THE EVOLUTION OF THE MONETARY AGGREGATES

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CHAPTER 1

INTRODUCTION

Nature of the Problem

Monetary economics has seen an ebb-and-flow in the emphasis placed upon the role of the quantity of money, as well as on the emphasis placed on different definitions. Before the Keynesian macroeconomic revolution, the money supply was given a primary place as the determinant of the aggregate price level, and of nominal values in the economy in economic theory, although little empirical work was done. After the Keynesian revolution, the monetary aggregates became of secondary importance. With the monetarist counterrevolution of the 1960s, the money supply once again received substantial attention. However, most economists employed the narrow money supply M1, despite Friedman's and Schwartz's preference for the broader M2. With the breakdown in M1 velocity in the 1980s, emphasis shifted to M2. As even the velocity of this broader aggregate became unstable in the early 1990s, most macroeconomists once again shifted their attention to other monetary indicators, primarily the Federal funds rate. This constitutes a shift in thinking back to the 1950s, similar to the Keynesian emphasis on interest rates.

The Federal Reserve publishes three primary measures of the money supply. The basic M1 definition is composed of currency held outside of banks, checkable deposits (other than those held by the U.S. government and interbank deposits), and travelers checks. M2 is composed of M1 plus savings accounts, money market deposit accounts, small time deposits, and retail money market mutual funds. M3 comprises M2 plus large negotiable certificates of deposit of $100,000 or more (large time deposits), institutional money market mutual funds, and both overnight and term repurchase agreements and Eurodollars. L, a mnemonic for liquidity, is no longer published.[1] It is composed of M3 plus liquid U.S. Treasury securities (mostly Treasury bills), commercial paper, bankers acceptances, and U.S. savings bonds. L is frequently referred to as "liquid assets." Another definition of the money supply, not reported by the Board of Governors but used by the Federal Reserve Bank of St. Louis, is MZM, which includes all items that are due immediately--M1, savings accounts, money market deposit accounts, and money market mutual fund balances, both retail and institutional.

To the extent that velocity is stable, the money supply tends to be a reliable indicator of economic activity. Indeed, if velocity is constant, then the percentage change in the money supply implies an equal percentage change in GDP.

However, the record indicates that velocity is not stable. Partly to account for the instability in velocity, it is common in studies to introduce a lag of several quarters in the money-income relationship, with current money supply growth predicting future growth in nominal GDP. Even with this adjustment, however, money growth remains an imprecise predictor of future economic activity.

M1 velocity seemed to be reasonably stable from 1951-1981, with a trend growth rate of about 3% per year. However, it became highly volatile in the post-1981 period. This is shown in figure 1, where velocity peaked in the third quarter of 1981. "The velocity of M1 . . . maintained a fairly steady upward climb during the 1960s and 1970s.

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[1] The Federal Reserve last published statistics for L in the third quarter of 1998.

During the 1980s, however, M1 velocity deviated considerably from its previous path. M1 velocity appeared to become 'unstable,' thus justifying critics' opposition to monetary targeting." (Hafer and Wheelock, 2001, p. 17) The turnover of M1 became so unstable that this aggregate no longer provided reliable guidance on the future course of economic activity. A number of factors were cited as contributing to these velocity fluctuations, among them financial deregulation and innovation. The Federal Reserve itself discontinued setting target ranges for M1 in 1987.

As M1 fell out of favor, researchers naturally turned to the broader monetary aggregates. M2 appeared to provide some useful predictive power, but even this definition of the money supply was found to possess a less-than-stable velocity. Though the Federal Reserve continued to set growth ranges for M2 and M3, these ranges received only secondary emphasis, behind the basic Federal funds rate target.[2]

With the lessened standing given to M2, a small but growing number of analysts have begun to employ the broader M3 definition of the money supply in their analysis. The phenomenon of unstable money demand, along with a shift in emphasis to broader monetary aggregates such as M3, has not been unique to the United States:

> In the mid-1970s—after the breakdown of the Bretton Woods fixed exchange rate system—several central banks adopted a strategy of targeting the growth rate of a monetary aggregate to control inflation. However, besides the fact that it was not well understood which monetary aggregate to target, the demand for whatever was defined as money showed up to be unstable in time, forcing central banks to several revisions of the definitions of monetary

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[2] See Friedman and Kuttner (1992) for a discussion of the Federal Reserve's experience in first adopting and then downgrading target growth ranges for the various monetary aggregates.

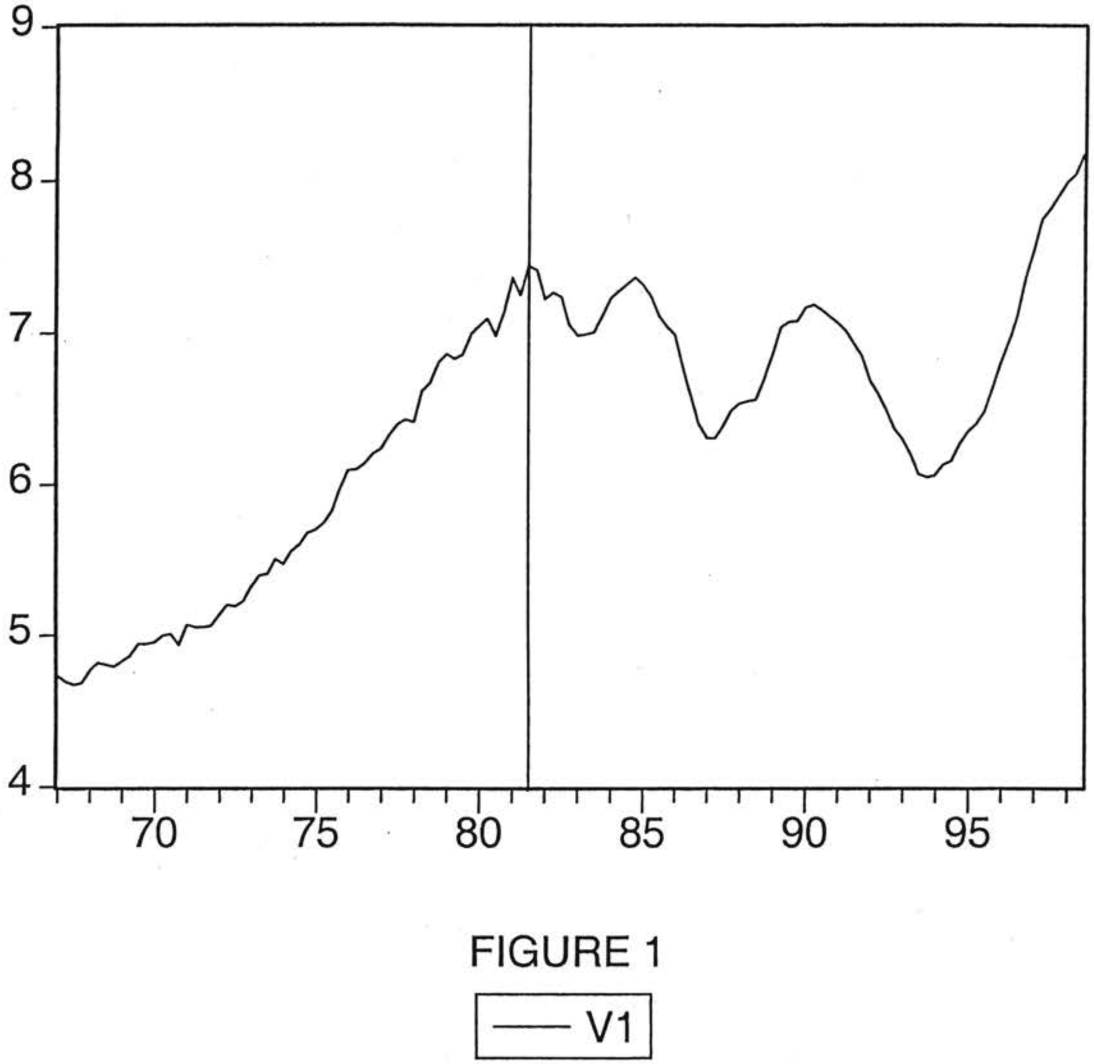

FIGURE 1

Horizontal Axis measures calendar year with 19__ deleted.
Vertical Axis measures velocity of M1.

> aggregates targeted, and some—especially the USA and UK—to abandon monetary targeting ultimately. Experience in Germany with monetary targeting is not so disappointing, although the Bundesbank had to change its intermediate monetary target from 'central bank money stock at constant reserve ratios' (CBM) to money M3 in 1988 because of the instability of the demand for CBM. Most empirical studies of Germany found evidence of a stable demand for M3. (Gaab, 1995, pp. 160-161)

M1 is based on the medium-of-exchange definition of money. MZM is based on a slightly broader but still limited concept, all items of zero maturity. Upon broadening the measure of money beyond these two definitions, it does not seem logical to cease adding money substitutes until all items in L are reached. All are commonly recognized as "cash equivalents," "money substitutes," and "liquid assets."[3] M2 includes money substitutes typically held by consumers, but excludes money substitutes often held by wealthier individuals and larger corporations. The Federal Reserve has long used the difference between the Treasury bill rate and the rate paid on assets in M2 as "M2 opportunity cost." (Board of Governors of the Federal Reserve System, 1999, p. 545) The velocity of M2 is positively related to this opportunity cost. Some substitution, therefore, is presumed to occur between M2 assets and money market assets such as Treasury bills. M3 includes some money substitutes held by institutions (such as negotiable certificates of deposit), but excludes others, in particular, Treasury bills, which, along with repurchase agreements, are the most liquid money market

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[3]Much of the emphasis on the importance of liquidity stems from the work of Gurley and Shaw (1960), who analyzed the influence of nonmonetary financial intermediaries and financial wealth on the economic system.

instruments. Commercial paper, the short-term open-market debt of corporations, is also an important money-market instrument.[4] Issuance of commercial paper by finance companies, like bank issuance of negotiable certificates of deposit, creates a liquid financial instrument, the proceeds from which are used to fund loan operations. Through their holding companies, banks themselves sometimes obtain funds from the commercial paper market. Nevertheless, the macroeconomic literature is notably absent of an emphasis on L, despite the importance of the items in this measure to the financial system.

While the monetarist prescription of nearly-exclusive emphasis on the money supply has largely been rejected in the consensus opinion in the economics profession and in government policy circles, the monetarist position that monetary policy exerts a more powerful influence than fiscal policy has generally been accepted. Monetary policy is now seen as the primary macroeconomic stabilization device, but its stance is measured by short-term interest rates rather than by the growth rate of a monetary aggregate. Nevertheless, there is some promise that broader monetary aggregates may provide some useful information on the future course of macroeconomic activity.

Overview of Study

Through time the view of the relationship between monetary aggregates and the economy has undergone change. This study employs the vector autoregression technique to determine the relationship of the money supply to the economy in differing time periods. The period 1867-1960, covered by Friedman and Schwartz (1963), is

[4]The amount of commercial paper outstanding is well in excess of $1,000 billion, exceeding the amount outstanding of any other money market instrument. (Hubbard, 2000, p. 62)

examined first. Second, the period covered by the famous Andersen-Jordan study coming out of St. Louis, 1952-1968, is examined. Third, this study conducts tests for the years following the St. Louis study during which velocity's trend remained fairly stable, 1968-1981. Finally, the period 1981-1998 is examined, during which the monetary aggregates fell out of favor, being replaced by interest rates in the conduct of Federal Reserve policy. During the latter two periods, the money measures in current use, M1, M2, and M3, are all analyzed. Also during the latter two periods, the broadest monetary aggregate, L, and the relatively narrow aggregate, MZM, are tested, along with the primary competing indicator of monetary policy, the Federal funds rate. The foregoing variables are tested to determine their relationship to measures of macroeconomic activity. Chapter 2 reviews previous literature on the study's coverage. Chapter 3 presents methodology for the study. Chapter 4 gives results and discussions, and Chapter 5 gives conclusions and makes recommendations for future research.

CHAPTER 2

REVIEW OF BACKGROUND RESEARCH

Early Literature

Economic doctrine before the Keynesian Revolution of the 1930s placed more emphasis on the monetary aggregates, in the form of the quantity theory of money. The Classical quantity theory of money concluded that the money supply would be the primary determinant of nominal macroeconomic magnitudes, particularly the price level. In the equation of exchange, $MV = PQ$, velocity was assumed to be approximately constant, largely because of habit and because the technology of the payments system was assumed not to change. In addition, the quantity of production was assumed to be approximately constant in the short run, and to vary with real factors of production like population and industrial progress in the long run. Therefore, the money supply determined the aggregate price level. (Friedman, 1968c, p. 433; Chick, 1996, p. 553; Fisher, 1922, p. 14)

Several hundred years ago gold and silver were commonly used as money. As banking practices developed, controversy arose as to which, if any, banking instruments should be regarded as money. Many writers considered these items to be one of several forms of credit and not money. To such writers, only metallic money and government-issued paper money qualified. (Friedman and Schwartz, 1970, pp. 94-95) However, many analysts, while not terming bank notes and deposits "money," nevertheless accepted that these instruments could raise the volume of spending and the level of prices in a nation. Cantillon,[1] for example, felt that the acceleration of spending caused by banking activities was "equivalent to an increase of actual money up to a point." (1730-34, p. 161) The British Banking School of the mid-1800s concluded that bank notes and deposits, like credit generally, could raise the velocity of circulation but were not themselves money. This School therefore opposed special attempts to limit bank note issuance. However, the opposing Currency School felt that bank notes did function as money and should therefore be limited.[2] (Friedman and Schwartz, 1970, p. 95)

David Ricardo, Henry Thornton, and Alfred Marshall were among those economists who considered bank notes, but not bank deposits, to qualify as components of the money supply. (Friedman and Schwartz, 1970, p. 98) As was also common for writers of his time, Irving Fisher classified currency, including bank-issued currency, as money, while he considered deposits to be claims on money. (Steindl, 1995, p. 95) However, he termed both currency and bank deposits "circulating media," concluding that:

> . . . while a bank deposit transferable by check is included as circulating media, it is not money. A bank *note*, on the other hand, is both circulating media and money. Between these two lies the final line of distinction between what is money and what is not. True, the line is delicately drawn, especially when we come to such checks as cashier's checks or certified checks, for the latter are almost identical with bank notes. Each is a demand liability on a bank, and each confers on the holder the right to draw money. Yet while a note is

[1]Cantillon was a banker by profession.

[2] The British government ultimately adopted the Currency School's position in 1844.

generally acceptable in exchange, a check is *specially* acceptable only, *i.e.* only by the consent of the payee. (Fisher, 1922, p. 11, italics in original)

Although not common practice, a few early writers before the modern era did classify bank deposits as money. Among them were John Law,[3] Albert Galatin, Henry Sidgwick, R.G. Hawtrey, and D.H. Robertson. (Friedman and Schwartz, 1970, p. 101) To Robertson, for example, money was any item "widely accepted in payment for goods, or in discharge of other kinds of business obligation." (1922, p. 2) "John Smith's checks may be widely accepted in discharge of his obligations, and are therefore rightly regarded, according to the definition which we have chosen, as money: and Bank of England five-pound notes are universally accepted in the United Kingdom in discharge of obligations, and are certainly money." (ibid., p. 3)

Although the Classics placed importance on the money supply as a key economic variable, the later monetarist economists placed much more emphasis on empirical observation of actual money supply figures. Among the few early writers who did examine monetary aggregates was Irving Fisher. Although he separated deposits from currency, rather than combining them into one aggregate, Fisher reported and commented on actual movements in both items. (Steindl, 1995, pp. 99-102) In the 1930s Lauchlin Currie compiled an annual aggregate based on the medium-of-exchange definition of money, composed of both currency and demand deposits, which differed from the modern M1 in a few minor details. (Steindl, 1995, pp. 61-62) Most analysts of the time, though, did not report actual money supply data. Furthermore, the Federal Reserve did not publish regular money supply figures, composed of both currency and

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[3] Law became involved in a program to change the monetary system of France, and was also involved in the Mississippi Bubble speculation.

bank deposits, until the 1940s. (Friedman and Schwartz, 1970, p. 272) In the October 1930 edition of the *Federal Reserve Bulletin*, for example, no figures for an M1 or M2 money supply are listed in the statistical section. (Board Of Governors, 1930) "Money in circulation" is listed as a Reserve Bank Credit Factor, but refers only to Federal Reserve Notes held by the public and in bank vaults, not to bank deposits. (ibid., p. 618) Later in this *Bulletin* the level of commercial bank deposits is given, but only with reference to several other bank balance sheet items such as loans and investments, and not as a component of a money supply figure. (ibid., p. 650)

With the Keynesian Revolution of the 1930s came a decreased theoretical emphasis on monetary policy but an increased emphasis on active macro-economic stabilization. In Keynes' *The General Theory of Employment, Interest and Money*, the monetary transmission mechanism postulated was that a decrease in the interest rate resulted in an increase in investment expenditures, which in turn caused aggregate income to increase. In turn, national income then expanded, according to the multiplier.

Monetary History **and St. Louis Studies**

The Keynesian theory was very much in vogue in the post-World War II period. In the 1960s, however, a competing macroeconomic theory received much attention, the monetarist theory. Led by Milton Friedman, this theory asserted that it was monetary fluctuations, not "autonomous expenditures," that produced business cycle fluctuations. In addition, Friedman ranked monetary policy, not fiscal policy, as the primary stabilization device. Furthermore, the money supply, not interest rates, was seen as the appropriate indicator of monetary policy. Friedman and Schwartz (1963) emphasized the old M2 definition of the money supply, currency plus demand deposits plus time deposits at commercial banks. Continuous M2 figures ran from 1867-1960, and Friedman and Schwartz only listed a narrower M1 series beginning after the Federal Reserve was created:

> Our figures do not classify deposits in commercial banks at this early date [1867] into demand and time deposits, because this distinction had little meaning, either for banks or their customers. Reserve requirements for banks were levied against deposits, without distinction between demand and time. Demand deposits, like time deposits, frequently paid interest; and time deposits, like demand deposits, were frequently transferable by check. The distinction became of major importance to banks (and so reliable data became available on a continuous basis for the two categories separately) only after 1914, when the Federal Reserve Act introduced differential requirements for demand and time deposits. (1963, p. 4)

During the 1960s and 1970s, in which monetarism and Keynesianism sparred for economists' favor, monetarists produced a series of studies from the Federal Reserve Bank of St. Louis which emphasized the M1 definition of the money supply. The "St. Louis study" of 1968 used standard regression techniques with an Almon polynomial lag, and found that fiscal policy measures produced no statistically significant effect on nominal GNP, but that both M1 and the monetary base explained a substantial proportion of the changes in GNP. The first article, authored by Leonall Andersen and Jerry Jordan, appeared in the November 1968 issue of The Federal Reserve Bank of St.

Louis *Review* and covered the period from the first quarter of 1952 to the second quarter of 1968. Both the M1 monetary aggregate and the monetary base produced positive, lasting, and statistically significant effects on gross national product. None of the fiscal measures (full-employment surplus, full-employment revenues, and full-employment expenditures) had a permanent influence on GNP, although government expenditures produced a slightly significant positive effect after a one-quarter lag and a barely significant negative effect after a three-quarter lag, seeming to indicate that a modest initial stimulative effect was followed by a "crowding out" of its influence. (1968, p. 17) Though greeted with much criticism by Keynesian economists, no direct refutation of the study's findings appeared to be identified.[4]

Friedman's and Schwartz's study and the St. Louis regressions were among the leading monetarist empirical works establishing a link between the monetary aggregates and economic activity.[5] Friedman and Schwartz presented a long and impressive examination of history from 1867-1960 based on graphs and historical narrative, rather than econometric tests. The money supply was shown to possess a substantial relationship to the economy over the long time period covered. Especially noteworthy was the text's emphasis that the Great Contraction of 1929-33 may have been related to monetary events, as the supply of money declined by approximately one-third during this economic collapse. The St. Louis study used regression analysis, focussed on the monetary-fiscal policy debate, and brought the monetarist evidence eight years forward

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[4] Friedman and Heller discussed the study's pros and cons in *Monetary vs. Fiscal Policy* (1969).

[5] Brunner and Meltzer were also among the leading figures establishing the case for an empirical relationship between the monetary aggregates and economic activity. See the discussion later in this chapter under "Other Empirical Money Supply Studies."

(to 1968). A series of related articles appeared in later issues of the Federal Reserve Bank of St. Louis *Review*, some by skeptical Keynesian analysts, some by St. Louis economists providing further evidence for the monetarist theory.

Implicitly, however, the St. Louis study assumed stability in velocity. In one of the last studies supportive of the original findings, Hafer (1982) found that only limited adjustments to the narrow definition of the money supply were necessary to maintain its usefulness as an indicator of economic activity. "As the 1980s progressed, however, continued instability of velocity caused all but the most diehard supporters to abandon short-run monetary aggregate targets." (Hafer and Wheelock, 2001, p. 18)

Financial deregulation and innovation contributed to the weakening of the relationship between gross domestic product and the money supply:

> Deregulation, other institutional changes, and uncertainty about the Fed's commitment to disinflation probably explain much of the unstable behavior of velocity in the 1980s. The Depository Institution [*sic*] Deregulation and Monetary Control Act of 1980 (DIDMCA) instituted a six-year process ending the prohibition of interest payments on transaction accounts at commercial banks and deregulating rates on other accounts. These changes, and various financial innovations, were followed by volatile flows between classes of financial assets that altered the empirical relationships between national income and monetary aggregates. Monetary aggregates quickly lost favor as short-run policy targets when movements in velocity became difficult to explain or predict. In essence, changes in the structure of the economy altered the short-run relationships between traditional monetary aggregates and policy objectives.

> Monetarist models, including the St. Louis model, were not equipped to handle such changes, and their forecasting performance suffered as a result. (Hafer and Wheelock, 2001, p. 18)

Although the Federal Reserve dropped its strict M1 target in 1982,[6] the central bank continued to set monitoring ranges for this measure. In 1987, the Federal Reserve dropped its M1 range altogether, but continued to set ranges for M2 and M3. In the early 1990s, however, M2 and M3 velocities jumped erratically upward. In 1993, the Board of Governors downgraded M2 and M3 as reliable indicators of monetary policy. (Friedman and Kuttner, 1996, p. 79)

Other Empirical Money Supply Studies

Brunner and Meltzer reviewed the Federal Reserve's operating procedure. They found that in the 1950s and 1960s the central bank had no systematic framework for analyzing the link between its actions and subsequent movements in the economy. Instead, it emphasized rules of thumb and a "feel" for money market conditions, including the level of interest rates. (1983, pp. 59-60) They found that historically the Federal Reserve had produced monetary growth which was pro-cyclical in nature, and that the actual variances of changes in GNP were larger than if a constant growth rate of the M1 money supply had occurred instead. (ibid., p. 91) Responding to pressure from the academic community and Congress, the Federal Reserve eventually gave greater attention to the basic money stock M1 and the other monetary aggregates, but "these pressures had little influence on operating procedures until October 1979." (ibid., p. 79)

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[6] Many analysts have questioned the Federal Reserve's commitment to the money supply targets during the "monetarist experiment" of 1979-1982. See, for example, Hafer and Wheeler (2001, pp. 16-17).

At that time the Federal Reserve officially gave priority to the monetary aggregates, and switched to a stricter system of control based on nonborrowed reserves.

Barnett, Offenbacher, and Spindt test the stability of relationships between the economy and the monetary aggregates, emphasizing the specially-constructed Divisia aggregates. After performing several tests on both the conventional sum aggregates and their specially-constructed Divisia measures, they find that:

> In the causality tests, the Divisia aggregates generally performed better than the corresponding sum aggregates, although sum M2 did rather well. Divisia *L* was perhaps the best aggregate in those tests. In terms of the demand-for-money functions, the best forecasting results were acquired with Divisia M1 and Divisia *L*. The most stable demand-for-money functions were acquired with Divisia M3 and Divisia *L*. In addition, the velocity function for Divisia M3 was found to be stable. In the reduced-form comparisons, sum M1 performed better than Divisia M1, but at higher levels of aggregation the Divisia aggregates became increasingly superior to corresponding sum aggregates, with Divisia *L* usually providing the best reduced-form results. . . While no aggregate was uniformly best relative to all of our criteria, our results reflect most favorably on Divisia *L*. (1984, p.1075)

Nganga concludes that a strong theoretical case can be made for the use of Divisia measures over simple-sum monetary measures. The empirical evidence for the Divisia measures, however, is "mixed at best." (1996, p. 96) (The present study does not investigate Divisia aggregates, employing only simple-sum measures.)

Motley (1988) first proposed an MZM-type measure.[7] William Poole (1991) suggested calling it MZM, or money-zero maturity. MZM has received less study than the traditional M1, M2, and M3. Recently, however, this definition of the money supply has received increasing attention. Northern Trust Company Chief Domestic Economist Paul Kasriel, for example, states in the trust company's newsletter that:

> There are a number of definitions of money. Which real money supply would be most helpful in giving us a "heads up" on real GDP growth? I ran some money supply "races" to see which entry, when deflated by the Personal Consumption Expenditure (PCE) chained price index, could best forecast real GDP growth. The winner was MZM – money with a zero maturity. MZM consists of currency, traveler's checks, checkable deposits, savings deposits and money market mutual fund shares - both retail and institutional. What all of these components of MZM have in common is that they are assumed by the holder to be immediately redeemable at par. (2000, p. 1)

Carlson and Keen note that MZM includes all types of financial instruments which are easily convertible into transaction accounts with no risk of capital loss. Ordinary securities, on the other hand, are usually subject to transaction costs and risk of capital loss, and ordinary time deposits are usually subject to penalties for early withdrawal. (1996, p. 16) MZM has been less distorted by deregulation and financial innovation than other measures. Reflecting on economists' experience in using monetary aggregates,

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[7] Motley originally called the measure "nonterm M3." Overnight repurchase agreements and overnight Eurodollars were included, but have since been removed from the MZM series reported by the Federal Reserve Bank of St. Louis. See Carlson and Keen (1996, pp. 16-18) for a good discussion of the development of the MZM aggregate.

they note that:

> The literature is replete with examples of estimated models that fail the test of time. Most fall victim to the effects of financial innovation, if not of regulation and deregulation. Financial innovation, for example, can lead to the development of new instruments like MMMFs,[8] first introduced in the mid-1970s. Generally, such instruments are not included in the official money measures until an empirical basis becomes well established. MMMFs were first included in the 1980 redefinition of M2. (ibid., p. 17)

In statistical tests, MZM, when adjusted for opportunity cost, has maintained a fairly stable relationship with nominal GDP since 1974.[9] This relationship persists despite major deregulation initiatives, financial innovation, substantial disinflation, and "three relatively unique business cycles" since 1974. (ibid., pp. 18-19). The stability of MZM demand indicates that "the zero-maturity distinction is an important and durable dividing line for aggregating monetary assets." (ibid., p. 21) The income elasticity of demand for MZM balances is approximately unity, and the opportunity cost elasticity, based on interest differentials, is –4.33. An increase of one percentage point in MZM opportunity cost reduces equilibrium MZM demanded by more than four percent. (ibid., p. 20)

Carlson and Keen suggest that MZM could play a policy role, especially in conjunction with assessments of the indicator properties of other aggregates. However, due to MZM's relatively high interest elasticity and the uncertainty associated with

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[8] MMMFs are money market mutual funds. Although balances kept in these funds are not actual bank deposits and are not covered by government deposit insurance, they are sufficiently similar in nature that they may be regarded as the equivalent of high-yielding savings accounts.

[9] The financial upheavals since 1974 "laid waste to most other measures of the money supply." (Carlson and Keen, 1996, p. 22)

future interest rate movements, MZM does not appear to be well-suited to serve as an explicit monetary target. (ibid., p. 21)

Based on the sample period 1960-1992, Feldstein and Stock (1994, pp. 7-62) find strong evidence of an empirical relationship between M2 and nominal GDP. But tests based on sample periods extending farther into the 1990s show evidence of a breakdown in the M2-GDP relationship. Estrella and Mishkin, for example, examine both the monetary base and the M2 definition of the money supply. They "focus on their role as information variables, since any more ambitious use, such as in a policy rule, would presuppose some information content in the aggregates. Our results show that in the United States since 1979, the monetary aggregates fall considerably short of those requirements." (1997, p. 279)

In a recent article, Lown, Peristiani, and Robinson argue that the unusual financial difficulties faced by banks and thrift institutions in the late 1980s and early 1990s were responsible for the breakdown in the relationship between M2 and GDP. Adjusting M2 for weaknesses in financial institutions' capital positions during the 1980s and 1990s, they find that M2's closer relationship with the economy reappears. "Our findings," they conclude, "suggest that during periods of time when there are no disturbances to financial institutions, the M2 monetary aggregate might very well contain useful information about the future direction of the economy." (1999, p. 20)

Laurent finds that M2 actually does maintain some statistical association with real GDP in the 1990s, a statistical association which is in fact closer than that of the Federal funds rate. Over the period of economic weakness from the second quarter of 1990 to the third quarter of 1993, the average ex post squared error using M2 in the prediction of real GDP is less than half that of the Federal funds rate. Using the real interest rate, the ex post squared error lies between that of M2 and the nominal Federal funds rate.[10] During this period of economic weakness short-term interest rates fell sharply but the growth rate of the broad M2 money supply was quite low. According to Laurent:

> The fundamental factor was the severe financial stress experienced by money-creating depositories. The closing of insolvent depositories, increased capital requirements, and stricter supervision combined to weaken the normal stimulative impact of a given cut in short-term interest rates.
>
> One lesson for monetary policy is that it is particularly dangerous to use short-term interest rates as indicators of monetary policy when depositories are under severe financial stress. In such situations, broad money is a much better indicator of monetary policy. (1999, p. 504)

Carlson et al. examine three broad measures of the money supply, M2, MZM, and M2M (M2 minus small time deposits) for cointegrating relationships with the economy. A "key issue" they consider is whether empirical evidence exists for the link between broad aggregates, nominal economic activity, and opportunity cost of the balances. (1999, p. 2) In contrast to M2, tests demonstrate a strong relationship between income and both MZM and M2M, when the opportunity cost on these measures is included in the analysis. The income elasticities on MZM and M2M are clearly significant and approximately unity in value. The opportunity cost effects are observed to operate throughout the entire period tested. (ibid., pp. 7-8) Most of the instability in M2 demand results from the small time deposit component. Like Lown, Peristiani, and Robinson,

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[10]The relative ex ante squared errors of the different monetary indicators mirror those of the ex post squared errors.

Carlson et al. find that M2 does have predictive content when account is made for a permanent upward shift in the velocity of M2 from 1990-1994. At that time:

> The restructuring of depositories acted as a catalyst in the development of mutual funds, especially bond mutual funds. Bond funds are subject to capital losses in the short run, but in the long run they yield relatively higher rates than deposit instruments. When short-term interest rates began falling in 1989, the mutual fund industry intensified marketing strategies that informed households about bond funds, which were yielding significantly higher returns. Capital-constrained thrifts were effectively limited in their pricing responses. As a result, many households, apparently for the first time, diversified their portfolios out of M2 deposits into bond mutual funds. It appears now that for many of these households, bond funds have become a permanent and significant part of their portfolios, thus supplanting bank CDs. (ibid., p. 9)

Gurley and Shaw examine money in a complex system with many financial assets. They conclude that contrary to "traditional formulations of quantity theory, the volume and structure of . . . financial assets is relevant both to the demand function for real money balances and to the ability of the monetary authority to impose its influence on such real variables as the interest rate, income, employment, and wealth." (1960, p. 177) Throughout the nineteenth century and into the twentieth, the ratio of income to financial assets has tended to follow a pattern similar to that of the ratio of income to narrowly-defined money. (ibid., pp. 177-179)

Phillip Cagan examines M1, M2, M3, and L. Based on linear velocity trends and projections of money-demand equations, M1 and liquid assets perform best, followed by M2. For the period 1953.III-1980.IV, the standard deviation from trend for M1 velocity is lower than for the other broad aggregates. M2's percent deviation from trend for velocity is 2.5, M3's was 2.6, and L's is 2.1. (1982, p. 665)

Monetary policy in many foreign nations has proceeded similarly to that in the United States, with the narrow medium-of-exchange definition of money being replaced in emphasis by the broader aggregates. (Miller and VanHoose, 1993, p. 55) The Bank of France has employed a French M2, composed of currency, checking accounts, and savings accounts available at sight, a measure which most closely resembles the U.S. MZM. Germany's Bundesbank has switched from the narrow central bank money (CBM) to M3 as its primary target.[11] The Bank of Japan currently reports three money supply figures: M1, M2+CDs, and "Broadly-defined Liquidity." (Bank of Japan, 2001, pp. 1-4) The new European Central Bank, in charge of monetary policy in the 12 nations of Europe which have adopted the euro, reports three definitions of the money supply: narrow money M1, intermediate money M2, and broad money M3. Intermediate money M2 is primarily composed of deposit accounts, whereas broad money M3 includes many money market instruments. The European Central Bank states that "A high degree of liquidity and price certainty makes these instruments close substitutes for deposits. As a result of their inclusion, M3[12] is less affected by substitution between various liquid asset

[11] See Battan et al. (1990) for a detailed discussion of the changing use of monetary aggregates by central banks in various countries.

[12] Although the European Central Bank targets an interest rate in its conduct of monetary policy, it also closely monitors the growth rate of the M3 money supply. Buergin reports that "Faster M3 growth makes it harder for the ECB to help Europe's flagging economy by lowering borrowing costs again. The ECB justified the rate cut on May 10 [2001] by pointing to a moderation in M3 growth—a gauge of future inflation—even as inflation stayed above what the ECB says is acceptable for 11 months. . . . The central bank says money supply growth of 4.5 percent is needed to maximize growth without generating inflation." (2001, p. 1)

categories than narrower definitions of money, and is therefore more stable." (2001, p. 2)

Federal Reserve Definitions of the Money Supply

The Board of Governors originally emphasized the basic M1 definition of the money supply, and for many years published figures for that aggregate only. However, in the 1960s and early 1970s:

> further refinements were made in the money stock series as additional data became available; as banking practices changed—particularly as such changes were related to the transfer of foreign funds; and as other banking institutions, such as agencies and branches of foreign banks and Edge Act corporations, became a more significant factor in the structure of U.S. financial institutions. Still other refinements have become necessary as a result of relatively recent introductions—such as NOW (negotiable order of withdrawal) accounts, telephonic transfers of funds, and overdraft arrangements—which have brought about a lessening of the distinction between demand deposits and other liquid assets. In recognition of the proliferation of such close substitutes for money as these are, the Board has broadened the concept of the money stock measures that it uses in implementing monetary policy. By April 1975, five such measures were being published, as compared with only a single measure as late as 1971. (Board of Governors, 1976, p. 5)

Growing similarities between depository institutions, as well as the rise of money market mutual funds, caused the Federal Reserve to re-define the monetary aggregates in 1980. As discussed by Simpson (1980), one factor in the decision to modify the monetary aggregates was the emergence of deposits transferable by check from thrift institutions. Mutual savings banks in the Northeast had begun to offer interest-bearing checkable deposits, or N.O.W. accounts, whereas earlier only commercial banks could offer checking accounts. Since eventually commercial banks, mutual savings banks, savings and loan associations, and credit unions all offered checkable deposits, the distinction among the different institutions became blurred. In addition, money market funds offered balances in the form of mutual fund share accounts which were quite deposit-like in nature. Although these accounts were not government-insured deposits, they allowed the investor to withdraw funds at any time much like a savings account, and some money funds even allowed checks to be written on their balances. To account for these and other financial innovations, the central bank changed its money supply definitions as follows (Simpson, 1980, pp. 98-99):

Pre-1980 definitions:

M1: Demand deposits and currency held by the nonbank public (including demand deposits due to foreign commercial banks and official institutions).

M2: M1 + savings accounts and regular time deposits at commercial banks.

M3: M2 + accounts at mutual savings banks, savings and loan associations, and credit unions.

M4: M2 + large, negotiable certificates of deposit.

M5: M3 + large, negotiable certificates of deposit.

M6: M5 + short-term U.S. government securities + commercial paper + bankers acceptances + U.S. savings bonds.

<u>1980 definitions:</u>

M1A: Currency plus non-interest bearing demand deposits held by the nonbank public (*not* including demand deposits due to foreign commercial banks and official institutions).

M1B: M1A + interest-bearing checkable deposits (primarily N.O.W. accounts).

M2: M1 + savings accounts and regular time deposits at all depository institutions + all money market mutual fund balances + overnight Eurodollars and overnight repurchase agreements.

M3: M2 + large, negotiable certificates of deposit + term Eurodollars and term repurchase agreements.

L: M3 + short-term U.S. government securities + commercial paper + bankers acceptances + U.S. savings bonds.

The 1980 definitions are the approximate versions of the monetary aggregates in current use. In 1981, however, the Federal Reserve placed travelers checks in M1A.[13] Soon thereafter it chose to drop M1A and to convert M1B into simply M1.[14] In March of 1982, institutional money market mutual fund balances were removed from M2 but kept in M3 (Board of Governors, 1982b, p. 186). In mid-1996, overnight Eurodollars and overnight repurchase agreements were removed from M2 but kept in M3 (Board of Governors, 1996, p. 327).[15]

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[13]These travelers checks of nonbank issuers had earlier been excluded mostly due to limitations on data availability. See Board of Governors (1981a, pp. 561-562).

[14] The December 1981 edition of the *Federal Reserve Bulletin* was the last in which separate M1A and M1B aggregates were listed. (Board of Governors, 1981, p. A3 and Board of Governors, 1982a, p. A3)

[15] Illustrative of the reduced emphasis given to the monetary aggregates is the continued listing, in several recent textbooks, of overnight repurchase agreements and overnight Eurodollars in the M2

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Current (2001) definitions:

M1: Currency plus checkable deposits held by the nonbank public + travelers checks.

M2: M1 + savings accounts + money market deposit accounts + regular time deposits + retail money market mutual fund balances.

M3: M2 + large, negotiable certificates of deposit + institutional money market mutual fund balances + Eurodollars and repurchase agreements, both overnight and term.

L: M3 + short-term U.S. government securities + commercial paper + bankers acceptances + U.S. savings bonds (the Federal Reserve last published figures for L in the third quarter of 1998).

Conceptual Issues

Drawing a line to determine which assets are money and which are not is difficult in today's complicated and rapidly evolving financial system. Lindsey and Wallich, in a discussion of the conduct of monetary policy, note that:

> Monetary aggregates represent collections of financial assets, grouped according to their degree of 'moneyness.' Narrow measures of money comprise currency and fully checkable deposits to encompass the public's primary transactions balances. Broader measures also include other highly liquid accounts with additional savings features. Sharp lines of demarcation separating the various aggregates are difficult to draw as the characteristics of various assets often shade into one another over a wide spectrum, especially in

definition of the money supply, despite their removal in 1996. See Hubbard (2000, p. 26), Arnold (2001, pp. 280-281), and Mishkin (2001, p. 57).

countries with developed, deregulated, and innovative financial markets. (1987, p. 512)

Benjamin Friedman and Kenneth Kuttner review the money-economic evidence, noting that unstable money demand may cause observed fluctuations in money to fail to anticipate later movements in output or prices.[16] More rapid monetary growth, for example, can simply reflect an increase in money demand being accommodated by the monetary authority, and may not portend an increase in output or prices. The problem, Friedman and Kuttner feel, is likely to be especially acute in a modern financial system "that offers myraid forms of liquid instruments, of which only an arbitrary subset is defined as any particular measure of money like M1 or M2." (1996, p. 109) Therefore the relationship between any particular definition of the money supply and output may not be stable.

Richard Andersen and Robert Rasche note that increased usage of sweep programs by depository institutions has depressed the amount of balances listed in the M1 aggregate. Sweep programs automatically transfer funds between money market deposit accounts (which are listed in M2 but not in M1) and checking accounts. The advantage to the bank offering this service is that its required reserves are reduced. Today the amount of checkable deposits reclassified as MMDAs is estimated to total nearly \$400 billion, whereas checkable deposits not so reclassified total approximately \$600 billion. (2001, p. 51)

A banking system possessing accounts which are automatically swept from savings to

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[16]See the section "Interest Rate Studies" later in this chapter for a discussion of the empirical results in the Friedman-Kuttner study.

checking creates an ambiguity in determining which items belong in a narrow medium-of-exchange measure of money. The savings balances are not currently checkable deposits, but will become so when a check is presented for payment.[17] Not only has M1's empirical relationship with the economy broken down, but the existence of sweep programs effectively causes some medium-of-exchange accounts to lie outside of reported M1 balances.[18] Sweep balances are present in MZM, but some of the other balances in that aggregate are not transferable by check (although they are almost always redeemable on demand at no significant cost).

M2 balances include small time deposits with maturities exceeding one year, which in nature may be more similar to long-term capital market instruments than to checkable deposits.[19] As early as the mid-1970s the Board of Governors noted that:

> in recent years there has been a growing amount of illiquidity among some of the deposit forms included in the total. During the past decade time deposits at commercial banks and thrift institutions have increasingly taken the form of nonnegotiable certificates of deposit (CD's) with specified maturities of 2 to 4 years or more. These certificates can be redeemed

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[17]The number of automatic transfers from savings to checking is limited to six per month. More transfers cause the account to be reclassified as a transaction deposit and result in the imposition of reserve requirements. (Anderson and Rasche, 2001, pp. 53-56)

[18]Customers may only be given routine notices of the sweep program's existence and may not be fully cognizant of the details of deposit reclassification taking place:

> At its start, deposit-sweeping software creates a "shadow" MMDA deposit for each customer account. These MMDAs are not visible to the customer, that is, the customer can make neither deposits to nor withdrawals from the MMDA. To depositors, it appears as if their transaction-account deposits are unaltered; to the Federal Reserve, it appears as if the bank's level of reservable transaction deposits has decreased sharply. (Anderson and Rasche, 2001, p. 52)

[19] Small time deposits in retirement-based IRA accounts are currently excluded from M2. (Board of Governors, 1999, p. A3)

> before maturity, but only by forfeiting some of the interest that has accrued on them. As such certificates approach maturity, the interest loss on a $5,000 certificate, for example, can be several hundred dollars, making the transaction-cost of redemption high for an asset classified as 'liquid.' (1976, pp. 10-11)

It does not seem logically consistent that the M1 definition of the money supply includes corporate checking accounts but that broader money supply measures exclude near-monies held by corporations. Corporate holdings of M1 balances actually exceed those held by households (Board of Governors, 2001b, p. 84).[20] M2, however, includes only money substitutes held by consumers, generally excluding money substitutes held by corporations and wealthier individuals. According to Case Sprenkle, corporations use different money substitutes than consumers:

> For them, the question as to what, at least theoretically, should be the closest substitutes for money has a completely different answer [than time deposits]. The simplest answer is that whatever are the chief money market assets of the time will be the closest substitutes for money. The closest substitutes for money (narrowly defined) are thus not the usual time and savings deposits but rather, in the U.S., Treasury Bills and repurchase agreements, consumer finance and other company paper. (1969, p. 527)

Although the M3 definition of the money supply includes some corporate money substitutes (such as negotiable certificates of deposit), it excludes many others.

[20]The Federal Reserve estimates that approximately 60% of U.S. currency issued is held outside of the United States. In addition, over half of U.S. currency, in dollar value, has been issued in the form of $100 bills. (Allison and Pianalto, 1997, p. 559)

Friedman and Schwartz state that in the process of compiling continuous money supply statistics, "the large negotiable certificates of deposit . . . are a recent development that have no counterpart earlier. We are inclined to regard them as more nearly comparable to market instruments such as commercial paper than to the items earlier classified as 'time deposits.'" (1970, p. 80) In practice, NCDs are not more money-like than other money-market instruments. The secondary market for Treasury bills, in fact, is slightly more active and liquid than that for NCDs. Although the secondary market for commercial paper is less active, maturities are quite short, often less than 30 days.[21] Over half the commercial paper outstanding is issued by financial institutions. (Kohn, 1993, pp. 212-213). Banks themselves may use both NCDs and commercial paper to obtain funds. Perspective on the similarity between commercial paper and negotiable certificates of deposit is offered by Kohn's review of money market activity after World War II:

> Banks were quick to realize that the growing commercial paper market offered them not only new ways of lending, . . . but also new ways of *borrowing*. Although banks themselves were not allowed to issue commercial paper, bank holding companies were. A holding company could sell commercial paper and use the proceeds to buy assets from the daughter bank; the money could then be used by the daughter bank to finance additional loans. . . . Moreover, banks soon invented a way around the prohibition on the direct issue of commercial paper—the

[21] Campbell, Campbell, and Dolan note that commercial paper "gives investors very high liquidity" and that banks sometimes use commercial paper as secondary reserves along with Treasury bills. (1988, p. 139) "Secondary reserves" are assets which banks may use to provide liquidity in meeting depositor withdrawals. See also Miller and VanHoose (1993, p. 206).

> negotiable certificate of deposit (NCD). . . . Although it cannot be redeemed before maturity, it can be sold to someone else. The purchaser may then redeem it from the bank, unless he in turn chooses to sell it. An NCD, because it can be bought and sold in this way, is really more like commercial paper or a T-bill than like an ordinary deposit. (1993, p. 238, italics in original)

The current definitions of the money supply suffer from conceptual inconsistencies. The narrow definition of money, M1, fails to include accounts automatically swept from savings to checking, which in nature are the practical equivalent of checkable deposits. M2 excludes certificates of deposit which are held in retirement accounts, but includes other accounts which mature in more than one years' time, which are also illiquid. M2 fails, however, to include corporate money substitutes. M3 includes some corporate money substitutes, but excludes others. Although large negotiable certificates of deposit, Eurodollars, and repurchase agreements are included, M3 fails to include other quite liquid money substitutes held by corporations, including Treasury bills and commercial paper. In terms of conceptual consistency, perhaps the strongest case can be made for defining money as either a sweep-adjusted M1 (medium-of-exchange definition), MZM (all items due immediately or of zero maturity), or L (all liquid assets). The Federal Reserve Bank of Cleveland, among others, has published M1 figures adjusted for sweep accounts. (Lachman, McKenna, and Zorska, 1999, p. 4) MZM balances may be drawn upon at any time for immediate spending. L may be consistently described as including all liquid assets, or all money market instruments, or as including all money substitutes.

Interest Rate Studies

Bernanke and Blinder use both Granger-causality tests and variance decompositions from vector autoregressions in an investigation of monthly data of interest rates and several other macroeconomic variables. They find that "the interest rate on Federal funds is extremely informative about future movements of real macroeconomic variables. . . . the reason for the forecasting success is that the funds rate sensitively records shocks to the supply of bank reserves; that is, the funds rate is a good indicator of monetary policy actions." (1992, p. 901) The results, say the authors, "are striking: the Federal funds rate is markedly superior to both monetary aggregates and to most other interest rates as a forecaster of the economy." (ibid., p. 903) Bernanke and Blinder feel that it is "reasonable to treat either the funds rate or the funds-rate spread as a measure of Federal Reserve policy which, though not statistically exogenous, is at least predetermined within the month. We therefore interpret the estimated dynamic responses of the economy to shocks to these alternative policy measures as reflecting the structural effect of monetary policy in the particular historical period." (ibid., p. 903) In a vector autoregression with a lag-length of six months and a forecast horizon of 24 months, the authors perform a variance decomposition producing error variances for the forecast of several measures of economic activity. A higher forecast error variance (FEV) from one variable indicates that that variable explains more of the fluctuations in another variable. The sum of the forecast error variances in the prediction of any given variable is 100%. The following figures are the percentage of forecast error variance accounted for by each variable in the prediction of industrial production, in which industrial production's own lags account for part of its forecast error variance:

CPI	M1	M2	BILL	BOND	FUNDS	OWN LAGS OF INDUSTRIAL PRODUCTION
3.1%	15.4%	8.7%	8.0%	0.8%	27.4%	36.6%

The funds rate clearly dominates M1, M2, the Treasury bill rate, and the Treasury bond rate. (ibid., p. 907)

Friedman and Kuttner report that "including data from the 1980s sharply weakens the postwar time-series evidence indicating significant relationships between money (however defined) and nominal income or between money and either real income or prices separately." (1992, p. 472) In a vector autoregression with a four-quarter lag and an eight-quarter forecast horizon, the authors' first sample period (1960.2-1979.3) indicates a far closer relationship between the monetary aggregates and nominal income than occurs during the latest sample period. (1970.3-1990.4) In the first sample period, M1 produces a forecast error variance of 27%, whereas M2 does less satisfactorily in explaining the movements in nominal income, producing a FEV of only 22%. In the latest sample period, however, the FEV values fall drastically, to 10% for M1 and 11% for M2. The Treasury bill rate, though, creates a higher forecast error variance in the latter time period, climbing from a value under 10% up to 15%. (ibid., p. 478)

Hafer and Kutan question the standard conclusion that interest rates are superior predictors of output over money when samples include the decade of the 1980s. In their tests, these results depend critically on the stationarity assumption. When a time series contains a unit root, standard statistical assumptions may be violated. The existence of the unit root implies that the series has explosive properties. Differencing the series one or more times typically eliminates the unit root, so such series are best represented by a difference-stationary model. On the other hand, trend-stationary models assume that no unit root is present, and fluctuations around a trend in the series is stationary (mean-reverting). (1997, pp. 48-49) Assuming difference-stationarity produces the standard results, in which the money supply loses most of its predictive content when data from the 1980s are included. However, money and output remain statistically related if trend-stationarity is instead assumed. (ibid., p. 48)

Christopher Sims finds that even before the 1980s, the vector autoregression evidence supporting money's empirical relationship to output weakens when an interest rate is added to the model. For the 30-year period spanning 1948-1978, he finds that in a monthly model with 12 lags the percentage of forecast error variance of industrial production accounted for by M1 falls from 37% to only 4% when a short-term interest rate is added to the model. (1980a, pp. 251-253) The interest rate is ordered before the other variables in the model.

Leeper, Sims, and Zha confirm the result reported earlier by Sims: in a vector autoregression containing money, prices and output, variation in money helps to predict future output and prices, with the output response being quicker and less sustained than the price response. Innovations in output and prices, however, account for little of the variation in money. When a short-term interest rate such as the Federal funds rate is added to the system, though, a considerable amount of the movement in the money supply may be predicted. In addition, a substantial fraction of the variation in output is attributable to interest rate innovations, whereas the proportion of output variation predictable from money supply surprises declines substantially. In addition, visual examination of graphical evidence shows that most recessions in the United States have been preceded by increases in interest rates. If these interest rate hikes are interpreted as periods of monetary tightening, then "the evidence for an important role of monetary policy in generating recessions seems strong." (1996, p. 17) In reviewing the paper's results after its presentation at the Brookings Institution, Bernanke concludes that the evidence indicates that "Interest rates, such as the federal funds rate or the Treasury bill rate, are better indicators of monetary policy than are reserves or monetary aggregates." (ibid., p. 71)

In vector autoregressions with output and monetary indicators, Eichenbaum (1992), Sims (1992), and others find both an output puzzle and a price puzzle. The "output puzzle" occurs when positive innovations in the Federal funds rate are followed by an increase in production. Similarly, the "price puzzle" occurs when positive innovations in the Federal funds rate are followed by an increase in the price level. Walsh (1998) also finds that a positive shock to the funds rate is initially followed by small increases in both output and the price level. Walsh's output response turns slightly negative in less than a year and then turns sharply negative. His price response remains positive for many more months. Some analysts feel the basic VAR analysis of monetary policy fails to include important information. When oil or commodity prices are added to a VAR system also containing money and the price level, the magnitude of the price puzzle tends to decline. (Walsh, 1998, p. 27)

Steven Bovee applies vector autoregression analysis to a model containing 14 variables, among them the Federal funds rate, the M2 money supply, national output, and the unemployment rate. In the variance decomposition of the responses, Bovee finds that the Federal funds rate accounts for 7% of the forecast error variance of national output. (1998, p. 55) The impulse response function of output to Federal funds rate innovations is not statistically significant.[22] The forecast error variance (FEV) of output in response to money supply innovations is also 7%, the same value as the Federal funds rate produces. While the response of unemployment to money supply shocks is 7%, unemployment's response to Federal funds shocks is much larger in the 14-variable model, at 17%. (ibid., p. 57) In addition, the impulse response function of unemployment to the Federal funds rate is statistically significant. (ibid., p. 53)

Christina and David Romer examine monetary indicators in six episodes since World War II from which an examination of Federal Reserve records appears to indicate that the Fed decided to reduce economic activity in order to lower the rate of inflation. Since these decisions were mainly motivated by concerns about inflation, the actions were largely independent of contemporaneous real developments. (1990, p. 153) During the six episodes of intended anti-inflationary policy, money growth fell, the Treasury bill rate increased substantially, the spread between the Federal funds rate and the Treasury bill rate rose sharply, and the spread between the commercial paper rate and the Treasury bill rate widened substantially. Evidence exists, then, that changes in money growth and interest rates, and changes in interest rates, partially reflect shifts in monetary policy. (ibid., pp. 188-189)

Summation

Ever since banking practices developed, controversy has surrounded the appropriate definition of money, as well as the relationship between the quantity of money and the

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[22]Bovee, however, feels that this result may have been related to the complicated interrelationships involved in a model containing so many variables.

economy. The review of past literature indicates some tendency for the preferred definition to expand over time to encompass more and more financial assets. In the Classical era checkable deposits were often excluded from the money supply. In the 1980s, the M2 definition of money briefly displaced M1 as the primary monetary indicator. Yet as M2 fell out of favor in the 1990s, no other monetary aggregate took its place. Instead, attention shifted to interest rates. Previous literature has produced formal evidence that the case for a statistical link between the money supply and the economy, once close, has been materially less so in the last 20 years. The relationship between money and the economy appeared to be much closer in Friedman and Schwartz and in the St. Louis study than in more recent studies. Today, few economists attach informational value to the narrow money measure M1. MZM has some appeal as an alternative definition, being composed of all readily spendable assets of zero maturity. However, it is not officially recognized by the Board of Governors. Some economists attach limited informational value to movements in the M2 and M3 aggregates, but the Federal Reserve no longer attaches priority to remaining within its monitoring ranges for these measures. L is perhaps the natural measure of a broad money supply, being composed of all money substitutes. The Federal Reserve has never set a target or monitoring range for L, though, and no longer publishes figures for this aggregate. In addition, L has generally been ignored by the literature. This study explicitly includes L, in order to compare this measure's relationship to the economy with that of the other monetary aggregates. In contrast to the liquid assets measure, short-term interest rates such as the Federal funds rate have received substantial attention in the economics literature as predictors of future economic activity. Several researchers have reported that short-term interest rates provide substantial information on future movements in real output, and, when subject to comparisons with the monetary aggregates, rates are usually shown to provide a closer statistical link to real output than the monetary aggregates.

CHAPTER 3

METHODOLOGY

As discussed in the previous chapter, economists' views of the association between the monetary aggregates and the economy have varied over time. This chapter presents a framework for examining the empirical relationship over four different historical periods.

Monetary History Era

In the first series of tests, the relationships between the monetary aggregates and nominal gross national product during the era discussed by Friedman and Schwartz is examined:

A. The M2 money supply for the years 1869-1960.

B. The M1 money supply for the years 1915-1960.

C. The M2 money supply for the years 1915-1960.

All tests use annual data, and employ the vector autoregression (VAR) technique with variance decompositions and impulse response functions. Nominal GNP, M1, and M2 increase in time, with unit roots present at the 5% level of statistical significance in each. Therefore all are logged and differenced to eliminate the potential statistical problems associated with the use of variables possessing unit roots. (A discussion of the vector autoregression technique and unit roots appears later in this chapter.) The variables actually used in the vector autoregression analysis are the change in the logarithm of M1, the change in the logarithm of M2, and the change in the logarithm of nominal gross national product.[1]

The money supply and interest rates are both used as indicators of monetary policy. Therefore, an interest rate is next inserted concurrently into the foregoing models. This produces the following models examining the influence on nominal gross national product:

D. The M2 money supply and the interest rate concurrently for the years 1869-1960 (interest rate ordered before M2).

E. The M1 money supply and the interest rate concurrently for the years 1915-1960 (interest rate ordered before M1).

F. The M2 money supply and the interest rate concurrently for the years 1915-1960 (interest rate ordered before M2).

The interest rate used is the yield on long-term corporate bonds.[2] The series is compiled by Robert Gordon (1986, Appendix B), and is composed of linked data from railroad bonds and Baa (lower investment grade) corporate bonds. This series, however, has a unit root, so the variable actually used in the foregoing tests is the change in the long-term corporate bond rate, which is given the notation DLTR.

Data are obtained from Robert Gordon (1986, Appendix B). M1 is the narrow transactions definition of money. M2 is linked to the equivalent of the current definition, M1 plus deposits in all depository institutions, not just deposits in commercial banks.

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[1]The lag-length used in the VAR models in the Friedman and Schwartz era is two years. Based on the Akaike Information Criterion, this is the optimal lag length in the first model with the M2 money supply over 1869-1960. However, according to an alternative criterion for determining optimal lag length, the Schwartz Criterion, the optimal lag length is only one year.

[2]No Federal funds market existed until after the creation of the Federal Reserve in 1913, and only since 1954 has the Federal Reserve compiled continuous statistics on the Federal funds rate. (Board of Governors, 1976, pp. 640-641)

St. Louis Era

In the second series of tests, the variables employed by Andersen and Jordan are tested to determine their empirical relationship to gross national product:

A. M1 and the full-employment budget ratio for 1952-1968.

B. M1, full-employment expenditures, and full-employment revenues for 1952-1968.

C. M1 and full-employment expenditures for 1952-1968.

D. The monetary base, full-employment expenditures, and full-employment expenditures.

All tests use quarterly data, from the first quarter of 1952 to the second quarter of 1968, as in the original St. Louis study. Vector autoregressions are performed with variance decompositions and impulse response functions. Andersen and Jordan use one concurrent quarter and three lagged quarters in their regression analysis. Here a lag-length of four quarters is employed in the vector autoregression. Andersen and Jordan present four primary equations, the first including M1 and the budget surplus; the second with M1, expenditures, and revenues; the third with M1 and expenditures; and the fourth with the monetary base, expenditures, and revenues. This section's tests are analogous to the four Andersen-Jordan equations.

Changes in the variables are used in their statistical tests, with the changes measured in billions of dollars. Unit roots, however, are present in the changes in gross national product, M1, the monetary base, and full-employment expenditures at the 5% level of significance. Therefore gross national product, M1, and the monetary base are all logged and differenced. The change in the natural logarithm of the monetary base, however, still has a unit root. The first difference of the change in the logarithm of the monetary base does not, though, so this is the measure entered for the monetary base. With the monetary aggregates and GNP now changed from billions of dollars to relative log-changes, the budgetary figures are also adjusted. These measures are not quite comparable to the others, however. The full-employment surplus is a residual calculation, sometimes with a negative numerical value when the budget falls into deficit. Logarithms may not be computed for negative numbers. Therefore full-employment receipts are divided by full-employment expenditures to create a new variable, the budget ratio. The variables then used in the second series of tests are the change in the logarithm of nominal gross national product, the change in the logarithm of M1, the first difference of the change in the logarithm of the monetary base, the change in the logarithm of the full-employment budget ratio, the change in the logarithm of full-employment expenditures, and the change in the logarithm of full-employment receipts.

Data for seasonally-adjusted M1 are taken from Board of Governors (1976), and data for seasonally-adjusted monetary base figures are taken from the St. Louis Federal Reserve Bank "Fred" website at <www.stls.frb.org/fred/data.> The monthly figures given are converted to quarterly averages. Data for the full-employment surplus, full-employment expenditures, and full-employment revenues each quarter are available in Carlson (1967) for the years 1952-1966, and in Frank de Leeuw et al. (1980) for the years 1967-1968. Full-employment budget figures show what the respective measures would be when the economy is operating at full or high employment, and are commonly used so that the figures are reasonably independent of the state of the economy, rather than simply being a reflection of it. Seasonally-adjusted, quarterly figures for nominal gross national product are taken from United States Department of Commerce, Bureau of

Economic Analysis (1986).

The Commerce Department currently reports gross domestic product as the primary measure of national output, whereas in the 1960s it reported gross national product as the measure of national output. The difference between the two is quite small. Gross national product equals gross domestic product plus net factor income from abroad. Gross national product measures income going to American citizens, whereas gross domestic product measures production inside a nation's borders.

The Era 1968-1981

In the third series of tests, vector autoregressions are performed with variance decompositions and impulse response functions. Here the relationships between several monetary measures and measures of macroeconomic activity is examined:

A. Each monetary measure (M1, MZM, M2, M3, L and the Federal funds rate) is tested to determine its relationship to real GDP.
B. Each monetary measure (M1, MZM, M2, M3, L, and the Federal funds rate) is tested to determine its relationship to nominal GDP.
C. Each monetary measure (M1, MZM, M2, M3, L, and the Federal funds rate) is tested to determine its relationship to the gross domestic product deflator (or implicit price deflator).

In the foregoing empirical tests, only one monetary measure is present along with the measure of aggregate economic activity in each VAR. However, it is also of interest to investigate the relationship to economic activity when both a measure of the money supply and the interest rate are present. Sims (1980a, p. 250), for instance, finds that the percentage of forecast error variance of output explained by the money supply declines drastically when an interest rate is included in the equation. In the next series of tests, each monetary aggregate is tested for its relationship to aggregate economic activity, when the Federal funds rate is also present in each vector autoregression run. The Federal funds rate is ordered before the monetary aggregate in order to facilitate the closest comparison to the earlier Sims study:

D. Each monetary aggregate (M1, MZM, M2, M3, and L) is tested to determine its relationship to real GDP, with the Federal funds rate also present. (Federal funds rate ordered before the monetary aggregate).

E. Each monetary measure (M1, MZM, M2, M3, and L) is tested to determine its relationship to nominal GDP, with the Federal funds rate also present. (Federal funds rate ordered before the monetary aggregate).

F. Each monetary measure (M1, MZM, M2, M3, and L) is tested to determine its relationship to the gross domestic product deflator (or implicit price deflator), with the Federal funds rate also present. (Federal funds rate ordered before the monetary aggregate).

Each of the foregoing tests use quarterly data, with a lag-length of four quarters.[3] The

[3]This lag length is the same as that used in the second series of tests over the St. Louis period. In preliminary tests using model 3A in which M1 and real GDP are the variables present during the sample period 1968.3-1981.3, the Akaike Information Criterion indicates that a lag of four quarters is optimal. However, the Schwarz Criterion indicates that a lag of two quarters is optimal.

period covered begins after the St. Louis study, in the third quarter of 1968, and ends with the peak in velocity of M1 in the third quarter of 1981. Data for the MZM (or money zero maturity) aggregate are available only from 1974 to the present. Therefore all statistical runs in which this aggregate is present include only 1974.1-1981.3 rather than 1968.3-1981.3.

Bernanke and Blinder (1992) report clearly higher forecast error variance values for the Federal funds rate than for either M1 or M2 in the prediction of industrial production and several other measures of economic activity. Their vector autoregression, though, uses monthly data with 6 lags, equivalent to two quarters. For comparative purposes, another series of statistical runs are conducted in which the lag-length is shortened to two quarters:

G. Each monetary aggregate (M1, MZM, M2, M3, and L) is tested to determine its relationship to real GDP, with the Federal funds rate also present in each VAR (Federal funds rate ordered before the monetary aggregate), with a two-quarter lag length.

H. Each monetary measure (M1, MZM, M2, M3, and L) is tested to determine its relationship to nominal GDP, with the Federal funds rate also present in each VAR (Federal funds rate ordered before the monetary aggregate), with a two-quarter lag length.

I. Each monetary measure (M1, MZM, M2, M3, and L) is tested to determine its relationship to the gross domestic product deflator (or implicit price deflator), with the Federal funds rate also present in each VAR (Federal funds rate ordered before the monetary aggregate), with a two-quarter lag length.

In all of the foregoing tests, from 3A-3I, all variables except the Federal funds rate are logged and differenced. However, several possess unit roots: M1, M2, M3, L, the Federal funds rate, and the implicit price deflator. The first differences of these variables are taken to eliminate the unit roots. Table 1 gives the notation for the variables used in all the VAR tests.

M1, M2, and M3 values are available at the Board of Governors Web site at <www.bog.frb.fed.us> (as well as at the St. Louis Federal Reserve Bank Web site). The Federal Reserve Bank of St. Louis "Fred" data site on the Worldwide Web is used to access dollar values of MZM, the broad monetary aggregate L (liquid assets), the Federal funds rate, real GDP, nominal GDP, and the implicit price deflator. The "Fred" site is available at <www.stls.frb.org/fred/data> on the Worldwide Web.

M1, MZM, M2, M3, liquid assets, and the Federal funds rate are available as monthly figures and converted to quarterly averages for this study. Real GDP, nominal GDP, and the implicit price deflator are reported in quarterly form (originally compiled by the Bureau of Economic Statistics of the Commerce Department).

Seasonally-adjusted M1, MZM, M2, M3, L, real GDP, nominal GDP, and the implicit price deflator are used.

The Era 1981-1998

In the fourth series of tests, the relationships between several monetary measures and measures of macroeconomic activity is examined:

A. Each monetary aggregate (M1, MZM, M2, M3, and L) is tested to

TABLE 1

LIST OF VARIABLES

M1	Change in logarithm of M1.
DM1	First difference of change in logarithm of M1.
MZM	Change in logarithm of MZM.
M2	Change in logarithm of M2.
DM2	First difference of change in logarithm of M2.
DM3	First difference of change in logarithm of M3.
DL	First difference of change in logarithm of L.
DLTR	First difference of long-term corporate bond rate.
DFF	First difference of Federal funds rate.
NGNP	Change in logarithm of nominal GNP.
RGDP	Change in logarithm of real GDP.
NGDP	Change in logarithm of nominal GDP.
DIPD	First difference of change in logarithm of implicit price deflator.

determine its relationship to real GDP, with the Federal funds rate also present in each VAR (Federal funds rate ordered before the monetary aggregate).

B. Each monetary measure (M1, MZM, M2, M3, and L) is tested to determine its relationship to nominal GDP, with the Federal funds rate also present in each VAR (Federal funds rate ordered before the monetary aggregate).

C. Each monetary measure (M1, MZM, M2, M3, and L) is tested to determine its relationship to the gross domestic product deflator (or implicit price deflator), with the Federal funds rate also present in each VAR (Federal funds rate ordered before the monetary aggregate).

As in the third series of tests covering 1968-1981, the fourth series of tests covering 1981-1998 employ quarterly data. In tests 4A-4C, a lag-length of four quarters is used in the vector autoregression analysis. The following additional tests, shortening the length of the lag, are also conducted:

D. Each monetary aggregate (M1, MZM, M2, M3, and L) is tested to determine its relationship to real GDP, with the Federal funds rate also present in each VAR (Federal funds rate ordered before the monetary aggregate), with a two-quarter lag length.

E. Each monetary measure (M1, MZM, M2, M3, and L) is tested to determine its relationship to nominal GDP, with the Federal funds rate also present in each VAR (Federal funds rate ordered before the monetary aggregate), with a two-quarter lag length.

F. Each monetary measure (M1, MZM, M2, M3, and L) is tested to determine its relationship to the gross domestic product deflator (or implicit price deflator), with the Federal funds rate also present in each VAR (Federal funds rate ordered before the monetary aggregate), with a two-quarter lag length.

Since the Federal Reserve ceased publication of figures for L after the third quarter of 1998, the fourth series of tests cover the period 1981.4-1998.3. The variables used and data sources for the fourth series of tests are the same as those in the third series of tests.

Discussion of Statistical Issues

An assumption in most statistical analyses is that the data are stationary. A stationary data series possesses a constant mean, and variances and covariances that are time-independent. Unit root tests are often used in investigating the stationarity of a time series. The standard Augmented Dickey-Fuller (ADF) Test, available in the EViews 3.1 statistical package, is employed in this study to determine whether any series has a unit root. (The ADF test is only one of several possible techniques available in the investigation of unit roots, but is among the more widely-utilized.) If data are nonstationary, they may be differenced one or more times to achieve stationarity. The number of times a series must be differenced to achieve stationarity is the order of integration of the time series. A variable integrated of order zero I(0) is stationary in its original form, whereas a series integrated of order one I(1) requires first-differencing before becoming stationary.

The vector autoregression (VAR) has become a widely-used technique in time-series analysis. This econometric method treats all variables in the system are endogenous. Each variable is a function of lagged values of all the other variables. The vector autoregression is a relatively open or non-theoretical technique in that it does not require a rigid, prior theoretical specification of the model. The data itself largely determine the dynamic structure of the model, rather than the a priori determination made by the researcher. For the present study, all variables in the system are treated as endogenous, as originally suggested by Sims (1980b). Although generally appropriate for an open investigation of empirical evidence, VAR model results can be influenced by variable selection, lag specification, and the ordering of the variables. These potential problems may, however, be mitigated by careful selection of variables and lags and by the use of sensitivity tests for changes in variables, lags, and orderings.

In the VAR system of equations, the error terms or innovations are shocks to the individual equations. These are used to analyze the dynamics of the system. Results from vector autoregressions are commonly analyzed through the use of variance decompositions (VD) and impulse response functions (IRF). The researcher specifies a forecast horizon of perhaps 10 future periods for these analyses. Since time series error terms are almost always correlated, the Cholesky decomposition is used in EViews 3.1 to attribute the common effects to the variable appearing first in the system. The results may be affected by the ordering chosen in the VAR system, and investigators sometimes employ sensitivity analysis in analyzing the influence of ordering the variables. The variance decomposition shows the percentage of the k-step ahead squared prediction error in a variable arising from innovations in each variable, including lags of the own variable being forecasted. The forecast error variance (FEV) is similar to the coefficient of determination (or R-squared) used in regression analysis in that the value must lie between zero and one and also in that a higher value is more satisfactory. A higher FEV value indicates that one variable explains a larger amount of the fluctuation in another variable. In addition, forecast error variances allow the researcher to compare the relative influences of different variables in the system. The impulse response functions show the effect over time on each variable of a one standard deviation shock to the error terms (or innovations) in the equations. With logged values of the data, the impulse responses may be interpreted as cumulative growth rates relative to base. A positive movement in the impulse response function indicates an increase in the growth rate relative to the rate at the time of a shock. Impulse response functions are an important analytical tool in the investigation of the dynamic effect through time of one variable on another.[4] Variance decompositions seem to provide the most straightforward comparison of the variables being tested in the system. However, Braun and Mittnik (1993) argue that they are more sensitive to specification errors than impulse response functions. Both variance decompositions and impulse response functions may be affected by the ordering of the variables.

Summation

This chapter lays the groundwork for the results presented in Chapter 4. There a first series of vector autoregression tests examines the relationship between the monetary

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[4] See Bovee (1998, pp. 17-47) for a fine description of the vector autoregression in a study similar to this one; Bovee analyzed the channels of influence of the Federal funds rate on the economy.

aggregates and macroeconomic activity in the *Monetary History* period, a second series of tests examines the relationship in the St. Louis period, a third series of tests examines the relationship in the period 1968-1981, and a fourth series of tests examines the relationship in the period 1981-1998. The EViews 3.1 statistical software package is employed to conduct the statistical tests.

CHAPTER 4

RESULTS AND DISCUSSION

Monetary History Era

This chapter presents the results of the empirical tests. In table 2 a vector autoregression analysis is applied to Friedman and Schwartz, in which forecast error variance values from variance decompositions are displayed. Each row is a separate VAR, and the variable being forecast is NGNP, the change in the logarithm of nominal GNP. In the first row M2 is tested over the lengthy period 1869-1960, with a lag-length of two years. NGNP is affected by its own innovations (43.7% of forecast error variance), but M2 explains over half of the forecast error variance (FEV) of NGNP, 56.3%. The larger the forecast error variance explained by a variable, the greater its explanation of the fluctuations in the target variable. As M2 explains over 50% of the FEV of NGNP, M2's performance is very good. Innovations in M2 explain a large percentage of the innovations in NGNP.

The influence of the annual M1 measure is presented in the second row of table 2 over the period 1915-1960. Here the monetary aggregate explains almost two-thirds of the FEV of NGNP, whereas the latter variable's own innovations explain over 35% of its forecast error variance. The third row of table 2 gives the FEV with M2 in the model covering the comparable 1915-1960 time period. Here M2, like M1 before it, explains over half the error variance of NGNP, approximately 60%.

Figure 2 displays the graphs of the impulse response functions (IRFs) for the *Monetary History* era. In the top graph, covering the period 1869-1960, innovations in

TABLE 2

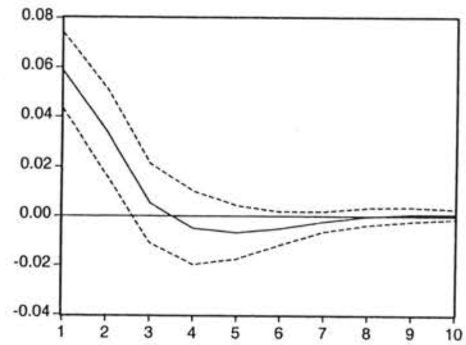
MONETARY HISTORY ERA
FORECAST ERROR VARIANCE OF NGNP

		Forecast Error Variance	
Sample Period	Monetary Aggregate	Money Supply	NGNP
1869-1960	M2	56.3	43.7
1915-1960	M1	65.3	34.7
1915-1960	M2	59.6	40.4

Percent of forecast error variance in NGNP accounted for by the column variable.
Far left-hand row variable is the specific monetary aggregate appearing in the model.
Each row of the table is a separate VAR run.
Annual data are used.
Lag-length is two years.
Forecast horizon is 10 years.
NGNP is the change in the logarithm of nominal gross national product.
M2 is the change in the logarithm of M2 money supply.
M1 is the change in the logarithm of M1 money supply.
Data source is Gordon, Robert J., ed., *The American Business Cycle,* Chicago, University of Chicago Press, 1986, Appendix B. Nominal GNP is computed by Gordon from figures for net national product in Milton Friedman and Anna J. Schwartz, *Monetary Trends in the United States and the United Kingdom: Their Relation to Income, Prices, and Interest Rates, 1867-1975* (Chicago, University of Chicago Press, 1982), pp. 122-129, added to capital consumption from Simon Kuznets, *Capital in the American Economy: Its Formation and Financing* (Princeton: University of Princeton Press, 1961), table R8, p. 499, linked to later figures from *Long-Term Economic Growth, 1860-1970* (Washington, D.C.: Department of Commerce, 1973), linked to later figures from *National Income and Product Accounts of the United States, 1929-76* (Washington, D.C.: Department of Commerce, 1981).

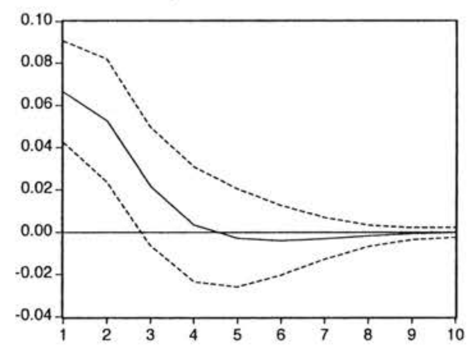
1869-1960

Response of NGNP to M2



1915-1960

Response of NGNP to M1



1915-1960

Response of NGNP to M2

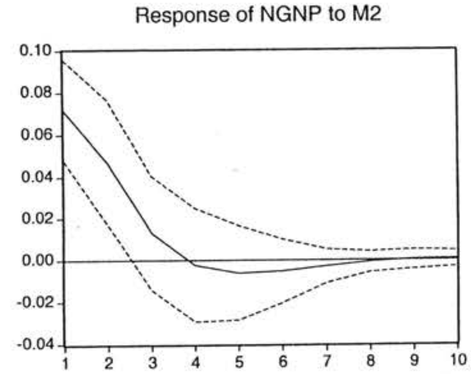


FIGURE 2.

MONETARY HISTORY

Horizontal Axis: Years in the forecast horizon.
Vertical Axis: Cumulative growth rate relative to base.
The impulse response function is the response to a one standard deviation shock.
The standard error bands represent two standard deviations.

M2 forecast for a total of 10 periods ahead. The response of NGNP to a one standard deviation shock or innovation to M2 is given. The results are consistent with monetarist theory. The initial response of NGNP to movements in M2 is positive, and is clearly statistically significant for the year. The standard error bands are indicated by the dotted line. If both standard error bands lie on the same side of the zero horizontal line, the variable has a statistically significant effect on NGNP for the respective periods. The standard error bands represent two standard deviation, and indicate that results are significant at the 5% level. In the first year the response is positive and significant, in the second year the response is smaller but still positive and significant, and by the third year the response has become statistically insignificant.

The second graph in figure 2 is the IRF function of NGNP to M1. The response is broadly similar to that from M2, being both initially positive and significant. Once again the first year's response of gross national product to the monetary aggregate is very positive and very significant. In the second year, the response is smaller, but still positive and significant. The impulse response function of NGNP in reaction to innovations in M2 appears in the last graph of figure 2. Again, the response in the first year is quite positive and significant. In the second year, the smaller response remains positive and significant. By the third year, the response is no longer statistically significant.

Including the change in the long-term corporate bond rate (DLTR) as a variable in the model lessens, but does not eliminate, the influence of the money supply. As table 3 indicates, the percentage of forecast error variance accounted for by each of the respective measures of money is in the range of about 25%. The long-term interest rate

TABLE 3

MONETARY HISTORY ERA
INCLUDING LONG-TERM INTEREST RATE
FORECAST ERROR VARIANCE OF NGNP

		Forecast Error Variance		
Sample Period	Monetary Aggregate	Money Supply	DLTR	NGNP
1869-1960	M2	28.5	27.3	44.2
1915-1960	M1	27.6	38.5	33.9
1915-1960	M2	24.3	36.9	38.8

Percent of forecast error variance in NGNP accounted for by the column variable.
Far left-hand row variable is the specific monetary aggregate appearing in the model.
Each row of the table is a separate VAR run.
Annual data are used.
Lag-length is two years.
Forecast horizon is 10 years.
NGNP is the change in the logarithm of nominal gross national product.
M2 is the change in the logarithm of M2 money supply.
M1 is the change in the logarithm of M1 money supply.
DLTR is the change in the long-term corporate bond rate.
Data source is Gordon, Robert J., ed., *The American Business Cycle,* Chicago, University of Chicago Press, 1986, Appendix B. Nominal GNP is computed by Gordon from figures for net national product in Milton Friedman and Anna J. Schwartz, *Monetary Trends in the United States and the United Kingdom: Their Relation to Income, Prices, and Interest Rates, 1867-1975* (Chicago, University of Chicago Press, 1982), pp. 122-129, added to capital consumption from Simon Kuznets, *Capital in the American Economy: Its Formation and Financing* (Princeton: University of Princeton Press, 1961), table R8, p. 499, linked to later figures from *Long-Term Economic Growth, 1860-1970* (Washington, D.C.: Department of Commerce, 1973), linked to later figures from *National Income and Product Accounts of the United States, 1929-76* (Washington, D.C.: Department of Commerce, 1981).

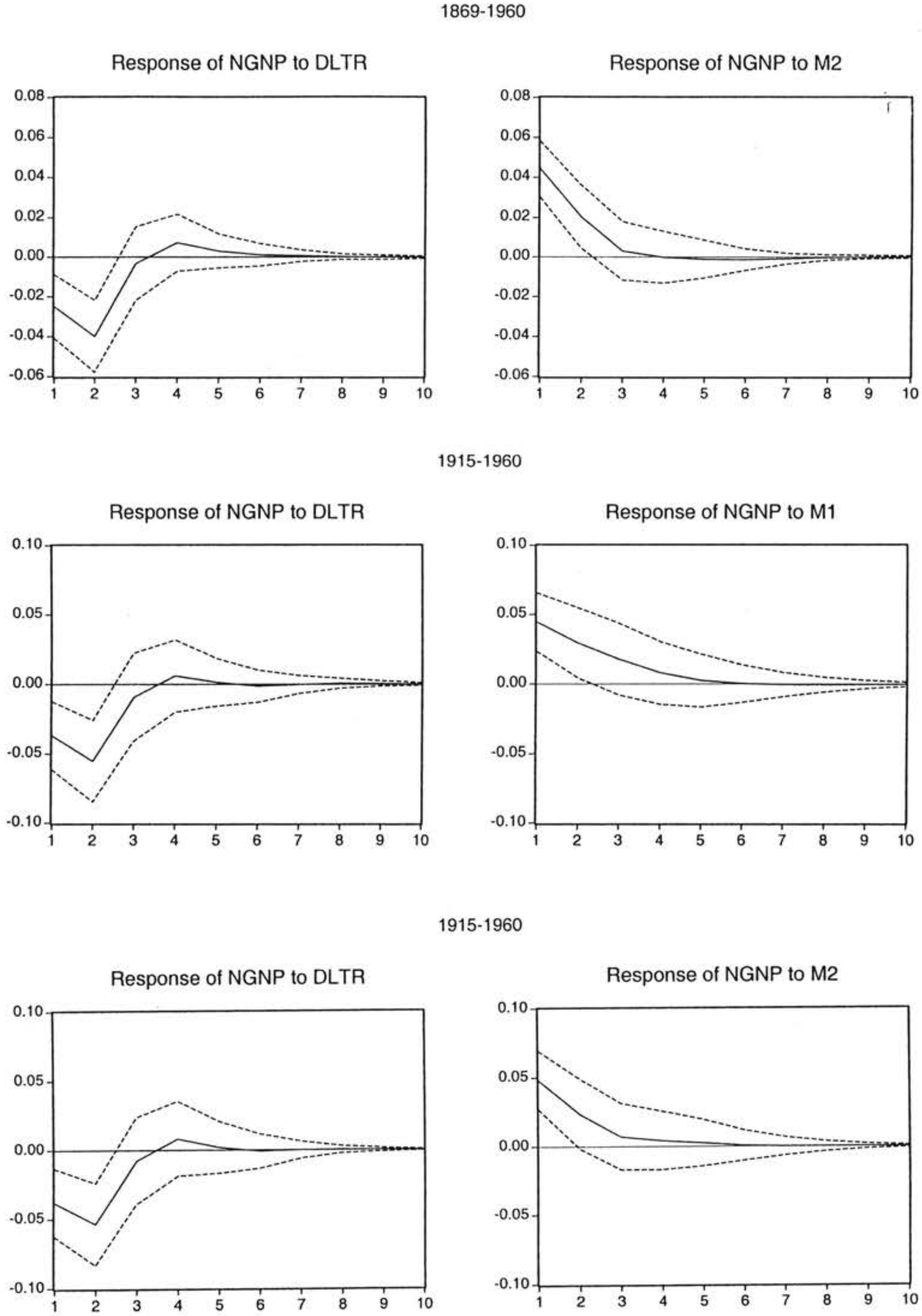


FIGURE 3

MONETARY HISTORY WITH INTEREST RATE

Horizontal Axis: Years in the forecast horizon.
Vertical Axis: Cumulative growth rate relative to base.
The impulse response function is the response to a one standard deviation shock.
The standard error bands represent two standard deviations.

accounts for somewhat more of the fluctuation in NGNP, but still less than 50%. Vector autoregression results, however, may be affected by variable ordering. Here the long-term corporate bond rate (Gordon series, 1986, pp. 781-784) is ordered before the money supply.[1] When the variables are re-ordered to place the money supply variable first (ahead of the interest rate), the common shocks of the two variables will be adduced to the money supply instead of to the interest rate. This raises the forecast error variance of the money supply and decreases the error variance of the interest rate. The results are in fact materially affected if the money supply is ordered before the interest rate. In results not shown in the table, M2 accounts for 47% of FEV of NGNP, and DLTR, only 9% of FEV of NGNP, when M2 is ordered before the long-term interest rate over the period 1869-1960. Over the period 1915-1960, M1 accounts for 57% of FEV of NGNP, and DLTR, only 9% of FEV of NGNP, when the narrow money supply is ordered before the long-term interest rate.

Figure 3 presents the impulse response functions when the long-term interest rate is included in the model along with the money supply (interest rate ordered before the money supply). In the top graph, covering 1869-1960, innovations to DLTR create negative and significant responses on NGNP in the first two years. Innovations to M2 create positive responses on NGNP, but these responses are smaller than in figure 2 in which only M2 and NGNP are present in the model. The next graph presents the impulse response functions from a model including both the long-term interest rate and the M1 money supply over the years 1915-1960. Innovations to DLTR create negative

[1]Sims (1980a) had ordered the interest rate (in this case, the short-term commercial paper rate) before the M1 money supply in one of the first VAR analyses including both an interest rate and the money supply.

and significant responses on NGNP in the first two years. Innovations to M1 create positive responses on NGNP, but these responses are smaller than in the earlier figure 2 in which only M1 and NGNP are present in the model. The bottom section of figure 3 displays the impulse response functions from the corporate bond rate and the M2 money supply over the period 1915-1960. The long-term interest rate again produces negative and significant effects, whereas the M2 money supply again produces positive but smaller effects.

For the *Monetary History* era, the vector autoregression analysis produces evidence supporting the proposition that the monetary aggregates provide substantial information regarding future movements in aggregate economic activity. In the variance decompositions, the forecast error variances of the response of gross national product to M1 and M2 are over 50%, and the impulse response function in each case indicates that the monetary aggregates produce positive and statistically significant effects on NGNP. Although the influence of the money supply declines when a long-term interest rate is included in the model, it remains substantial.[2]

St. Louis Era

In table 4 the vector autoregression is applied to the time frame of the St.

[2]When the monetary aggregate is ordered before the interest rate, the FEV of the aggregate is near 50%, far in excess of the FEV of the interest rate.

TABLE 4

ST. LOUIS ERA
FORECAST ERROR VARIANCE OF NGNP

	Monetary Aggregate	BR	E	R	NGNP
M1	33.8	5.8			60.3
M1	35.8		11.7	5.9	46.6
M1	35.7		13.4		50.8
DMB	5.5		19.3	3.0	72.2

Percent of error variance in NGNP accounted for by the column variable.
Far left-hand row variable is the specific monetary aggregate appearing in the model.
Each row of the table is a separate VAR.
Variables are ordered in the VAR as listed across the row.
The fiscal policy variables present in the specific VAR run are identified by the column variables which have actual numerical entries.
Quarterly data are used.
Lag-length is four quarters.
Forecast horizon is 10 quarters.
NGNP is the change in the logarithm of nominal gross national product.
M1 is the change in the logarithm of M1 money supply.
DMB is the first difference of the change in the monetary base, St. Louis series.
BR is the budget ratio, which is the change in the logarithm of the ratio of full-employment receipts to full-employment expenditures.
E is the change in the logarithm of full-employment expenditures.
R is the change in the logarithm of full-employment receipts.
Period covered is 1952.I-1968.II.

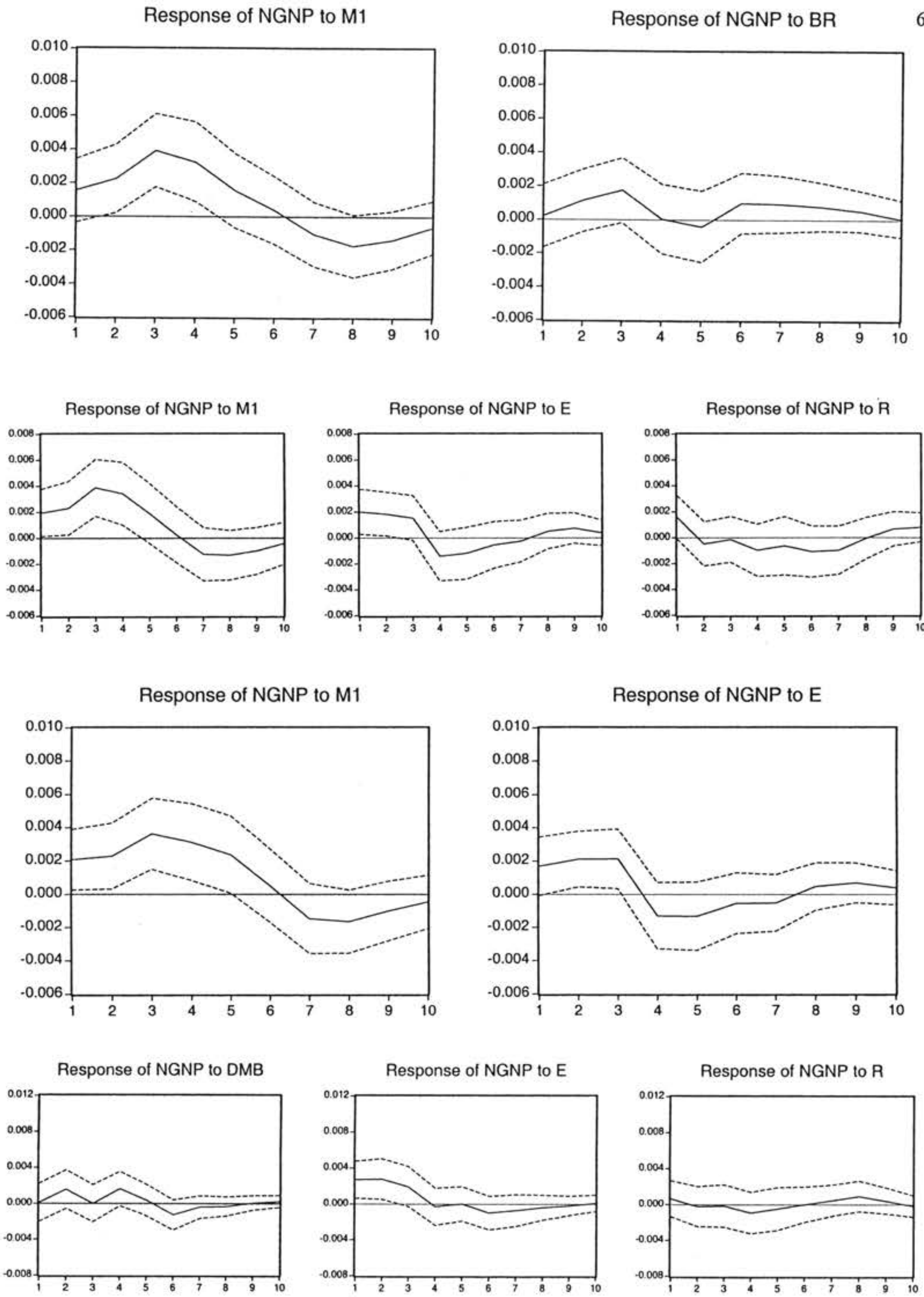


FIGURE 4
1952.1-1968.2
ST LOUIS ERA

Horizontal Axis: Quarters in the forecast horizon.
Vertical Axis: Cumulative growth rate relative to base.
The impulse response function is the response to a one standard deviation shock.
The standard error bands represent two standard deviations.

Louis study. M1 is the change in the logarithm of M1, DMB is the first difference of the change in the logarithm of the monetary base, BR is the change in the logarithm of the ratio of full-employment receipts divided by full-employment expenditures, E is the change in the logarithm of full-employment expenditures, R is the change in the logarithm of full-employment receipts, and NGNP is the change in the logarithm of nominal gross national product. The time period is the first quarter of 1952 through the second quarter of 1968, the lag-length is four quarters, and the forecast horizon is 10 quarters. Each of the four rows is a separate VAR, and each includes those variables respectively present in Andersen's and Jordan's four equations.

The variables are ordered monetary aggregate, fiscal measure(s), NGNP. The variable being forecast is NGNP. The first row clearly supports the proposition that M1 provides both substantial and greater information on movements in GNP than does BR, the full-employment budget ratio. Approximately one-third of the forecast error variance of NGNP is accounted for by the change in the logarithm of the narrow money supply, whereas less than 10% is explained by the change in the logarithm of the government's fiscal balance.

Andersen and Jordan list the monetary measures before the fiscal measures in their tables. However, while multicollinearity is sometimes an issue in multiple regression analysis, variable "ordering" does not affect the results as it does in VAR analysis. When the variables are re-ordered to place the fiscal variable first (ahead of the monetary variable), the common shocks of the two variables will be adduced to the fiscal variable instead of to the monetary variable. This raises the forecast error variance of the fiscal measure and decreases the error variance of the money supply. In a separate VAR (not shown in table 4) for the prediction of NGNP in which the variables are ordered BR, M1, NGNP, the forecast error variance is 8% emanating from BR, 31% from M1, and 60.3% from NGNP's own innovations. The relatively favorable result for the monetary aggregate does not arise due to variable ordering. It continues to forecast about one-third of the error variance even when ordered behind the fiscal variable. (The variable ordered last in both cases, NGNP, continues to explain exactly the same percentage of its own forecast error variance, 60.3%.)

The second row of table 4 replaces the budget ratio with full-employment expenditures and full-employment revenues as the measures of fiscal policy. M1 continues to forecast about one-third of the error variance of NGNP, well in excess of any fiscal variables. E does forecast somewhat more than BR did, however, while R is responsible for less than 10% of FEV.

The third row of table 4 gives the VAR forecast error variance results when E alone measures fiscal policy. M1 accounts for 36% of the FEV in the prediction of NGNP, whereas E accounts for less than half of that, at 13%. In the fourth and final row of table 4, the change in the money supply is replaced by the change in the monetary base. Here the influence of the monetary aggregate falls to only about 5% of FEV, far less than the 19% of FEV from E.[3]

Figure 4 graphs the impulse response functions for the prediction of NGNP over the St. Louis era. The first row of graphs gives responses from the model ordered M1, BR, NGNP. The influence of M1 is initially positive as predicted by theory, and statistically

[3] When the change in the logarithm of the monetary base is tested (instead of the first difference of the change in the logarithm of the base), the FEV of NGNP in response to shocks in the base rises to 20%. However, the change in the logarithm of the monetary base has a unit root.

significant in the second, third, and fourth quarters. By the fifth-quarter, the response, though positive, has fallen below the level of statistical significance. By the sixth quarter, NGNP essentially shows no reaction to innovations in M1. The impulse response function, like those from the *Monetary History* era, is consistent with monetarist theory. The first row of figure 4 also graphs the response of NGNP to shocks in the full-employment budget ratio. Unlike the monetary aggregate, the fiscal variable fails to have a significant effect on gross national product. These results are quite comparable to Andersen's and Jordan's results, in which the lagged M1 coefficients are positive and significant, but the lagged full-employment surplus coefficients are not significant.

The second row of figure 4 gives the impulse response functions of NGNP to M1, E, and R. NGNP responds positively and significantly for the first several quarters to innovations in M1. The reaction to government expenditures is positive, as predicted by economic theory, for the first three quarters (it is clearly statistically significant in the first two quarters). NGNP's response to full-employment revenues, on the other hand, is insignificant for all quarters. The third row of figure 4 graphs the impulse response functions in the VAR model M1, E, NGNP. The results are similar to those obtained in the prior row, despite the absence of R from the model. M1 creates positive responses in quarters 1-5, with the largest response occurring in the third quarter. E produces positive and significant effects in the second and third quarters. All in all, the impulse response functions from this VAR support the position that the M1 money supply has a stronger and more predictable effect on the economy than do measures of fiscal policy, although government expenditure does produce a small positive effect.

The final row of figure 4 shows the impulse response functions for the model DMB, E, R, NGNP. The response of NGNP to DMB is insignificant. The response to E, though, is positive and significant in the first two quarters, as predicted by theory. The response of nominal gross national product to R is insignificant for all quarters.

The results presented in table 4 and in figure 4 are broadly consistent with the hypothesis that the narrow M1 money supply provides substantial information on the future course of gross national product. The empirical evidence found in this series of vector autoregressions supports the evidence found in the regression analysis reported by Andersen and Jordan in 1968: the money supply produces a substantial and positive effect on aggregate economic activity, much larger than the effect of any fiscal measures. In addition, full-employment expenditures produce a more powerful effect in this VAR analysis than full-employment revenues, as was also the case in the St. Louis regression analysis.

Monetarists presented their most substantial empirical studies in the mid-1960s, with the Friedman and Schwartz work being published in 1963 and the St. Louis study coming out in 1968. As the empirical evidence stood then, the case that the money supply had a close statistical relationship to aggregate economic activity seemed strong. Later, however, the evidence was to weaken, as instabilities in velocity created a much looser link between the monetary aggregates and the economy.

Third Period: 1968.3-1981.3

During the third period tested, 1968.3-1981.3, the forecast error variances in the prediction of national output are similar to those during the St. Louis period.

As shown in table 5, the error variance from M1 is 30% in the forecast of real GDP, and 27% in the forecast of nominal GDP. This is slightly lower than the forecast accuracy during the earlier St. Louis time frame, but the narrow monetary aggregate continues to have a fairly substantial relationship to economic activity through 1981.

In the forecast of inflation, represented by the variable DIPD, M1 accounts for a much smaller percentage of the error variance. This result may partly reflect a longer lag in effect in the response of prices to monetary growth. Monetarists have long maintained that "the first effects of changes in money growth are on output; later, the rate of inflation changes." (Meltzer, 1993, p. 130) For all the monetary measures, the FEVs in the forecast of DIPD are much reduced from those of RGDP or NGDP.

Row 2 of table 5 shows that MZM produces even higher FEVs than does M1 in all three measures of economic activity. However, the smaller sample size cautions against making strong conclusions based on this monetary aggregate (data for MZM begin in 1974, due to the availability of statistics from the St. Louis Federal Reserve Bank website).

M2's forecast accuracy is lower than M1's for real GDP and nominal GDP, but higher for DIPD. For either real or nominal GDP, M1 accounts for about 30% of the error variance, whereas M2 accounts for about 20%. Federal Reserve Regulation Q may have caused some distortions in the growth of M2 during the third test period. This regulation restricted the interest rates that depository institutions could pay on savings accounts and time deposits. During periods of rising market interest rates, many depositors withdrew funds from depository institutions and placed them directly in money market investments. These periods of disintermediation lowered the growth rate

TABLE 5

Third Period: 1968.3-1981.3

Real GDP Forecast Error Variance

	Monetary Measure	RGDP
DM1	30.55	69.44
MZM	33.57	66.43
DM2	17.74	82.27
DM3	12.66	87.34
DL	24.99	75.01
DFF	40.73	59.27

Nominal GDP Forecast Error Variance

	Monetary Measure	NGDP
DM1	26.61	73.39
MZM	35.05	64.95
DM2	23.38	76.62
DM3	14.50	85.50
DL	19.33	80.67
DFF	31.71	68.29

Implicit Price Deflator Forecast Error Variance

	Monetary Measure	DIPD
DM1	4.51	95.49
MZM	16.45	83.55
DM2	17.48	85.52
DM3	10.23	89.77
DL	3.60	96.40
DFF	21.70	78.30

Percent of forecast error variance in RGDP, NGDP, or DIPD accounted for by the column variable.
Far left-hand row variable is the specific monetary measure appearing in the model.
Each row of the table is a separate VAR.
Lag-length is four quarters.
Forecast horizon is 10 quarters.
Period is 1968.3-1981.3.
MZM is for 1974.1-1981.3.

of the M2 aggregate. (Hubbard, 2000, pp. 360-363)

Broadening the definition of money beyond M2 to M3 fails to improve forecast accuracy in the third period. M3's forecast error variance in the prediction of all three measures of economic activity is below 15%, lower than the forecast error variances emanating from M2.

Fully broadening the definition of money to include all liquid assets does improve forecast accuracy for RGDP and NGDP. This is most noticeable in the case of real GDP, in which 25% of the FEV is accounted for by L, clearly higher than the 18% and 13% values accounted for by M2 and M3, respectively. However, liquid assets' forecast of nominal GDP is somewhat less impressive, being above that of M3 but below that of M2. And in the prediction of DIPD, L has the lowest FEV of all monetary measures. Furthermore, L's forecast accuracy is below that of the narrow monetary aggregate M1 for all three measures of economic activity.

Even during this "monetarist" era before the breakdown of velocity relationships in the 1980s, the Federal funds rate has slightly higher FEV values than do the monetary aggregates. The Federal funds rate possesses the highest forecast error variance of all monetary indicators for both real GDP and the implicit price deflator. For nominal GDP, the Fed funds rate is second to MZM (but MZM's sample size is shortened by several years due to data availability). Thus both the monetary aggregates and interest rates perform well as indicators from 1968.3-1981.3, but the Federal funds rate performs better than all monetary aggregates except for MZM.

Interest rates and monetary aggregates may sometimes produce conflicting signals as to the stance of monetary policy. They may, however, produce consistent indications.

Ordinarily, during periods of tight monetary policy, the Federal funds rate increases and the growth rates of the monetary aggregates decrease, so that both measures produce consistent signals.

As previously noted, the weaker response of DIPD to the various monetary measures may occur partly due to the slower response of prices to monetary changes. A scenario envisioned by monetarist analysis is that when an expansion in the growth rate of the money supply occurs, "much or most of the rise in income will take the form of an increase in output and employment rather than in prices. People have been expecting prices to be stable, and prices and wages have been set for some time in the future on that basis. It takes time for people to adjust to a new state of demand." (Friedman, 1968a, p. 10)

Figure 5 graphs the impulse functions in response to innovations in the variable DM1. The response of RGDP in the top graph indicates that DM1 has a positive and statistically significant impact in the first three quarters, with the largest impact in the second quarter (in the St. Louis era the third quarter produces the peak response). Figure 5 also produces the graph of the impulse response function of nominal GDP to the most narrow monetary aggregate. The response is quite similar to that of RGDP, with positive and significant responses in the early quarters. However, the IRF of DIPD's response to M1 in figure 5 indicates no significant reaction. These three graphs, then, are consistent with the monetarist position that most of the early response of changes in monetary policy falls on output rather than prices.

Figure 6 displays the impulse response functions of RGDP, NGDP, and DIPD respectively to innovations in MZM. The result here is not quite as impressive for MZM

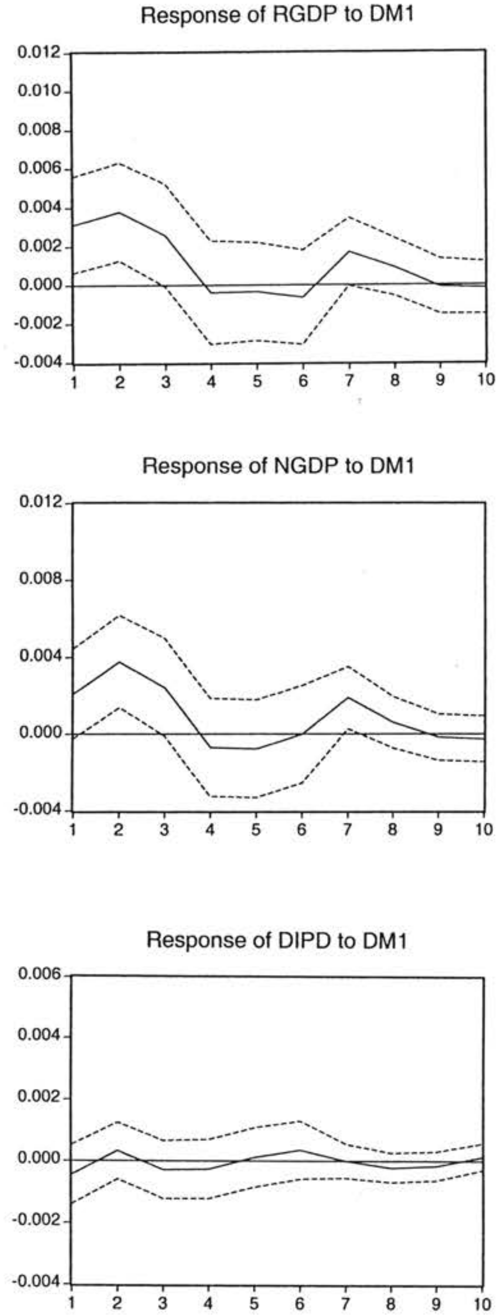


FIGURE 5

DM1 1968.3-1981.3

Horizontal Axis: Quarters in the forecast horizon.
Vertical Axis: Cumulative growth rate relative to base.
The impulse response function is the response to a one standard deviation shock.
The standard error bands represent two standard deviations.

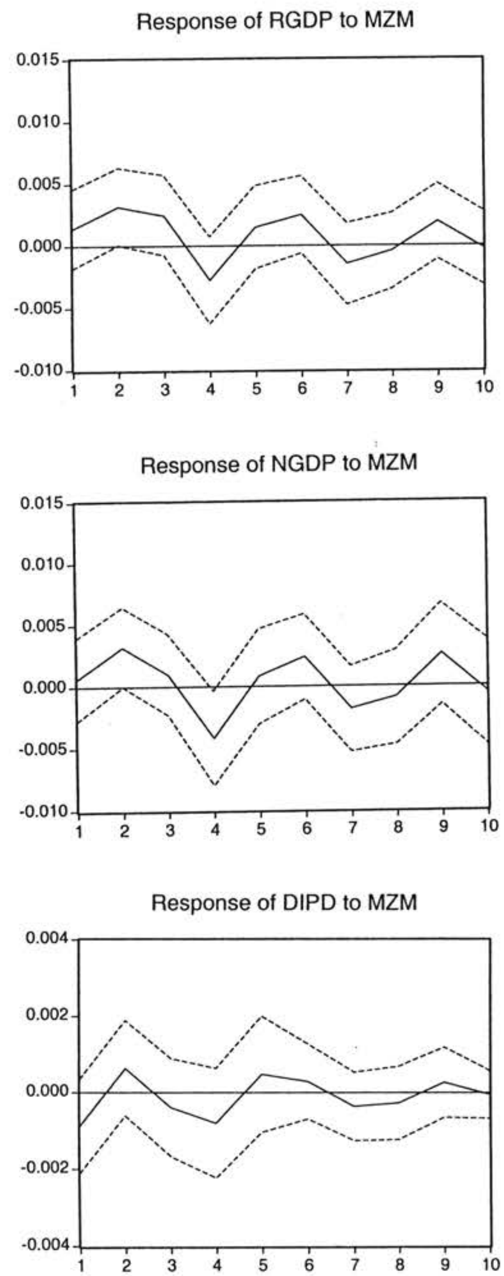


FIGURE 6

MZM 1968.3-1981.3

Horizontal Axis: Quarters in the forecast horizon.
Vertical Axis: Cumulative growth rate relative to base.
The impulse response function is the response to a one standard deviation shock.
The standard error bands represent two standard deviations.

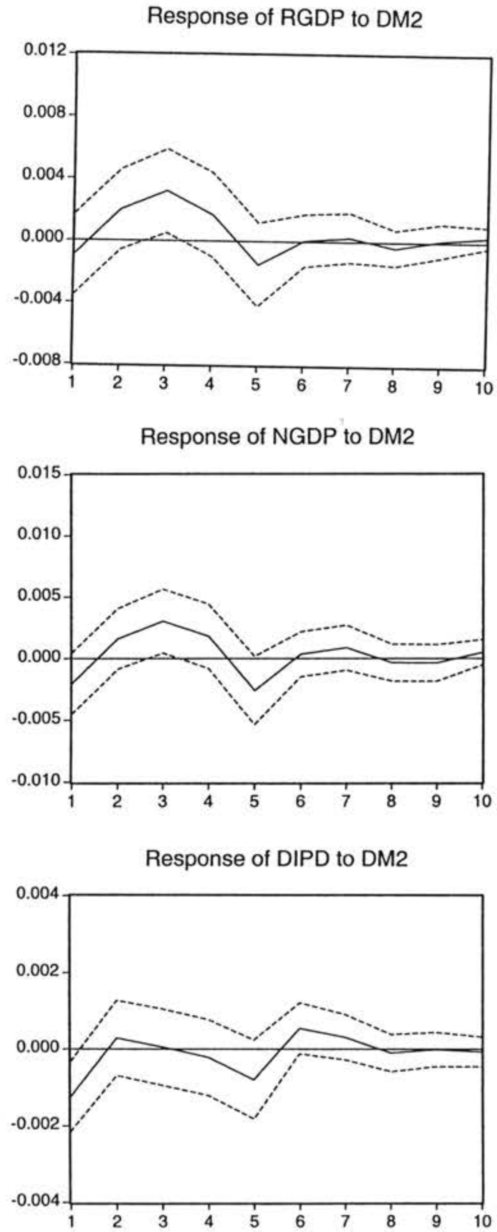


FIGURE 7

DM2 1968.3-1981.3

Horizontal Axis: Quarters in the forecast horizon.
Vertical Axis: Cumulative growth rate relative to base.
The impulse response function is the response to a one standard deviation shock.
The standard error bands represent two standard deviations.

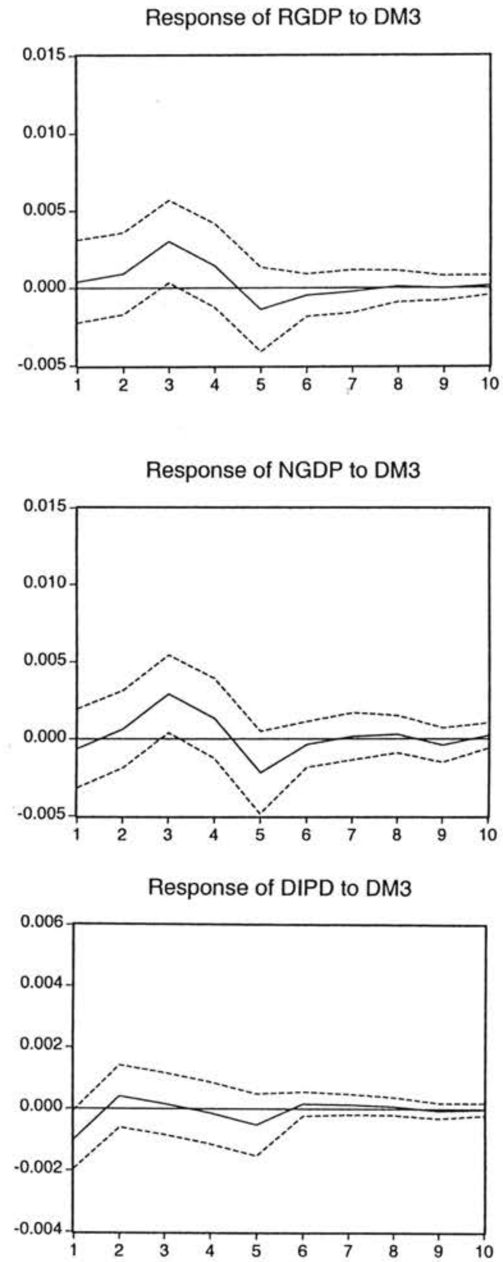


FIGURE 8

DM3 1968.3-1981.3

Horizontal Axis: Quarters in the forecast horizon.
Vertical Axis: Cumulative growth rate relative to base.
The impulse response function is the response to a one standard deviation shock.
The standard error bands represent two standard deviations.

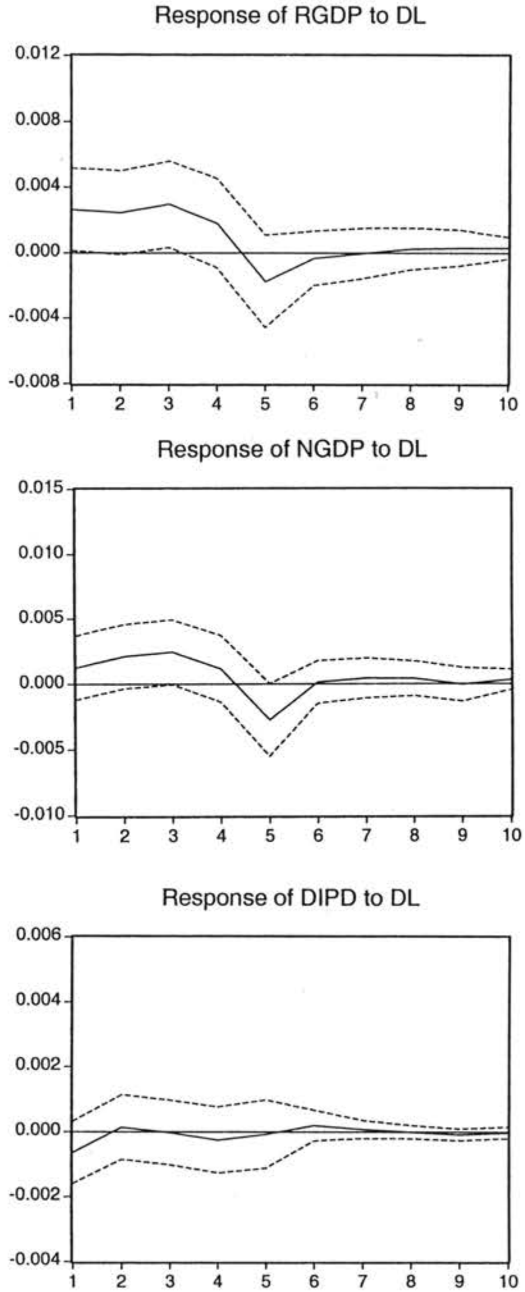


FIGURE 9

DL 1968.3-1981.3

Horizontal Axis: Quarters in the forecast horizon.
Vertical Axis: Cumulative growth rate relative to base.
The impulse response function is the response to a one standard deviation shock.
The standard error bands represent two standard deviations.

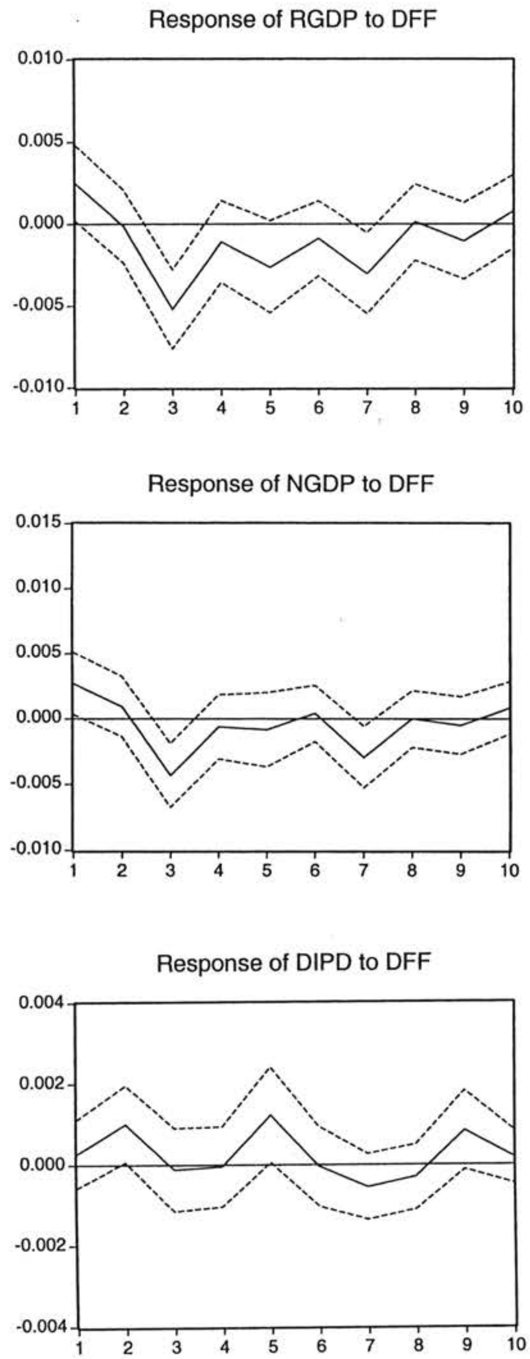


FIGURE 10

DFF 1968.3-1981.3

Horizontal Axis: Quarters in the forecast horizon.
Vertical Axis: Cumulative growth rate relative to base.
The impulse response function is the response to a one standard deviation shock.
The standard error bands represent two standard deviations.

as the high forecast error variance values displayed in table 5. Although the first three quarters are positive as predicted by theory, in only the second quarter is the response at the margin of statistical significance.

Figure 7 graphs the impulse response functions of the three measures of economic activity to shocks in M2. Consistent with the error variances listed in table 5, the impulse responses are somewhat smaller in magnitude than those emanating from M1. RGDP and NGDP respond positively in the second, third, and fourth quarters, but only the third quarter is large enough to pull the lower standard error band above zero. DIPD reacts insignificantly to this aggregate, except in the first quarter when the reaction is negative.

The IRFs in figure 8 for the responses of RGDP, NGDP, and DIPD to M3 are virtually identical to those from M2, with the third quarter response of RGDP and NGDP being both positive and significant.

The responses produced by L in figure 9 on RGDP, NGDP, and DIPD indicate, once again, little response on inflation. However, real GDP responds positively and at about the margin of significance in the first three quarters. The response of nominal GDP is slightly weaker, but similar in outline. Analogous with the higher forecast error variances in table 5, L creates larger (and quicker) responses on RGDP and NGDP in the impulse response functions than does M3. Although the impulse response functions for L are somewhat larger than for M3, the response functions for M1 are larger still. The broader aggregates do not produce responses as sizable as those of M1 in the third period.

The effects of shocks to the Federal funds rate on economic activity are graphed in figure 10. The response of DIPD is the weakest, but the second quarter has an unexpected positive and significant response. This "price puzzle" is a common feature of vector autoregression analysis on the Federal funds rate. (Leeper, Sims and Zha, 1996, pp. 24-25; Walsh, 1996, pp. 27-30) Both RGDP and NGDP respond positively at first, an example of the "output puzzle" which has also been encountered previously by other researchers. (Leeper, Sims and Zha, 1996, p. 24; Walsh, 1996, pp. 29-30) In the third quarter, however, the response is very negative and significant, as predicted by theory. The impulse response functions generally confirm the variance decomposition evidence, which indicates that the Federal funds rate has a substantial statistical relationship with real GDP and nominal GDP in the period 1968.3-1981.3.

All in all, the statistical results from table 5 and figures 5-10 provide evidence for some monetarist positions and also some evidence for non-monetarist positions. The results for the first two measures of economic activity, real GDP and nominal GDP, are probably more reliable than the results in forecasting DIPD, which may be affected by a longer lag in effect (the lag-length in the analysis is four quarters) and possibly by omitted variables such as commodity prices. M1, the aggregate preferred by the Federal Reserve Bank of St. Louis and initially targeted by the Board of Governors in the "monetarist experiment" of 1979-1982 (Hafer and Wheelock, 2001, pp. 17-18), creates error variance values in the forecast of real and nominal GDP of about 30%. These are near the values shown in table 4 from the St. Louis era. Of the other money supply definitions officially recognized by the Board of Governors, none is found to be superior to the narrow M1 aggregate. L, however, produces a FEV of 25% in the forecast of real GDP, not far from M1's value. In the forecast of nominal GDP, though, L's FEV value falls below that of both M1 and M2 (as well as MZM and DFF). But although the monetary aggregates, especially M1, display a substantial relationship to the economy from 1968.3-1981.3, the Federal funds rate displays a somewhat closer relationship. DFF has the highest forecast error variance for real GDP, and the second highest forecast error variance for nominal GDP (exceeded only by MZM, the results from which are based on the smaller sample size). The impulse response functions for the third period show significant results for both the Federal funds rate and many of the monetary aggregates in the forecasts of NGDP and RGDP, although generally not in the forecast of DIPD.

Table 6 presents the FEVs of the monetary variables from variance decompositions over the period 1968.3-1980.3, when the Federal funds rate and the respective monetary aggregate are included together in each vector autoregression. Tables 5 and 6 may be compared for the effect on each monetary aggregate of adding the interest rate to the VAR. In the forecast of output (real GDP), the error variance from M1 does decline when the Federal funds rate is included in the model. However, the decline is not very dramatic. The FEV value declines from 31% to 27%. Furthermore, DFF actually has a lower FEV in the combined model than does M1, despite being ordered ahead of the monetary aggregate in the model.

In the forecast of nominal GDP, the addition of the interest rate does not lower the forecast error variance from M1 at all (in fact the interaction actually leads to a small increase in the FEV value). Table 5 indicates that M1 has little effect on DIPD alone. When combined with the interest rate, it has even less effect, as shown in table 6.

The error variances produced by MZM decline in the combined model when either

TABLE 6

Third Period: 1968.3-1981.3
Federal Funds Rate Concurrent With Monetary Aggregate

Real GDP Forecast Error Variance / Nominal GDP Forecast Error Variance

	Real GDP: Monetary Aggregate	Real GDP: DFF	Real GDP: RGDP	Nominal GDP: Monetary Aggregate	Nominal GDP: DFF	Nominal GDP: NGDP
DM1	27.20	24.09	48.71	27.89	19.22	52.89
MZM	20.08	24.21	55.71	25.38	27.62	47.00
DM2	15.25	41.42	43.33	9.54	39.60	50.87
DM3	10.08	45.73	44.19	9.35	37.13	53.52
DL	15.46	38.18	46.36	16.90	32.41	50.69

Implicit Price Deflator Forecast Error Variance

	Monetary Aggregate	DFF	DIPD
DM1	3.20	17.72	79.08
MZM	39.45	28.66	31.89
DM2	8.92	20.31	70.76
DM3	5.90	23.89	70.21
DL	2.03	20.08	77.89

Percent of forecast error variance in RGDP, NGDP, or DIPD accounted for by the column variable.
Far left-hand row variable is the specific monetary aggregate appearing in the model.
Each row of the table is a separate VAR. (Although the variables are listed in the table for exposition with the monetary aggregate before the Federal funds rate, in the actual VAR the variables are ordered Federal funds rate, monetary aggregate, measure of economic activity.)
Lag-length is four quarters.
Forecast horizon is 10 quarters.
MZM is for 1974.1-1981.3.

real GDP or nominal GDP is forecast, but remain above 20%. When DIPD is forecast, MZM's recorded influence strangely increases upon adding the Fed funds rate to the model. The influence of the M2 money supply on real GDP is little affected by the inclusion of the interest rate. The forecast error variance of nominal GDP, however, declines from 23% to less than 10%. The FEV of DIPD falls from 17% to 9%. Without the interest rate in the model, M3 has less predictive power than does M2. Combining the Federal funds rate with the M3 aggregate lowers the FEV values of M3 modestly, which continue to be below those of M2.

The influence of the broadest aggregate, L, is affected by the interest rate. In the forecast of RGDP, FEV falls from 25% to 15%, whereas in the forecast of NGDP, FEV falls from 19% to 17%. The forecast error variance in the prediction of DIPD remains low whether or not the Federal funds rate is present in the model.

Although DFF is ordered before the monetary aggregate in the vector autoregression equations analyzed in the table, its FEV values are also affected by the presence of the additional variable. While the response of RGDP to DFF alone in the model results in an error variance of 41% (table 5), the addition of the basic M1 money supply to the VAR run lowers the FEV emanating from DFF to 24%. The inclusion of the broader aggregates M2, M3, or L, however, has little effect.

When nominal GDP is the target variable, M1 also lowers the relative influence of the funds rate substantially, but the broader aggregates do not (in fact the interaction slightly raises the recorded effect of DFF). When DIPD is the target variable, the FEV values emanating from DFF are only slightly affected.

Sims (1980a) uses M1 as the money supply in his analysis questioning the postwar evidence for monetarism. He finds that the forecast error variance in the response of output to the money supply declines substantially when a short-term interest rate is added to the model, from 37% to 4%. A comparison of tables 5 and 6 in this study, however, does not indicate such a drastic reduction in the money supply's statistical relationship to output. The forecast error variance of real GDP in response to innovations in M1 only declines by four percentage points, from 31% to 27%. Possibly accounting for the differing results is the longer and earlier time period tested by Sims (1948-1978, vs. 1968-1981 here) and the use of monthly, rather than quarterly, data in the Sims study.

Figure 11 displays the impulse response functions of RGDP, NGDP, and DIPD respectively when both M1 and the Federal funds rate are concurrent in the model. As in the variance decomposition results presented in table 6, the Federal funds rate is ordered before the monetary aggregate. DFF continues to create negative and significant responses in the third quarter of the forecast horizon on RGDP and NGDP even though M1 has been included in the VAR run. In addition, the price puzzle is still present in the second quarter in the response of DIPD to the Fed funds rate. Upon adding the interest rate to the model, the money supply continues to produce positive responses on RGDP and NGDP in the first three quarters. These responses, however, are not quite as large as when the funds rate is omitted from the VAR run. The variable DIPD continues to show little response to the variable DM1.

The impulse response functions from the VAR runs with both MZM and the funds rate concurrent in figure 12 appear volatile and produce few significant quarterly responses. However, the impulse response functions in figure 13 for the entire period

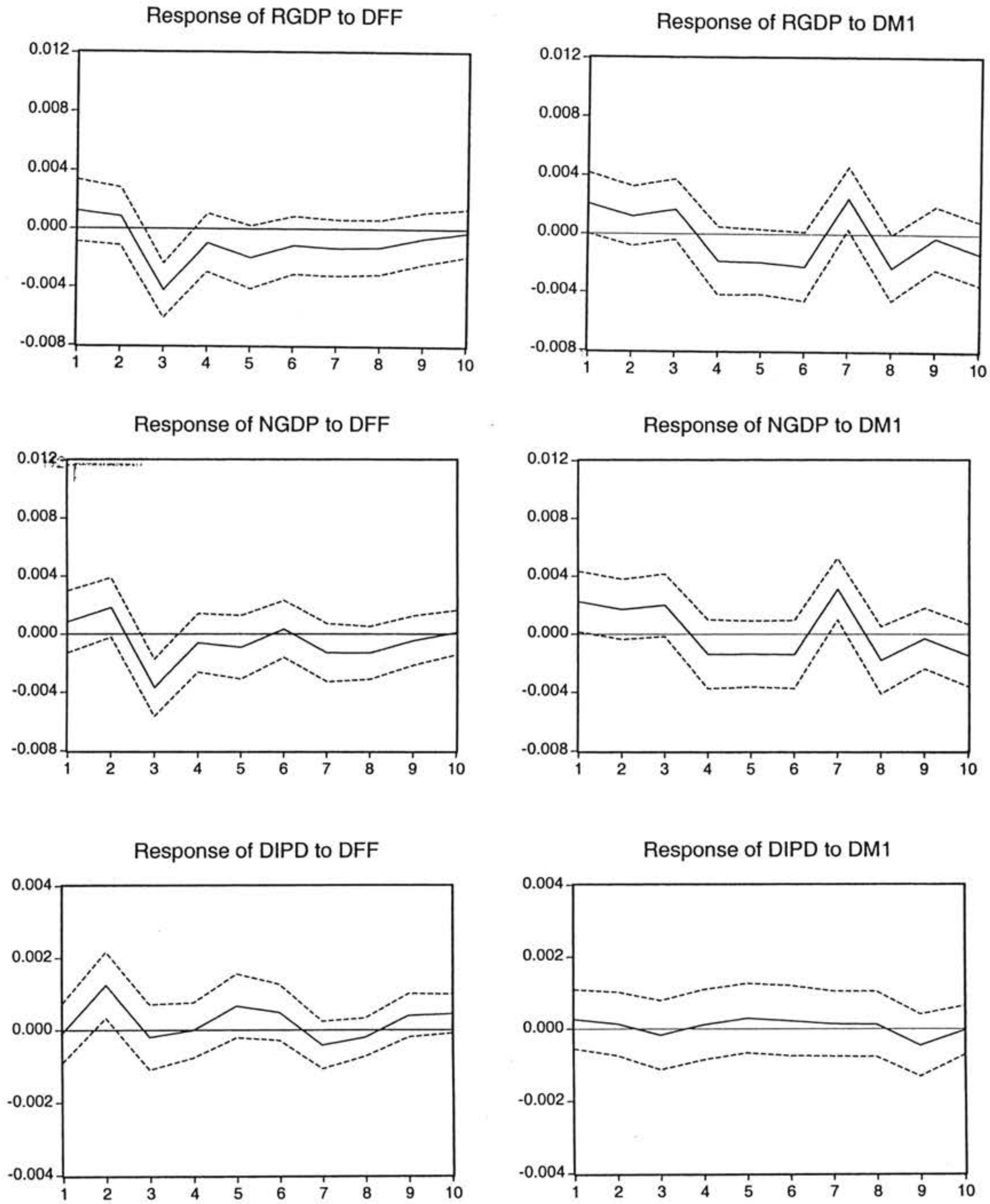


FIGURE 11

DFF and DM1 1968.3-1981.3

Horizontal Axis: Quarters in the forecast horizon.
Vertical Axis: Cumulative growth rate relative to base.
The impulse response function is the response to a one standard deviation shock.
The standard error bands represent two standard deviations.

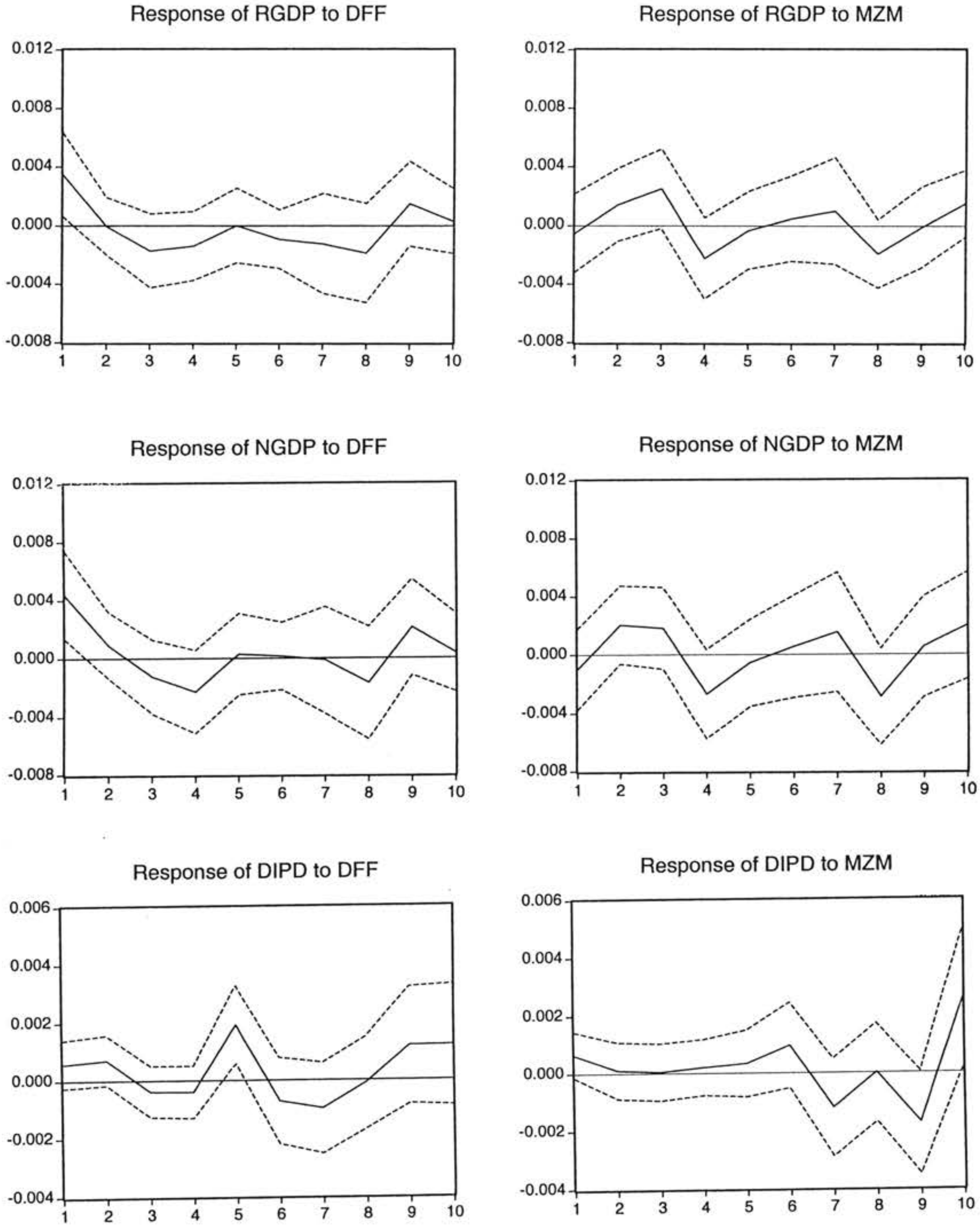


FIGURE 12

DFF AND MZM 1974.1-1981.3

Horizontal Axis: Quarters in the forecast horizon.
Vertical Axis: Cumulative growth rate relative to base.
The impulse response function is the response to a one standard deviation shock.
The standard error bands represent two standard deviations.

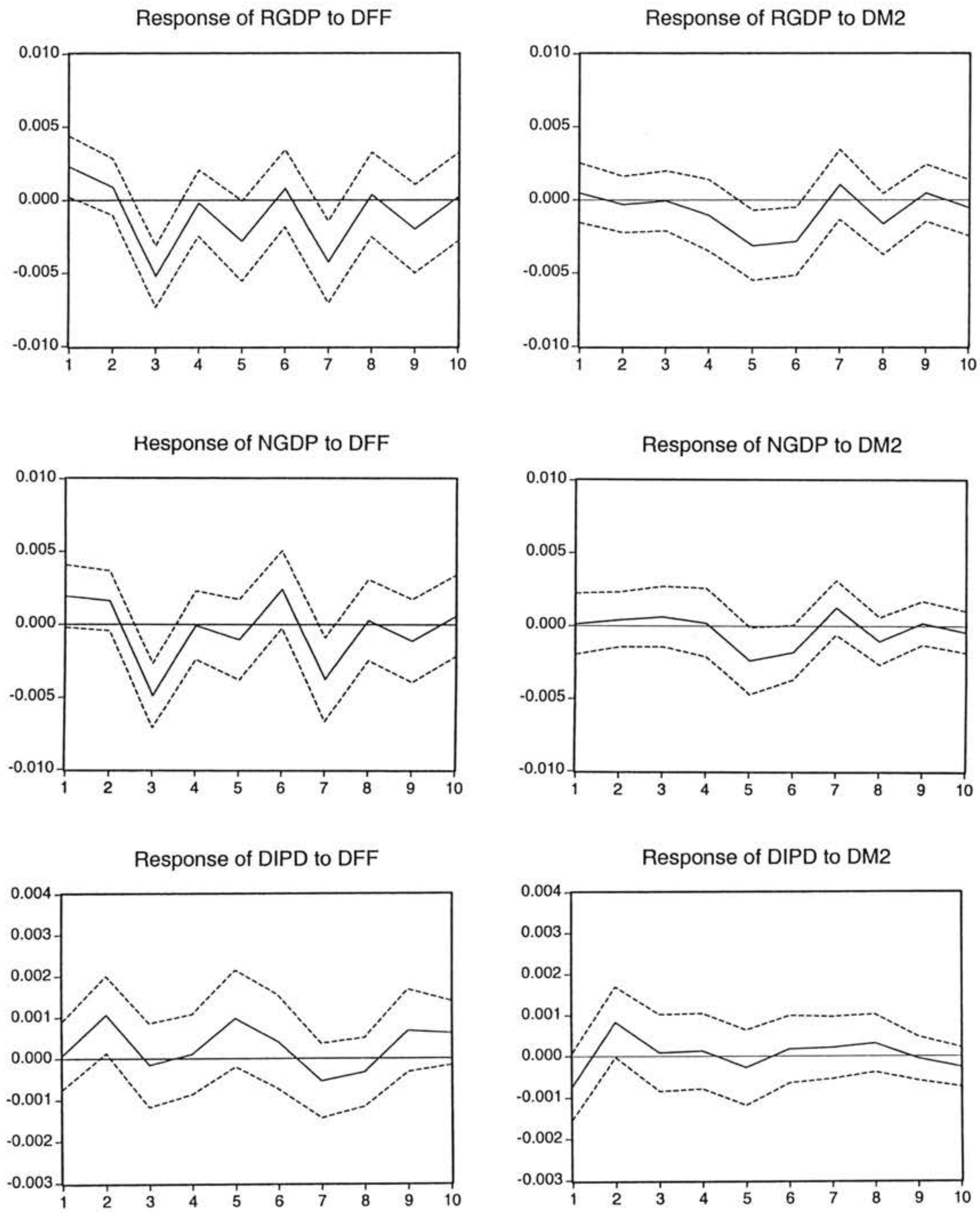


FIGURE 13

DFF AND DM2 1968.3-1981.3

Horizontal Axis: Quarters in the forecast horizon.
Vertical Axis: Cumulative growth rate relative to base.
The impulse response function is the response to a one standard deviation shock.
The standard error bands represent two standard deviations.

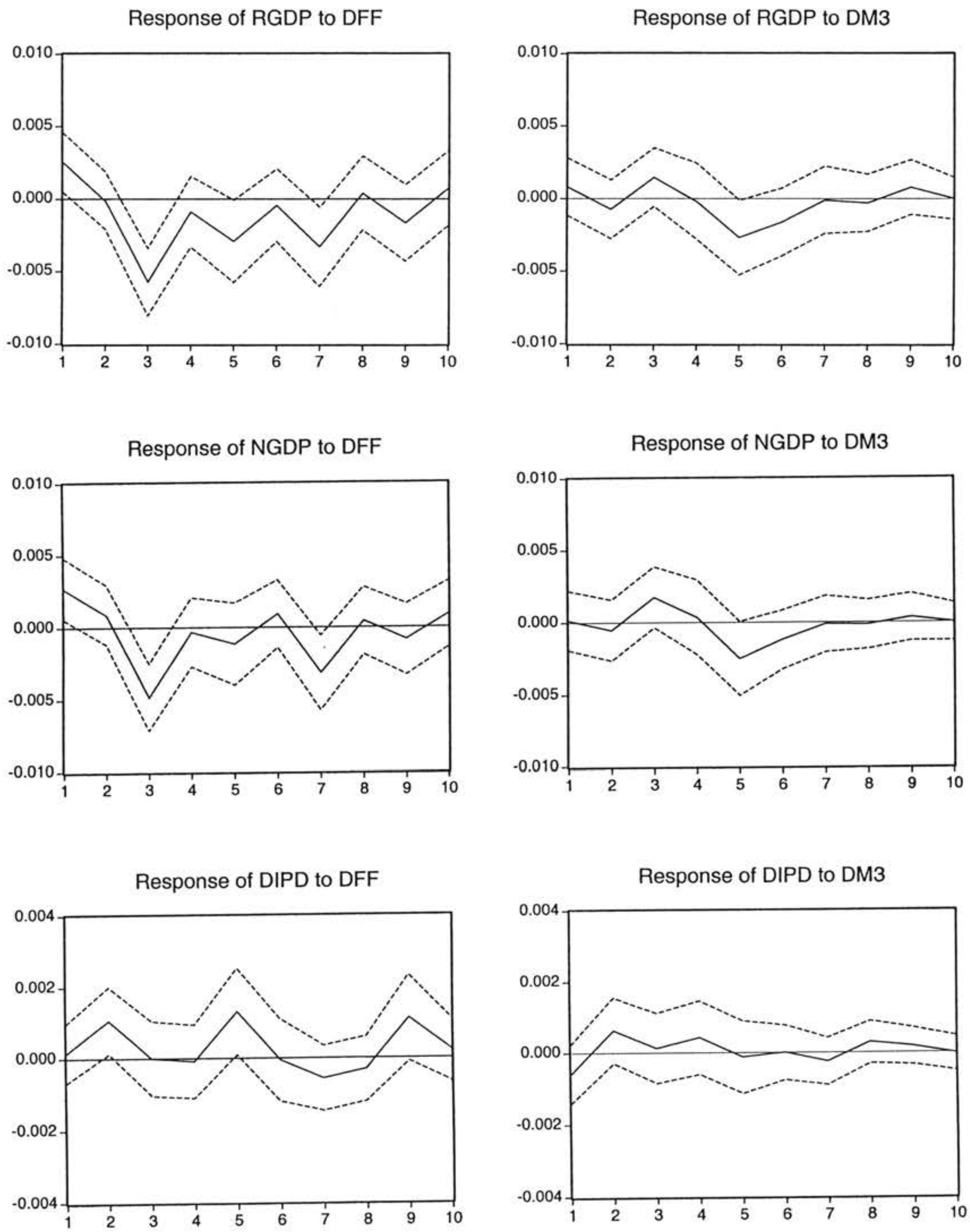


FIGURE 14

DFF AND DM3 1968.3-1981.3

Horizontal Axis: Quarters in the forecast horizon.
Vertical Axis: Cumulative growth rate relative to base.
The impulse response function is the response to a one standard deviation shock.
The standard error bands represent two standard deviations.

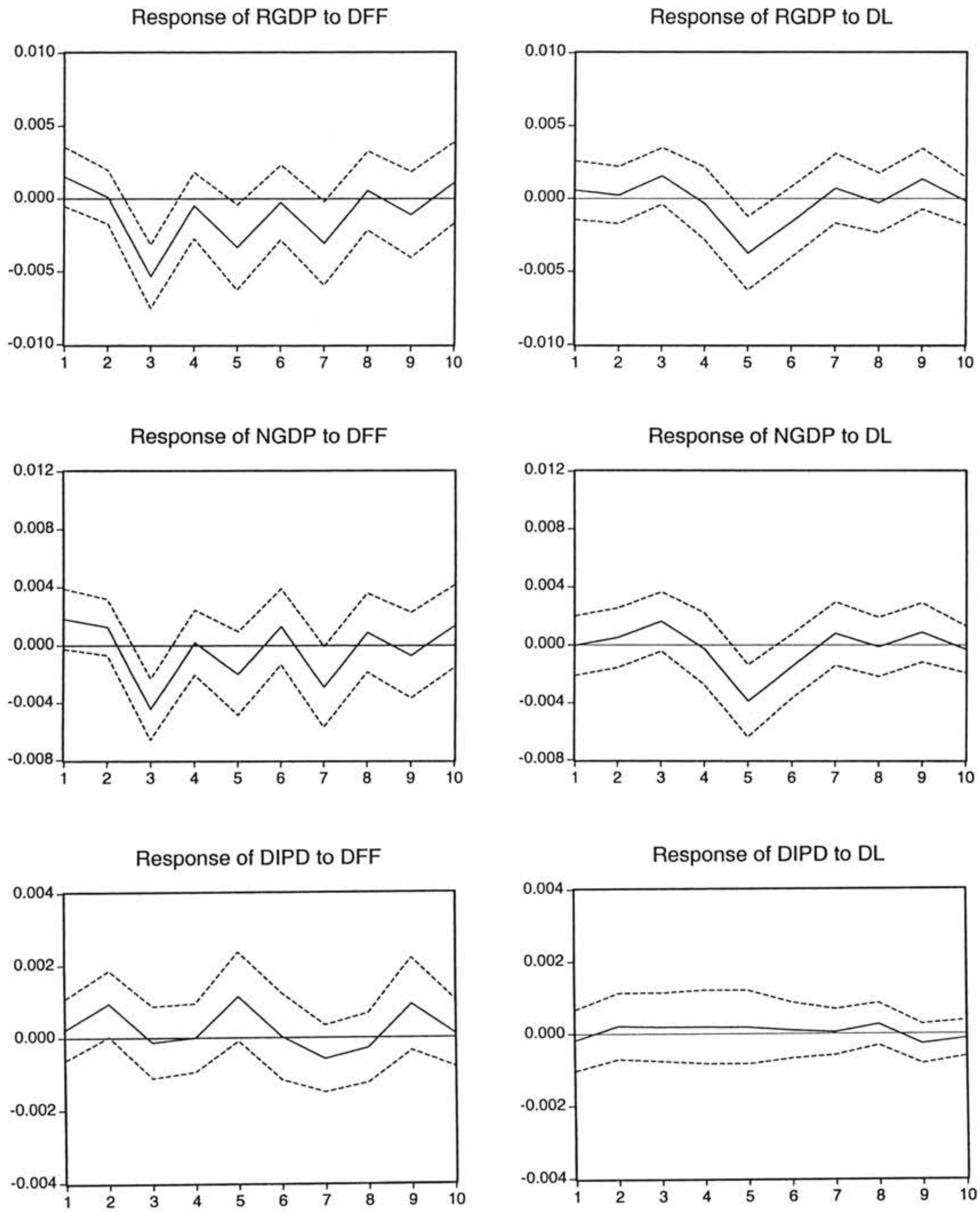


FIGURE 15

DFF AND DL 1968.3-1981.3

Horizontal Axis: Quarters in the forecast horizon.
Vertical Axis: Cumulative growth rate relative to base.
The impulse response function is the response to a one standard deviation shock.
The standard error bands represent two standard deviations.

1968.3-1981.3 in which M2 and the Federal funds rate are concurrent in the model also show some instability. As when no monetary aggregate is present, the response of RGDP and NGDP to DFF are again negative in the third quarter, and the response of DIPD is again positive in the second quarter. But no significantly positive responses come from M2, and an unusual negative response of RGDP occurs in the fifth and sixth quarters.

Figure 14 continues the analysis to the M3 aggregate concurrent with the Federal funds rate. The response of economic activity to DFF is much the same as in the previous graphs. M3 has no significant effect on any of the economic measures.

Figure 15 graphs the IRFs when L and the interest rate are present together in the model. The responses to DFF are little affected by the presence of the broadest monetary aggregate. However, the inclusion of the short-term interest rate results in no significant responses being recorded from L, except negative reactions in the fifth quarter when either RGDP or NGDP is being forecast. This is the same result as occurs when M2 is the monetary aggregate in the model.

The combination of monetary aggregate and interest rate in the same model has only a small effect on the impulse response functions produced from the Federal funds rate. However, the effect is somewhat greater on the IRFs emanating from the monetary aggregates. The broader aggregates produce no theoretically correct, statistically significant responses. In addition, M1's influence weakens somewhat in the combined model.

Bernanke and Blinder (1992, p. 907) find that the Federal funds rate clearly dominates the M1 and M2 money supplies in a vector autoregression analysis using monthly data with a six-month lag. This lag (two quarters) is shorter than the four-quarter lag employed to produce the results shown in tables 5 and 6. Bernanke's and Blinder's primary test period is for 1959-1989.[4] They also test the earlier period 1959-1979, and find that the error variance in the forecast of industrial production then is 28% due to shocks in the Federal funds rate, 12% due to shocks in M1, and 7% due to shocks in M2.

Table 7 displays forecast error variances from variance decompositions in which the lag-length is shortened to two quarters (from four quarters in tables 5 and 6). All other characteristics of the statistical tests are the same as in table 6: the Federal funds rate is concurrent with the monetary aggregate, and the time period is 1968.3-1981.3. As a comparison of tables 6 and 7 indicates, shortening the lag length reduces the influence of the monetary aggregates relatively more than that of the Federal funds rate. The forecast error variances listed for the monetary aggregates decline substantially from table 6 to table 7. In the forecast of real GDP, the FEV from M1 falls from 27% to 7%, the FEV from MZM falls from 20% to 13%, the FEV from M2 falls from 15% to only 2%, the FEV from M3 falls from 10% to 3%, and the FEV from L declines from 15% to 8%. The forecast error variance from DFF, though, declines from only 24% to 19%. The size of the disparity between the influence of the Federal funds rate and the measures of the money supply is largely due to the shorter lag-length. At the four-quarter lag length, the FEVs arising from the money supplies are substantially larger. It has not been

[4]Results for the forecast of industrial production are shown on page 32 of Chapter 2, "Review of Background Research."

TABLE 7

Third Period: 1968.3-1981.3
Two-Quarter Lag
Federal Funds Rate Concurrent With Monetary Aggregate

Real GDP Forecast Error Variance

	Monetary Aggregate	DFF	RGDP
DM1	7.30	19.26	73.42
MZM	12.77	35.89	51.34
DM2	1.61	20.81	77.58
DM3	3.36	21.76	74.88
DL	7.59	22.87	69.55

Nominal GDP Forecast Error Variance

	Monetary Aggregate	DFF	NGDP
DM1	10.62	16.45	72.94
MZM	7.35	37.83	54.82
DM2	1.59	15.87	79.54
DM3	3.71	19.68	76.61
DL	6.45	20.18	73.38

Implicit Price Deflator Forecast Error Variance

	Monetary Aggregate	DFF	DIPD
DM1	3.40	9.48	87.12
MZM	2.97	18.46	78.57
DM2	2.08	8.88	89.04
DM3	2.22	8.78	89.00
DL	0.03	9.16	90.82

Percent of forecast error variance in RGDP, NGDP, or DIPD accounted for by the column variable.
Far left-hand row variable is the specific monetary aggregate appearing in the model.
Each row of the table is a separate VAR. (Although the variables are listed in the table for exposition with the monetary aggregate before the Federal funds rate, in the actual VAR run the variables are ordered Federal funds rate, monetary aggregate, measure of economic activity.)
Lag-length is two quarters.
Forecast horizon is 10 quarters.
Period is 1968.3-1981.3.
MZM is for 1974.1-1981.3.

unusual for monetarist analysis to find lags in effect of changes in the money supply exceeding half a year. In the original Andersen-Jordan study, positive coefficients on M1 are obtained at lags exceeding six months. (Andersen and Jordan, 1968, p. 17) Philip Cagan writes that ". . . monetary effects have variable lags of one to several quarters or more." (1987, p. 494) Friedman has suggested that the full lag in effect of monetary policy exceeds even a full year. (Chandler, 1968b, p. 424) In addition, Chairman Greenspan has recently acknowledged the "variable and long lags of monetary policy." (2001)

The influence of FEV values is similar when nominal GDP is the variable being forecast. All values in the monetary aggregate column are reduced by over 50% when the lag-length is reduced from four to two quarters. However, only one DFF value is reduced by over 50% (comparing tables 6 and 7, the DFF column under Nominal GDP). In forecasting the implicit price deflator, the monetary aggregate FEV values are already quite low at the four-quarter lag-length. Four out of five of the aggregates' values decline still further at the two-quarter lag-length. In table 7, DFF FEV values are always more than twice as large as the respective monetary aggregate FEV values.

In table 5, the results indicate that the Federal funds rate is only slightly superior to the basic M1 money supply as a monetary indicator. In table 6, with both the funds rate and M1 concurrent in the VAR run, the funds rate is actually slightly inferior to the narrow monetary aggregate. In table 7, however, the funds rate clearly exceeds M1 in its ability to forecast economic activity, especially real output. The broader monetary aggregates, including M2, are even more reduced in influence by the reduction in the lag-length. The use of a two-quarter, rather than four-quarter, lag-length appears to substantially improve the relative performance of the Federal funds rate over the monetary aggregates in the period before 1981. At the four-quarter lag, the superiority of the funds rate over the aggregates is not so striking in the pre-1981 period.

Figures 16-20 display the impulse response functions when a two-quarter lag is used with the Federal funds rate concurrent with the monetary aggregate. Figure 16 produces the impulse response functions for M1; figure 17, the IRFs for MZM; figure 18, the IRFs for M2; figure 19, the IRFs for M3; and figure 20, the IRFs for L. In general, the results are similar to those shown in figures 11-15 in which the four-quarter lag is employed. DFF creates a negative and significant response on RGDP and NGDP in the third quarter, but a positive response on DIPD in the second quarter. The monetary aggregates produce insignificant effects on economic activity. M1's effects are larger than the other monetary aggregates, but still statistically insignificant.

Fourth Period: 1981.4-1998.3

Table 8 provides the variance decomposition results from the fourth period, 1981.4-1998.3, in which the Federal funds rate is entered concurrently with each monetary aggregate in each vector autoregression. The lag-length is four quarters and the forecast horizon is 10 quarters. With regard to the prediction of RGDP, the highest FEV figure arises from the M2 money supply, the second highest from the Federal funds rate, and the third highest from the MZM money supply (other than RGDP's own shocks). With regard to the forecast of NGDP, the highest FEV value arises from the Federal funds rate, the second highest from the MZM money supply, and the third highest from the M2 money supply (other than NGDP's own shocks). With regard to the implicit price

TABLE 8

Fourth Period: 1981.4-1998.3
Federal Funds Rate Concurrent With Monetary Aggregate

Real GDP Forecast Error Variance

	Monetary Aggregate	DFF	RGDP
DM1	6.27	15.78	78.45
MZM	13.74	10.62	75.62
DM2	15.91	6.24	77.85
DM3	11.18	8.69	80.12
DL	7.72	13.32	78.96

Nominal GDP Forecast Error Variance

	Monetary Aggregate	DFF	NGDP
DM1	6.03	21.36	72.61
MZM	11.86	18.25	69.89
DM2	10.87	8.41	80.72
DM3	6.43	12.56	81.01
DL	7.76	18.04	74.21

Implicit Price Deflator Forecast Error Variance

	Monetary Aggregate	DFF	DIPD
DM1	1.62	3.36	95.02
MZM	3.17	2.18	94.65
DM2	9.13	2.99	87.88
DM3	4.70	2.40	92.91
DL	8.42	4.58	87.00

Percent of forecast error variance in RGDP, NGDP, or DIPD accounted for by the column variable.
Far left-hand row variable is the specific monetary aggregate appearing in the model.
Each row of the table is a separate VAR. (Although the variables are listed in the table for exposition with the monetary aggregate before the Federal funds rate, in the actual VAR the variables are ordered Federal funds rate, monetary aggregate, measure of economic activity.)
Lag-length is four quarters.
Forecast horizon is 10 quarters.
Period is 1981.4-1998.3.

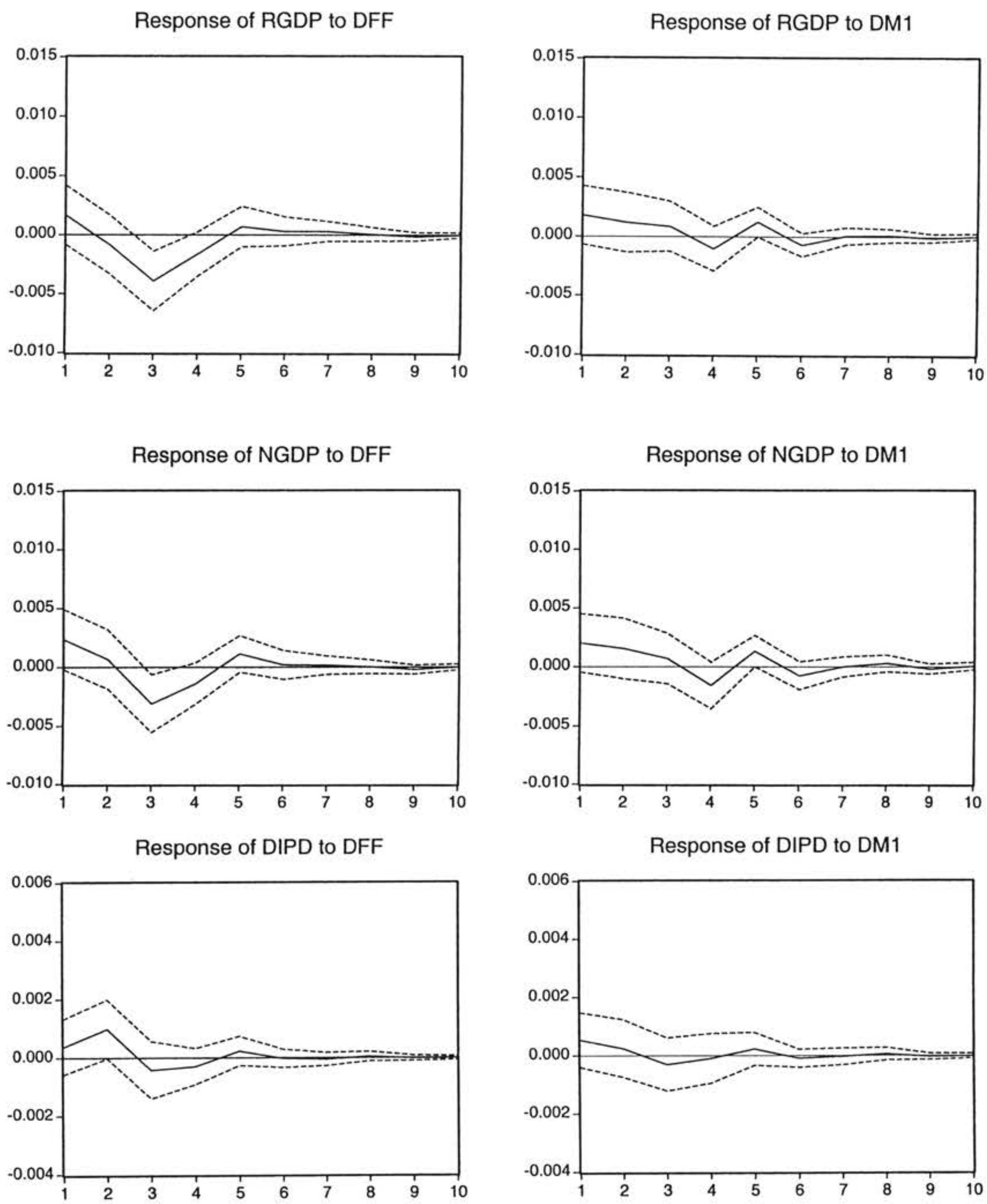


FIGURE 16

TWO QUARTER LAG
DFF AND DM1 1968.3-1981.3

Horizontal Axis: Quarters in the forecast horizon.
Vertical Axis: Cumulative growth rate relative to base.
The impulse response function is the response to a one standard deviation shock.
The standard error bands represent two standard deviations.

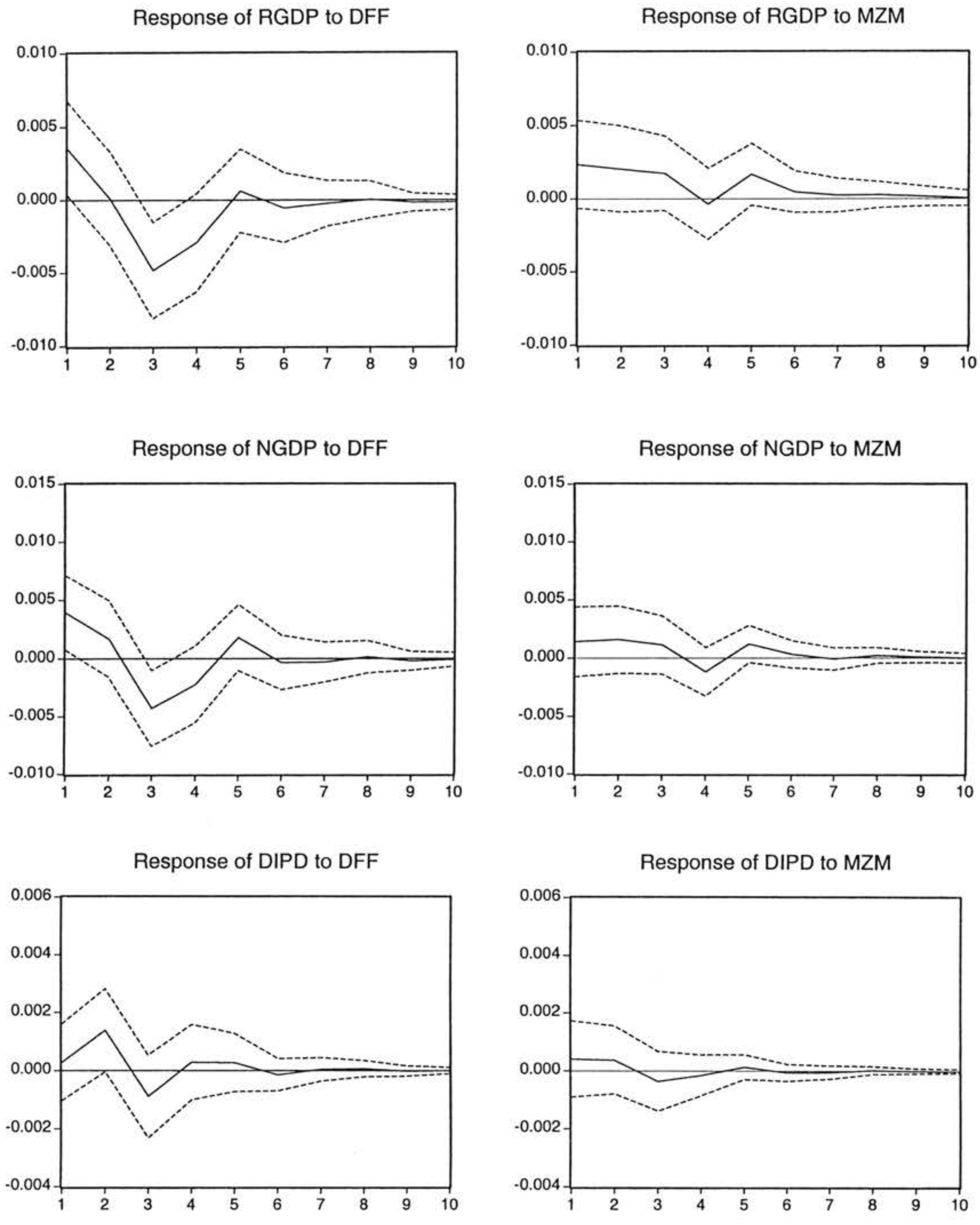


FIGURE 17

TWO-QUARTER LAG
DFF AND MZM 1968.3-1981.3

Horizontal Axis: Quarters in the forecast horizon.
Vertical Axis: Cumulative growth rate relative to base.
The impulse response function is the response to a one standard deviation shock.
The standard error bands represent two standard deviations.

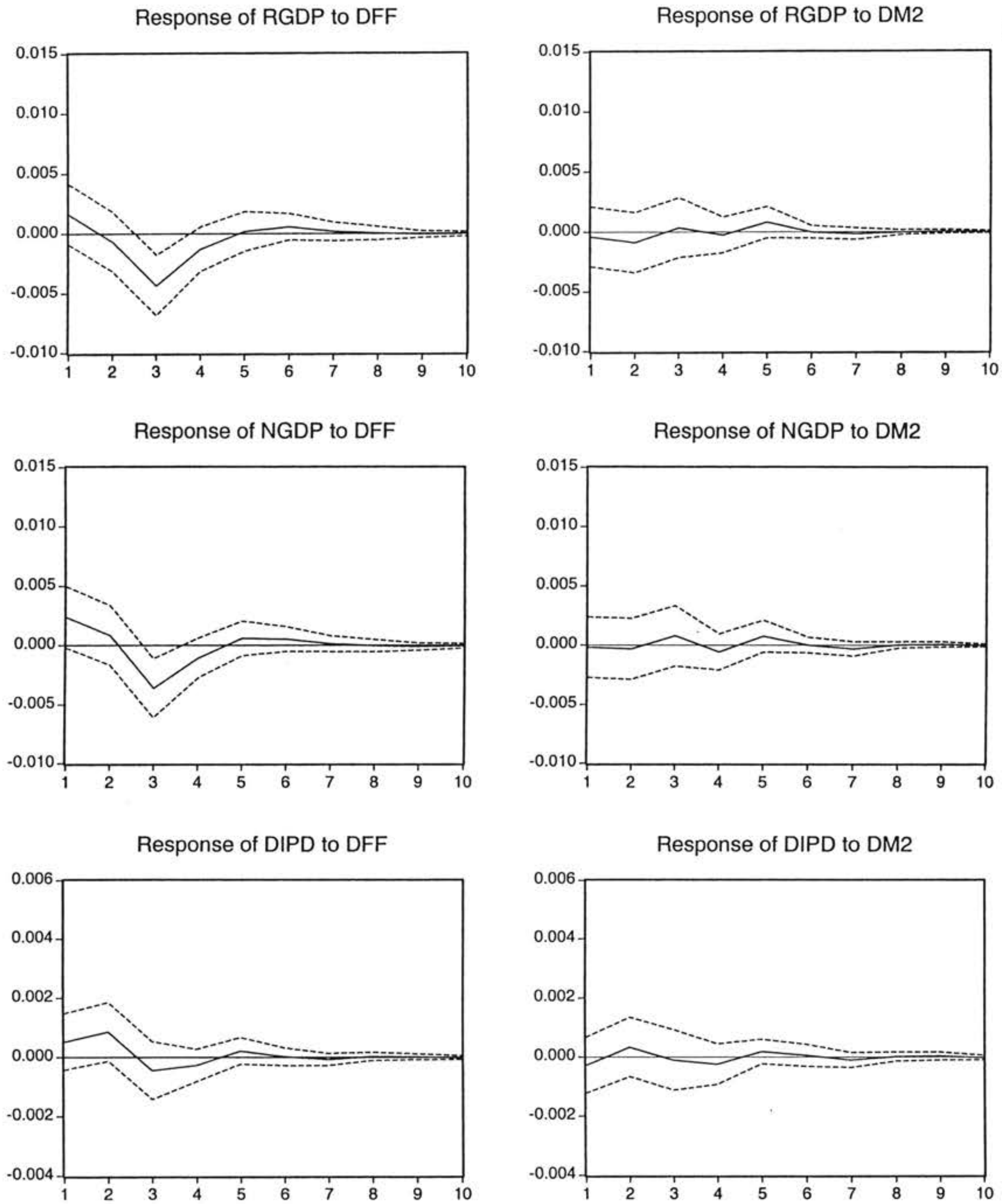


FIGURE 18

TWO-QUARTER LAG
DFF AND DM2 1968.3-1981.3

Horizontal Axis: Quarters in the forecast horizon.
Vertical Axis: Cumulative growth rate relative to base.
The impulse response function is the response to a one standard deviation shock.
The standard error bands represent two standard deviations.

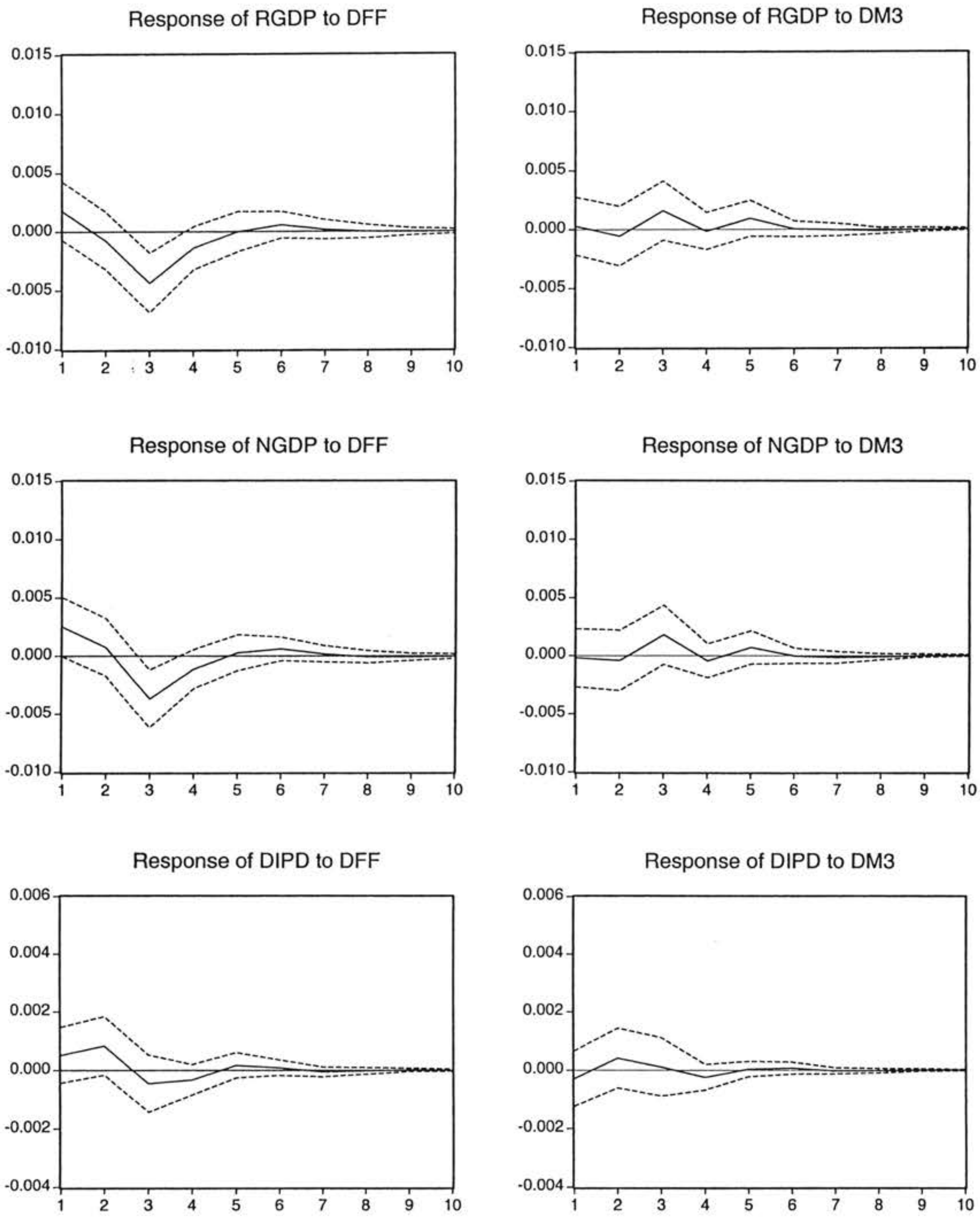


FIGURE 19

TWO-QUARTER LAG
DFF AND DM3 1968.3-1981.3

Horizontal Axis: Quarters in the forecast horizon.
Vertical Axis: Cumulative growth rate relative to base.
The impulse response function is the response to a one standard deviation shock.
The standard error bands represent two standard deviations.

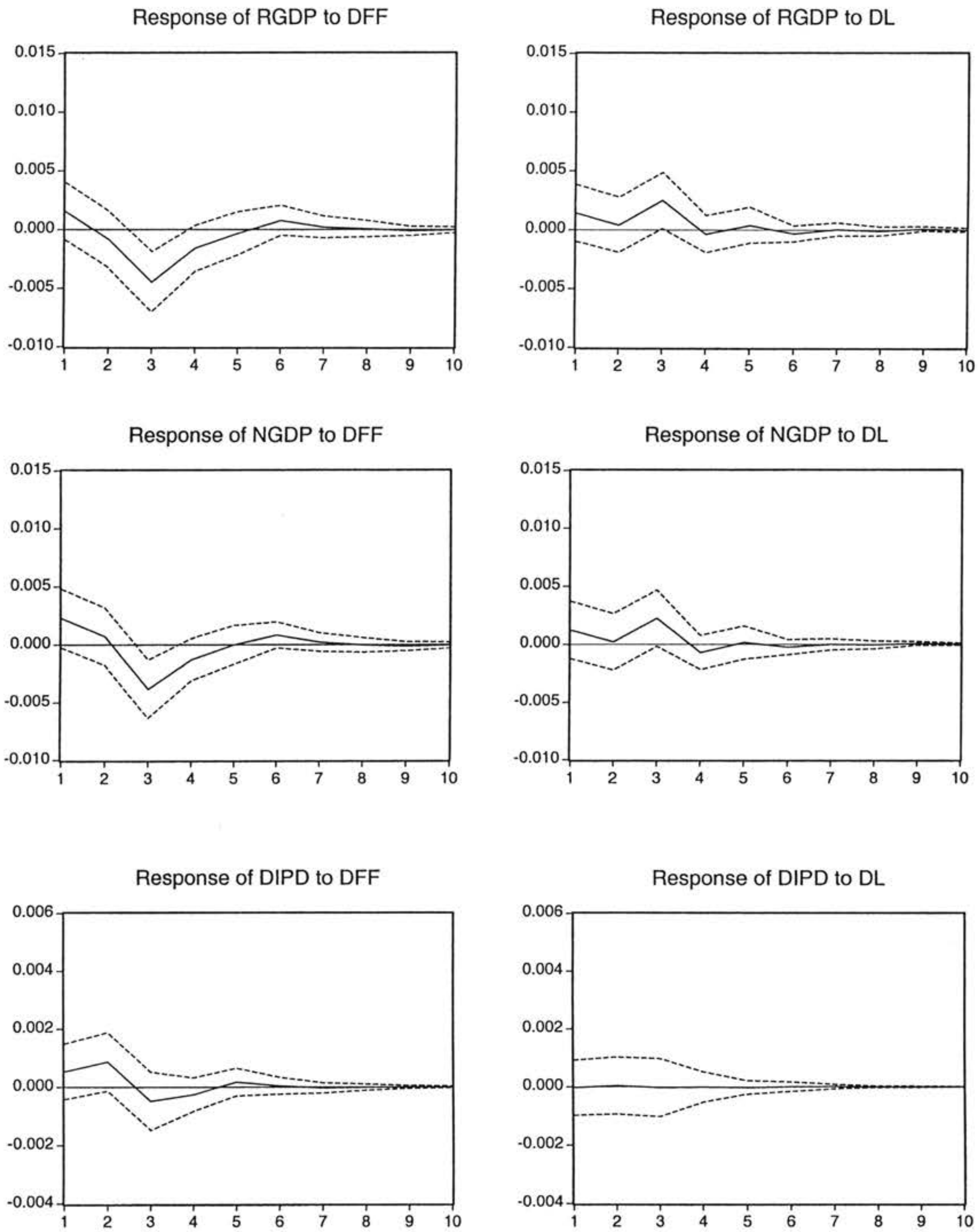


FIGURE 20

TWO-QUARTER LAG
DFF AND DL 1968.3-1981.3

Horizontal Axis: Quarters in the forecast horizon.
Vertical Axis: Cumulative growth rate relative to base.
The impulse response function is the response to a one standard deviation shock.
The standard error bands represent two standard deviations.

deflator, the highest forecast error variance value emanates from the M2 money supply, the second highest from L, and the third highest from the Federal funds rate (other than DIPD's own shocks).

Almost all forecast error variance values produced by the monetary aggregates are lower than those from the earlier period 1968.3-1981.3, which appear in table The relationship between the medium-of-exchange definition of the money supply and the economy deteriorates substantially as M1 explains only 6% of the forecast error variance of real GDP in the fourth period, vs. 27% in the third period. Similarly, M1 accounts for just 6% of the FEV of nominal GDP in the fourth period, vs. 28% in the third period. (The forecast error variance of DIPD explained by M1 also declines.) The vector autoregression analysis clearly supports the position that the M1 money supply ceased having a close relationship to economic activity after 1981.

The percentage of error variance accounted for by the MZM money supply also declines from the third to the fourth period. However, the decline here is not as dramatic as is the case for M1. MZM continues to explain over 10% of the FEV of RGDP and NGDP. Curiously, M2 maintains approximately the same predictive power from the third to the fourth test periods, with FEV values in the range of 10%-15%. The distortions associated with disintermediation from 1968.3-1981.3 may have been approximately equal in magnitude to the distortions affecting this aggregate after 1981, including the weakened capital position of depository institutions during part of this period. M3's prediction of RGDP actually improves slightly in the latter test period, although its FEV in the prediction of NGDP falls to only 6%. Finally, L's percentage of forecast error variance explained for all three measures of economic activity drops below

10% after 1981, being about only half as large as the earlier period's values for RGDP and NGDP.

The monetary aggregates clearly declined in their predictive ability. This was most evident for M1. M2 actually suffered no decline at all, although its FEV values in the fourth period are substantially below those from M1 in the third period (in the forecast of RGDP and NGDP).

In the comparison of the different aggregates over the final test period, M2 achieves the highest forecast error variance in the prediction of RGDP and DIPD, whereas MZM achieves the highest forecast error variance in the prediction of NGDP. The Federal funds rate tends to possess a more satisfactory predictive ability than the monetary aggregates over the fourth test period, but not to a very great degree. In the forecast of RGDP, the highest FEV from the Federal funds rate, 15.78%, is only about equal to the highest FEV arising from a measure of the money supply (M2), 15.91%.[5] DFF has more accuracy in the forecast of NGDP, in which its highest FEV, 21.36%, clearly exceeds the highest FEV emanating from a money supply, 11.86%. However, DFF is actually bettered by over half of the monetary aggregates in the forecast of DIPD.

One striking result in the comparison between tables 6 and 8 is the decline in the ability of the Federal funds rate to accurately forecast economic activity. Not only do the monetary aggregates suffer a decrease in predictive ability, but the interest rate does as well. In the forecast of RGDP, for example, the FEV explained by DFF is as high as 45.73% in the third period, but achieves a peak value of only 15.78% in the fourth period. When NGDP is the variable forecast, DFF explains up to 39.60% of its

[5]Furthermore, in the actual VAR the Federal funds rate is ordered before the measure of the money supply. In the prediction of RGDP, the average FEV value for all five monetary aggregates is 10.96%. The average FEV value for the Federal funds rate is 10.93%.

fluctuation in the third test period, but no more than 21.36% in the fourth. And in the prediction of DIPD, the decline in forecast accuracy is even more drastic.

The foregoing result is unexpected, as many analysts (as well as the Federal Reserve) employ the Federal funds rate as the primary indicator of monetary policy. Apparently, a considerable amount of slack exists in the relationship between the funds rate and the economy, and the amount of slack in that relationship has increased in the last 20 years. Although many macroeconomic changes have occurred over the last two decades, it is not evident what changes are sufficient to explain it. The weakened financial condition of depository institutions in the early 1990s is probably responsible for a part of the decline,[6] but may not fully explain it. From 1968.3-1981.3, the inflation rate accelerated from approximately 4% to 10%, and the energy crisis caused the price of oil and other forms of energy to more than triple. From 1981.3-1998.3, inflation decelerated from about 10% to 2%, and oil prices went through volatile up-and-down swings. Federal Reserve operating procedure underwent an evolution as the central bank responded to accelerated rates of inflation in the 1970s. It experimented with the use of monetary targets and ultimately adopted the Federal funds rate as its instrument of control. In the earlier period, some analysts felt that the Federal Reserve reacted too slowly to building inflationary events, often raising the Federal funds rate in only small, insufficient increments.[7] During the latter period, the Federal Reserve changed the Federal funds rate by substantial amounts. It is not clear that any of the foregoing factors, except for the weakened capital condition of depository institutions, should have led to a decline in

[6] See Laurent (1997).

[7] See Balke and Emery (1994) and Thornton (1997).

the Federal funds rate's relationship with economic activity. Some of the factors, such as a decline and relative stabilization of the inflation rate in the 1980s and 1990s, may even have contributed to a closer relationship between interest rate movements and the economy in the latter time period.[8]

Figures 21-25 graph the impulse response functions for the concurrent model, with four-quarter lag, for the fourth period. The output puzzle remains present in the first quarter response of gross domestic product to shocks in the Federal funds rate. The response turns negative by the third quarter and continues negative for several more quarters. Compared to the third period responses, the reaction to Fed funds shocks is slower and smaller. No significant responses occur in ate. The response turns negative by the third quarter and continues negative for several more quarters. Compared to the third quarter response, the reaction to Federal funds shocks is slower and smaller. No significant response occurs in reaction to M1 shocks. None of the results is statistically significant, reinforcing the conclusion that M1 no longer possesses a close relationship to economic activity. MZM, on the other hand, produces a positive and significant response in the second quarter on RGDP and NGDP. M2, also, produces a positive and significant response in the second quarter on RGDP and NGDP. M3 causes no significant responses, although the first few quarters are positive. Finally, L creates a positive and barely significant response on RGDP and NGDP in the first quarter.

Overall, the evidence from the impulse response functions in the fourth period reinforces the conclusion drawn from the forecast error variance evidence listed in

[8]In the third test period, increases in the inflation rate may have caused changes in the nominal interest rate to produce misleading signals. The increase in the inflation rate may itself have contributed to the increase in the interest rate, according to the Fisher effect.

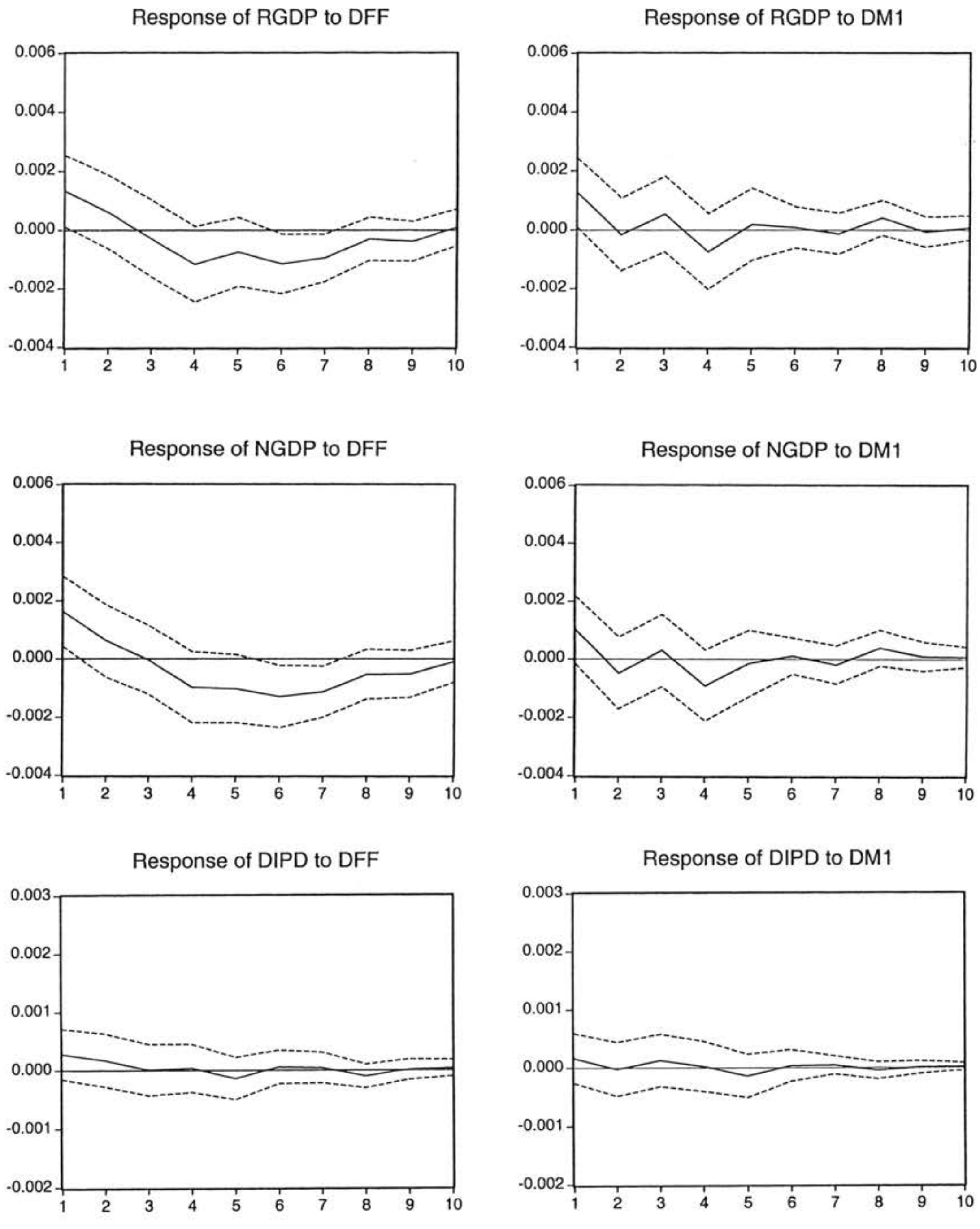


FIGURE 21

DFF AND DM1 1981.4-1998.3

Horizontal Axis: Quarters in the forecast horizon.
Vertical Axis: Cumulative growth rate relative to base.
The impulse response function is the response to a one standard deviation shock.
The standard error bands represent two standard deviations.

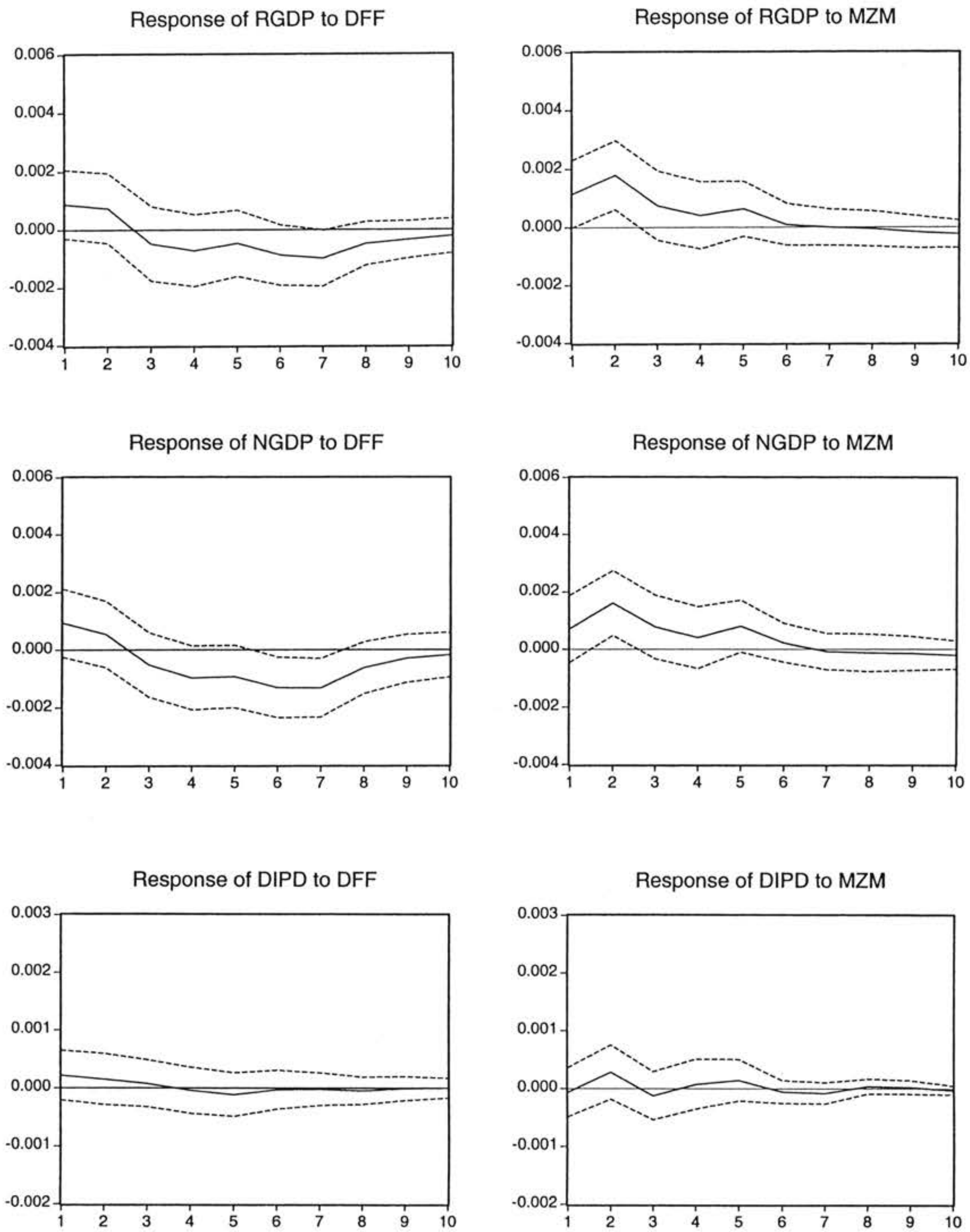


FIGURE 22

DFF AND MZM 1981.4-1998.3

Horizontal Axis: Quarters in the forecast horizon.
Vertical Axis: Cumulative growth rate relative to base.
The impulse response function is the response to a one standard deviation shock.
The standard error bands represent two standard deviations.

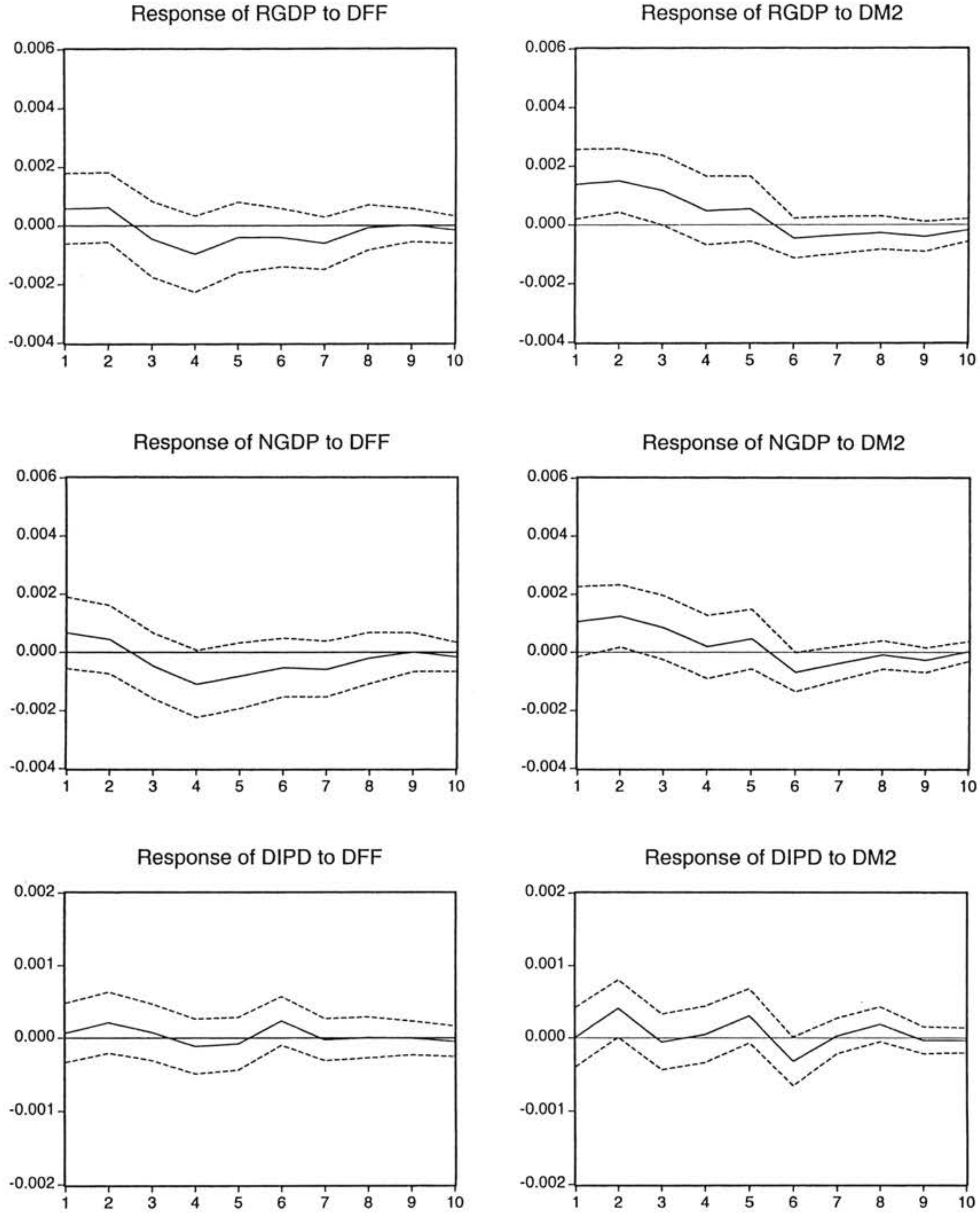


FIGURE 23

DFF AND DM2 1968.3-1981.3

Horizontal Axis: Quarters in the forecast horizon.
Vertical Axis: Cumulative growth rate relative to base.
The impulse response function is the response to a one standard deviation shock.
The standard error bands represent two standard deviations.

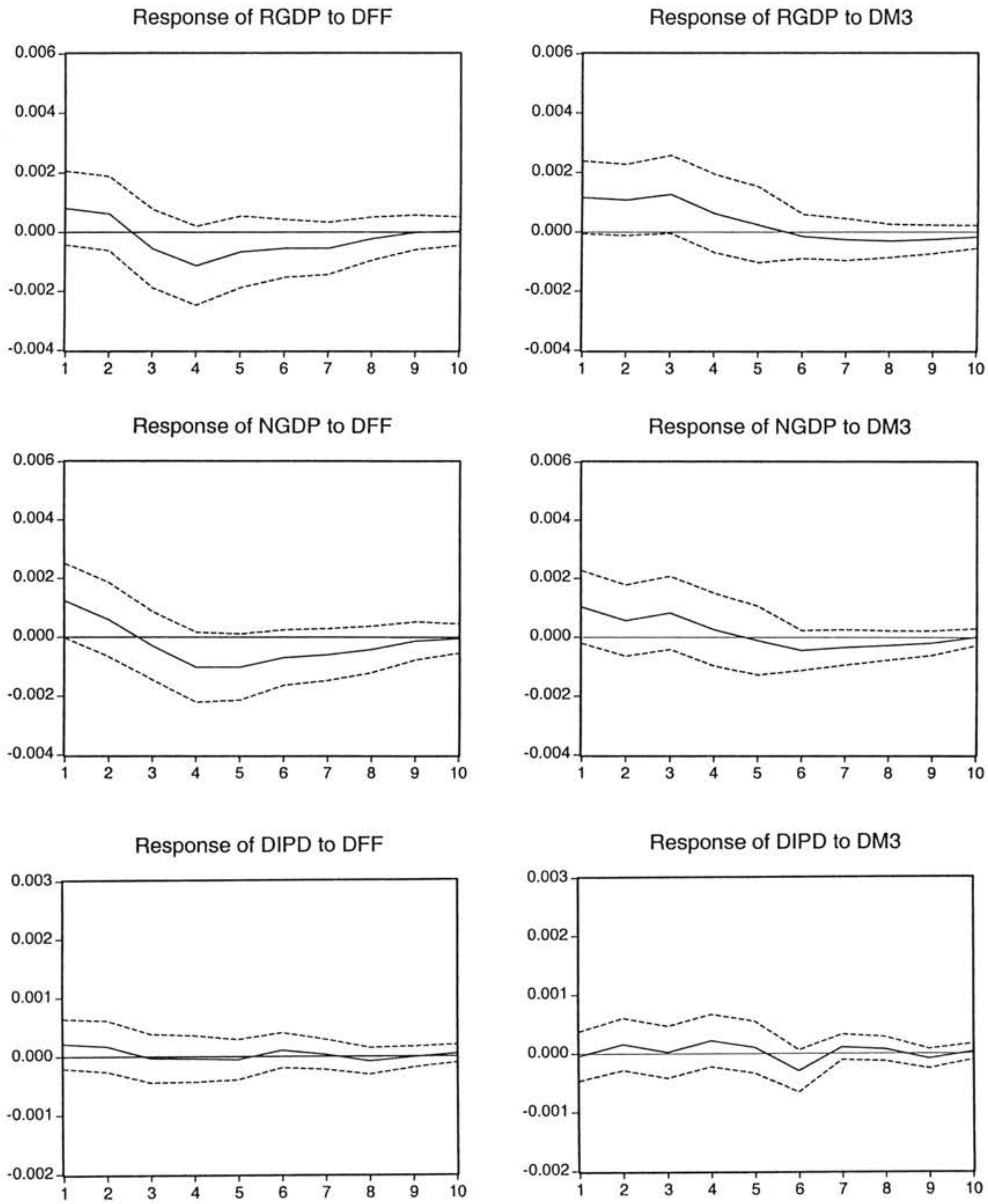


FIGURE 24

DFF AND DM3 1981:4-1998:3

Horizontal Axis: Quarters in the forecast horizon.
Vertical Axis: Cumulative growth rate relative to base.
The impulse response function is the response to a one standard deviation shock.
The standard error bands represent two standard deviations.

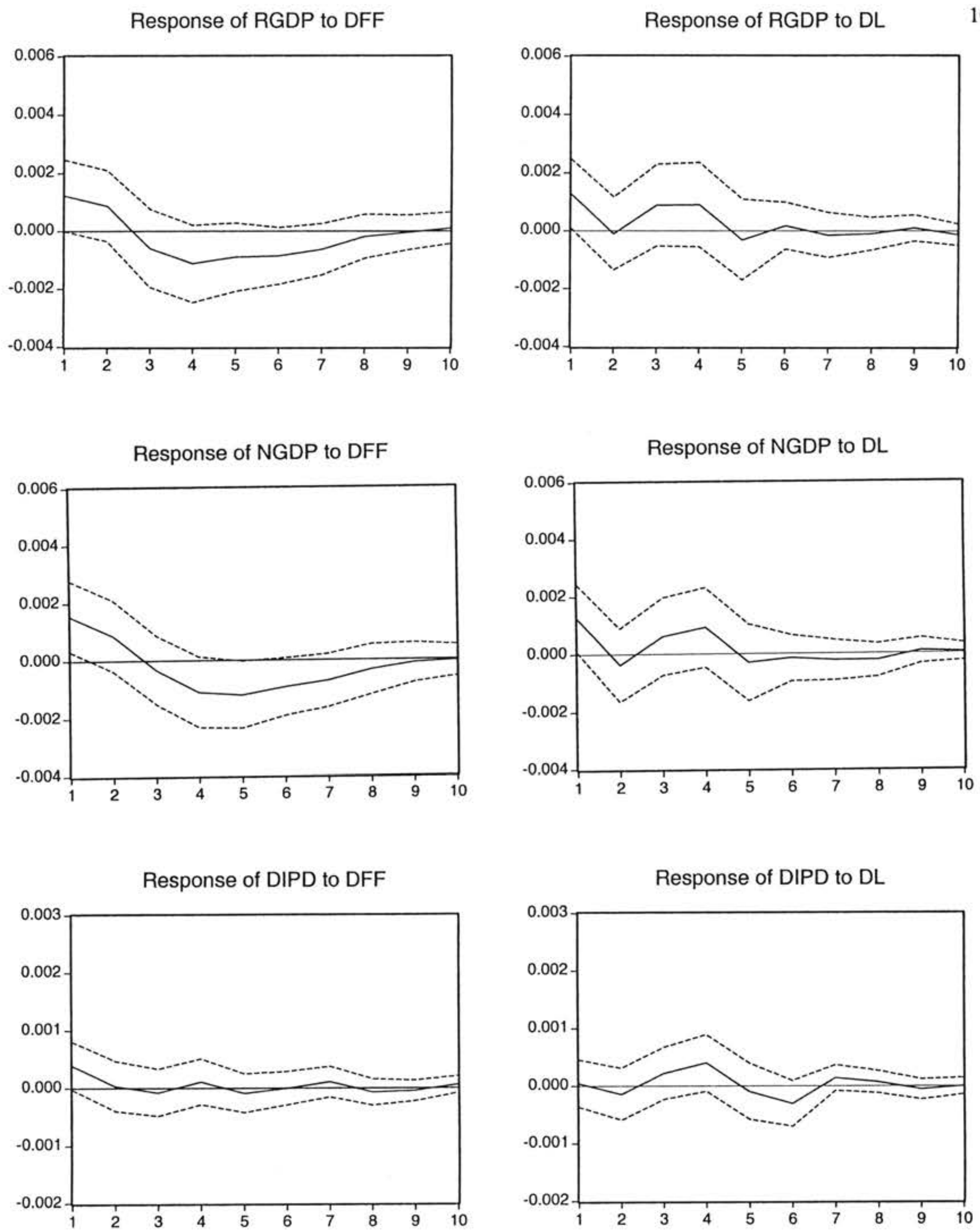


FIGURE 25

DFF AND DL 1981.4-1998.3

Horizontal Axis: Quarters in the forecast horizon.
Vertical Axis: Cumulative growth rate relative to base.
The impulse response function is the response to a one standard deviation shock.
The standard error bands represent two standard deviations.

table 8: the relationship between the monetary aggregates and the economy has weakened considerably in the last 20 years. Furthermore, the relationship between the Federal funds rate and economic activity has also weakened in the last two decades.

Table 9 lists the forecast error variance values for the fourth-period model with two-quarter lag, Federal funds rate concurrent with monetary aggregate. In comparison with the four-quarter lag values listed in table 8, the influence of the M1 money supply is not much affected, but that influence is already fairly small. MZM forecast error variance increases slightly with the two-quarter lag in the prediction of both real and nominal GDP. The broader aggregates, M2, M3, and L, all suffer substantially in their predictive ability when the shorter lag length is used. In the forecast of DIPD, the FEV from all monetary aggregates declines to L, all suffer substantially in their predictive ability when the shorter lag length is used. In the forecast of DIPD, the FEV from all monetary aggregates declines to insubstantial levels when the lag-length is shortened. Although the decline in forecast error variance values from DFF is not as large as from the broad aggregates, shortening the lag-length also weakens the influence of DFF in the fourth test period.

At the four-quarter lag, the predictive ability of the MZM definition of the money supply is only about equal to that of the M2 version. M2 predicts real GDP more accurately, whereas MZM predicts nominal GDP more accurately. The predictive ability of all versions of the money supply is lower when the implicit price deflator is the variable forecast, but here M2 dominates. In general, MZM and M2 possess the most accurate forecasting ability at the four-quarter lag. At the two-quarter lag, however, the MZM money supply dominates over other versions. Only MZM produces a forecast

TABLE 9

Fourth Period: 1981.4-1998.3
Two-Quarter Lag
Federal Funds Rate Concurrent With Monetary Aggregate

Real GDP Forecast Error Variance

	Monetary Aggregate	DFF	RGDP
DM1	6.05	9.03	84.92
MZM	16.04	9.13	74.82
DM2	2.18	6.72	91.10
DM3	4.05	6.60	89.35
DL	3.63	8.69	87.68

Nominal GDP Forecast Error Variance

	Monetary Aggregate	DFF	NGDP
DM1	4.52	11.56	83.92
MZM	12.70	11.35	75.95
DM2	1.07	7.41	91.52
DM3	2.32	9.07	88.60
DL	4.78	11.73	83.49

Implicit Price Deflator Forecast Error Variance

	Monetary Aggregate	DFF	DIPD
DM1	0.60	4.66	94.74
MZM	0.96	4.35	94.69
DM2	3.43	3.46	93.11
DM3	0.93	4.33	94.74
DL	3.48	6.50	90.02

Percent of forecast error variance in RGDP, NGDP, or DIPD accounted for by the column variable.
Far left-hand row variable is the specific monetary aggregate appearing in the model.
Each row of the table is a separate VAR. (Although the variables are listed in the table for exposition with the monetary aggregate before the Federal funds rate, in the actual VAR the variables are ordered Federal funds rate, monetary aggregate, measure of economic activity.)
Lag-length is two quarters.
Forecast horizon is 10 quarters.
Period is 1981.4-1998.3.

error variance value in the double-digit range, both in the prediction of RGDP and in the prediction of NGDP. Here MZM's forecast accuracy also exceeds that of the Federal funds rate.

As discussed earlier, Bernanke and Blinder (1992, p. 907) find that a vector autoregression with both interest rates and the basic M1 and M2 money supplies present produces results which greatly favor the funds rate. The variance decomposition analysis in tables 5-9 suggests that those results are dependent on two items: (1) the use of the 6-month lag, and (2) the time period included in the sample. Before 1981, the monetary aggregates produce fairly sizable FEV values in the prediction of output or income when a full-year lag is employed. The half-year lag causes a great reduction in their recorded effect. Furthermore, the error variance in the forecast of output falls well below 20% for the funds rate when the sample period is extended through the 1990s, whether the lag is a half or full year. The Bernanke-Blinder study is now almost ten years old. The sample periods used in that study, 1959-1979 and 1959-1989, fail to fully capture the recent reduction in the forecast accuracy of the Federal funds rate.

Figures 26-30 display the impulse response functions from the fourth test period with a two-quarter lag. The general form of the functions is often similar to that displayed in figures 21-25, in which the lag-length is four quarters. The Federal funds rate produces small positive responses in the first two quarters on RGDP and NGDP, and small negative responses in the third and later quarters. DIPD usually does not respond significantly to shocks in any of the variables, although a small first quarter price puzzle is still present in the reaction to DFF. M1 creates a positive stimulus at the margin of significance on RGDP in the first quarter. MZM, on the other hand, produces positive and significant responses in the first, second, and third quarters on RGDP, and an only slightly weaker response on NGDP. Differing from the four-quarter IRFs, M2 creates no significant responses when two-quarters are used. This result is consistent with the forecast error variance values in tables 8 and 9, in which the shortened lag-length substantially reduces the FEV accounted for by M2. Neither M3 nor L produce any significant responses at the two-quarter lag length.

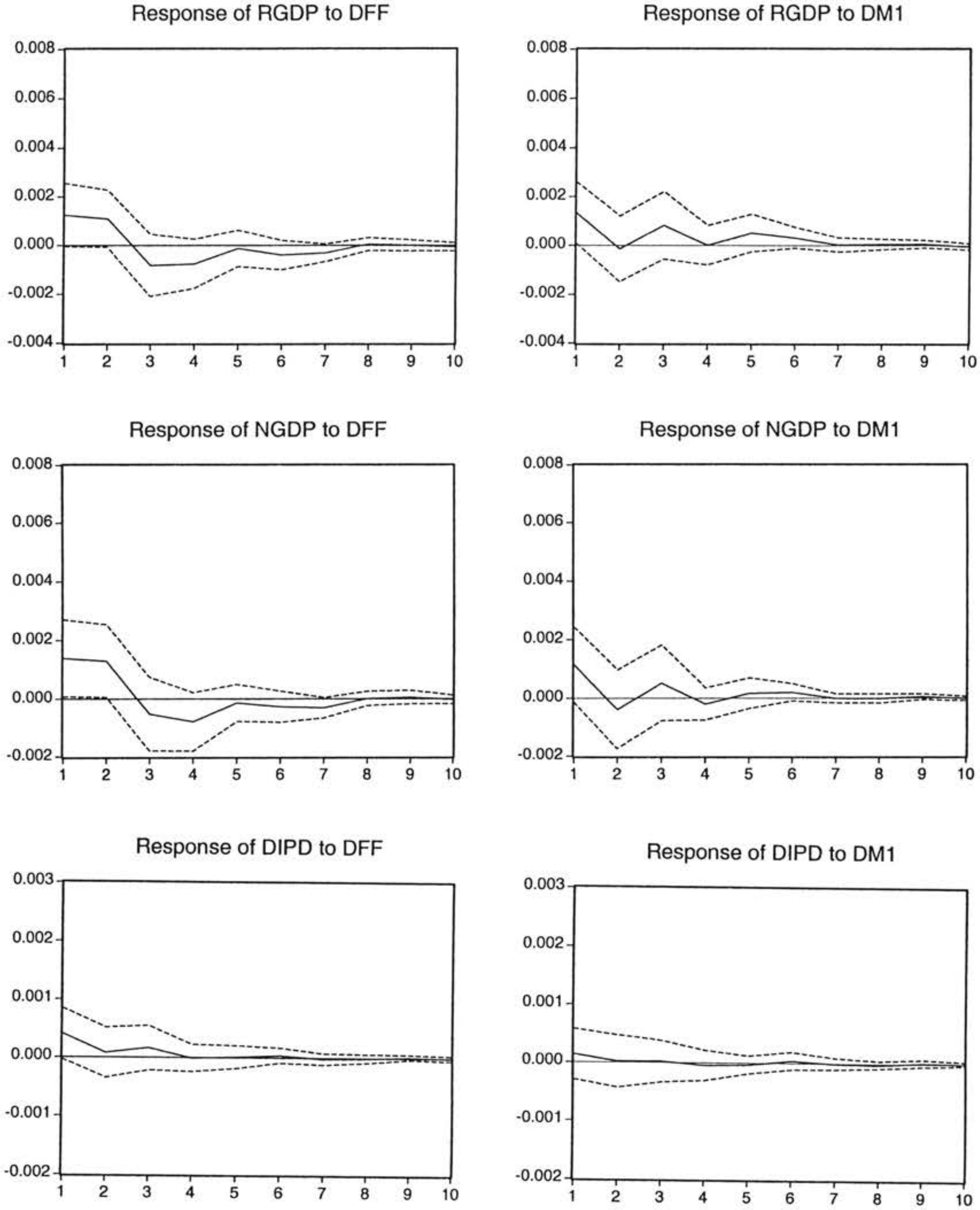


FIGURE 26

TWO-QUARTER LAG
DFF AND DM1 1981.4-1998.3

Horizontal Axis: Quarters in the forecast horizon.
Vertical Axis: Cumulative growth rate relative to base.
The impulse response function is the response to a one standard deviation shock.
The standard error bands represent two standard deviations.

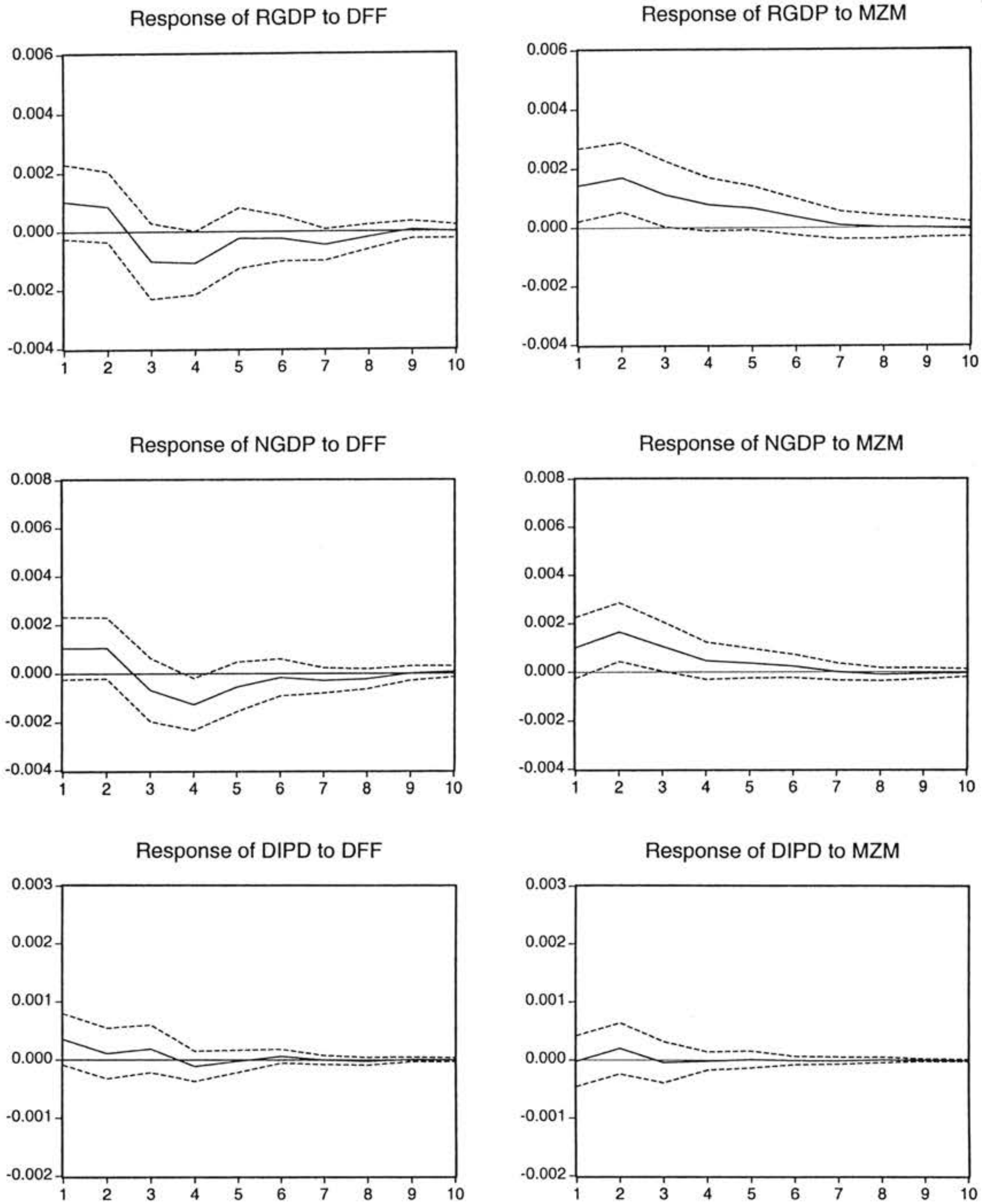


FIGURE 27

DFF AND MZM 1981.4-1998.3

Horizontal Axis: Quarters in the forecast horizon.
Vertical Axis: Cumulative growth rate relative to base.
The impulse response function is the response to a one standard deviation shock.
The standard error bands represent two standard deviations.

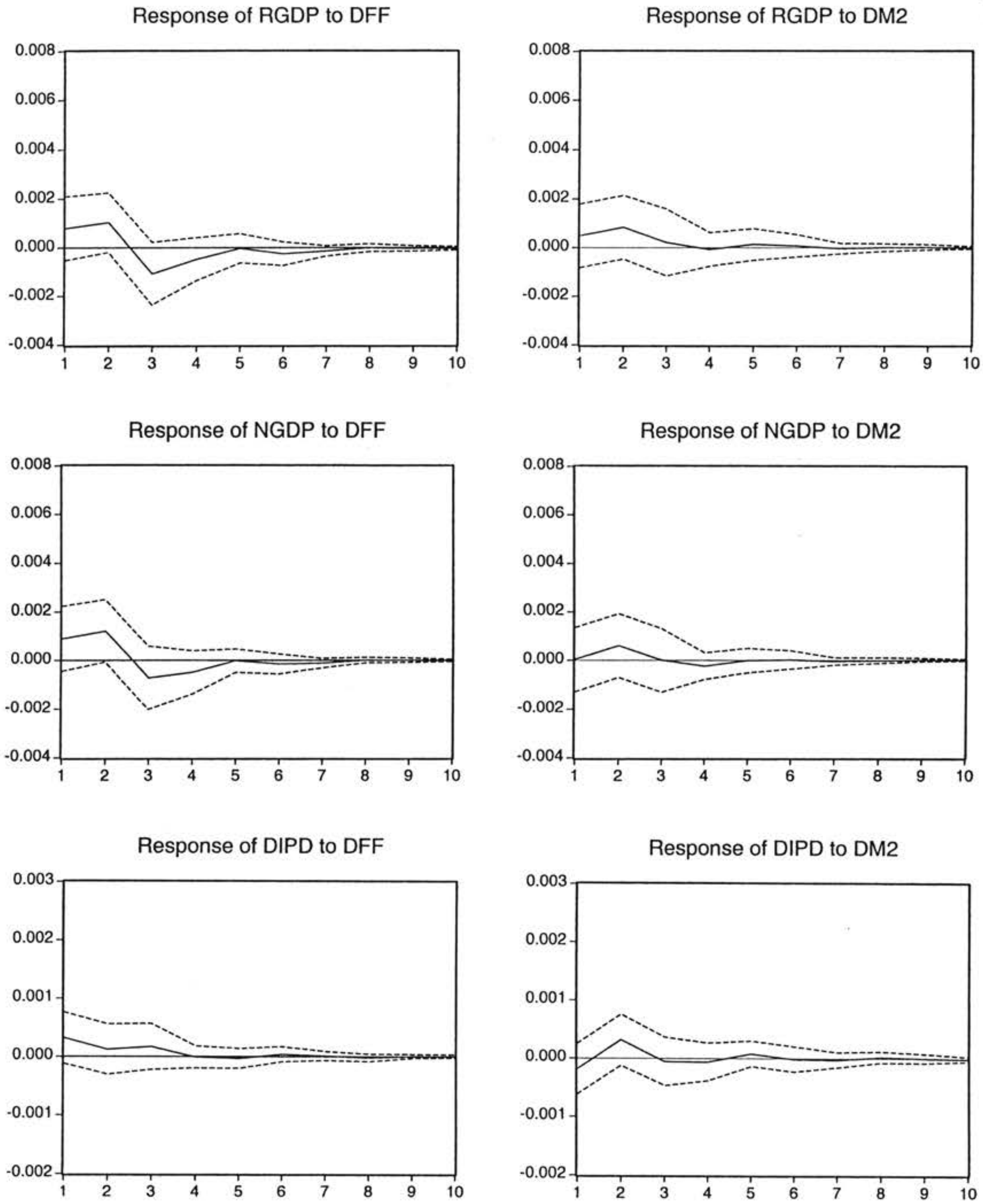


FIGURE 28

TWO-QUARTER LAG
DFF AND DM2 1981.4-1998.3

Horizontal Axis: Quarters in the forecast horizon.
Vertical Axis: Cumulative growth rate relative to base.
The impulse response function is the response to a one standard deviation shock.
The standard error bands represent two standard deviations.

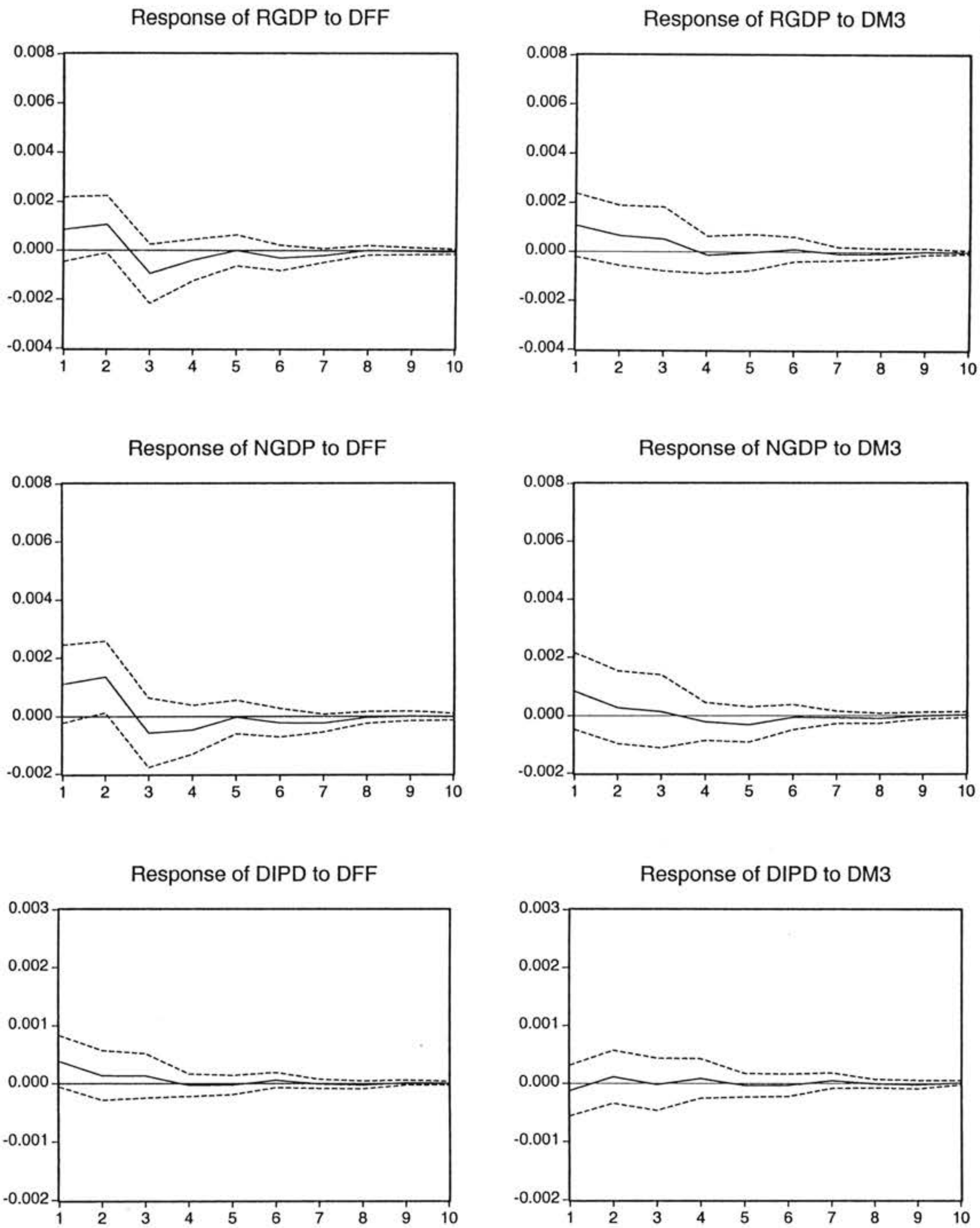


FIGURE 29

TWO-QUARTER LAG
DFF AND DM3 1981.4-1998.3

Horizontal Axis: Quarters in the forecast horizon.
Vertical Axis: Cumulative growth rate relative to base.
The impulse response function is the response to a one standard deviation shock.
The standard error bands represent two standard deviations.

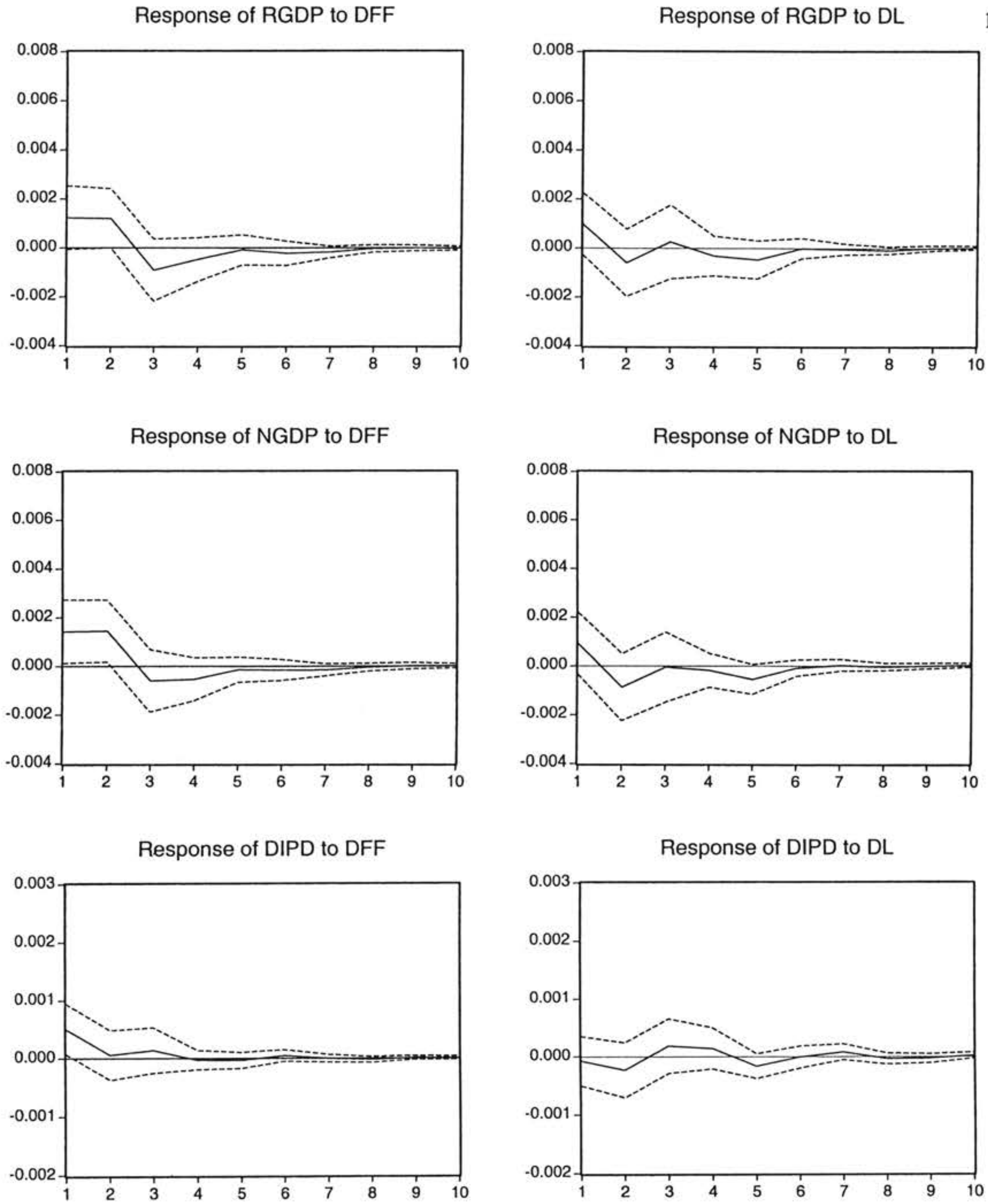


FIGURE 30

TWO-QUARTER LAG
DFF AND DL 1981.4-1998.3

Horizontal Axis: Quarters in the forecast horizon.
Vertical Axis: Cumulative growth rate relative to base.
The impulse response function is the response to a one standard deviation shock.
The standard error bands represent two standard deviations.

CHAPTER 5

CONCLUSIONS

Primary Conclusions

This study examines the empirical evidence over a long span of history on the relationship between the monetary aggregates and economic activity. It finds that a substantial relationship has existed for most of the last 100 years, but that this relationship has weakened in the last 20 years. However, it also finds that the relationship between a competing indicator of monetary policy, the short-term interest rate, and the economy has also weakened in the last 20 years.

The vector autoregression analysis is employed in the statistical tests. Over the *Monetary History* era, spanning the years 1889-1960 in the VAR tests, both the forecast error variance analysis from the variance decompositions and the impulse response functions indicate that the M1 and M2 aggregates have positive and significant forecasting ability with regard to movements in economic activity.

The VAR tests covering the St. Louis era support the original regression results. The basic M1 money supply has a closer statistical relationship to macroeconomic activity than do various measures of fiscal activity. The percentage of error variance accounted for by M1 in the forecast of nominal GNP is about 35%, whereas the fiscal measures account for only about 10% of FEV.

In the third period, covering the time frame after the Andersen-Jordan study but before the breakdown in M1 velocity in the 1980's, the vector autoregression analysis, now expanded to include multiple definitions of the money supply, also supports the monetarist proposition that the money supply is an important determinant of economic activity. Of the monetary aggregates tested, MZM shows the strongest relationship to gross domestic product, producing an error variance of over 30% in the forecast of the latter variable. However, the sample period for MZM is shortened.[1] Of the aggregates with complete data over the third period (1968.3-1981.3), M1 forecasts output the most accurately, with a forecast error variance of about 30%. L, the broadest aggregate, creates a FEV of 25%. Although L's predictive ability is superior to that of M2 and M3, it is inferior to that of M1.

Even in this period in which the conventional measures of the money supply maintain the ability to predict economic activity, the Federal funds rate does as well. The error variance from the Federal funds rate in the forecast of output, at 41%, exceeds that from the various measures of the money supply. When the Federal funds rate is added to the model concurrently with each definition of the money supply, the forecast error variance attributed to the money supply declines only slightly, not substantially as it did in the original Sims (1980a) analysis.

When the lag-length is shortened to two quarters from four-quarters, the recorded influence of the monetary aggregates is reduced substantially. The use of the shorter lag creates a relative gain for the Federal funds rate in comparison with the monetary aggregates in the forecast accuracy of economic activity.

In the fourth test period, from 1981.4-1998.3, the forecast accuracy of the monetary indicators greatly declines. In particular, the M1 money supply, with among the strongest relationships to the economy before 1981, forecasts very little of the

[1] Statistics for MZM on the St. Louis Federal Reserve Bank Fred website begin only in 1974.

movement in GDP in the fourth test period. Furthermore, none of the broader aggregates is as accurate in the forecast of economic activity in the fourth test period as M1 is in the third test period. The broader aggregates, however, display a closer relationship to GDP during the fourth test period than does M1. With the four-quarter lag, MZM and M2 show the most satisfactory forecast results. With the two-quarter lag, MZM shows the highest forecast accuracy. Although the Federal Reserve currently uses the Federal funds rate as its operating target, the vector autoregression analysis indicates that this interest rate has also suffered a deterioration in its relationship to economic activity. The FEV of real GDP in response to innovations in the Federal funds rate declines from about 40% in the pre-1981 period to about 15% in the post-1981 period. In the latter period, the FEV from MZM actually exceeds that from the Federal funds rate.

Implications

Milton Friedman (1960) and other monetarist economists have suggested that monetary policy be conducted by rule, in which the growth rate of a monetary aggregate is maintained at a predetermined rate. The loosening of the relationship between the aggregates and the economy, as well as the Federal Reserve's greater success in the last 20 years at stabilizing the economy through discretionary changes in the Federal funds rate, weakens the case for a strict monetary rule. Large and often unpredictable fluctuations in velocity make it unlikely that a constant growth rate of any version of the money supply is capable of creating greater stability in economic activity. However, the results here also indicate that the forecast ability of the Federal funds rate is also quite limited, suggesting that the central bank should take great care in setting this interest rate.

The Federal Reserve dropped its M1 range in 1987. The results here indicate that due to the weakened forecast ability of this measure of the money supply, the Federal Reserve should continue to use other indicators of monetary policy. One factor currently distorting the growth rate of the narrow money supply is the increasing use of sweep accounts by depository institutions. Presently, sweep balances are recorded as savings accounts, but they are actually available for transaction purposes. Reported M1 balances have clearly been depressed as a result. (Anderson and Rasche, 2001, p. 51 and p. 62) The Federal Reserve should explore the possibility of reporting two M1 figures (much as it reported an M1A and an M1B in the early 1980s), with one version including sweep accounts and the other excluding them. It is likely that the Federal Reserve would have already adopted a revision such as this one if the monetary aggregates had the primary place in policy which they had at one time. But since the aggregates are no longer central in setting monetary policy, revising their definitions probably has low priority.

Empirically, MZM has a fairly close relationship with economic activity. Of the definitions of the money supply tested, it produces the highest forecast error variance values in the prediction of real and nominal gross domestic product for the period 1968.3-1981.3 when the aggregates are entered alone in the model, and the second highest values (behind M1) when the aggregates are entered concurrently with the Federal funds rate. In the fourth test period, its forecast accuracy is approximately equal to that of M2's when a four-quarter lag is used, and superior when a two-quarter lag is used. Conceptually, its definition is more consistent than that of either M2 or M3. MZM is composed of all items of zero maturity which are due immediately. M2 and M3 are composed of more arbitrarily-chosen items which are approximately "near-monies." Further research on the details of MZM's relationship with the economy should be conducted, and the Board of Governors should consider elevating MZM to the status of an official definition of the money supply. It is likely, however, that the relationship between GDP and MZM entails more complexities than a simple linear projection would indicate. Previous researchers (Carlson et al., 1999) have found that opportunity cost is quite important.

If the Federal Reserve does in fact adopt MZM as an official definition of the money supply, the central bank should seriously consider eliminating the M2 version. The two include many overlapping items: M1, savings accounts, and retail money market mutual funds. They differ in that MZM includes institutional money market mutual funds, whereas M2 includes small time deposits. Most of the instability in M2 velocity occurs due to the small time deposit component.[2] Many small time deposits have maturities exceeding one year, and to some degree these instruments substitute more for bond-type investments than for transactions balances. Nevertheless, M2 has shown some forecast accuracy in the past. In the fourth test period, this aggregate predicts as well as MZM at a four-quarter lag, although not as well at a two-quarter lag. Some research (Carlson et al., 1999, Lown, Peristiani, and Robinson, 1999) has indicated that after the large upward swing in its velocity in the early 1990s, M2 may have once again become a more reliable indicator. Chairman Greenspan, commenting recently on economic

[2] See Carlson et al. (1999).

developments, placed some significance on the behavior of M2, noting that "the growth of liquidity, as measured by M2, has picked up." (2001)

The Federal Reserve should also consider revising or eliminating the M3 version of the money supply, possibly replacing it with L. M3 includes some money substitutes but excludes others which are just as significant. Whereas negotiable CDs are included, Treasury bills and commercial paper are excluded. L consistently includes all money substitutes, rather than an artificially-limited set of them. Of the error variance values in the primary tests in table 4 (1968.3-1981.3), M3 produces the lowest figures in the forecast of both real GDP and nominal GDP. L forecasts more accurately. However, both M3 and L show low forecast accuracy in the last 20 years (table 7 and 8). Conceptually, L seems superior to M3. Empirically, it only seems about equal.[3]

Future Research

In addition to considering changes in the official definitions of the money supply, future researchers could pursue a number of other profitable avenues. Further investigation could be conducted to determine the causes of the monetary aggregates' reduced influence in the last 20 years. Financial innovation, deregulation, and flows between different classes of financial assets are likely to be among the factors. In particular, future researchers could examine the response of financial flows between different financial assets to various factors. In addition, the broad aggregate L, which includes so many financial assets, may have a more complex relationship to the

[3] Before ceasing publication of the liquid assets measure in late 1998, the Federal Reserve often required more time to compile statistics for L than for M3 and the narrower aggregates. See, for example, Board of Governors (1998, p. A13), in which figures for L (and nonfinancial debt) are not available for the most recent month.

economy and also to other, longer-term financial assets. These potential relationships should be investigated. Since the Federal funds rate is now the Federal Reserve's primary operating tool, research could be conducted on the causes of the Federal funds rate's lessened relationship to the macroeconomy in the last 20 years. Those factors which create slack in the Federal funds rate's relationship to the economy could be identified and investigated. Finally, the sensitivity of results to the length of lags and other characteristics in the statistical runs could be investigated.

Final Summation

The empirical evidence obtained in this study through vector autoregression analysis confirms that the relationship between the economy and the monetary aggregates has lessened in the last 20 years. Of measures of the money supply, M1 shows the largest decline in forecast accuracy. Of alternative measures, both MZM and L have positive characteristics in terms of conceptual consistency: MZM as all items of zero maturity, and L as all items which are used as money substitutes. Empirically, however, MZM maintains the closer relationship to GDP for the last 20 years. In addition, M2 maintains an empirical relationship of approximately equal magnitude. Finally, the analysis in this study indicates that the statistical relationship between interest rates and economic activity has also weakened in the last 20 years.

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APPENDIX—SUMMARY STATISTICS

MONETARY HISTORY ERA: 1869-1960

	Mean	Standard Deviation	Maximum	Minimum
M1*	.0544	.0818	.2580	-.1252
M2	.0568	.0658	.2378	-.1804
NGNP	.0455	.0915	.2356	-.2752
DLTR	-.0427	.4963	2.2500	-1.7500

*1915-1960.

ST. LOUIS ERA: 1952.1-1968.2

	Mean	Standard Deviation	Maximum	Minimum
M1	.0072	.0060	.0231	-.0062
DMB	-.0001	.0075	.0301	-.0207
BR	.0045	.0332	.1421	-.0550
E	.0193	.0313	.1369	-.0609
R	.0155	.0190	.1024	-.0534
NGNP	.0196	.0112	.0347	-.0112

THIRD PERIOD: 1968.3-1981.3

	Mean	Standard Deviation	Maximum	Minimum
DM1	-.0002	.0100	.0413	-.0226
MZM	.0149	.0172	.0618	-.0184
DM2	.0000	.0067	.0173	-.0130
DM3	.0002	.0058	.0202	-.0142
DL	.0002	.0044	.0111	-.0100
RGDP	.0072	.0108	.0384	-.0201
NGDP	.0237	.0107	.0570	.0015
DIPD	.0002	.0039	.0082	-.0082
DFF	.2189	1.4784	6.0100	-3.0500

FOURTH PERIOD: 1981.4-1998.3

	Mean	Standard Deviation	Maximum	Minimum
DM1	.0001	.0093	.0237	-.0199
MZM	.0205	.0238	.1702	-.0119
DM2	.0000	.0073	.0312	-.0275
DM3	.0000	.0045	.0116	-.0115
DL	-.0001	.0047	.0098	-.0125
RGDP	.0078	.0067	.0230	-.0158
NGDP	-.0149	.0065	.0332	-.0029
DIPD	-.0002	.0021	.0037	-.0049
DFF	-.1772	.8467	.9700	-3.9900

2

VITA

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