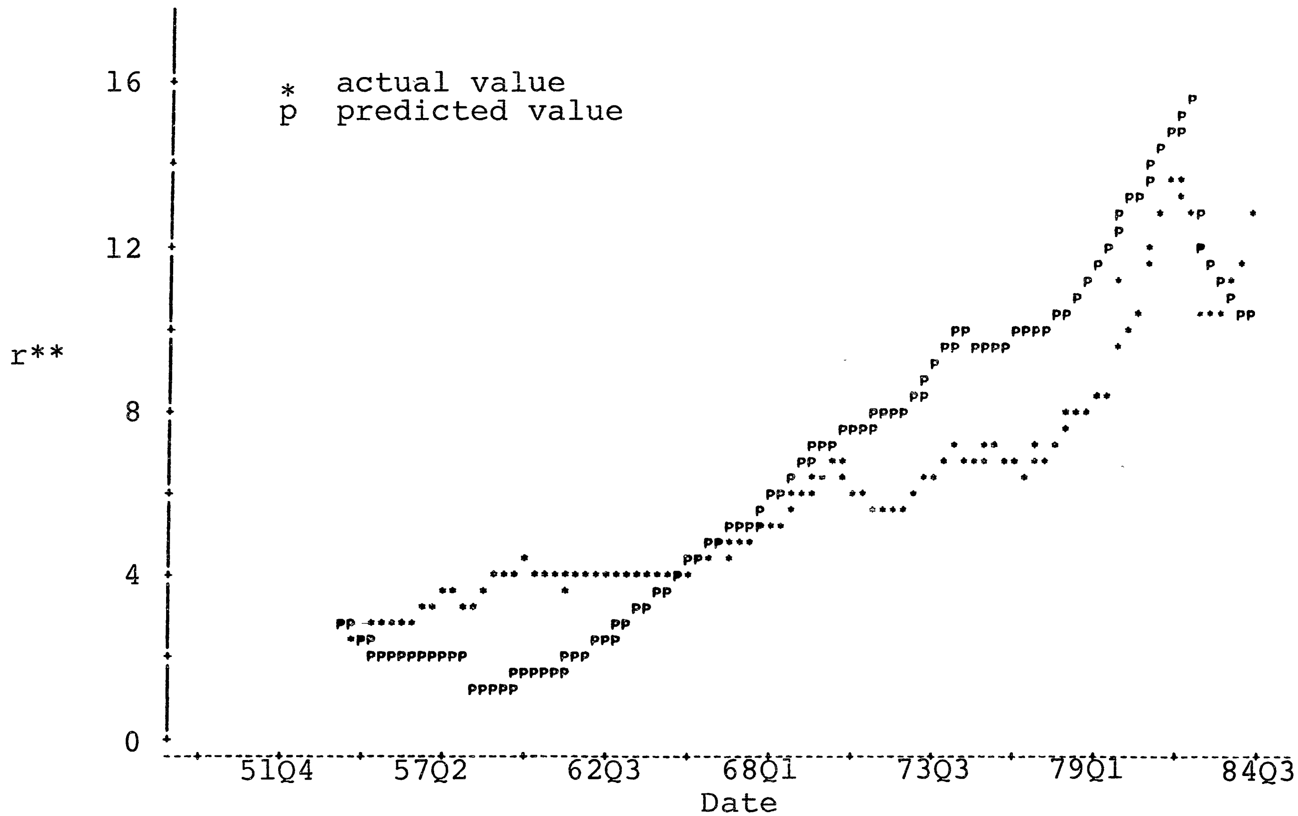

Figure 2. Long-Term Real Treasury Bond Rate, r**
(Percent per Annum)

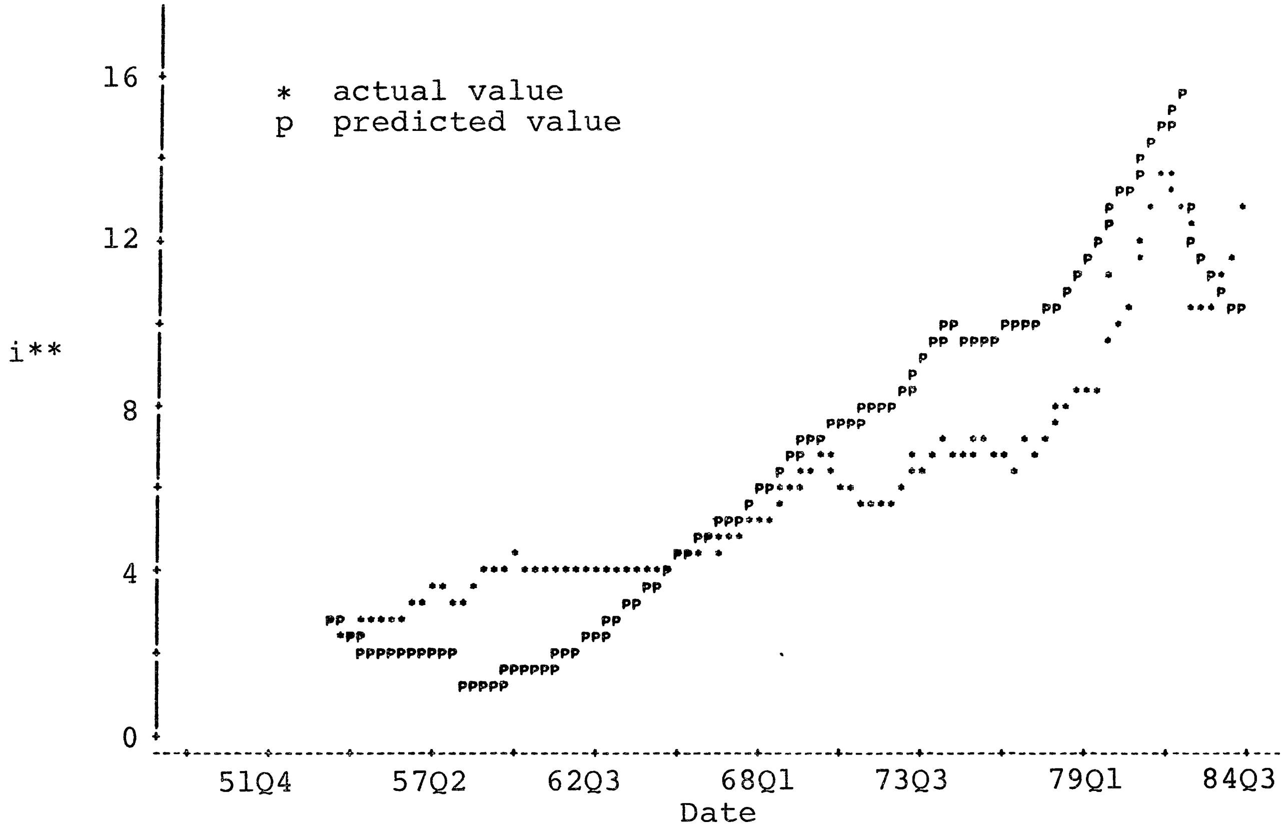

Figure 3. Long-Term Treasury Bond Rate, i**
(Percent per Annum)

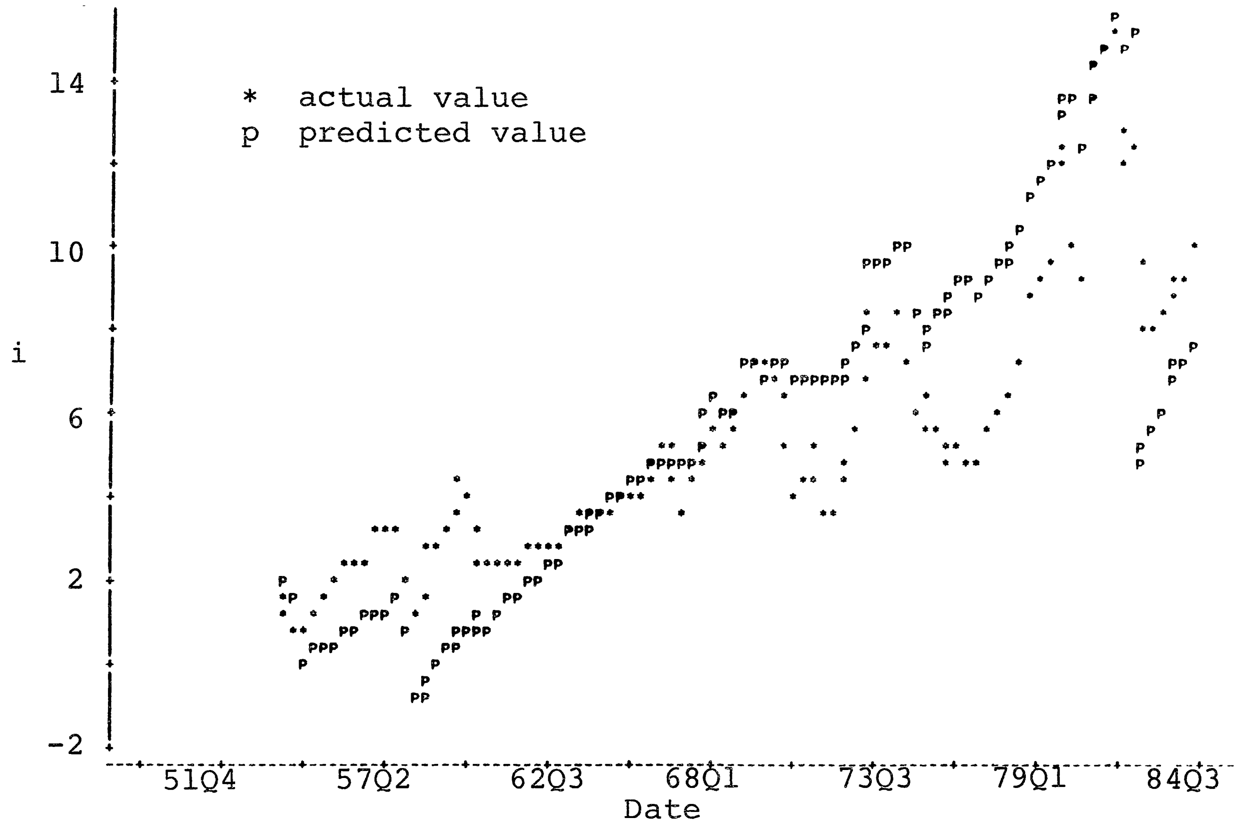

Figure 4. Three-Month Treasury Bill Rate, i
(Percent per Annum)

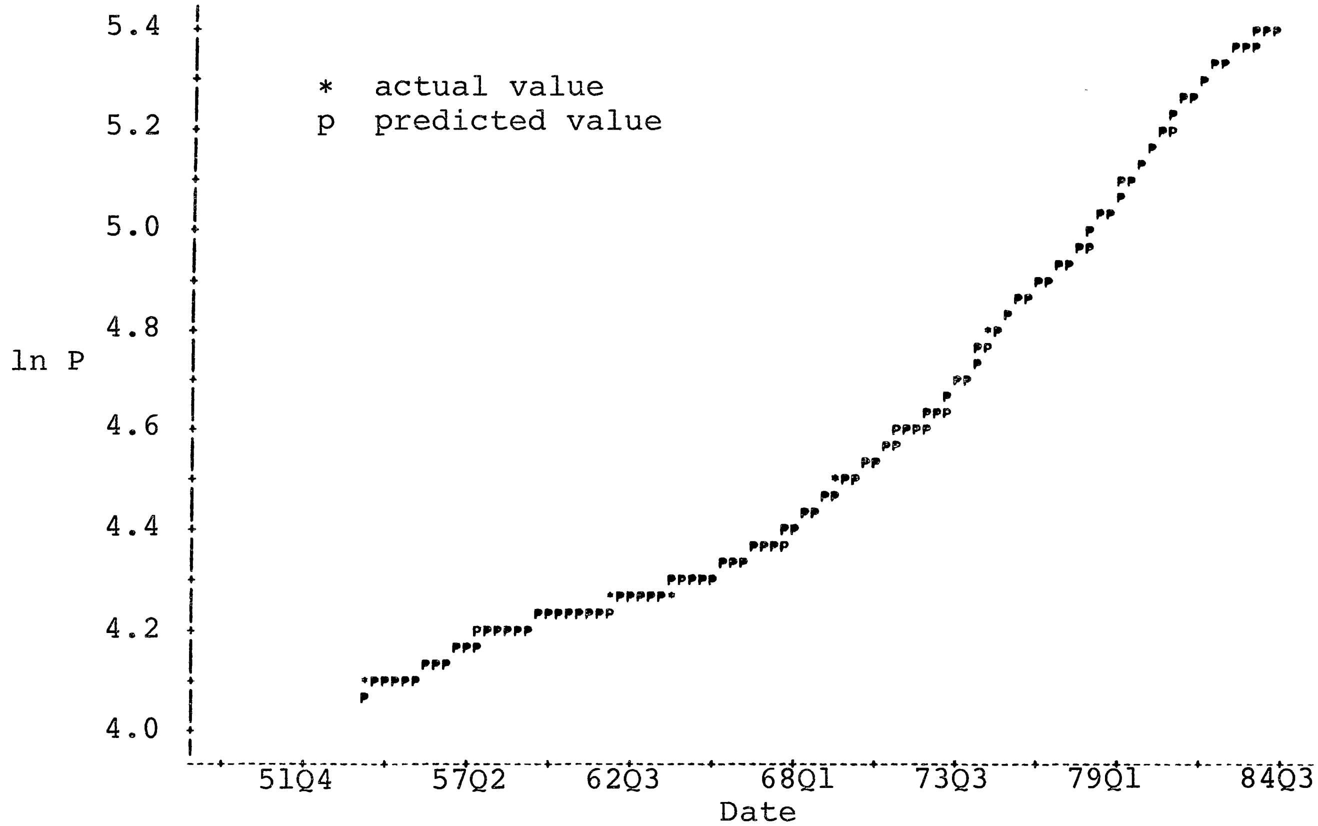

Figure 5. Implicit Price Deflator for GNP, ln P (1972=100)

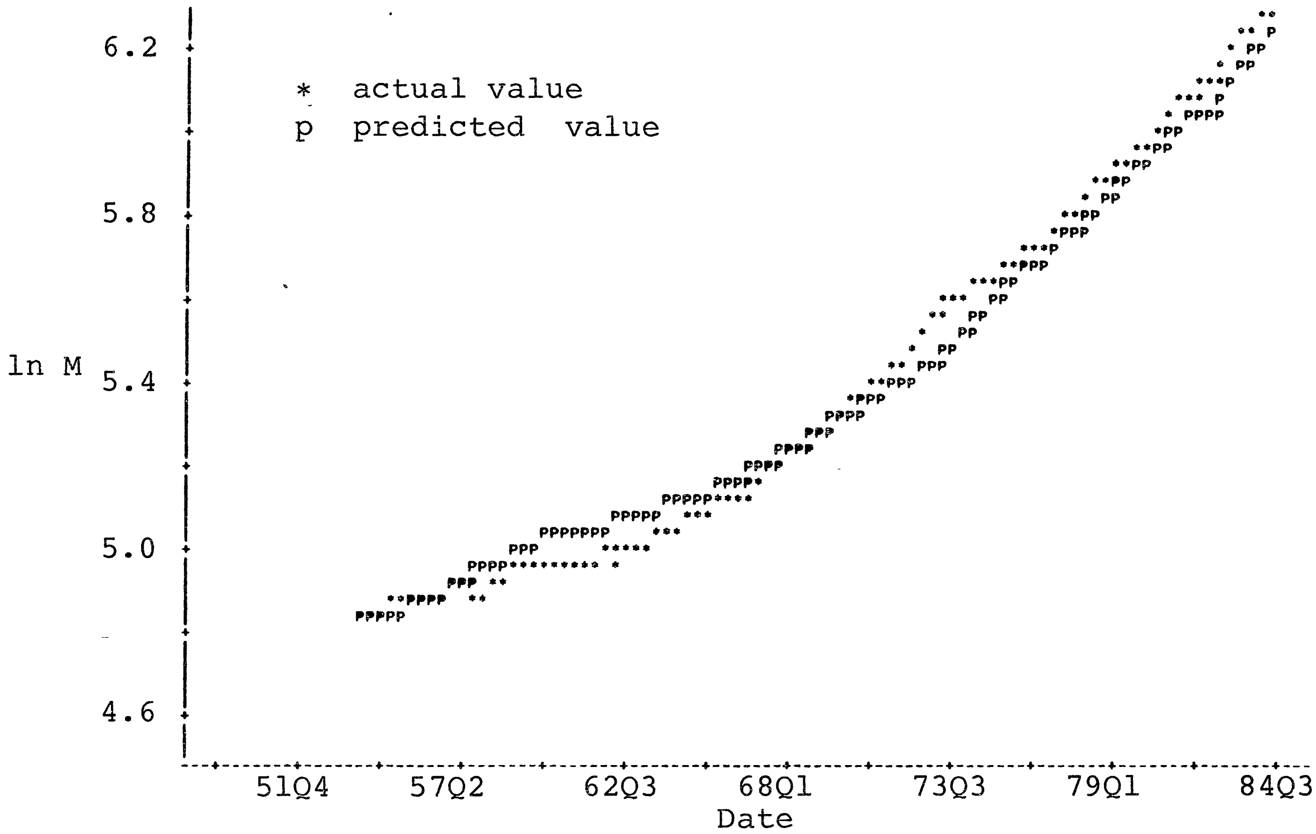

Figure 6. The Money Stock, ln M (Billions of Dollars)

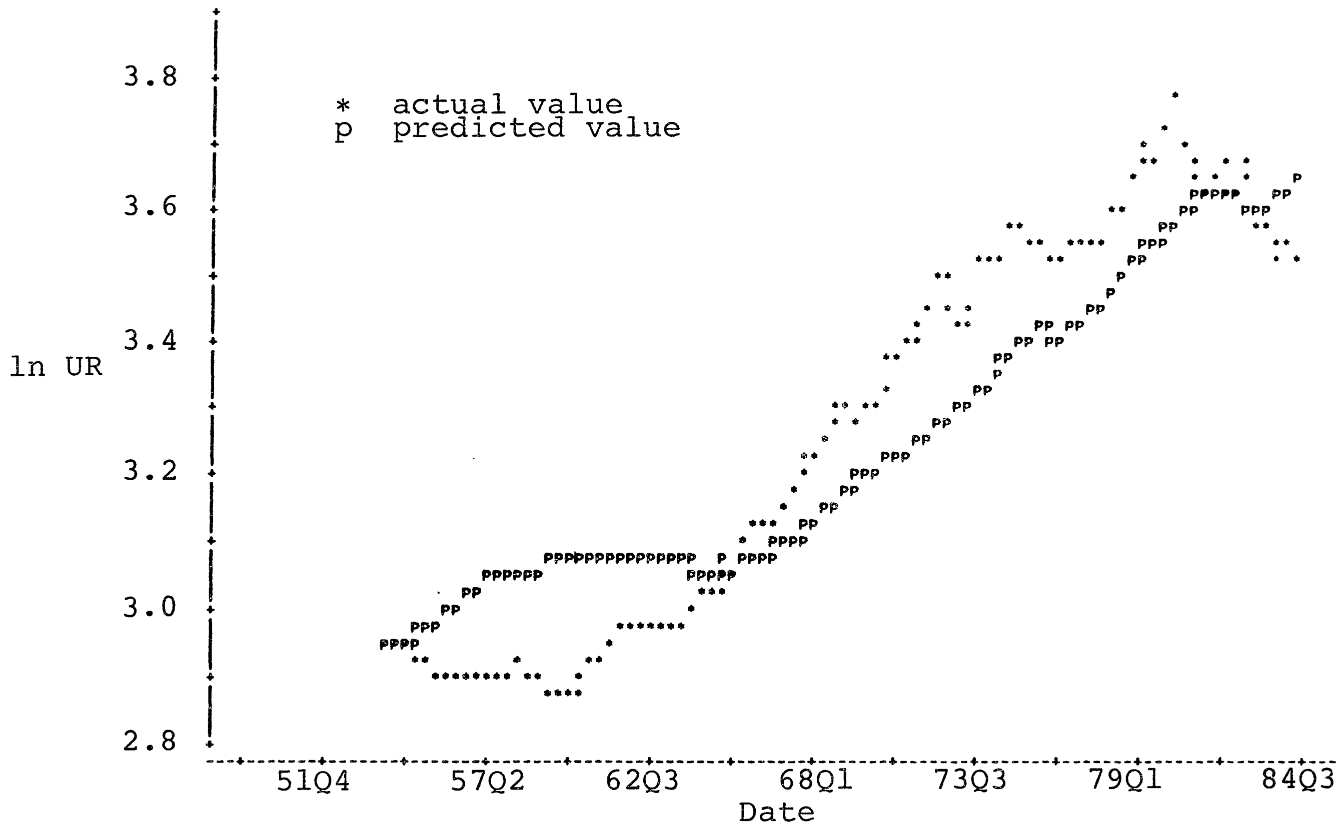

Figure 7. Nonborrowed Reserves, ln UR (Billions of Dollars)

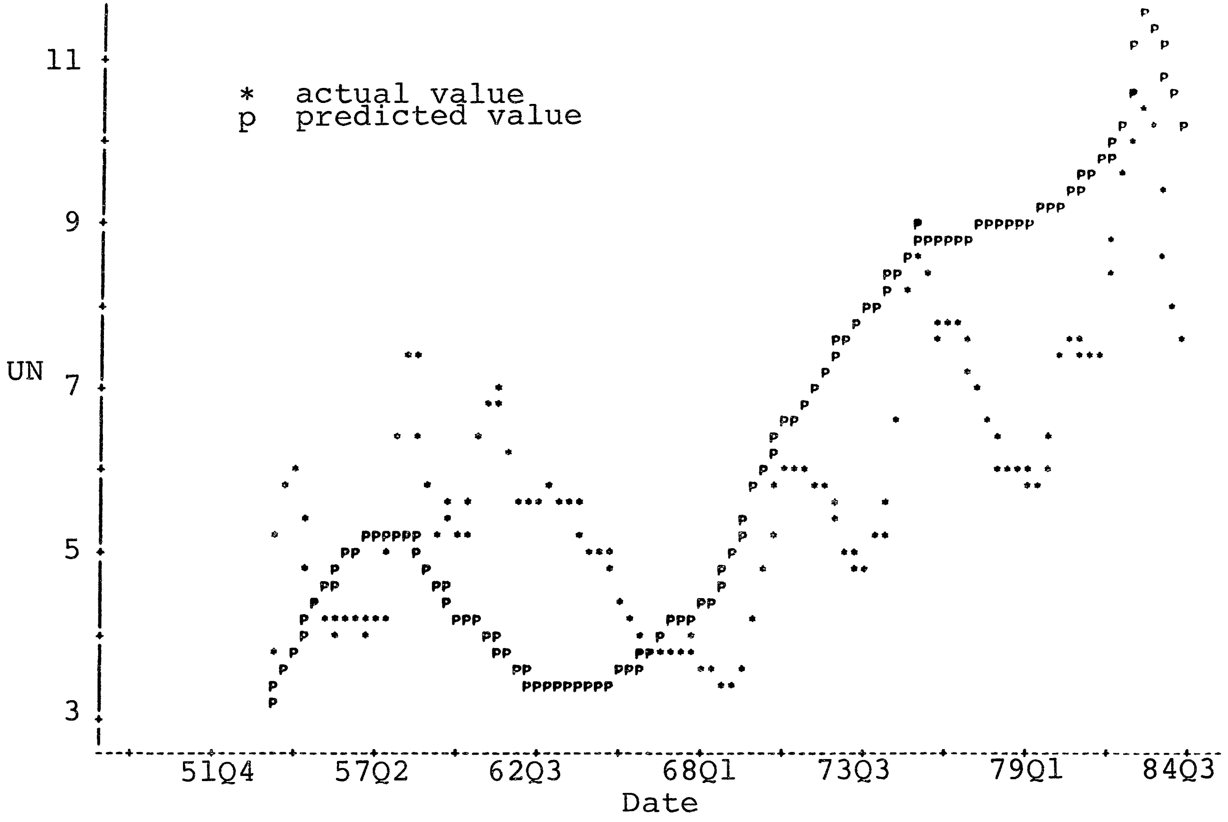

Figure 8. Unemployment Rate, UN (Percent)

The Dynamic Response of the Model

Changes in the policy-controlled parameters affect the real and nominal magnitudes through the economic system. The dynamic multipliers for each endogenous variable are calculated by changing the parameter of the constant term in the reaction function--equation (4.7)--from 0.1084 to 0.2000 first with other things being equal, and then changing the parameter of the lagged dependent variable in equation (4.7) from 0.9653 to 0.8600 with other things being equal. The first observations of the dynamic multipliers start from 1953:4 since the lagged endogenous variables are included in the model. The impact and the total multipliers for each endogenous variable resulting from changes in policy-controlled parameters are listed in Table II. The interim multipliers are shown on Figures 9-24. On these figures, some observations are hidden.

Monetary actions have an immediate effect and a cumulative effect on each endogenous variable, and these effects depend on the size of changes in policy-controlled parameters. The oscillatory movements of the interim multipliers are around zero. And most signs of the impact multipliers and total multipliers of endogenous variables are opposite. These suggest that the first period effect and most of the subsequent period by period effects on endogenous variables of changes in the policy-controlled parameters generally do not support theoretical expectations because the endogenous variables have interacted. Only the cumulative effects are consistent with theoretical rational expectations. In general, expansionary policy increases the money stock, prices, and real income in the short run, it also decreases the unemployment rate and interest rates. There exists a short-run Phillips relations. The model shows that, over the entire period, the influence of money on money income falls on real income and on prices. Since all interim multipliers exhibit an oscillatory movement around zero, this is a stable model. Only the interim multipliers of real income and the unemployment rate (Figures 9, 16, 17, and 24) exhibit a damped oscillatory movement and tend to converge to zero. This implies that monetary policy cannot affect real income and the unemployment rate in the long run, but can affect all other endogenous variables. These results suggest that monetary policy is effective in the short run, but ineffective in the long run. However, the empirical evidence does not support the view that monetary policy cannot affect the real interest rate in the long run.

TABLE II

DYNAMIC MULTIPLIERS OF CHANGES IN POLICY-CONTROLLED PARAMETERS

variable	restrict h_1=0.2000 impact multiplier	restrict h_1=0.2000 total multiplier	restrict h_6=0.8600 impact multiplier	restrict h_6=0.8600 total multiplier
ln y	-0.0001	0.0124	-0.0001	0.0347
r**	0.0266	-0.1844	0.0779	-0.2998
i**	0.0266	-0.1847	0.0779	-0.3005
i	0.0869	-0.0076	0.2569	0.2196
ln P	-0.0001	0.0002	-0.0001	0.0004
ln M	0.0001	0.0092	0.0003	0.0221
ln UR	-0.0020	0.0062	-0.0070	0.0017
UN	0.0039	-0.4921	0.0106	-1.2498

note: h_1 represents the parameter of the constant term in equation (4.7).

h_6 represents the parameter of the lagged dependent variable in equation (4.7).

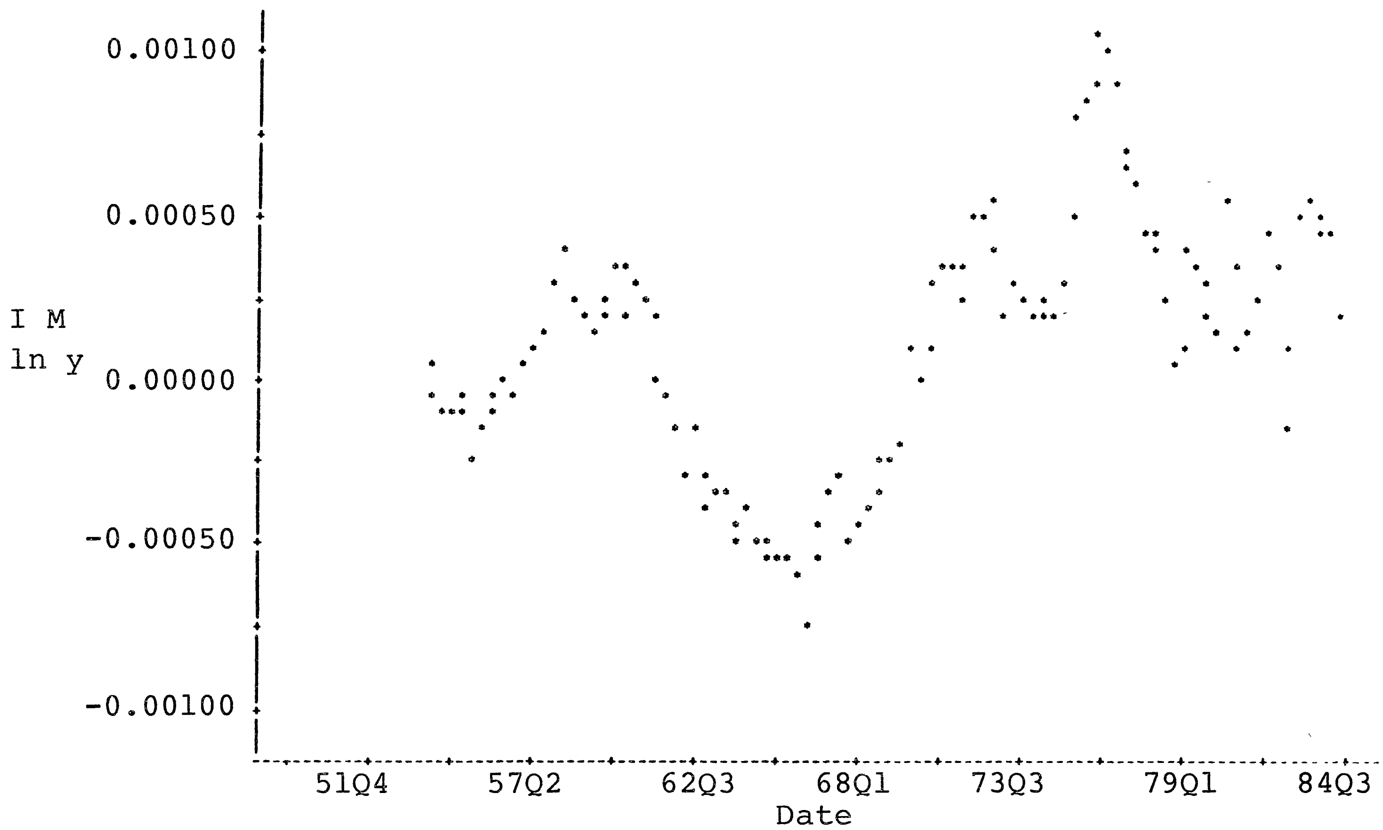

Figure 9. Interim Multipliers for ln y as h_1 = 0.2000

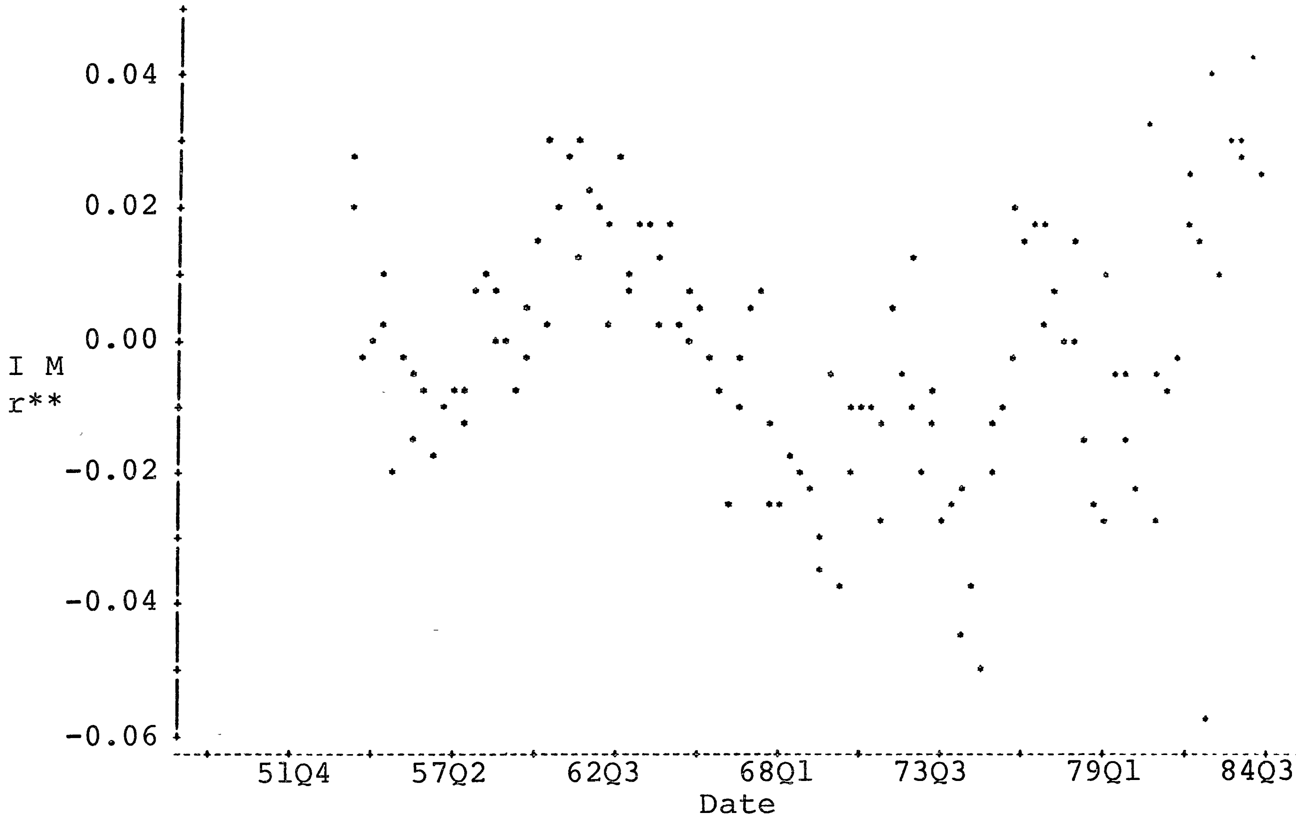

Figure 10. Interim Multipliers for r** as h_1 = 0.2000

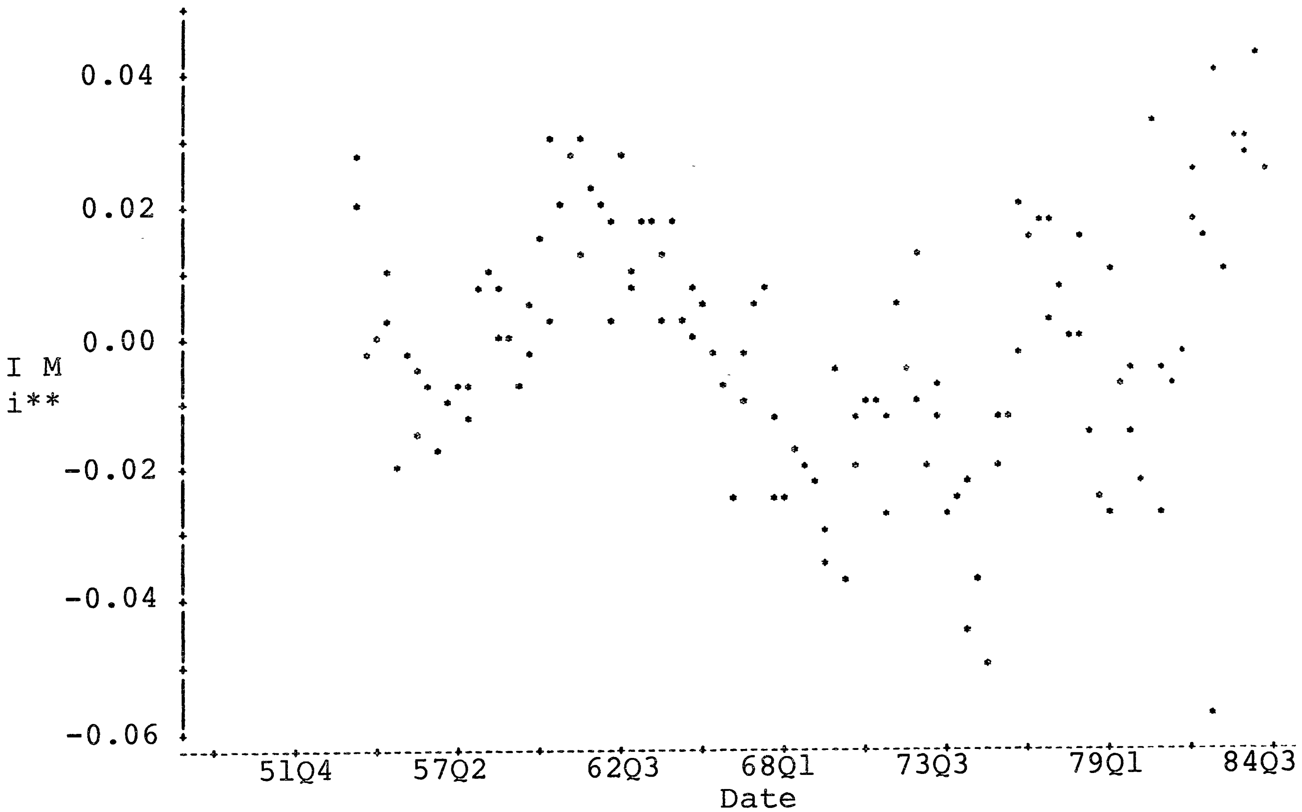

Figure 11. Interim Multipliers for i** as $h_1 = 0.2000$

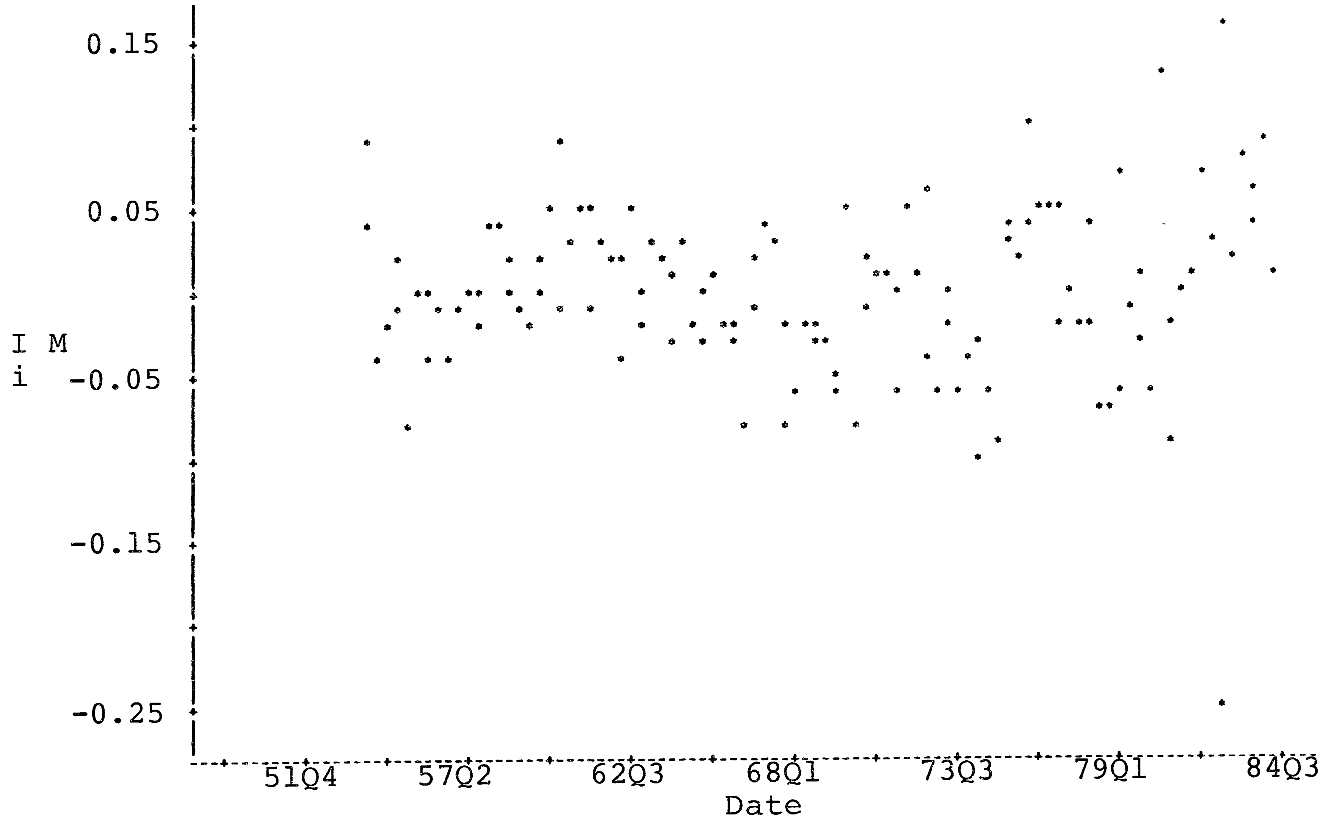

Figure 12. Interim Multipliers for i as h_1 = 0.2000

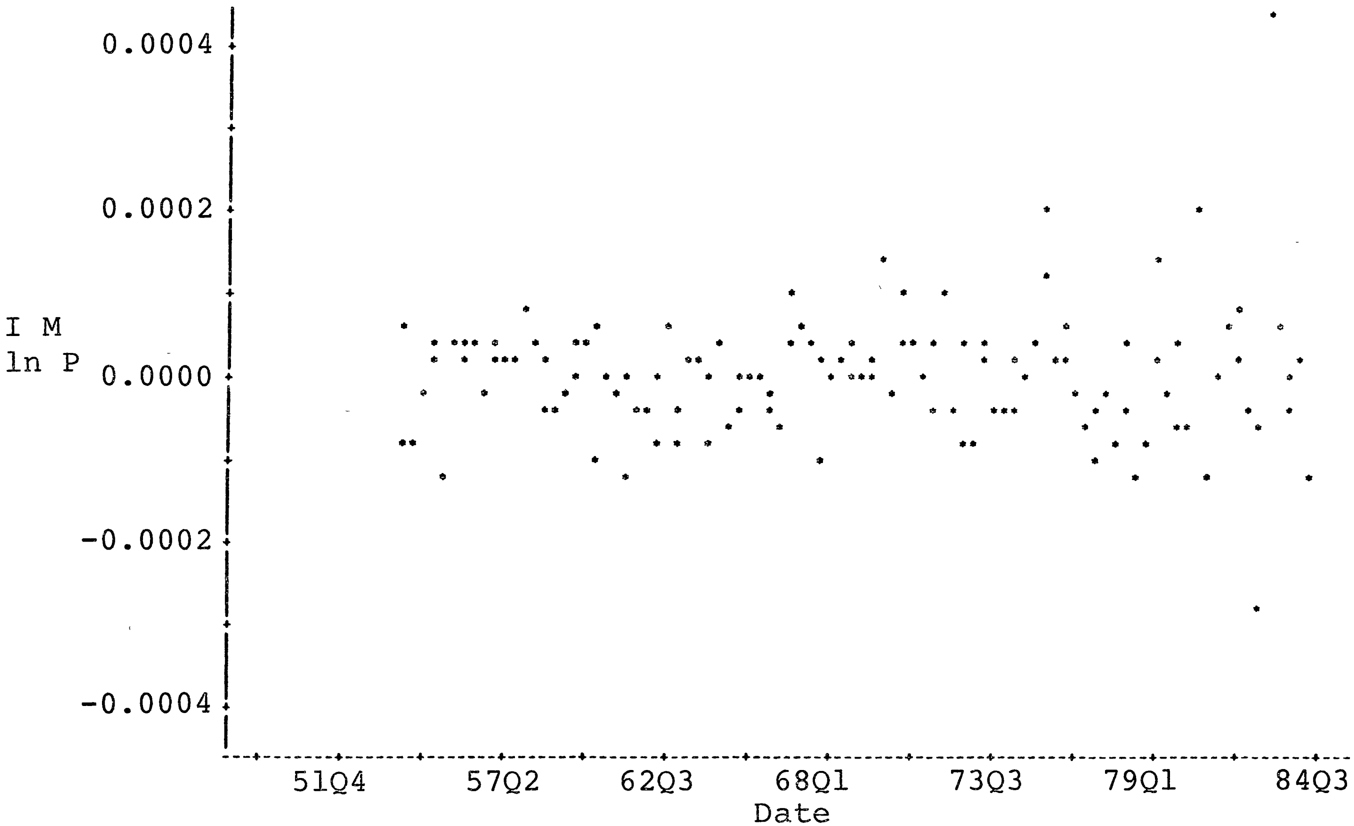

Figure 13. Interim Multipliers for ln P as h_1 = 0.2000

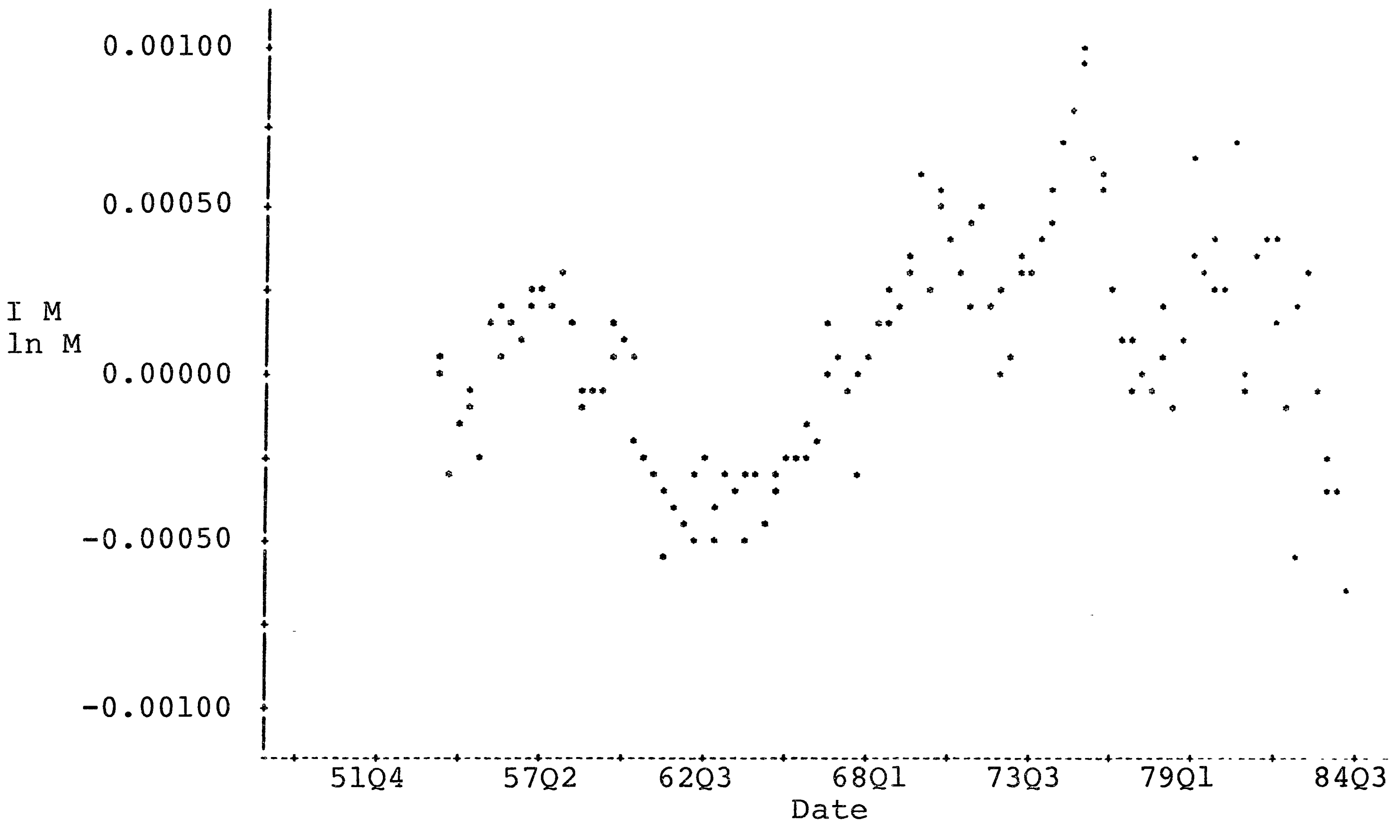

Figure 14. Interim Multipliers for ln M as $h_1 = 0.2000$

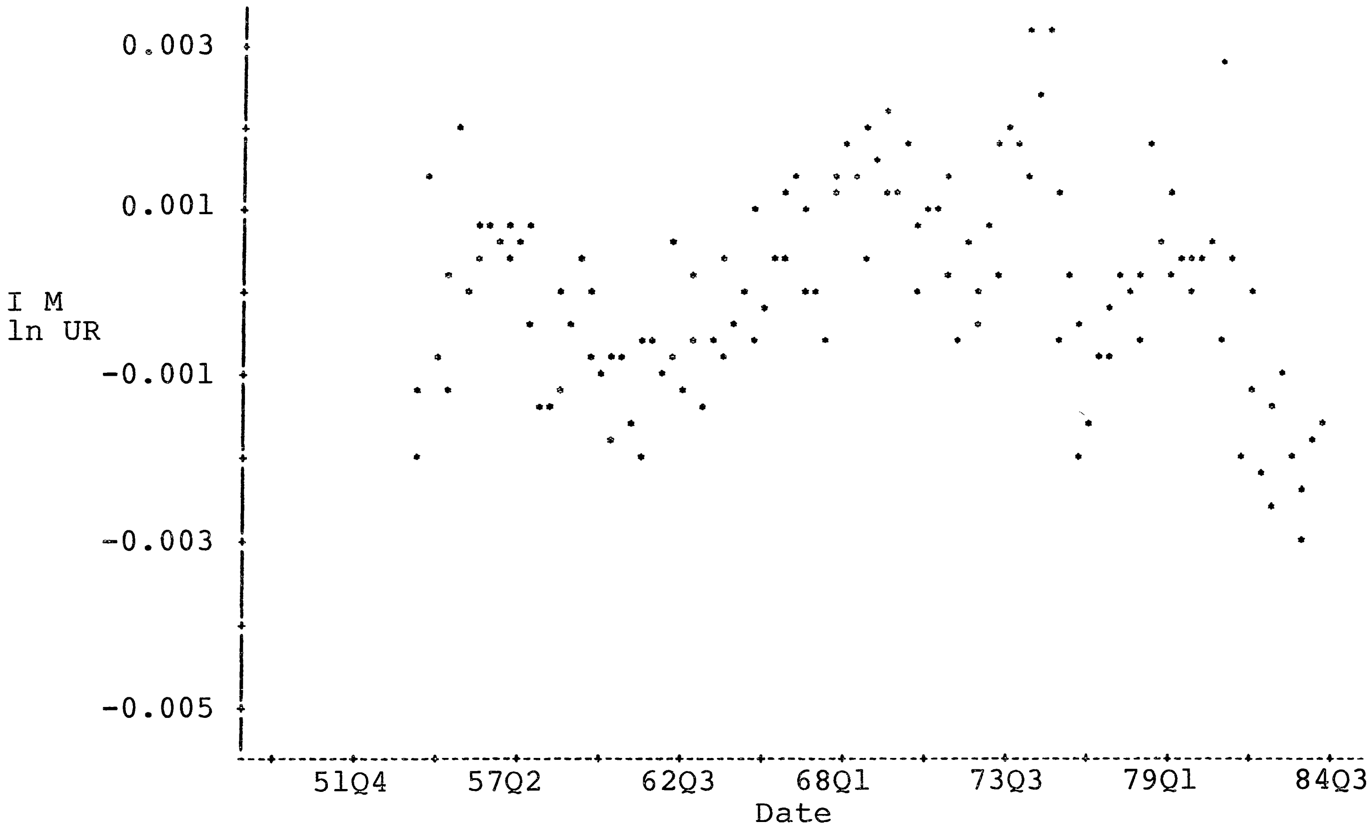

Figure 15. Interim Multipliers for ln UR as h_1 = 0.2000

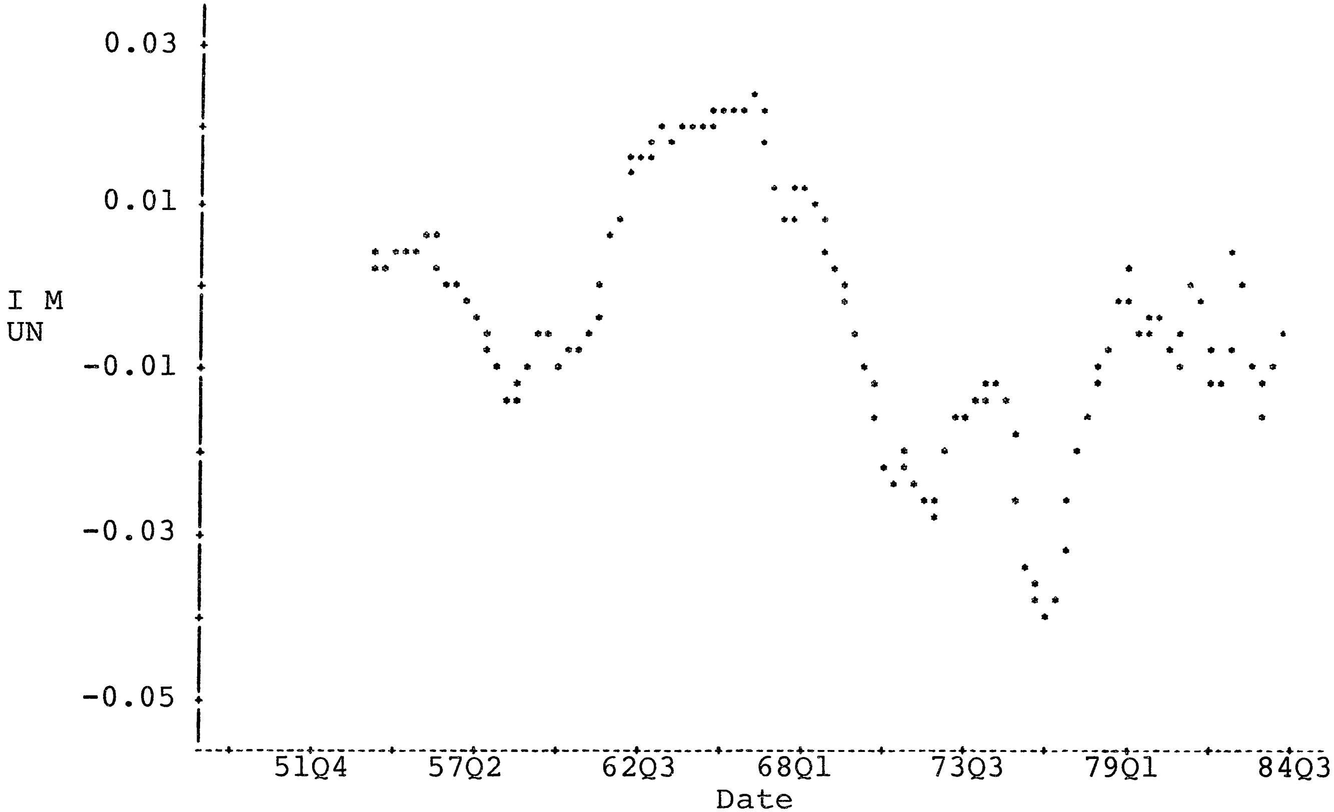

Figure 16. Interim Multipliers for UN as $h_1 = 0.2000$

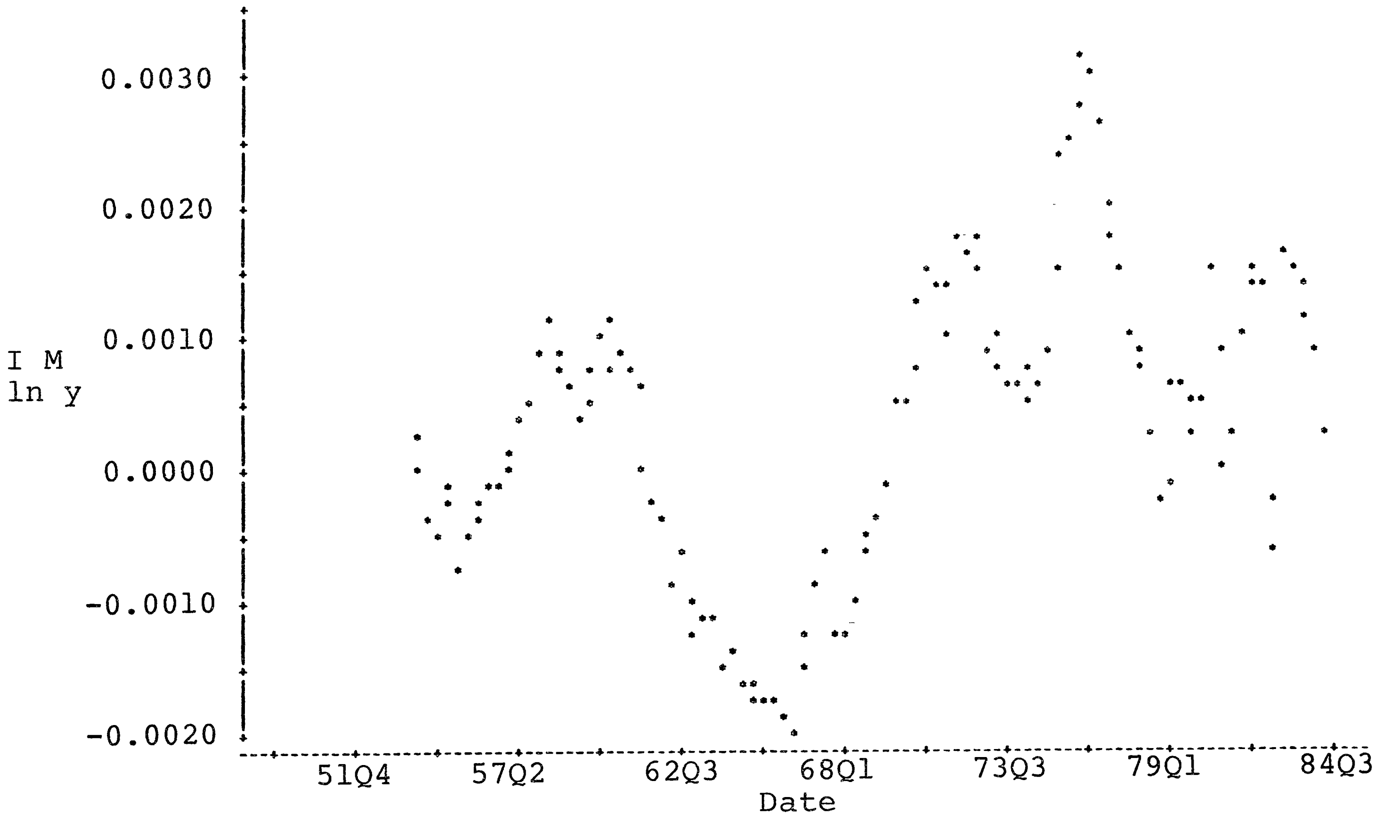

Figure 17. Interim Multipliers for ln y as h_6 = 0.8600

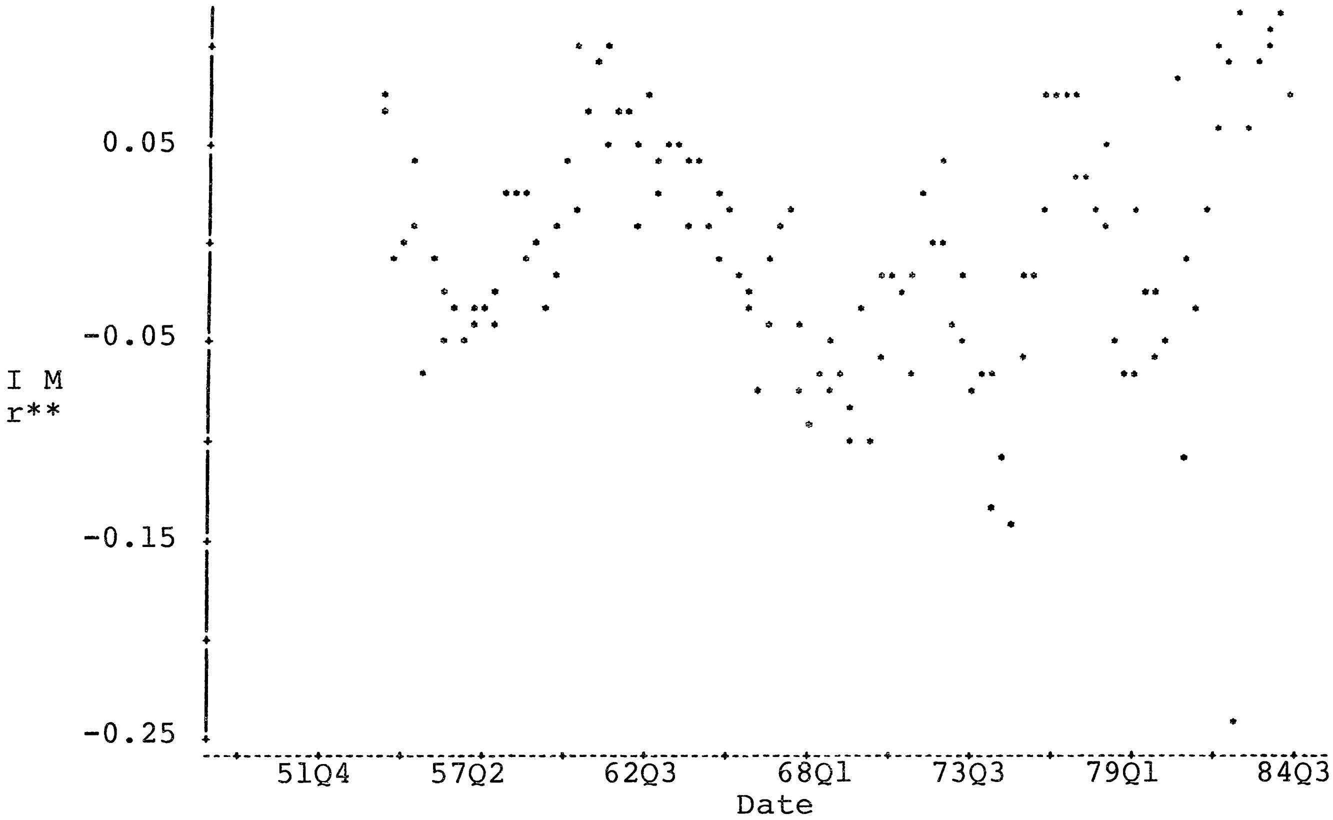

Figure 18. Interim Multipliers for r** as $h_6 = 0.8600$

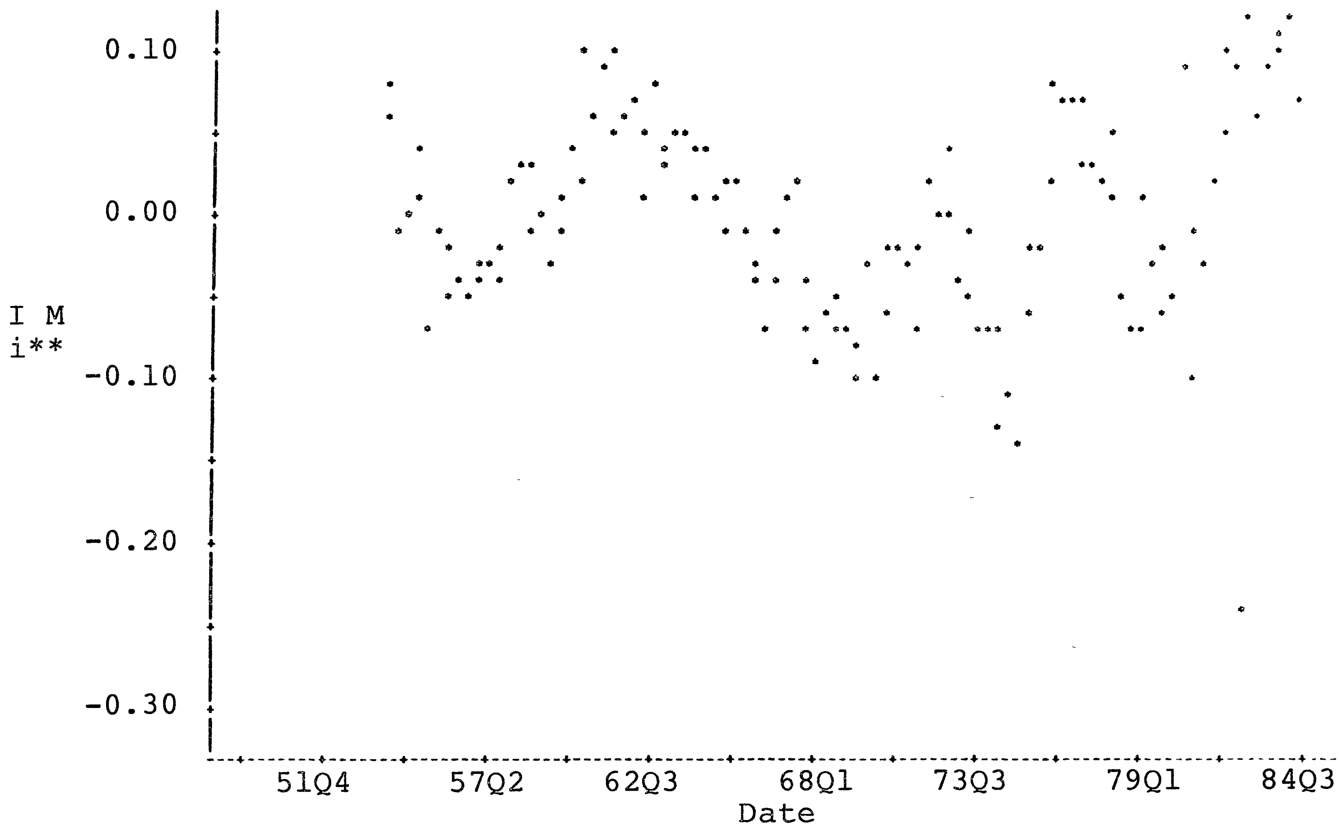

Figure 19. Interim Multipliers for i** as h_6 = 0.8600

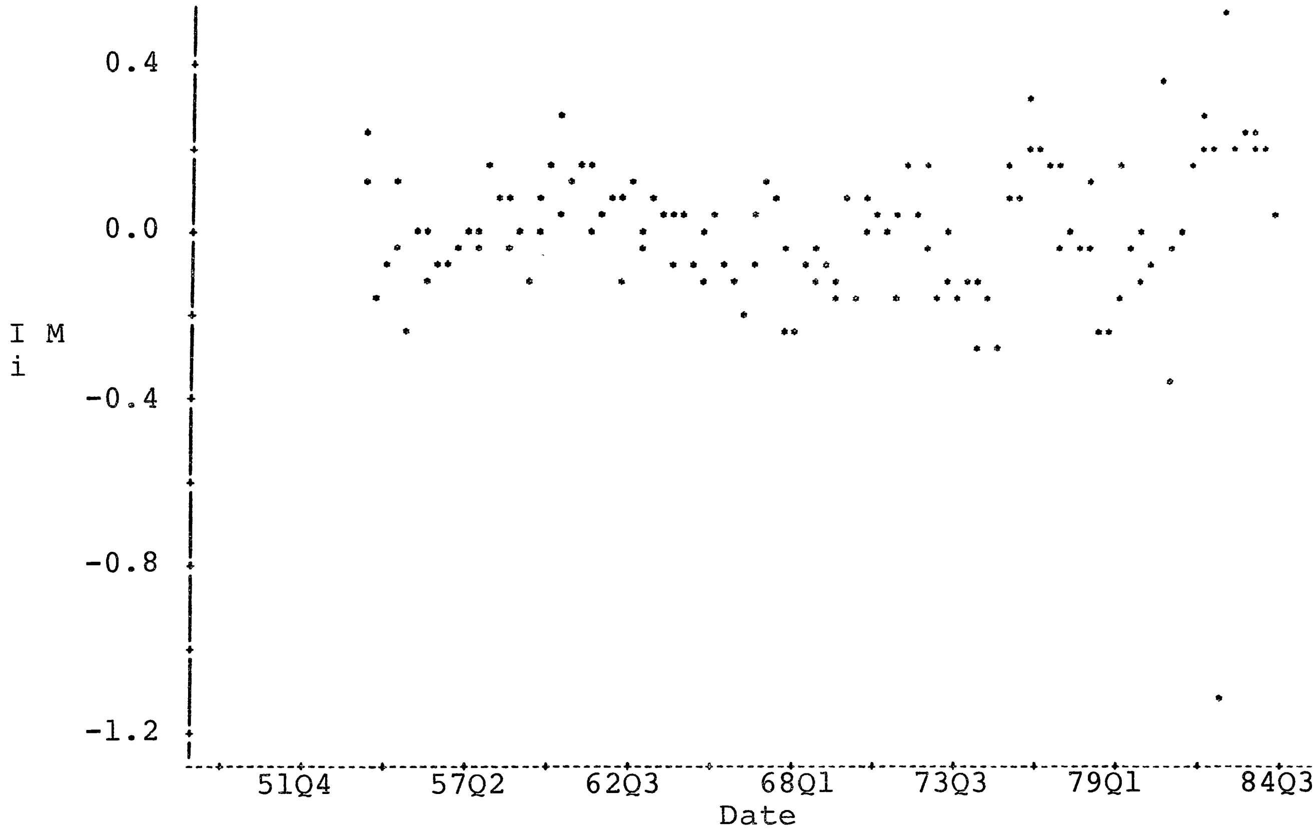

Figure 20. Interim Multipliers for i as h_6 = 0.8600

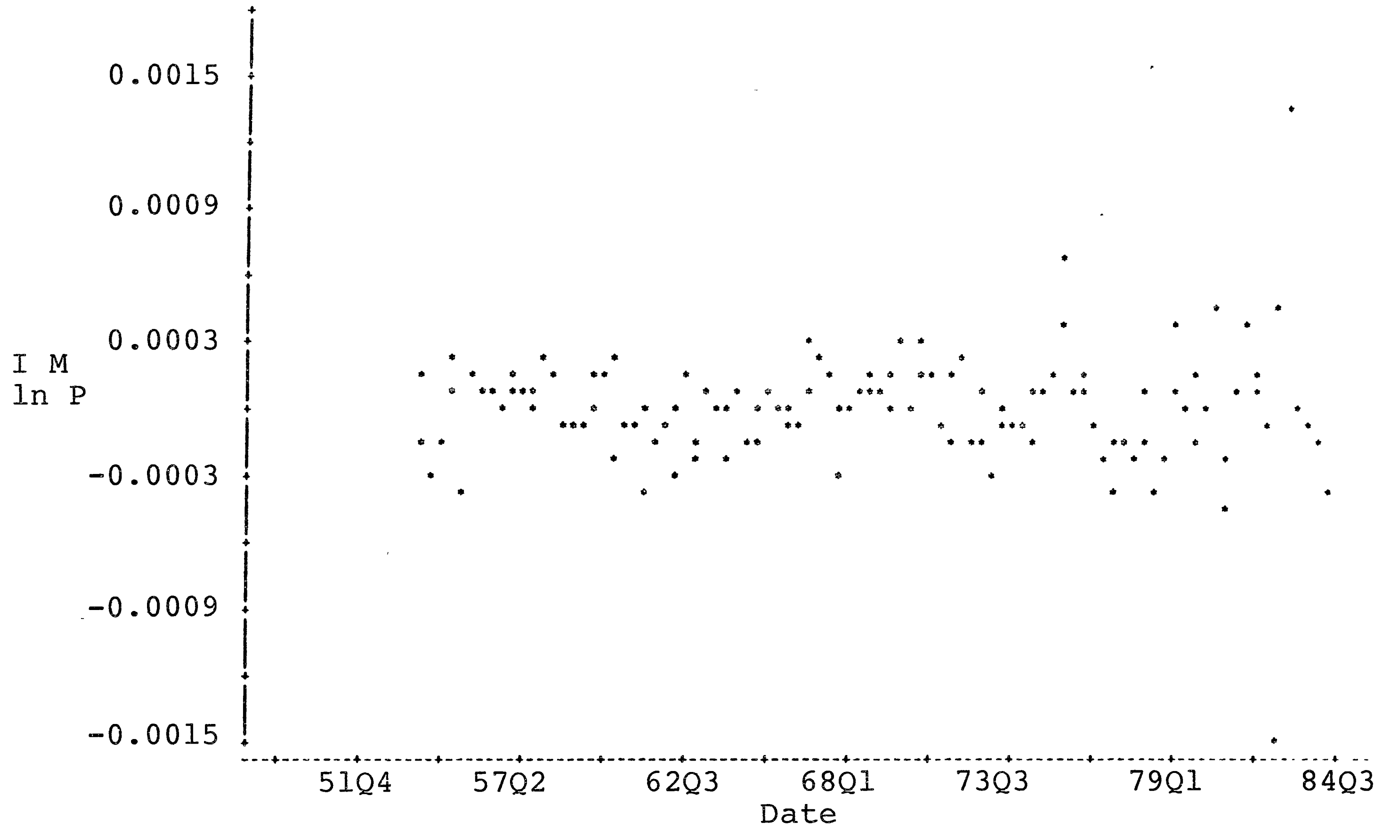

Figure 21. Interim Multipliers for ln P as h_6 = 0.8600

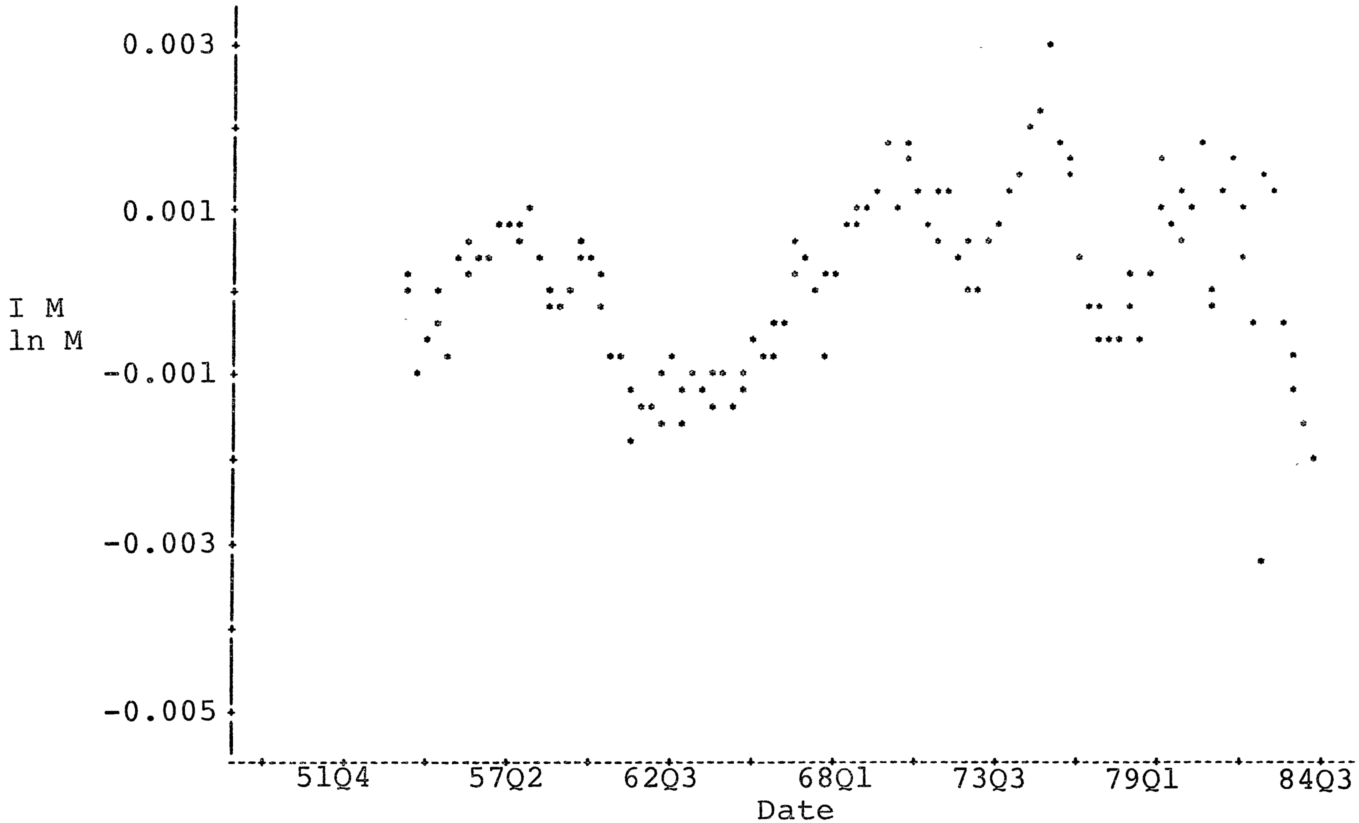

Figure 22. Interim Multipliers for ln M as $h_6 = 0.8600$

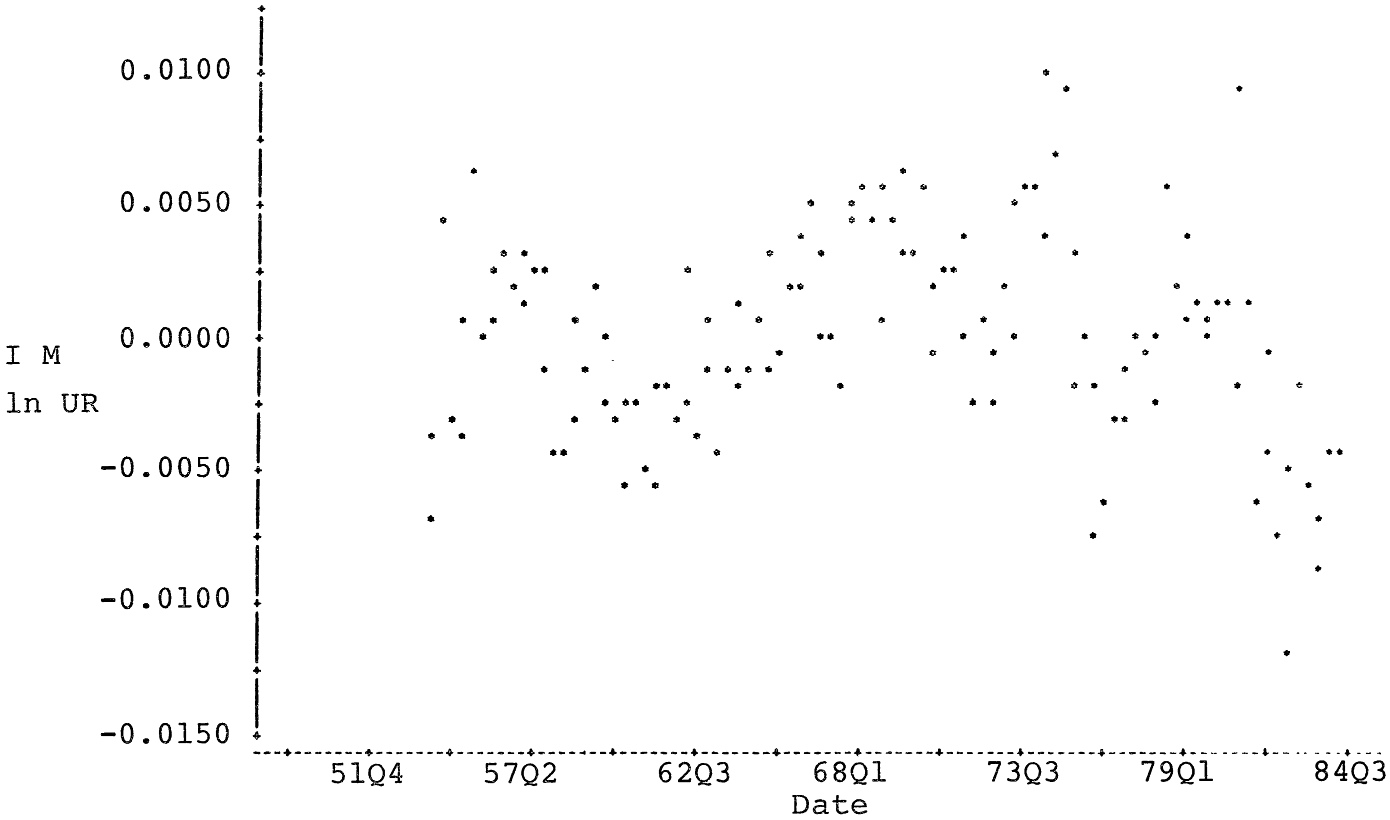

Figure 23. Interim Multipliers for ln UR as $h_6 = 0.8600$

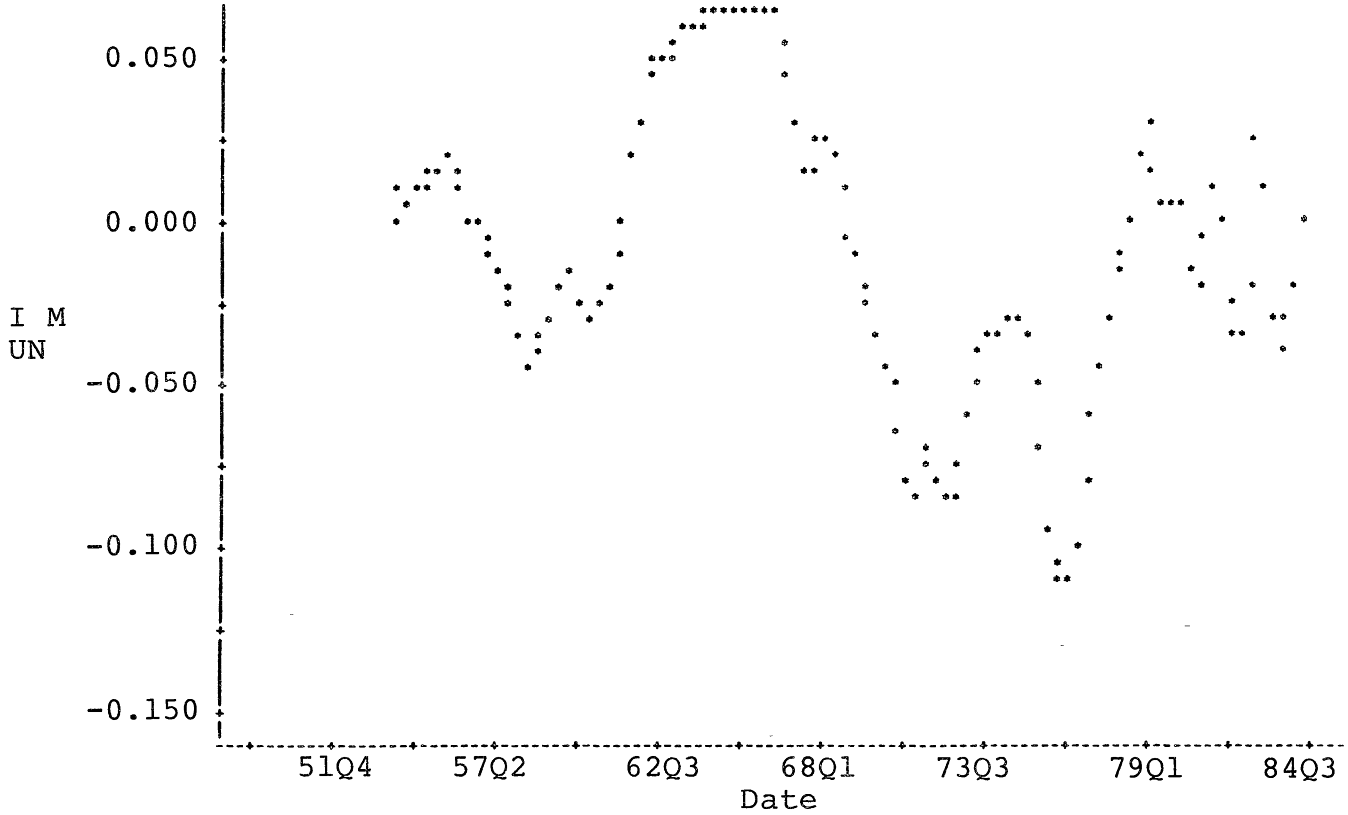

Figure 24. Interim Multipliers for UN as h_6 = 0.8600

Endnotes

[1]When the lagged endogenous variable is present, the Durbin-Watson (DW) statistic is no longer useful in testing for serial correlation because the DW statistic is often close to 2 even when the errors are serially correlated [Pindyck and Rubinfeld, 1981].

[2]Positive first-order serial correlation is present in equations (4.4), (4.8), and (4.11) at the 5 percent significance level. Fifth-order serial correlation is present in equation (4.5) at the 5 percent significance level. Lagged endogenous variables are included in these equations.

[3]Since the lagged endogenous variables are involved in the model, the first observation of dynamic simulation starts from 1953:4.

[4]The coefficient of $\ln UR_{t-1}$ is less than 1 if the constant term of equation (4.1) is restricted to be zero. Also, it is less than 1 in 3SLS estimates.

[5]i_{t-1}, i^{**}_{t-1}, $\ln UR_{t-1}$, $(\ln M_{t-1} - \ln P_{t-1})$, $(H_t - H_{t-1})$, $\ln y_{t-1}$, $\ln y_{t-2}$, $\ln y_{t-3}$, UN_{t-1}, BP_t, $\ln G_t$, $\ln TAX_{t-1}$, $\ln P_{t-1}$, $\ln P_{t-2}$, t, i^d_t, and Z_t are used as a combination of instruments for $\ln y_t$ and $\ln P_t$, respectively.

[6]The combination of instruments for $\ln M_t$ is the same as that for $\ln y_t$ or $\ln P_t$.

[7]The combination of instruments for $\ln UR_t$ is the same as that for $\ln y_t$ or $\ln P_t$.

[8]Most expected values of the current exogenous variables are estimated by an integrated autoregressive-moving average (ARIMA) model. The ARIMA(p,d,q) model is (7,1,1) for i_t^d, (10,1,2) for Z_t, (1,2,1) for H_t, and (14,2,0) for $\ln G_t$. BP_t is estimated by BP_{t-1} because it is a random walk with white noise.

CHAPTER V

CONCLUSION

In this paper, the Federal Reserve open market operations are used as a policy instrument to examine the Federal Reserve behavior. Based on the values of the F statistic and the corrected R^2 of reaction functions, equations (4.1) and (4.2), the evidence is strong that the Federal Reserve reacts to policy goals or intermediate targets. The monetary authority has acted countercyclically in the sense that the nonborrowed reserves is negatively related to the inflation rate and real balance on current account, and is positively related to the change in the unemployment rate; or is negatively related to the change in interest rates and the growth rate of the money stock. However, among these target variables, only the coefficient of the change in the unemployment rate is significant at the 5 percent level. In equation (4.2), nonborrowed reserves are negatively related to the growth rate of the money stock since 1970. The empirical results do not support the proposition that the Federal Reserve is responsible for the procyclical growth of the money stock since 1970. The significant parameter estimate of the dummy variable, D2, in equation (4.2) indicates that the adoption of a reserve-aggregate approach to monetary control in October 1979 has had a significant effect on the Federal Reserve behavior.

Theoretically and empirically, the money stock is endogenously determined by actions of the monetary authority, the banking system, and the public. The significant parameter estimate of the dummy variable, D3, in equation (4.3) indicates that the movements of the money stock were significantly affected by financial innovation and deregulation in the early 1980s.

The dynamic response of the small macroeconometric model to changes in policy-controlled parameters is analyzed to test the effectiveness of monetary policy. The impact, interim, and total multipliers for each endogenous variable indicate that changes in policy actions disturb the system in the short run because the inability of agents to distinguish between real and nominal shifts. Based on the interim multipliers of real income and the unemployment rate, it is suggested that monetary policy is neutral in the long run. The effects of the unanticipated policy changes on real and nominal magnitudes depend on the size of policy changes. In the short run, an increase in nonborrowed reserves increases the money stock, prices, and real income; it also decreases interest rates and the unemployment rate. There exists a short-run Phillips relation. From Figures 2 and 3 and from the dynamic multipliers, the fluctuations in long-term real and nominal interest rates are almost the same which implies that the unanticipated inflation rate is small.

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APPENDIX A

THE DERIVATION OF THE REDUCED FORM OF REAL INCOME

Substituting equation (3.11) into (3.7) to eliminate UN_t yields

$$\begin{aligned} \ln UR_t = {} & (h_1+h_2s_1) + h_6 \ln UR_{t-1} - h_2s_4 \ln M_{t-1} - h_4 \ln P_t \\ & + (h_4+h_2s_4) \ln P_{t-1} + (h_3-h_2s_2) \ln y_t \\ & + (h_2s_2-h_2s_3-h_3) \ln y_{t-1} + h_2s_3 \ln y_{t-2} \\ & + (h_2s_6-h_2) UN_{t-1} - h_5 BP_t + h_2s_5 t + e_{1,t} \\ & + h_2 e_{9,t} \end{aligned} \tag{A.1}$$

Substituting equation (A.1) into (3.6) to eliminate $\ln UR_t$ gives

$$\begin{aligned} \ln M_t = {} & (g_1+g_2h_1+g_2h_2s_1+g_7D3) + g_3 i_t + g_2h_6 \ln UR_{t-1} \\ & - g_2h_2s_4 \ln M_{t-1} - g_4 i_t^d - g_5 Z_t - g_6 H_t + g_6 H_{t-1} \\ & - g_2h_4 \ln P_t + (g_2h_4+g_2h_2s_4) \ln P_{t-1} \\ & + (g_2h_3-g_2h_2s_2) \ln y_t + (g_2h_2s_2-g_2h_2s_3-g_2h_3) \ln y_{t-1} \\ & + g_2h_2s_3 \ln y_{t-2} + (g_2h_2s_6-g_2h_2) UN_{t-1} - g_2h_5 BP_t \\ & + g_2h_2s_5 t + e_{3,t} + g_2 e_{1,t} + g_2h_2 e_{9,t} \end{aligned} \tag{A.2}$$

Substituting equation (3.9) into (3.10) to eliminate i_t^{**} yields

$$\begin{aligned} r_t^{**} = {} & k_1 + (k_2+k_3) i_t - k_3 i_{t-1} + k_4 i_{t-1}^{**} - E(\ln P_t | I_t) \\ & + \ln P_{t-1} + e_{7,t} \end{aligned} \tag{A.3}$$

Substituting equation (A.3) into (3.4) to eliminate r_t^{**}

gives

$$\ln y_t = (d_1-d_2k_1) - (d_2k_2+d_2k_3)\ i_t + d_2k_3\ i_{t-1} - d_2k_4\ i^{**}_{t-1}$$
$$- d_3\ r^{**}_{t-1} + d_4 \ln M_t + d_2\ E(\ln P_t|I_t) - d_4 \ln P_t$$
$$- d_2 \ln P_{t-1} + d_8 \ln y_{t-1} + d_5 \ln G_t - d_6 \ln TAX_{t-1}$$
$$+ d_7\ t + e_{4,t} - d_2\ e_{7,t} \qquad (A.4)$$

Let equation (A.2) = (3.5) solve for i_t

$$i_t = \alpha_1 + \alpha_2 \ln UR_{t-1} + \alpha_3 \ln M_{t-1} + \alpha_4\ i^d_t + \alpha_5\ Z_t + \alpha_6\ H_t$$
$$+ \alpha_7\ H_{t-1} + \alpha_8 \ln P_t + \alpha_9 \ln P_{t-1} + \alpha_{10} \ln y_t$$
$$+ \alpha_{11} \ln y_{t-1} + \alpha_{12} \ln y_{t-2} + \alpha_{13}\ UN_{t-1} + \alpha_{14}\ BP_t$$
$$+ \alpha_{15}\ t + \alpha_{16}\ e_{5,t} + \alpha_{17}\ e_{3,t} + \alpha_{18}\ e_{1,t} + \alpha_{19}\ e_{9,t} \qquad (A.5)$$

where $\alpha_1 = (f_1-g_1-g_2h_1-g_2h_2s_1-g_7D3)/DEN1$

$\alpha_2 = -\ g_2h_6/DEN1$

$\alpha_3 = (f_4+g_2h_2s_4)/DEN1$

$\alpha_4 = g_4/DEN1$

$\alpha_5 = g_5/DEN1$

$\alpha_6 = g_6/DEN1$

$\alpha_7 = -\ g_6/DEN1$

$\alpha_8 = (1+g_2h_4)/DEN1$

$\alpha_9 = -\ (f_4+g_2h_4+g_2h_2s_4)/DEN1$

$\alpha_{10} = (f_2-g_2h_3+g_2h_2s_2)/DEN1$

$\alpha_{11} = (g_2h_3-g_2h_2s_2+g_2h_2s_3)/DEN1$

$\alpha_{12} = -\ g_2h_2s_3/DEN1$

$\alpha_{13} = (g_2h_2-g_2h_2s_6)/DEN1$

$\alpha_{14} = g_2h_5/DEN1$

$\alpha_{15} = -\ g_2h_2s_5/DEN1$

$\alpha_{16} = 1/DEN1$

$\alpha_{17} = -\ 1/DEN1$

$\alpha_{18} = -\ g_2/DEN1$

$\alpha_{19} = -\ g_2 h_2/DEN1$

$DEN1 = f_3 + g_3$

Substituting equation (A.5) into (A.4) to eliminate i_t, and then equating to equation (3.8) solves for $\ln P_t$:

$$\begin{aligned}\ln P_t = {} & \beta_1 + \beta_2\ i_{t-1} + \beta_3\ i^{**}_{t-1} + \beta_4\ r^{**}_{t-1} + \beta_5\ \ln UR_{t-1} \\ & + \beta_6\ \ln M_t + \beta_7\ \ln M_{t-1} + \beta_8\ i^d_t + \beta_9\ Z_t + \beta_{10}\ H_t \\ & + \beta_{11}\ H_{t-1} + \beta_{12}\ \ln P_{t-1} + \beta_{13}\ E(\ln P_t | I_t) \\ & + \beta_{14}\ \ln y_{t-1} + \beta_{15}\ \ln y_{t-2} + \beta_{16}\ UN_{t-1} + \beta_{17}\ BP_t \\ & + \beta_{18}\ \ln G_t + \beta_{19}\ \ln TAX_{t-1} + \beta_{20}\ t + \beta_{21}\ e_{4,t} \\ & + \beta_{22}\ e_{5,t} + \beta_{23}\ e_{3,t} + \beta_{24}\ e_{1,t} + \beta_{25}\ e_{6,t} \\ & + \beta_{26}\ e_{7,t} + \beta_{27}\ e_{9,t} \end{aligned} \tag{A.6}$$

where $\beta_1 = (d_1 - j_1 - d_2 k_1 - \alpha_1 d_2 k_2 - \alpha_1 d_2 k_3 - \alpha_{10} d_2 j_1 k_2 - \alpha_{10} d_2 j_1 k_3)$ $/DEN2$

$\beta_2 = d_2 k_3/DEN2$

$\beta_3 = -\ d_2 k_4/DEN2$

$\beta_4 = -\ d_3/DEN2$

$\beta_5 = (-\alpha_2 d_2 k_2 - \alpha_2 d_2 k_3)/DEN2$

$\beta_6 = d_4/DEN2$

$\beta_7 = (-\alpha_3 d_2 k_2 - \alpha_3 d_2 k_3)/DEN2$

$\beta_8 = (-\alpha_4 d_2 k_2 - \alpha_4 d_2 k_3)/DEN2$

$\beta_9 = (-\alpha_5 d_2 k_2 - \alpha_5 d_2 k_3)/DEN2$

$\beta_{10} = (-\alpha_6 d_2 k_2 - \alpha_6 d_2 k_3)/DEN2$

$\beta_{11} = (-\alpha_7 d_2 k_2 - \alpha_7 d_2 k_3)/DEN2$

$\beta_{12} = (-d_2 - \alpha_9 d_2 k_2 - \alpha_9 d_2 k_3)/DEN2$

$\beta_{13} = (d_2 + j_2 + \alpha_{10} d_2 j_2 k_2 + \alpha_{10} d_2 j_2 k_3)/DEN2$

$$\beta_{14} = (d_8 - j_3 - \alpha_{11} d_2 k_2 - \alpha_{11} d_2 k_3 - \alpha_{10} d_2 j_3 k_2 - \alpha_{10} d_2 j_3 k_3)/\mathrm{DEN2}$$

$$\beta_{15} = (-\alpha_{12} d_2 k_2 - \alpha_{12} d_2 k_3)/\mathrm{DEN2}$$

$$\beta_{16} = (-\alpha_{13} d_2 k_2 - \alpha_{13} d_2 k_3)/\mathrm{DEN2}$$

$$\beta_{17} = (-\alpha_{14} d_2 k_2 - \alpha_{14} d_2 k_3)/\mathrm{DEN2}$$

$$\beta_{18} = d_5/\mathrm{DEN2}$$

$$\beta_{19} = -\ d_6/\mathrm{DEN2}$$

$$\beta_{20} = (d_7 - \alpha_{15} d_2 k_2 - \alpha_{15} d_2 k_3)/\mathrm{DEN2}$$

$$\beta_{21} = 1/\mathrm{DEN2}$$

$$\beta_{22} = (-\alpha_{16} d_2 k_2 - \alpha_{16} d_2 k_3)/\mathrm{DEN2}$$

$$\beta_{23} = (-\alpha_{17} d_2 k_2 - \alpha_{17} d_2 k_3)/\mathrm{DEN2}$$

$$\beta_{24} = (-\alpha_{18} d_2 k_3 - \alpha_{18} d_2 k_3)/\mathrm{DEN2}$$

$$\beta_{25} = (-1 - \alpha_{10} d_2 k_2 - \alpha_{10} d_2 k_3)/\mathrm{DEN2}$$

$$\beta_{26} = -\ d_2/\mathrm{DEN2}$$

$$\beta_{27} = (-\alpha_{19} d_2 k_2 - \alpha_{19} d_2 k_3)/\mathrm{DEN2}$$

$$\mathrm{DEN2} = d_4 + j_2 + \alpha_8 d_2 k_2 + \alpha_8 d_2 k_3 + \alpha_{10} d_2 j_2 k_2 + \alpha_{10} d_2 j_2 k_3$$

The conditional mathematical expectation of $\ln P_t$ is

$$\begin{aligned} E(\ln P_t | I_t) = {} & \beta_1 + \beta_2\ i_{t-1} + \beta_3\ i^{**}_{t-1} + \beta_4\ r^{**}_{t-1} + \beta_5\ \ln UR_{t-1} \\ & + \beta_6\ E(\ln M_t | I_t) + \beta_7\ \ln M_{t-1} + \beta_8\ \hat{i}^d_t + \beta_9\ \hat{z}_t \\ & + \beta_{10}\ \hat{H}_t + \beta_{11}\ H_{t-1} + \beta_{12}\ \ln P_{t-1} \\ & + \beta_{13}\ E(\ln P_t | I_t) + \beta_{14}\ \ln y_{t-1} + \beta_{15}\ \ln y_{t-2} \\ & + \beta_{16}\ UN_{t-1} + \beta_{17}\ \hat{BP}_t + \beta_{18}\ \ln \hat{G}_t \\ & + \beta_{19}\ \ln TAX_{t-1} + \beta_{20}\ t \end{aligned} \tag{A.7}$$

Subtracting equation (A.7) from (A.6) yields

$$\begin{aligned} \ln P_t - E(\ln P_t | I_t) = {} & \beta_8\ e^{i^d}_t + \beta_9\ e^{Z}_t + \beta_{10}\ e^{H}_t + \beta_{17}\ e^{BP}_t \\ & + \beta_{18}\ e^{G}_t + \beta_{21}\ e_{4,t} + \beta_{22}\ e_{5,t} \\ & + (\beta_6 + \beta_{23})\ e_{3,t} + \beta_{24}\ e_{1,t} + \beta_{25}\ e_{6,t} \\ & + \beta_{26}\ e_{7,t} + \beta_{27}\ e_{9,t} \end{aligned} \tag{A.8}$$

Substituting equation (A.8) into (3.8) gives

$$\ln y_t = \gamma_1 + \gamma_2 \ln y_{t-1} + \gamma_3 e_t^{i^d} + \gamma_4 e_t^Z + \gamma_5 e_t^H + \gamma_6 e_t^{BP} + \gamma_7 e_t^G + \gamma_8 e_{4,t} + \gamma_9 e_{5,t} + \gamma_{10} e_{3,t} + \gamma_{11} e_{1,t} + \gamma_{12} e_{6,t} + \gamma_{13} e_{7,t} + \gamma_{14} e_{9,t} \qquad (A.9)$$

APPENDIX B

THE ANTICIPATED GNP PRICE DEFLATOR EQUATION

Substituting equations (A.5) and (3.8) into (A.2) yields

$$\ln M_t = \delta_1 + \delta_2 \ln UR_{t-1} + \delta_3 \ln M_{t-1} + \delta_4\, i_t^d + \delta_5\, Z_t + \delta_6\, H_t$$
$$+ \delta_7\, H_{t-1} + \delta_8 \ln P_t + \delta_9 \ln P_{t-1} + \delta_{10}\, E(\ln P_t | I_t)$$
$$+ \delta_{11} \ln y_{t-1} + \delta_{12} \ln y_{t-2} + \delta_{13}\, UN_{t-1} + \delta_{14}\, BP_t$$
$$+ \delta_{15}\, t + e_t \qquad \text{(B.1)}$$

where $\delta_1 = g_1+g_2h_1+g_2h_2s_1-g_2h_2s_2j_1+g_2h_3j_1+g_3\alpha_1+g_3\alpha_{10}j_1+g_7D3$

$\delta_2 = g_2h_6+g_3\alpha_2$

$\delta_3 = -g_2h_2s_4+g_3\alpha_3$

$\delta_4 = g_3\alpha_4-g_4$

$\delta_5 = g_3\alpha_5-g_5$

$\delta_6 = g_3\alpha_6-g_6$

$\delta_7 = g_3\alpha_7+g_6$

$\delta_8 = -g_2h_2s_2j_2+g_2h_3j_2-g_2h_4+g_3\alpha_8+g_3\alpha_{10}j_2$

$\delta_9 = g_2h_2s_4+g_2h_4+g_3\alpha_9$

$\delta_{10} = g_2h_2s_2j_2-g_2h_3j_2-g_3\alpha_{10}j_2$

$\delta_{11} = g_2h_2s_2-g_2h_2s_2j_3-g_2h_2s_3-g_2h_3+g_2h_3j_3+g_3\alpha_{10}j_3+g_3\alpha_{11}$

$\delta_{12} = g_3\alpha_{12}+g_2h_2s_3$

$\delta_{13} = -g_2h_2+g_2h_2s_6+g_3\alpha_{13}$

$\delta_{14} = -g_2h_5+g_3\alpha_{14}$

$\delta_{15} = g_2h_2s_5+g_3\alpha_{15}$

$$e_t = g_3\alpha_{16}\, e_{5,t} + (1+g_3\alpha_{17})\, e_{3,t} + (g_2+g_3\alpha_{18})\, e_{1,t}$$
$$+ (-g_2h_2s_2+g_2h_3+g_3\alpha_{10})\, e_{6,t} + (g_2h_2+g_3\alpha_{19})\, e_{9,t}$$

The conditional mathematical expectation of $\ln M_t$ is

$$\begin{aligned} E(\ln M_t|I_t) = {} & \delta_1 + \delta_2 \ln UR_{t-1} + \delta_3 \ln M_{t-1} + \delta_4 \hat{i}^d_t + \delta_5 \hat{z}_t \\ & + \delta_6 \hat{H}_t + \delta_7 H_{t-1} + \delta_9 \ln P_{t-1} \\ & + (\delta_8+\delta_{10})\, E(\ln P_t|I_t) + \delta_{11} \ln y_{t-1} \\ & + \delta_{12} \ln y_{t-2} + \delta_{13} UN_{t-1} + \delta_{14} \hat{BP}_t + \delta_{15}\, t \end{aligned} \tag{B.2}$$

Substituting equation (B.2) into (A.7) gives

$$\begin{aligned} E(\ln P_t|I_t) = {} & \vartheta_1 + \vartheta_2\, i_{t-1} + \vartheta_3\, i^{**}_{t-1} + \vartheta_4\, r^{**}_{t-1} + \vartheta_5 \ln UR_{t-1} \\ & + \vartheta_6 \ln M_{t-1} + \vartheta_7 \hat{i}^d_t + \vartheta_8 \hat{z}_t + \vartheta_9 \hat{H}_t + \vartheta_{10} H_{t-1} \\ & + \vartheta_{11} \ln P_{t-1} + \vartheta_{12} \ln y_{t-1} + \vartheta_{13} \ln y_{t-2} \\ & + \vartheta_{14} UN_{t-1} + \vartheta_{15} \hat{BP}_t + \vartheta_{16} \ln \hat{G}_t \\ & + \vartheta_{17} \ln TAX_{t-1} + \vartheta_{18}\, t \end{aligned} \tag{B.3}$$

where $\vartheta_1 = (\beta_1+\beta_6\delta_1)/DEN3$

$\vartheta_2 = \beta_2/DEN3$

$\vartheta_3 = \beta_3/DEN3$

$\vartheta_4 = \beta_4/DEN3$

$\vartheta_5 = (\beta_5+\beta_6\delta_2)/DEN3$

$\vartheta_6 = (\beta_6\delta_3+\beta_7)/DEN3$

$\vartheta_7 = (\beta_6\delta_4+\beta_8)/DEN3$

$\vartheta_8 = (\beta_6\delta_5+\beta_9)/DEN3$

$\vartheta_9 = (\beta_6\delta_6+\beta_{10})/DEN3$

$\vartheta_{10} = (\beta_6\delta_7+\beta_{11})/DEN3$

$\vartheta_{11} = (\beta_6\delta_9+\beta_{12})/DEN3$

$\vartheta_{12} = (\beta_6\delta_{11}+\beta_{14})/DEN3$

$\vartheta_{13} = (\beta_6\delta_{12}+\beta_{15})/DEN3$

$\vartheta_{14} = (\beta_6\delta_{13}+\beta_{16})/\mathrm{DEN3}$

$\vartheta_{15} = (\beta_6\delta_{14}+\beta_{17})/\mathrm{DEN3}$

$\vartheta_{16} = \beta_{18}/\mathrm{DEN3}$

$\vartheta_{17} = \beta_{19}/\mathrm{DEN3}$

$\vartheta_{18} = (\beta_6\delta_{15}+\beta_{20})/\mathrm{DEN3}$

$\mathrm{DEN3} = 1-\beta_6\delta_8-\beta_6\delta_{10}-\beta_{13}$

APPENDIX C

DATA SOURCES

UR = Revised nonborrowed reserves, seasonally adjusted; in billions of dollars. Before November 1980, UR is the nonborrowed reserves of member banks; it is the nonborrowed reserves of depository institutions under the Monetary Control Act since November 1980. Source: Federal Reserve Bulletin.

UN = Unemployment rate for the civilian labor force , seasonally adjusted; in percent. Source: Business Statistics.

y = Real gross national product, seasonally adjusted; in billions of 1972 dollars. Source: Business Statistics.

P = Implicit price deflator for GNP; index number, 1972 = 100. Source: Business Statistics.

BP = Real balance on current account, seasonally adjusted; in billions of 1972 dollars. It is the sum of net exports of goods and services and net unilateral transfers to foreign countries excluding military grants of goods and services. Source: Business Statistics and Balance of Payments.

i = Three-month Treasury bill rate (open market rate on new issues in New York city); in percent per annum. Source: <u>Business Statistics</u>.

D1 = Dummy variable. It takes the value of 1 after 1969:4 and zero otherwise.

M = Revised money stock, M1, seasonally adjusted; in billions of dollars. For 1953:1-1959:4, M equals total demand deposits adjusted (i.e., demand deposits other than interbank and U. S. government less cash items reported as in process of collection) plus currency (outside the Treasury, Federal Reserve Banks, and vaults of all commercial banks). For December 1979-December 1981, M is M1B. Source: <u>Federal Reserve Bulletin</u>.

D2 = Dummy variable. It takes the value of 1 after 1979:3 and zero otherwise.

i^d = Discount rate of the Federal Reserve Bank of New York; in percent per annum. Source: <u>Business Statistics</u>.

Z = Reserve requirement of reserve city bank, or the member bank reserve requirement of net demand deposits over $400 million (since November 1972); in percent of deposits. Demand deposits subject to reserve requirements are gross demand deposits minus cash items in process of collection and demand balances due from domestic banks. Source: <u>Federal Reserve Bulletin</u>.

H = Ratio of currency held by the public to the money stock, seasonally adjusted. Source: <u>Federal Reserve</u>

Bulletin and *Business Statistics*.

D3 = Dummy variable. It takes the value of 1 after 1982:2 and zero otherwise.

r^{**} = Long-term real Treasury bond rate (over 10 years); in percent per annum. It is obtained from equation (4.10).

G = Real government purchases of goods and services, seasonally adjusted; in billions of 1972 dollars. Source: *Business Statistics*.

TAX = Real net receipts of government, seasonally adjusted; in billions of 1972 dollars. It is adjusted for Federal grants-in-aid to state and local governments. Source: *Business Statistics* and *Economic Report of the President*.

t = Time trend.

i^{**} = Long-term Treasury bond rate (over 10 years); in percent per annum. Source: *Business Statistics*.

VITA 2

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