Income Stabilization and Short-run Variability in Money

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In early 1970 the Federal Open Market Committee began to place greater emphasis on attaining desired growth paths of the monetary aggregates. Thus, over the past three years the Committee's directive to the Manager of the System Open Market Account frequently—but not always—gave primary emphasis to the objective of achieving certain desired growth rates in these aggregates.[1] In part, this strategy was based on the view that maintaining relatively stable growth in the monetary aggregates would tend to yield relatively stable growth in nominal gross national product (GNP) along some desired growth path.

Whatever the merits of this hypothesis on other grounds, it raises many questions of a definitional and operational nature. For example, on which of the several monetary aggregates should the Committee focus its primary attention? And, perhaps more importantly, over what period should the growth of this aggregate be stable or, stated another way, what type of variations in the growth of monetary aggregates should be considered "unstable"? Certainly, for example, most would agree as a practical matter that attaining stable monetary growth over a period of weeks or even months may be virtually impossible. Indeed, the Committee's directive to the Manager of the System Open Market Account has usually implied that the desired growth path of the aggregate be attained over periods of at least three months in duration. However, maintaining this desired quarterly growth path has proven to be a difficult task.[2] This, of course, raises an important question as to the consequences of short-term or quarter-to-quarter variations in the growth path of the monetary aggregates. That is, what are the limits—with respect to duration and magnitude of variations—within which deviations from a desired monetary growth path can or should be tolerated?

It is this latter question to which this paper is addressed. However, in focusing on this question, the paper bypasses several key issues which are by no means resolved. For example, it will assume throughout that M_1 (currency held by the public plus private demand deposits) is the "right" monetary aggregate—i.e., the relationship between changes in M_1 and changes in nominal GNP is closer and more stable than is the relationship between any of the other aggregates and GNP.[3] In fact, the empirical evidence is by no means conclusive on this point. The paper also assumes that policy makers are always in a position to formulate policy decisions by placing primary emphasis on attaining some desired growth path in nominal GNP.[4]

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[1] For a more complete discussion of the framework within which open market operations were conducted in this interval, see Alan R. Holmes and Paul Meek, "Open Market Operations and the Monetary and Credit Aggregates—1971", this *Monthly Review* (April 1972), pages 79-94, and Paul Meek and Rudolf Thunberg, "Monetary Aggregates and Federal Reserve Open Market Operations", this *Monthly Review* (April 1971), pages 80-89.

[2] See "Open Market Operations and the Monetary and Credit Aggregates—1971", *op. cit.*, page 94.

[3] Models which use aggregates other than M_1 (e.g., M_2 or bank credit) tend to have general characteristics that are very similar to the models used in this study. Thus, the choice of some aggregate other than M_1 as the "right" aggregate would not materially influence the results cited in this article.

[4] In reality, of course, policy makers are also concerned with, among other things, the manner in which a given rise in nominal GNP is allocated between prices and real output. Thus, attaining some desired growth path in nominal GNP by no means provides a one-dimensional criterion for evaluating the success of monetary policy.

This, however, may not always be the case for, over short-run intervals, other considerations—such as the liquidity crisis surrounding the Penn Central insolvency in June 1970—may entail some shifting of relative priorities. However, this assumption should not be viewed as a severely limiting constraint to the analysis since such events are not likely to produce a lasting reordering of policy priorities and objectives. Moreover, it can probably be argued that the time framework in which a desired GNP growth path should be viewed entails an interval of at least several and probably as many as four quarters. The latter also implies that policy would not be formulated with a view toward influencing quarter-to-quarter changes in GNP but rather with a view toward attaining some average growth rate in GNP over an interval of several quarters.

The primary conclusions of this study may be summarized as follows: the analysis suggests that quarter-to-quarter fluctuations in the growth rate of the money supply tend to have a relatively small impact on the growth path and level of nominal GNP. The relative insensitivity of GNP to short-run fluctuations in M_1 growth is primarily the result of the lags in the relationship between money and income. At the same time, the analysis also suggests that deviations from a desired path of monetary growth can have significant effects on the behavior of nominal GNP if these are allowed to persist for more than two quarters. These findings suggest that it may be more appropriate to focus on the growth of the monetary aggregates over six-month intervals rather than three-month or shorter intervals.

The first question to be considered is the extent to which variations in the quarterly growth path in M_1 have in fact induced a pattern of GNP expansion significantly different than would have occurred under conditions of stable monetary growth. The first two sections of the paper will consider this issue using three different econometric models of the aggregate economy. This exercise will focus primarily on the 1970-71 period, but results will be shown for other periods which suggest that the results are not affected by the period studied. Then, on the basis of these analyses and findings, the third section of the paper will attempt to provide some insights into the magnitude and duration of deviations from the desired monetary growth path that can be tolerated. This analysis also provides some insights into the manner in which money supply growth rates should be adjusted in response to unexpected deviations from the desired path of monetary growth. A final section will summarize the findings of the study and provide a brief discussion of some of its major implications.

THE EFFECTS ON GNP OF STABLE VERSUS UNSTABLE GROWTH IN M_1

Over 1970 and 1971, the narrowly defined money supply expanded at a compound annual rate of 5.8 percent.[5] However, measured on a quarterly average basis, the quarter-to-quarter growth pattern, particularly in 1971, was very erratic, ranging from 11.3 percent in the second quarter to 0.4 percent in the fourth quarter. These fluctuations in M_1 have been viewed with varying degrees of concern, and even alarm, both within and outside the Federal Reserve System. Indeed, some observers have suggested that these quarterly fluctuations have been responsible for the unstable behavior of the economy over the period as, for example, reflected in the erratic and uncertain growth path of GNP during much of the period. Others, however, have taken a more sanguine view of these developments while noting that, over longer periods of six months or a year, the growth rate in the money supply remained fairly close to 6-7 percent. Some insights into the merits of these differing views can be obtained by simulating the pattern of nominal GNP growth over this period on the assumption that monetary growth was perfectly stable on a quarterly basis at its overall average of 5.8 percent and comparing these results with those obtained using the actual quarterly growth pattern of money.

This exercise was undertaken with three different econometric models of the aggregate economy. In all cases, the analysis focused on the implications of the monetary growth path for the behavior of nominal GNP, primarily because much of the literature relating money to economic activity deals with the relationship between nominal money and nominal GNP. The first model used was a simple reduced-form equation relating changes in GNP to changes in M_1. The equation was fitted to the 1953-69 period using quarterly data.[6] Current and three quarterly lagged values of M_1 were utilized in the equation, which was fitted using a second degree Almon distributed lag.

Table I presents the results of the simulations using this model. In viewing these results, it should be emphasized

[5] Throughout this article, the money supply series prior to the February 1973 revision is used.

[6] In this equation—as well as in the models noted later—the changes in M_1 were based on quarterly average levels of the money supply. The use of an alternative measurement procedure in which the monetary growth rates are measured over spans of three-month intervals would not influence significantly the results cited in this article.

Table I

SIMULATED PATTERNS OF NOMINAL GNP GROWTH UNDER ALTERNATIVE ASSUMPTIONS CONCERNING THE GROWTH PATTERN OF M_1

1970-71; seasonally adjusted annual rates, in percent

Quarter	(1) Actual growth in GNP	(2) Simulated growth in GNP with actual growth path in M_1	(3) Simulated growth in GNP with smooth growth in M_1	(4) Difference in GNP growth path due to path of M_1 growth (3)—(2)	(5) Difference in GNP growth path over four-quarter spans due to M_1 growth path
1970: I	3.9	4.5	5.0	0.5	0.1
II	5.8	5.6	5.9	0.3	0.2
III	6.2	6.5	6.8	0.3	0.3
IV	1.4	6.7	7.5	0.8	0.5
1971: I	14.3	7.4	7.5	0.1	0.3
II	7.9	9.2	7.4	—1.8	—0.1
III	5.4	9.9	7.3	—2.6	—0.9
IV	8.3	7.7	7.3	—0.4	—1.1

that the quarter-to-quarter growth rate in the money supply is not a good "predictor" of the quarter-to-quarter growth path in GNP. This, however, is not the central issue in this study. Rather, we are concerned with the extent to which differences in the growth of GNP can be attributed to alternative growth paths in M_1. Some insights into this question can be gained by comparing the growth rates in GNP that were "predicted" by the model using the actual path of M_1 growth (column 2) with those obtained using the smooth path of monetary growth (column 3). These differences are summarized in columns (4) and (5). In six of the eight quarters covered, the differences in the quarter-to-quarter GNP growth rates obtained with the smooth monetary growth path, as opposed to the actual growth path, are less than 1 percentage point, and in only one case does the difference exceed 2 percentage points. Perhaps more importantly, over four-quarter spans, seven of the eight differences are less than 1 percent and the largest is 1.1 percent. Of course, the comparison in column (5) as it applies to the first three quarters of 1970 is biased somewhat by the use, in the smooth simulation, of lagged actual money supply growth rates for the last three quarters of 1969. However, this bias is not large[7] and is fully eliminated by the fourth quarter of 1970. Apart from this consideration, it is also interesting to note that the level of GNP at the end of 1971 attained by the smooth pattern of monetary expansion is within 0.6 percent of the level of GNP implied by the actual path of monetary growth. Thus, on the basis of this model—which is a strict monetarist model[8]—it appears that a perfectly smooth rate of monetary expansion over the 1970-71 period may have smoothed the quarter-to-quarter growth path in GNP relative to that experienced with the actual path of monetary growth, but would not have materially influenced the overall growth in GNP for this eight-quarter period.

Of course, it can be argued that these results are unique to the 1970-71 period. Such a claim could be based on the assertion that the cyclical character of the period, the heavy incidence of labor disputes, or the initial monetary conditions which prevailed (i.e., the fact that money supply growth was very slow in the second half of 1969) distort these results. Since these are distinct possibilities, the exercise was repeated for the period 1963-65. During this twelve-quarter period—which was marked by relatively steady and essentially noninflationary economic growth—the average quarterly rate of growth of M_1 amounted to 4.2 percent. However, the quarter-to-quarter rise in money

[7] This simulation was repeated using a smooth monetary growth rate equal to the average actual growth rate in money over the last three quarters of 1969. On the basis of this simulation, the largest difference corresponding to the numbers in column (5) for the first three quarters of 1970 was equal to 0.3 percentage point.

[8] This is a strict monetarist model in the sense that changes in the money supply are the sole determinant of changes in income. However, some monetarists, who view the relationship between money and income as highly unstable, might not accept such a model.

also displayed considerable variability over this period, ranging from a high of 6.7 percent to a low of 2.6 percent. Relative to its mean, the quarterly growth rate of the money supply was not as variable during 1963-65 as it was during the 1970-71 period.[9]

Table II compares the predicted quarterly growth pattern in GNP using the actual growth pattern of M_1 with the GNP growth pattern simulated using a smooth growth in M_1 for the 1963-65 interval. The evidence in Table II is generally consistent with the findings reported earlier for the 1970-71 period. Over the entire twelve-quarter period, the largest difference in the quarter-to-quarter growth path in GNP was about 1 percentage point. Similarly in seven of the twelve quarters studied, the growth rate in GNP as predicted by the simulation using the smooth M_1 path was within 0.5 percentage point of that predicted using the actual path of monetary expansion. Over four-quarter spans, the largest difference in the simulation results is 0.7 percentage point. Thus, even though the general economic climate in the 1963-65 period was very different from that of the 1970-71 period, these results also suggest that quarter-to-quarter variations in the growth of the money supply do not radically influence the pattern or the overall amount of GNP growth.

The two time periods used in the discussion above were selected for a number of reasons. The most important element in the selection process was the fact that the basic thrust of monetary policy was essentially unchanged within each of these two time spans. To be sure, in both periods the various indicators of monetary policy—whether viewed in terms of interest rates, money market conditions, or the growth rates in the monetary aggregates—displayed some movement. However, in both periods, the underlying thrust of policy was aimed at promoting monetary expansion to foster sustainable economic growth.

These situations may be contrasted with the experience of late 1968 and 1969 in which the Federal Reserve made a deliberate effort to restrict the rate of monetary expansion. Reflecting this basic policy shift, money supply growth decelerated sharply in 1969. For example, over the last three quarters of 1968 M_1 grew at an annual rate of about 8 percent, while over the same interval of 1969 it rose at a rate of only 2.8 percent. In neither case was M_1 growth smooth on a quarterly basis at these rates of increase. Moreover, while these quarter-to-quarter fluctuations in M_1 growth were probably of little consequence in terms of income behavior, it should be recognized that on the basis

[9] For the twelve quarters during 1963 through 1965 the coefficient of variation for the money supply growth rate was 31.4, while in 1970-71 it was 53.5. The coefficient of variation is the standard deviation of a series divided by its mean and multiplied by 100.

Table II

SIMULATED PATTERNS OF NOMINAL GNP GROWTH UNDER ALTERNATIVE ASSUMPTIONS CONCERNING THE GROWTH PATTERN OF M_1

1963-65; seasonally adjusted annual rates, in percent

Quarter	(1) Actual growth in GNP	(2) Simulated growth in GNP with actual growth path in M_1	(3) Simulated growth in GNP with smooth growth in M_1	(4) Difference in GNP growth path due to path of M_1 growth (3)—(2)	(5) Difference in GNP growth path over four-quarter spans due to M_1 growth path
1963: I	3.8	4.8	4.7	—0.1	0
II	4.8	5.9	5.9	0	—0.1
III	7.4	6.8	7.1	0.3	0.1
IV	7.7	7.1	7.5	0.4	0.2
1964: I	8.1	6.5	7.5	1.0	0.4
II	6.8	6.3	7.4	1.1	0.7
III	7.1	7.4	7.2	—0.2	0.6
IV	3.9	7.8	7.1	—0.7	0.3
1965: I	11.4	7.3	7.1	—0.2	0
II	8.0	6.6	7.1	0.5	—0.2
III	9.4	6.4	7.0	0.6	0.1
IV	11.4	7.5	6.9	—0.6	0

Table III

SIMULATED PATTERNS OF NOMINAL GNP GROWTH UNDER ALTERNATIVE ASSUMPTIONS CONCERNING THE GROWTH PATTERN OF M_1 USING THE SMP MODEL

1970-71; seasonally adjusted annual rates, in percent

Quarter	(1) Actual growth in GNP	(2) Simulated growth in GNP with actual growth path in M_1	(3) Simulated growth in GNP with smooth growth in M_1	(4) Difference in GNP growth path due to path of M_1 growth (3)—(2)	(5) Difference in GNP growth path over four-quarter spans due to M_1 growth path
1970: I	3.9	0.9	1.0	0.1	0
II	5.8	5.3	5.5	0.2	0.1
III	6.2	2.6	2.9	0.3	0.2
IV	1.4	—0.3	0.2	0.5	0.2
1971: I	14.3	14.4	14.5	0.1	0.3
II	7.9	8.7	7.8	—0.9	—0.1
III	5.4	6.5	5.3	—1.2	—0.4
IV	8.3	10.4	10.0	—0.4	—0.7

of the models used in this study the underlying deceleration in money supply growth from 8 percent to 3 percent was a major factor in explaining the slowdown in nominal income growth that occurred in 1969 and 1970. In short, while quarter-to-quarter fluctuations in M_1 growth around some average rate of increase may be of little consequence for income behavior, a major change in the underlying rate of increase such as occurred between 1968 and 1969 will tend to have an important bearing on the behavior of nominal income.

THE EVIDENCE USING DIFFERENT MODELS

To gain further insights into the consequences of fluctuations in the growth of M_1, the procedures used earlier were repeated for the 1970-71 period with two different econometric models. The first of these was a modified version of the SSRC-MIT-Pennsylvania (SMP) econometric model of the United States economy and the second was the St. Louis Federal Reserve Bank econometric model. These models differ in a number of essential characteristics—including their size. The St. Louis model is a small one in which changes in nominal GNP are determined by changes in the money supply (M_1) and changes in full-employment Federal budget expenditures.[10] This relationship is summarized in a single reduced-form equation similar to that noted on page 88. On the other hand, the SMP model is a large structural one of the United States economy, involving some 300 equations and identities which solve for a wide range of economic variables including nominal GNP. In the SMP model, however, changes in the money stock influence the level and change in GNP through their impact on other variables.[11] For example, increases in the money supply tend to reduce interest rates and stimulate investment spending. In turn, other spending components will rise, all of which contribute to the overall increase in GNP arising from some initial monetary stimulus.

To test the implications of stable money growth with the SMP model, an initial simulation was conducted for the 1970-71 period in which all of the exogenous variables —including the money supply—were set at their actual readings. The model was then solved for nominal GNP. The same procedure was repeated except that, in place of the actual pattern of money growth, M_1 was allowed to increase at a steady rate equal to its average growth rate over the entire eight-quarter period.[12] These simulation results, which are summarized in Table III, were com-

[10] See Leonall Andersen and Keith M. Carlson, "A Monetarist Model for Economic Stabilization", *Review* (Federal Reserve Bank of St. Louis, April 1970), page 11.

[11] See Frank deLeeuw and Edward Gramlich, "The Channels of Monetary Policy", *Federal Reserve Bulletin* (June 1969), pages 472-91.

[12] In performing these *ex post* simulations, the narrow money supply was treated as an exogenous variable.

pared with the control simulation to determine the extent to which the behavior of GNP would have differed had monetary growth been smooth. This exercise indicated that the growth pattern and ultimate level of GNP were very insensitive to the pattern of monetary expansion. On a quarterly basis, the largest difference between the growth in GNP predicted with the smooth path of monetary expansion and that predicted with the actual path of monetary expansion was about 1 percentage point. Additionally, the level of GNP attained at the end of the period in the smooth money supply simulation was within 1 percent of that attained using the actual money supply growth pattern. In short, within the framework of the SMP large econometric model, the variations in the growth pattern of M_1 over the 1970-71 period do not materially influence the pattern of GNP growth relative to what would have occurred had the money supply growth been perfectly stable on a quarterly basis. This tends to suggest that the results cited earlier do not depend on the particular model used.

The St. Louis econometric model provides another framework within which the consequences of stable versus unstable growth in the money supply can be viewed. In this experiment, changes and growth rates in nominal GNP were simulated for the period 1970-71 with the actual patterns of changes in the money supply and full employment Government expenditures.[13] Then, to isolate the implications of the growth path of M_1, the exercise was repeated using a smooth growth path of M_1, equal to its average quarterly rate of growth over the eight-quarter period ended 1971-IV, while maintaining the actual pattern of change in Government outlays. These results are shown in Table IV.

As Table IV indicates, the difference in the simulated growth path in GNP when the smooth money supply pattern was used (column 3) is not radically different from that obtained using the actual growth pattern (column 2). The largest difference (2.8 percentage points) occurs in 1971-III, following the rapid rise in the money stock during the first half of 1971. Over four-quarter spans, however, the largest error was 1.3 percent. Thus, these results are roughly comparable to those cited earlier.

Perhaps the most interesting aspect of these results relates to the erratic pattern of GNP growth that the St. Louis model predicts for 1971 in the smooth money case (column 3) despite the fact that all of the lagged M_1 variables are growing at a constant rate. This phenomenon is caused by the influence of the full employment expenditure variable in the GNP equation. Indeed, with M_1 growing at a constant rate, virtually all of the fluctuations in the predicted GNP growth path in 1971 are attributable to the fiscal variable and the pattern of coefficients on this variable. This suggests that, within the St. Louis model, fiscal policy—as measured by the change in full employment expenditures—is a source of considerable variability in the quarter-to-quarter growth path of nominal GNP.

To summarize the presentation to this point, the results cited suggest that the growth pattern of GNP is not par-

[13] The coefficients used in this exercise were those reported by Andersen and Carlson, *ibid.*

Table IV

SIMULATED PATTERNS OF NOMINAL GNP GROWTH UNDER ALTERNATIVE ASSUMPTIONS CONCERNING THE GROWTH PATTERN OF M_1 USING THE ST. LOUIS MODEL

1970-71; seasonally adjusted annual rates, in percent

Quarter	(1) Actual growth in GNP	(2) Simulated growth in GNP with actual growth path in M_1	(3) Simulated growth in GNP with smooth growth in M_1	(4) Difference in GNP growth path due to path of M_1 growth (3)—(2)	(5) Difference in GNP growth path over four-quarter spans due to M_1 growth path
1970: I	3.9	5.6	6.0	0.4	0.1
II	5.8	7.8	8.2	0.4	0.3
III	6.2	7.1	7.5	0.4	0.3
IV	1.4	6.2	6.8	0.6	0.4
1971: I	14.3	6.4	6.7	0.3	0.4
II	7.9	9.8	8.5	—1.3	0
III	5.4	12.4	9.6	—2.8	—0.8
IV	8.3	9.1	7.8	—1.3	—1.3

ticularly sensitive to the quarter-to-quarter variability in the rate of monetary expansion. Indeed, within the context of the models used and the time periods studied, the results indicate that quarterly deviations from some underlying rate of growth in M_1 have surprisingly little impact on the overall growth in GNP. Moreover, while these deviations do influence the quarter-to-quarter growth rates of GNP, the extent to which the variance in quarterly GNP growth rates can be attributed to the growth in M_1 appears to be small relative to other factors influencing the short-run growth path of GNP. These results are consistent with the findings of other studies which are relevant to the questions at issue in this article. For example, Carlson[14] and Burger, Kalish, and Babb,[15] while working in different frameworks, have reported findings showing that quarter-to-quarter fluctuations in the growth of M_1 tend to have only a relatively small impact on the behavior of GNP. This is not to say, however, that any amount of variance in the growth of M_1 is a matter of indifference. In this regard, the next section of this study will attempt to provide some insights into the magnitude and duration of deviations from a desired path of monetary expansion that can be tolerated. However, before considering this issue, some attention should be given to the reason why the results presented earlier are so insensitive to the path of M_1 growth.

The primary reason why the simulated paths of GNP growth are not particularly responsive to the quarter-to-quarter path of monetary growth relates to the length and structure of lags between changes in money and changes in GNP as contained in these models.[16] In all of the models used, the effects of changes in M_1 on GNP are spread over at least four to five quarters and the mean lag is about two quarters or longer.[17] This means that only half—or less—of the impact of a change in money has its influence on GNP within two quarters. Thus, if over a two-quarter period the money supply grew faster than desired, the effects of the overrun on GNP would be dampened by the presence of these lags.

To illustrate further the significance of the lags, let us consider the following hypothetical model. The percentage change in GNP is equal to the sum of the current and three lagged percentage changes in the money supply where the coefficients on each money variable are .25. Assume further that money has been growing at a steady rate of 6 percent. Under these conditions, the model would indicate that GNP growth would be 6 percent—i.e., the money coefficient (.25) times the growth in money (6 percent), summed over four quarters. If in the next quarter the money supply growth rate unexpectedly accelerated to 8 percent, the predicted rise in GNP would accelerate but only to 6.5 percent, i.e., by the amount of the current-quarter coefficient (.25) times the higher than expected growth in M_1 (8 minus 6, or 2 percent). If this situation persisted for two quarters, the model would indicate that the growth rate in GNP would accelerate to 7 percent in the second quarter. Assuming the growth in M_1 returned to its desired path of 6 percent thereafter, the 1 percent acceleration in GNP in the second quarter would represent the largest deviation from the GNP growth path of 6 percent. If, however, M_1 growth fell below its desired long-term growth in the third quarter, the long-run impact on GNP would be reduced accordingly. These latter considerations help to explain why the results cited earlier were so insensitive to the growth path of M_1. Indeed, even in 1971 when M_1 growth was most erratic, the overrun in growth in the first half of the year was partially neutralized by a marked slowing in the second half of the year.

SOME INSIGHTS INTO THE TOLERANCE LIMITS FOR SHORT-RUN FLUCTUATIONS IN M_1 GROWTH

The previous discussion has indicated that the effects of variable versus smooth patterns of monetary growth have not materially influenced the growth path of nominal GNP or the overall amount of growth in nominal income. However, this earlier analysis sheds little light on the magnitude and duration of deviations from desired monetary growth rates that should be viewed with concern. To conduct this phase of the investigation, eight-quarter simulations of nominal GNP were undertaken—each of which entailed progressively wider deviations in M_1 growth around an assumed long-term average rate of monetary expansion. These simulations were conducted using the single-equation model cited on page 88 and were based on the assumption that the desired growth in the money supply was 6 percent on a quarterly average basis (i.e., a 6

[14] Keith M. Carlson, "Projecting with the St. Louis Model: A Progress Report", *Review* (Federal Reserve Bank of St. Louis, February 1972), pages 22-23.

[15] Albert E. Burger, Lionel Kalish III, and Christopher T. Babb, "Money Stock Control and its Implications for Monetary Policy", *Review* (Federal Reserve Bank of St. Louis, October 1971), pages 15-17.

[16] For a full discussion of the lags in monetary policy, see Michael J. Hamburger, "The Lag in the Effect of Monetary Policy: A Survey of Recent Literature", this *Monthly Review* (December 1971), pages 289-97.

[17] As will be noted later, very short lags or variability in the length of the lags would alter these results.

Table V

QUARTERLY PATTERNS OF MONEY SUPPLY GROWTH

Seasonally adjusted annual rates of change of quarterly averages; in percent

Quarter	(1) Control	(2) Single-quarter deviation	(3) Two-quarter deviation	(4) Three-quarter deviation
I	6	8	8	8
II	6	4	8	8
III	6	6	4	8
IV	6	6	4	4
V	6	6	6	4
VI	6	6	6	4
VII	6	6	6	6
VIII	6	6	6	6

percent growth in M_1 was viewed as being consistent with the desired growth path of GNP). In all of these simulations it was further assumed that the money supply growth rate had been proceeding at the 6 percent annual rate in each of the four quarters preceding the start of the simulation period. A control simulation was run in which it was assumed that the desired M_1 growth rate was attained in each of the eight quarters in the simulation period. Then, alternative simulations were run, each of which involved progressively larger, but temporary, deviations from the desired M_1 path while retaining the 6 percent average rate of growth over the period as a whole. In the first simulation, for example, the growth rate in M_1 was assumed to rise to 8 percent (i.e., 2 percentage points above the desired rate) for one quarter and then to adjust downward so as to maintain the desired 6 percent growth path for the entire eight-quarter period. In successive simulations, the same 2 percentage point deviations were assumed to last for two and three quarters, respectively, before adjusting to the growth rate that would bring the average for the whole period to 6 percent. For purposes of illustration, Table V reports the pattern of money supply growth rates used in these simulations. The entire procedure was repeated for a second set of simulations in which the actual growth path of money was assumed to deviate from the desired growth path by 4 percentage points to a 10 percent annual rate per quarter. The results for the 8 and 10 percent cases are summarized respectively in Tables VI and VII.

Turning first to Table VI, column 1 represents the growth path of GNP projected by this model under the assumption of stable money growth at an annual rate of 6 percent per quarter. Column 2A traces the path of GNP expansion under the assumption that monetary growth amounted to 8 percent in the first quarter of the simulation period, fell to 4 percent in the second period, and remained constant at 6 percent for the balance of the simulation period. Column 2B records the differences in quarterly growth rates in GNP in the control simulation (column 1) from those generated by the alternate path of M_1 growth (column 2A). Column 2C measures the cumulative difference from the control simulation—i.e., it is a successive summation of the data in column 2B. Because the data in column 2C are successive additions of annual growth rates, they are somewhat difficult to comprehend directly. Therefore, to facilitate interpretation of these data, the addendum at the bottom of the table reports the differences in the level of nominal GNP implied by this simulation relative to the control simulation for each quarter in the simulation period.[18] Since the underlying M_1 growth rate of 6 percent is preserved over the entire eight quarters, the figures in column 2C and the differences in GNP levels tend to approach zero by the end of the eight quarters.

As Table VI indicates, the implications of a one-quarter deviation in M_1 growth to 8 percent are virtually negligible. The maximum deviation from the control path of GNP is 0.6 percentage point which, as noted in the lower part of the table, translates into only $1.5 billion. The data in simulation 3 indicate that an M_1 growth path of 8 percent for two quarters results in a maximum cumulative deviation from the control GNP path of 2.4 percentage points in the third quarter of the simulation period. By the end of the sixth quarter this simulated GNP growth pattern is approximately back on the control path. In dollar terms, the level of GNP in the third quarter of the simulation differs from the control path by $6.1 billion. While this difference may sound fairly large, it implies an error in the simulated level of GNP of less than 1 percent. Thus, even when M_1 growth deviates from the desired path by 2 percentage points in two successive quarters, the maximum impact of this divergence on the growth in GNP is relatively small as long as the unintended growth in money supply is offset in subsequent quarters.

The results of simulation 4, however, do produce what must be recognized as a significant deviation in GNP growth from the control path. Here, when M_1 growth exceeds the desired rate by 2 percentage points for three

[18] The level of nominal GNP in the fourth quarter of 1969 was used as the base for these simulations.

successive quarters, the maximum cumulative divergence from the GNP control simulation reaches 4.5 percentage points in the fourth quarter of the simulation (column 4C), which translates into a difference in the level of GNP of $11.6 billion.

Thus, on the basis of this experiment, it appears that 2 percentage point deviations from the desired growth path of M_1 for two successive quarters will involve relatively little deviation in terms of the pattern of growth—and ultimate level—of nominal GNP. However, if these deviations persist for three or more quarters, significant differences in the growth path of nominal GNP emerge and the time required to return to the control path of GNP lengthens proportionately.

Table VII reports the results of a separate set of simulations in which the M_1 growth path deviates from the desired path by 4 percentage points for one or more quarters (i.e., quarterly growth rates of 10 percent as opposed to the desired rates of 6 percent). In these simulations, a one-quarter deviation from the desired M_1 growth path does not yield significant differences in the growth pattern of GNP relative to the control simulation results. However, if the M_1 growth rate persisted at 10 percent for two or more quarters, significant differences do emerge. Thus, taken together, Tables VI and VII suggest that both the duration and the magnitude of deviations from the desired growth rate of M_1 may be of consequence in terms of the behavior of GNP.

The preceding discussion raises the question of how monetary authorities should respond to unexpected deviations from the desired growth path of M_1. Stated another way, what is the optimal strategy that the monetary authorities should employ in response to an observed deviation in M_1 from its desired growth rate? The analysis presented earlier suggests that, if the deviation is small—i.e., 1 or perhaps even 2 percentage points—the most appropriate response would probably be to ignore the deviation and continue to direct operations at the basic target (in this example 6 percent growth in M_1). However, if the error is large, the formulation of an optimal reaction strategy becomes more complex.

In general, of course, the formulation of the response strategy would depend in part on the direction of the error relative to the state of the economy. For example, assum-

Table VI

SIMULATED GROWTH PATTERNS OF NOMINAL GNP ASSUMING ALTERNATIVE PATTERNS OF MONETARY EXPANSION

Seasonally adjusted annual rates, in percent

Quarter	(1) Assuming steady growth in M_1 at 6 percent per quarter	(2) Assuming one-quarter deviation in monetary growth rate to 8 percent			(3) Assuming two-quarter deviation in monetary growth rate to 8 percent			(4) Assuming three-quarter deviation in monetary growth rate to 8 percent		
	%△ GNP	%△ GNP (A)	Difference from control (B)	Cumulative difference from control (C)	%△ GNP (A)	Difference from control (B)	Cumulative difference from control (C)	%△ GNP (A)	Difference from control (B)	Cumulative difference from control (C)
I	7.7	8.3	0.6	0.6	8.3	0.6	0.6	8.3	0.6	0.6
II	7.6	7.6	0	0.6	8.9	1.3	1.9	8.9	1.3	1.9
III	7.5	7.4	—0.1	0.5	8.0	0.5	2.4	9.3	1.8	3.7
IV	7.5	7.3	—0.2	0.3	7.0	—0.5	1.9	8.3	0.8	4.5
V	7.4	7.1	—0.3	0	6.6	—0.8	1.1	7.0	—0.4	4.1
VI	7.4	7.4	0	0	6.6	—0.8	0.3	5.9	—1.5	2.6
VII	7.4	7.4	0	0	7.1	—0.3	0	5.9	—1.5	1.1
VIII	7.4	7.4	0	0	7.4	0	0	6.5	—0.9	0.2
Addendum: Differences in levels of nominal GNP (in billions of dollars)										
I			1.5				1.5			1.5
II			1.5				4.8			4.8
III			1.2				6.1			9.4
IV			0.7				5.0			11.6
V			0				3.0			10.7
VI			0				0.8			6.7
VII			0				0			2.8
VIII			0				0			0.4

Table VII

SIMULATED GROWTH PATTERNS OF NOMINAL GNP ASSUMING ALTERNATIVE PATTERNS OF MONETARY EXPANSION

Seasonally adjusted annual rates, in percent

Quarter	(1) Assuming steady growth in M_1 at 6 percent per quarter	(2) Assuming one-quarter deviation in monetary growth rate to 10 percent			(3) Assuming two-quarter deviation in monetary growth rate to 10 percent			(4) Assuming three-quarter deviation in monetary growth rate to 10 percent		
	%△ GNP	%△ GNP (A)	Difference from control (B)	Cumulative difference from control (C)	%△ GNP (A)	Difference from control (B)	Cumulative difference from control (C)	%△ GNP (A)	Difference from control (B)	Cumulative difference from control (C)
I	7.7	8.9	1.2	1.2	8.9	1.2	1.2	8.9	1.2	1.2
II	7.6	7.5	—0.1	1.1	10.2	2.6	3.8	10.2	2.6	3.8
III	7.5	7.3	—0.2	0.9	8.5	1.0	4.8	11.2	3.7	7.5
IV	7.5	7.1	—0.4	0.5	6.5	—1.0	3.8	9.0	1.5	9.0
V	7.4	6.8	—0.6	—0.1	5.7	—1.7	2.1	6.4	—1.0	8.0
VI	7.4	7.4	0	—0.1	5.7	—1.7	0.4	4.3	—3.1	4.9
VII	7.4	7.4	0	—0.1	6.7	—0.7	—0.3	4.4	—3.0	1.9
VIII	7.4	7.3	—0.1	—0.2	7.3	—0.1	—0.4	5.7	—1.7	0.2
Addendum: Differences in levels of nominal GNP (in billions of dollars)										
I				3.1			3.1			3.1
II				2.9			9.4			9.4
III				2.3			12.0			18.6
IV				1.3			9.7			22.9
V				—0.2			5.3			20.7
VI				—0.3			0.9			12.7
VII				—0.4			—0.9			4.8
VIII				—0.5			—1.0			0.2

ing the economy is in a recession or underemployment situation, the authorities would presumably be somewhat more tolerant of overshooting the M_1 target than would be the case in a high employment or inflationary setting. Their response would also be conditioned by economic events during the period in which the money supply deviated from the desired growth path. That is, changing economic conditions could lead to a basic redefinition of policy targets that would in effect solve the response problem by default. Perhaps more importantly, the optimal response strategy would depend heavily on the nature of the initial disturbance that resulted in the undesired growth in money. For example, if the growth in M_1 accelerated because of some well-identified *temporary* shift in the demand for money, the acceleration in monetary growth would probably be self-correcting. Unfortunately, however, policy makers typically do not have sufficient information to make a firm judgment of the factors responsible for the unintended growth in the money supply. Therefore, the response of the monetary authorities to unintended growth in the money supply will often be formulated against a background of very imperfect knowledge of the underlying reasons for the unexpected behavior of M_1. In this sense, formulating an optimal response strategy can be viewed within the framework used in economic decision making. That is, the Federal Reserve System must formulate some loss function in that any strategy may entail some undesired effects or "losses". For example, simply ignoring the deviation (i.e., assuming it will be self-correcting) may entail the risk that money supply growth will remain above the desired rate, thereby giving rise to faster than desired growth in nominal GNP. Similarly, moving to offset the unintended growth—as was assumed to occur in the simulations in Tables VI and VII—may entail substantial "whipsaw" effects on money market conditions which in themselves may be further destabilizing. Thus, the policy strategy should be formulated in such a way as to minimize potential losses, given the information which is currently available.

To shed some light on the merits of alternate response strategies, a final set of simulations was conducted. In these simulations, it was assumed that M_1 growth had proceeded on target for three quarters but then accelerated to 10 percent. The simulations examined four different pat-

terns of response to the undesired acceleration in the rate of monetary growth on the assumption that developments in the economy did not give rise to the need to alter the basic policy objective of 6 percent growth in M_1. In the first, the monetary authorities were assumed to have offset fully the unexpected growth in money by forcing the M_1 growth rate to 2 percent in the following quarter and then returning it to 6 percent for the balance of the period (see Table VIII). In the second case, the offset was made over two quarters in which M_1 growth was held to 4 percent before returning to the 6 percent long-term average. In the third simulation, it was assumed that the monetary authorities made no attempt to offset the undesired growth in M_1 but merely moved back to the 6 percent target. In this case, the average quarterly rise in M_1 over the four quarters commencing in the quarter in which growth was 10 percent was not constrained to 6 percent. In the last simulation also, no attempt was made to offset the undesired growth, but it was assumed that it took two quarters to get M_1 growth back to the 6 percent figure.

In viewing these simulation results, it should be noted that each of them entails potentially different implications for money market conditions. Simulations I and II may imply a tightening—and perhaps a significant one—in money market conditions in periods $t + 1$ and/or $t + 2$, which would presumably be followed by some easing in $t + 3$ when M_1 growth moves back from 2 percent or 4 percent growth to the 6 percent figure. Simulations III and IV might also require some firming in money market conditions in $t + 1$. However, simulations III and IV would not entail the whipsaw effect implied by I and II. Whether or not these movements in money market conditions would occur—and the magnitude of any such moves—would depend upon the forces that trigger the initial disturbance that results in the 10 percent growth in money.

Table IX reports the simulated patterns of GNP expansion corresponding to each of the policy strategies outlined above. In all cases, the GNP growth rates tend to settle down at about 7.3 percent to 7.4 percent by the end of the simulation period since the M_1 growth path returns to 6 percent. Thus, the choice of a response strategy—to the extent that it can be made on the basis of nominal GNP[19]—must be based on the path of income growth and the overall amount of growth implied by each simulation. Cases I and II imply that GNP growth will decelerate for several quarters, then accelerate before leveling out at about 7.4 percent. For the four quarters ending in $t + 3$, these simulations imply GNP growth of 7.7 percent to 7.8 percent. Case III implies a more gradual deceleration in GNP growth which steadily moves back toward the stable growth rate of 7.4 percent. Over the four quarters ending in $t + 3$, the average growth rate in GNP is 8.6 percent, or 0.8 percentage point higher than the average of cases I and II. In case IV, the move back to the 7.4 percent growth in GNP is slower than in case III and the average growth rate in GNP over the four quarters ending in $t + 3$ rises to 9.1 percent, more than 1 percentage point greater than the increase in cases I and II.

On the basis of this comparison and the assumptions outlined earlier, it could be argued that strategy III would represent the preferable response to an unintended acceleration in the rate of monetary growth. This view is based on the following considerations: (1) The pattern of GNP growth is smoother than in cases I or II. (2) The overall rise in GNP in case III is within 1 percentage point of that in I or II. Perhaps more importantly, the difference in GNP growth in case III versus cases I and II does not seem large enough to justify the risks of the whipsaw effects on money market conditions that might accompany

Table VIII

ALTERNATIVE M_1 GROWTH RATES IN RESPONSE TO A ONE-QUARTER DEVIATION FROM THE DESIRED MONETARY GROWTH RATE

Seasonally adjusted annual rates, in percent

Quarter	Case I	Case II	Case III	Case IV
t—3	6	6	6	6
t—2	6	6	6	6
t—1	6	6	6	6
t	10	10	10	10
t+1	2	4	6	8
t+2	6	4	6	6
t+3	6	6	6	6
t+4	6	6	6	6
t+5	6	6	6	6
t+6	6	6	6	6

[19] It is not likely that the behavior of nominal GNP can be used as a one-dimensional loss function. Indeed, a precise definition of this function must specifically make allowance for the "losses" arising from other sources, such as increased volatility in interest rates or money market conditions. These costs can be approximated, but only within a much broader analytical framework than used above.

Table IX

SIMULATED PATTERNS OF NOMINAL GNP GROWTH UNDER ALTERNATIVE PATHS OF MONETARY EXPANSION

Seasonally adjusted annual rates, in percent

Quarter	Case I	Case II	Case III	Case IV
t	8.9	8.9	8.9	8.9
t+1	7.5	8.2	8.8	9.5
t+2	7.3	7.3	8.5	9.2
t+3	7.1	6.9	8.1	8.6
t+4	6.8	6.6	7.5	7.8
t+5	7.4	7.1	7.4	7.4
t+6	7.4	7.4	7.4	7.3
Average GNP growth rate over four quarters ending in t+3	7.7	7.8	8.6	9.1
Average GNP growth rate over seven quarters ending in t+6	7.5	7.5	8.1	8.4

an open market policy aimed at attaining the M_1 growth rates implied by I or II.

For the various reasons cited above, strategy III would seem preferable to either I or II. Relative to alternative IV, the third course of action also seems preferable simply because IV entails the risk that the rise in GNP over the four quarters ending in $t + 3$ could widen by more than 1 percentage point. Indeed, case IV seems to provide convincing evidence that wide deviations from the desired M_1 growth path should be corrected within two quarters. Beyond this, if strategy IV were followed and an unforeseen contingency such as the Penn Central crisis developed in $t + 2$, it might become impossible or impractical to slow further the rate of monetary growth. This might then result in a situation where monetary growth would remain above target for three quarters which, as noted earlier, might tend to have significant effects on GNP.

In summary, this exercise suggests that, in the face of imperfect information on the nature of disturbances that cause unexpected deviations from some desired growth path of M_1, the most appropriate operating strategy might be one in which the Federal Reserve simply attempts to bring the M_1 growth rate back to its desired rate in an orderly fashion. Stated another way, attempts to offset these deviations—even if successful in terms of M_1 behavior—do not significantly influence the overall behavior of GNP and may entail wide fluctuations in money market conditions.

SUMMARY

The major conclusions of this article can be summarized as follows:

(1) On the basis of econometric models used in this study, simulations of the behavior of nominal GNP using different econometric models and different time periods indicate that observed quarter-to-quarter fluctuations in the growth of M_1 have not resulted in growth paths of GNP that are significantly different from those that could have been reasonably expected to have occurred even if money growth were perfectly stable.

(2) The relative insensitivity of GNP to quarter-to-quarter fluctuations in M_1 growth is primarily the result of the lags in the relationship between money and income. Thus, the longer and more stable the lags are, the less important are these quarter-to-quarter changes in the M_1 growth rate.

(3) The simulations do imply that both the magnitude and duration of deviations in the money growth path from the desired path may be of some consequence. The evidence is strong that deviations from a desired monetary growth path should not be allowed to persist for more than two quarters even if they are relatively small—i.e., 2 percentage points. On balance, however, it appears that the M_1 control interval could be stated in terms of six-month intervals rather than shorter periods.

(4) In the face of uncertainty, a case can be made that open market policy should not attempt to offset one-quarter deviations in the monetary growth path—even if they are large. Rather, it could be argued that a preferable strategy is simply to bring M_1 growth back to its desired path in an orderly fashion.

All of these considerations suggest that the consequences of quarter-to-quarter fluctuations in the growth of the money supply may be considerably less important than is sometimes suggested. Of course, it can be argued that these tests are very imperfect criteria for evaluating the implications of short-run fluctuations in money supply growth, since they do not directly capture the adverse effects of the fluctuations on price and/or interest rate expectations or their possible implications for the general business atmosphere. While this point of view may have some validity, the analysis in this article also suggests that these adverse reactions to short-run fluctuations in the growth in money are not justified. Indeed, the "money supply watchers" would do well to focus their attention on money growth rates over periods of half years rather than month-to-month and quarter-to-quarter fluctuations in the growth of the money supply.