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In This Issue . . .

This issue contains four articles covering a broad range of policy issues. The first article focuses on the effects that changes in economic assumptions and circumstances have had on federal budget estimates since 1981. The second article studies the concentration of total deposits among banks in the Eighth District. The last two articles assess the predictability of the money multiplier and velocity growth, respectively.

In the first article, "The Critical Role of Economic Assumptions in the Evaluation of Federal Budget Programs," Keith M. Carlson examines the extent to which economic assumptions are responsible for the differences between President Reagan's initial March 1981 budget and the January 1983 budget.

The analysis focuses on the budget projections for fiscal 1986. In March 1981, the fiscal 1986 deficit was projected at $21 billion. In the January 1983 budget, this projection was revised upward to $203 billion without a proposed contingency tax plan. This change represents the net effect of deliberate changes in fiscal policy and changes in the economic assumptions underlying the projected receipt-expenditure patterns. If analysts wish to determine the extent to which policy changes are responsible for this changed projection, the effect of changes in economic assumptions on the deficit must be identified.

To identify this effect, Carlson recalculated the March 1981 budget on the basis of assumptions used in the January 1983 budget. He found that the changes in the budget estimates for fiscal 1986 that occurred between March 1981 and January 1983 were primarily influenced by revised economic assumptions and economic developments in 1982 that were considerably different from those foreseen in 1981. Consequently, changes in discretionary fiscal policy played a minor role in accounting for the sizable jump in the projected deficit for 1986.

In "Concentration in Local Commercial Banking Markets: A Study of the Eighth Federal Reserve District," Patrick J. Welch investigates the concentration of total deposits among banking organizations in 176 Eighth District local commercial banking markets and describes the distribution of observed levels of concentration according to a recently published Department of Justice criterion. He focuses on the extent to which concentration is due to total demand in local commercial banking markets, differences in state laws allowing branching and multibank holding companies, and physical space within local markets.

He finds that the majority of the markets studied are highly concentrated. Higher levels of concentration were found in markets that had smaller population and that were located in states that allow limited branching. The effect of state multibank holding company laws and the physical size of a market on concentration was ambiguous.

The third article, "Forecasting the Money Multiplier: Implications for Money Stock Control and Economic Activity" by R. W. Hafer, Scott E. Hein and Clemens J. M. Kool, examines one key aspect of monetary targeting: the ability to produce accurate forecasts of the money multiplier. The authors compare two techniques for generating such forecasts. One technique is based on the well-known procedures developed by Box and Jenkins. The second technique, which is derived from a Kalman filter process, represents a relatively new approach to multiplier forecasting.

The results indicate that both procedures yield quite accurate monthly multiplier forecasts. In general, however, the Kalman filter approach provides better results; that is, it has a lower average forecast error. The authors then simulate monthly and quarterly money growth rates for the 1980–82 period using both forecasting procedures for the money multiplier, by adjusting the level of the monetary base in line with the *ex ante* multiplier forecasts. The resulting multiplier forecast/money control procedure significantly reduces the quarterly variability of money growth.

Finally, the importance of reduced quarterly money growth volatility is examined by simulating nominal GNP growth for the period 1980–82 based on actual, desired and simulated M1 growth rates. The results show, other things equal, that reducing the quarterly volatility of money growth produces more stable economic growth.

In the last article, "Predicting Velocity Growth: A Time Series Perspective," Scott E. Hein and Paul T. W. M. Veugelers examine the accuracy of forecasting velocity growth over the last eight years. The forecasts generated are all *ex ante:* they utilize only information that was available at the time a forecast was made.

The evidence suggests that quarterly velocity growth fluctuates randomly about a fixed level. While it is clear that the magnitude of the quarter-to-quarter fluctuations has increased recently, the available evidence does not indicate that the fixed level has changed. Consequently, the best forecast of future velocity growth is simply the average level of past velocity growth. This simple forecasting approach to velocity growth generally works as well as other, more sophisticated procedures.

This article further provides evidence that it is easier to predict average velocity growth over longer time horizons than over shorter ones. The short-run random fluctuations in velocity growth are offsetting in nature, so that forecasting accuracy improves when longer-term velocity forecasts are made. This suggests that, other things equal, long-run GNP growth objectives are more likely to be achieved than short-run GNP goals.

The Critical Role of Economic Assumptions in the Evaluation of Federal Budget Programs

KEITH M. CARLSON

WHEN the Reagan administration announced its budget program in January this year, the projected deficits caused considerable public consternation. Near-term deficits were record-setting in magnitude and persistently large deficits loomed far into the future. The administration's January 1983 budget projections included a deficit of $225 billion (including off-budget outlays) for fiscal year 1983 and $157 billion in 1986. Without a proposed contingency tax plan, the administration estimated the fiscal 1986 deficit would be $203 billion.[1]

One problem inherent in evaluating prospective federal budgets is that receipts and outlays and, thus, the surplus or deficit depend crucially on the performance of the economy. This problem is magnified in a $3.2 trillion economy in which public attention still focuses on the *nominal* magnitude of the federal deficit. A decline of just one or two percentage points in the annual rate of real growth can add billions of dollars to the federal deficit.

The administration's January budget projections reflect both modifications of previous proposals and changes in economic assumptions. As a result, it is difficult to distinguish between the effect of the economy and the effect of policy shifts on the budget. Yet, if analysts wish to determine the extent to which policy changes are responsible for the changes in federal budget projections, the effect of changes in economic assumptions on the federal budget must first be identified.

To illustrate the critical role of economic assumptions, this article assesses the extent to which they are responsible for the differences between President Reagan's initial March 1981 budget and the January 1983 budget.[2]

THE SENSITIVITY OF THE BUDGET TO ECONOMIC ASSUMPTIONS

In recent years, the importance of economic assumptions in the process of preparing budget projections has grown. The last three budget documents contained sections on the sensitivity of the budget to economic assumptions. Yet, one of the best discussions of this interrelationship is still the 1962 Annual Report of the Council of Economic Advisers (CEA).

The Original 1962 CEA Analysis

The 1962 CEA developed a measure of discretionary fiscal action; at that time it was called the full-employment surplus.[3] This measure was developed because of

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[1] Since this article was prepared, the administration revised its estimate for fiscal 1986 to $139 billion. Without the contingency tax plan, the revised estimate would be $185 billion. See Office of Management and Budget, *Mid-Session Revision of the 1984 Budget* (July 1983).

[2] The conclusions of the article are not affected by the July 1983 revisions of the budget or of the GNP accounts.

[3] For a recent discussion of the full-employment (now called "high-employment") surplus, see Frank de Leeuw, Thomas M. Holloway, Darwin G. Johnson, David S. McClain and Charles A. Waite, "The High-Employment Budget: New Estimates, 1955–80," *Survey of Current Business* (November 1980), pp. 13–43; Frank de Leeuw and Thomas M. Holloway, "The High-Employment Budget: Revised Estimates and Automatic Inflation Effects," *Survey of Current Business* (April 1982), pp. 21–33; William Fellner, "The High-Employment Budget and Potential Output: A Critique," *Survey of Current Business* (November 1982), pp. 26–33; Frank de Leeuw and Thomas M. Holloway, "The High-Employment Budget and Potential Output: A Response," *Survey of Current Business* (November 1982), pp. 33–35.

the ambiguity associated with using the actual surplus or deficit as a measure of fiscal policy actions. The actual surplus or deficit depends on both the budget program *and* the state of the economy. Although the budget program fixes tax rates and expenditure programs, actual receipts and outlays vary automatically with economic activity. According to the 1962 CEA,

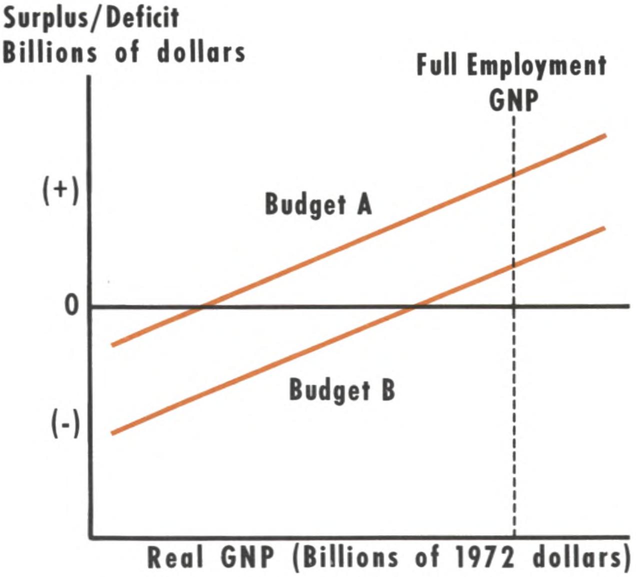
> To interpret the economic significance of a given budget it is, therefore, essential to distinguish the *automatic* changes in revenues and expenditures from the *discretionary* changes which occur when the government varies tax rates or changes expenditure programs.[4]

Figure 1 illustrates the reasoning behind the development of the full-employment surplus as a measure of discretionary fiscal action. On the horizontal axis is real gross national product (GNP); on the vertical axis is the dollar amount of the federal surplus or deficit.[5] Each budget line represents a fixed schedule of tax rates and expenditure programs with each line showing how the actual surplus or deficit depends on the level of real GNP. Given the U.S. tax structure, receipts increase with real economic activity, while outlays, which are sensitive to unemployment, tend to decrease with increases in real activity; thus, each budget line is upward sloping with respect to real GNP. Shifts of the budget line represent the action of policymakers on the budget, while movements along a budget line represent the effect of the economy on the budget.[6] Thus, for example, the budget line would shift from A to B if government outlays were increased or taxes reduced.

The advantage of using the analysis in figure 1 to compare different budget programs is that it separates the effect of the economy from the effect of the policymaker on the budget. Using figure 1, the 1962 CEA would have interpreted budget B as more expansionary than budget A; since, for example, government outlays are higher for budget B, a smaller share of full-employment real GNP is available for private purchase. Thus, full employment is easier to maintain because less private demand is required. Alternatively, inflation is more difficult to avoid because there are fewer goods and services to meet private demand. The figure illustrates clearly the pitfalls in assessing the economic impact of the budget by examining the surplus or deficit alone without regard for the level of economic activity.

Figure 1

Economic Activity at the Federal Budget



Shifts of the budget line indicate program shifts. Movements along the budget line indicate the automatic effect of changes in real GNP on the surplus or deficit. Changes in the surplus or deficit at full employment are a measure of program shift.

An Extended Analysis

The 1962 CEA analysis provides a useful starting point for analyzing budget policy in the 1980s. The analysis requires extension, however, in light of inflationary developments over recent years. This analysis is summarized in the schematic diagram on page 8 and figure 2, which focus on the determination of federal receipts and outlays.

Receipts — Given a structure of tax rates, the most important determinant of federal receipts is nominal GNP (see diagram). Most federal taxes are tied to bases that are sensitive to the movements of nominal GNP. Federal taxes are classified according to source: individual income, corporate income, social insurance, excise, and other. The most relevant bases for these tax sources are personal income, wages and salaries,

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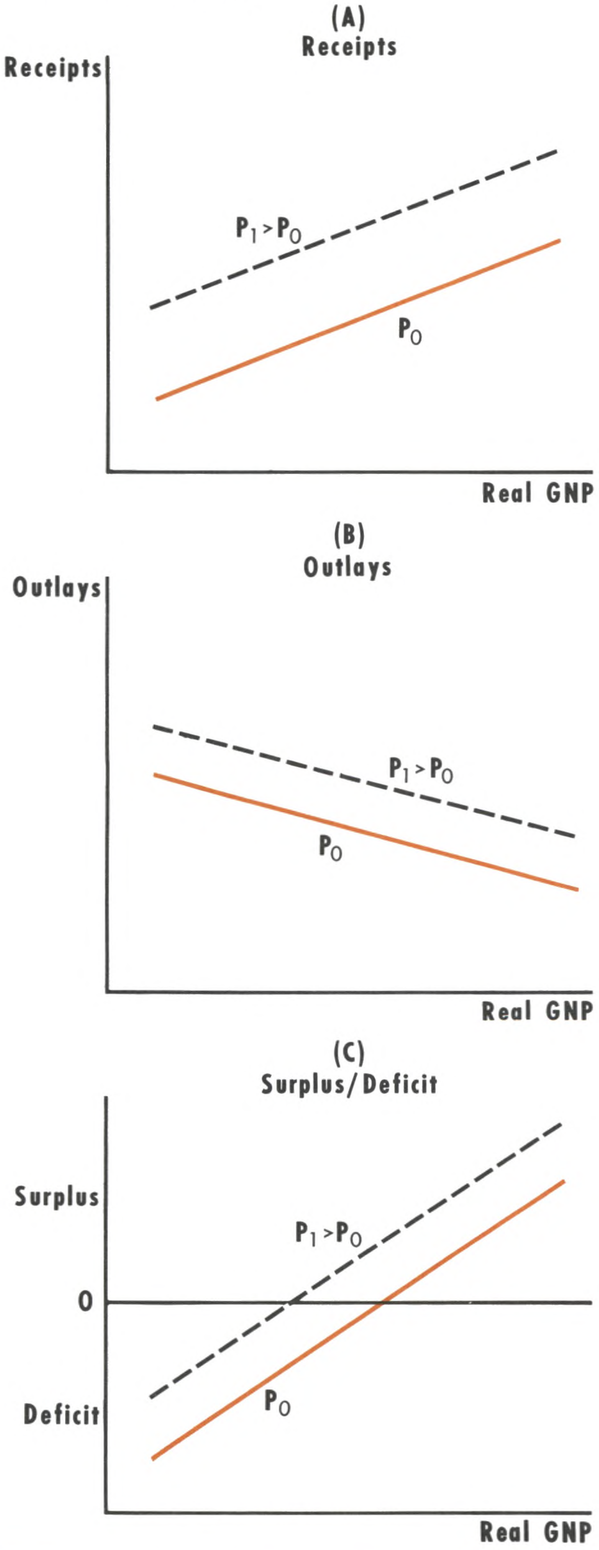
[4] *1962 Economic Report of the President*, which also includes the 1962 Annual Report of the Council of Economic Advisers, pp. 78–79.

[5] This differs slightly from the figure drawn in the 1962 CEA Report (p. 79). The CEA figure had the utilization rate (actual GNP as a percent of potential GNP) on the horizontal axis and the surplus/deficit as a percent of potential GNP on the vertical axis. To simplify the analysis here, dollar amounts are used on both axes.

[6] The purpose of the high-employment budget is to capture shifts of the budget line. This is done by focusing on the change in the surplus or deficit corresponding to a level of real GNP consistent with full employment of resources.

Figure 2

Economic Activity and the Federal Budget: An Extended Analysis



(A) Receipts

(B) Outlays

(C) Surplus/Deficit

corporate profits and sales. Each of these measures, in turn, moves closely with nominal GNP. A change in nominal GNP is translated quickly into a change in receipts in the same direction, largely because of the U.S. system of withholding and estimated payments.

The determination of federal receipts is shown in panel a of figure 2. Real GNP is plotted on the horizontal axis and receipts on the vertical axis. The dependence of receipts on nominal GNP is captured by drawing a different receipts line for each price level. Thus, with real GNP on the horizontal axis, the level of the receipts line is determined by the structure of tax rates and the price level. A policy change — that is, an increase (decrease) in tax rates — would be shown as an upward (downward) shift of the receipts line with prices unchanged. The effect of economic activity on receipts would be shown either as a movement along the receipts line or a shift because of a change in the price level. A higher price level will shift the receipts line upward; more receipts are collected at each level of real GNP because nominal GNP is higher as a result of a higher price level.

Outlays — Outlays (other than net interest) depend on both the price level and real GNP, but the response is different than for receipts (see schematic diagram). Price level effects on outlays have become more important in recent years as an increasing number of programs become indexed to the cost of living. Although social security is probably the best known of these programs, many other programs are now more or less automatically adjusted to offset price level changes. Changes in programs like Medicare and food stamps, in part, have reflected attempts to maintain program levels in response to changes in the price level.

In addition to programs that are adjusted automatically to changes in the price level, there are many government programs for which Congress makes discretionary changes to reflect changes in the price level. The most important program falling into this category is defense spending.

Besides the price level effects cited above, real economic activity also has an automatic effect on outlays. For the most part, this operates via the effect on unemployment: a reduction in real GNP or its rate of growth tends to increase unemployment and boosts expenditures for unemployment-sensitive programs.[7]

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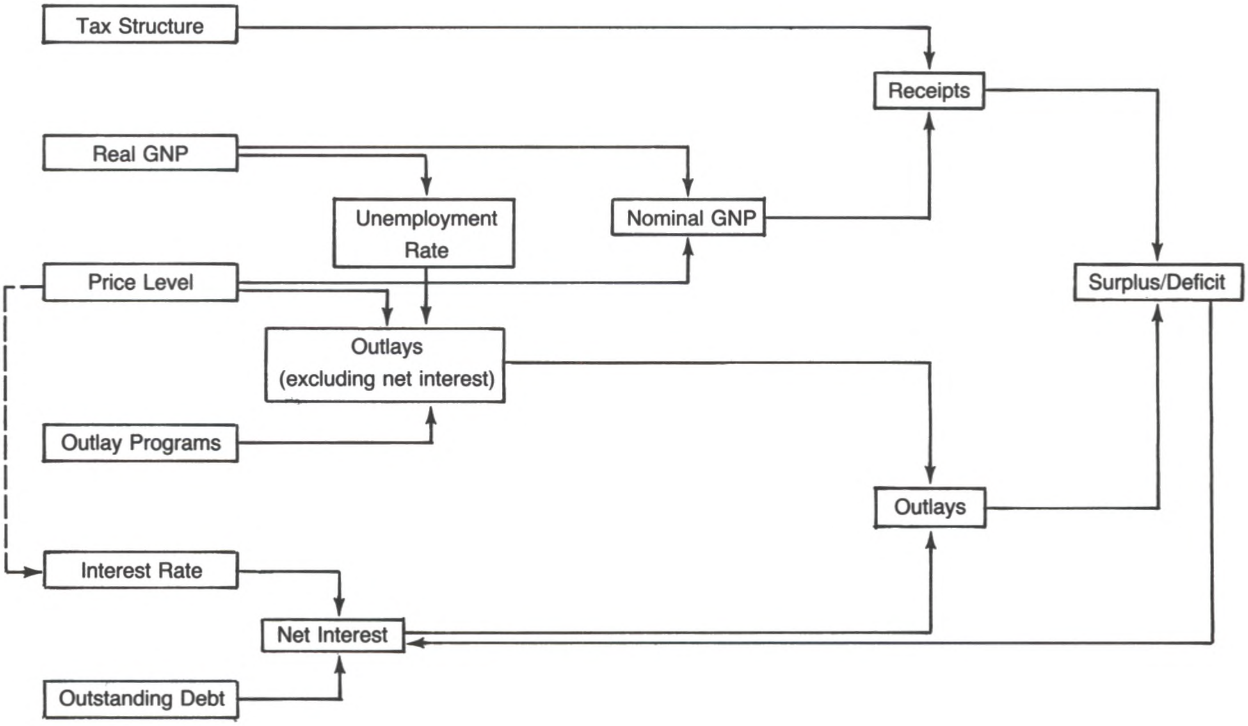
[7] This relationship between changes in real GNP and the unemployment rate is called Okun's law. See Arthur M. Okun, "Potential GNP: Its Measurement and Significance," *1962 Proceedings of the Business and Economic Statistics Section of the American Statistical Association*, pp. 98–104.

Schematic Diagram of Budget Determination



Although outlays for unemployment compensation are the best known of such programs, other types of expenditures are also affected by a slowing of real growth and rising unemployment. Among these are public assistance, food stamps and social security.

As shown in the schematic diagram, outlays are divided into two components: outlays other than interest and net interest. The reason for this division is that the determining factors operate differently. Net interest is singled out for special treatment because it depends on the interest rate and the amount of debt to be financed. The amount of debt to be financed, in turn, depends on the amount of debt inherited from earlier periods as well as the amount of the current surplus or deficit. Interest rate assumptions are a function of the rate of change of the price level rather than the level itself.

This complicated interaction of factors makes it difficult to generalize about the effect of economic assumptions on outlays. Nevertheless, panel b of figure 2 is an attempt to clarify the nature of the relationships.

If the outlay line is interpreted as outlays other than net interest, the analysis is straightforward. The determination of federal outlays is shown graphically in panel b of figure 2. Real GNP is charted on the horizontal axis and the dollar amount of outlays is charted on the vertical axis. The level of the outlay line is determined by the price level and by laws and programs relating to outlays. The line is downward sloping because an increase in real GNP reduces unemployment-sensitive outlays. The effect of a higher price level is to shift the outlay line upward. Outlays other than net interest will be greater for each level of real GNP because of indexed programs.

If, on the other hand, outlays are defined to include net interest, the effect of an increase in the price level on the outlay line is not unambiguously upward. For a given level of real GNP, an increase in the price level increases receipts. If the receipts effect is stronger than the outlay effect, the deficit declines (or the surplus increases), requiring a smaller amount of interest to be paid. Consequently, whether the outlay line shifts up or down in response to a change in the price level depends on the relative strength of the effect via noninterest outlays vs. the effect via the deficit and net interest.

Surplus/deficit — Panel c of figure 2 summarizes the net effect of factors determining receipts and outlays. With real GNP plotted on the horizontal axis and the surplus/deficit plotted on the vertical axis, the general appearance of the budget line is the same as figure 1. For a given fiscal program, an increase of real GNP results in a smaller deficit or larger surplus; an increase of real GNP increases receipts and reduces outlays. There is no ambiguity about the slope of the budget line when drawn with real GNP on the horizontal axis.

The nature of the response of the budget line to changes in the price level is a different matter. Whether the budget line shifts up or down depends on the relative shifts of the receipts and outlay lines. Receipts shift unambigously upward in response to a higher price level, but the effect on outlays is ambiguous. If there are a large number of indexed programs and the cost-of-living escalators are generous, or if a large number of discretionary programs are adjusted to price level changes, the upward shift of the outlay line could exceed that of the receipts line, leading to a downward shift of the budget line. Determining the effect of price level assumptions on the surplus or deficit is thus an empirical matter.

THE REAGAN BUDGET PROGRAM: 1981 VS. 1983

To illustrate the interaction of economic assumptions and budget projections, projections for fiscal year 1986 from the Reagan budgets of March 1981 and January 1983 are examined. The focus is on fiscal 1986 for several reasons: (1) a long horizon allows the effect of alternative assumptions to be brought into sharper focus; (2) most of the concern about the size of the budget deficit emphasizes the "out years," and thus approximates what the administration calls a "structural deficit"; (3) focusing several years out on the planning horizon, the full effect of the administration's budget program is captured.

The economic assumptions underlying the two Reagan budgets are summarized in table 1. The levels of GNP differ from those published in the relevant budget documents because of data revisions in the 1981–83 period. All GNP data in table 1 have been recalculated to be consistent with data as reported in early 1983.

Economic Assumptions

The GNP assumptions are presented in terms of both levels and rates of change. Normally, rates of change are more relevant. The levels of GNP are presented as well, however, because with a projection period of six years, small differences in rates of change can accumulate into significant differences in the levels.

As shown in table 1, the estimates of nominal GNP have been scaled down since 1981. The 1986 GNP estimate from the 1981 budget was $5,071 billion; the 1983 budget revised this estimate downward to $4,366 billion. In large part, this revision occurred because actual 1982 GNP turned out to be considerably below the projection made in 1981. The budget impact of this revised assumption is illustrated by assuming an average tax rate of 20 percent. With no change in tax laws (from late 1980), the effect of revised assumptions since early 1981 would be to reduce tax collections in 1986 by $140 billion [(4,336 − 5,071) × .20].

In 1981, the Reagan administration was very optimistic about future levels of real GNP. Real GNP for 1986 was projected at $1,873 billion (1972 dollars). In January 1983, this projection was revised downward to $1,707 billion. Over $100 billion of this revision was attributable to the overestimate of 1982 real GNP.

Price level estimates have also been scaled back since 1981. The 1981 budget projected the 1986 price level at 271.0 (1972 = 100). The lower-than-expected price level in 1982 produced a downward revision of projected price trends throughout the 1983–86 period.

Unemployment assumptions go hand-in-hand with the real growth assumptions. The administration's forecast of unemployment for 1986 was 5.6 percent. The 1983 budget jumped the unemployment assumption to 8.0 percent, reflecting both the sharp drop of real GNP in 1982 and the downward revision of the 1983–86 projections of real GNP.

Interest rate assumptions usually reflect inflation rates, but the assumptions shown in table 1 generally are not consistent with that relationship. In March 1981, the Reagan administration began with an optimistic outlook for interest rates for the long term, but the high interest rates of 1981 and 1982 led to a sharp upward revision in January 1983. Consequently, between 1981 and 1983 interest rate projections were increased even though projected inflation rates were reduced.

Table 1

Economic Assumptions of the Reagan Administration

	Actual	Assumed					
Date of forecast	1980	1981	1982	1983	1984	1985	1986
Nominal GNP (billions of dollars)							
March 1981	$2739	$3041	$3445	$3852	$4241	$4648	$5071
		(11.0)	(13.3)	(11.8)	(10.1)	(9.6)	(9.1)
January 1983	2739	3002	3102	3374	3685	4017	4366
		(9.6)	(3.3)	(8.8)	(9.2)	(9.0)	(8.7)
Real GNP (billions of 1972 dollars)							
March 1981	$1479	$1500	$1578	$1655	$1725	$1797	$1873
		(1.4)	(5.2)	(4.9)	(4.2)	(4.2)	(4.2)
January 1983	1479	1490	1472	1518	1578	1641	1707
		(0.7)	(−1.2)	(3.1)	(4.0)	(4.0)	(4.0)
GNP deflator (1972 = 100)							
March 1981	185.2	202.8	218.4	232.8	246.0	258.8	271.0
		(9.5)	(7.7)	(6.6)	(5.7)	(5.2)	(4.7)
January 1983	185.2	201.6	210.9	222.7	233.9	245.1	256.1
		(8.9)	(4.6)	(5.6)	(5.0)	(4.8)	(4.5)
Unemployment rate							
March 1981	7.5%	7.7%	7.0%	6.5%	6.3%	5.8%	5.6%
January 1983	7.5	8.3	10.7	10.6	9.7	8.7	8.0
Treasury bill rate							
March 1981	11.5%	11.1%	8.9%	7.8%	7.0%	6.0%	5.6%
January 1983	11.5	14.1	10.7	8.0	7.9	7.4	6.8

NOTE: All figures are for the fourth quarter of the year indicated (with percent change in parentheses), except for the Treasury bill rate which is an annual average. All figures have been adjusted to conform to the status of the data as presented in the January 1983 budget.

Budget Projections

The projections for the budget based on the economic assumptions in table 1 are summarized in table 2. The 1981 budget projected outlays (including off-budget) for 1986 at $961 billion. "Targeted" outlays were set at $912 billion, but the administration did not specify where the additional cuts were to be made. The 1983 budget projects 1986 outlays at $999 billion. This increase from $961 to $999 billion is roughly the amount by which actual 1982 outlays exceeded the original estimate.

The receipts side of the budget has taken a more dramatic turn since the Reagan administration took office in 1981. The 1981 Reagan budget projected receipts for 1986 at $940 billion. Included in this estimate were changes in tax law that reduced receipts by $218 billion from what they otherwise would be. Compared to the original Reagan proposals in 1981, total receipts estimates for 1986 have been scaled back by almost another $100 billion to $842 billion. Without the proposed contingency tax of $46 billion, the 1986 receipts estimate would be $796 billion.

The original Reagan budget projected the deficit for 1986 at $21 billion. The January 1983 budget has revised this estimate of the 1986 deficit to $157 billion. Without the contingency tax, the estimate of the 1986 deficit would be $203 billion.

AN ANALYSIS OF THE TWO REAGAN BUDGETS

The revisions in the budget by the Reagan administration appear to be very large, especially when attention is focused on the deficit for fiscal 1986. The January 1983 budget appears to be much more expansionary than the March 1981 budget. As shown in table 1, however, the economic assumptions have also been revised greatly. The questions asked here are to what

Table 2

Federal Budget Projections of the Reagan Administration (billions of dollars)

	Actual	Projected					
Date of projection	1980	1981	1982	1983	1984	1985	1986
Total receipts							
March 1981	$520.0	$600.3	$650.3	$709.1	$770.7	$849.9	$940.2
January 1983[1]	517.1	599.3	617.8	597.5	659.7	724.3	795.9
Total outlays (including off-budget)							
March 1981[2]	593.9	678.8	712.0	772.5	823.9	895.1	961.2
January 1983	590.9	678.2	745.7	822.2	862.5	929.0	999.0
Surplus/deficit (including off-budget)							
March 1981[1]	−73.8	−78.5	−61.7	−63.4	−53.2	−45.2	−21.0
January 1983[2]	−73.8	−78.9	−127.9	−224.8	−202.8	−204.7	−203.1

[1] Estimate for 1986 excludes proposed contingency tax of $46 billion.

[2] Estimate for 1986 excludes what the first Reagan budget called "additional outlay savings to be proposed."

extent have economic assumptions altered the estimates of the deficit in 1986, and to what extent do the revisions reflect program shifts?

Explanation of Procedure

To apply the analysis of figure 2 to the Reagan budgets, two alternatives are available. One is to convert the 1983 budget estimates to estimates based on the assumptions made in the 1981 budget. The other is to recalculate the 1981 budget on the basis of 1983 assumptions. Either way, the conclusion will be essentially the same, that is, the *relative* positions of the two budget lines will be about the same. The alternative chosen here is to compare the 1983 budget with the 1981 budget recalculated with assumptions from the January 1983 budget.

The primary basis for recalculating the 1981 budget is an estimate of the degree of response of outlays and receipts to changes in nominal and real GNP and the price level. These response coefficients were calculated from estimates given in the January 1983 budget.[8]

1981 vs. 1983 Budget: A Graphic Summary

Figure 3 summarizes the two budgets using the format developed in figure 2. A numerical summary appears in table 3.

Receipts — The solid line in the receipts panel of figure 3 is an estimate from the January 1983 budget of how 1986 receipts vary with real GNP, using the price level as projected in that budget. To compare the receipts line from the March 1981 budget (dashed line), one must recalculate those estimates with the January 1983 assumption about the price level. Once this is done, a comparison of the two receipts lines (the solid line and the dotted line), which can also be thought of as program lines, indicates very little change from 1981 to 1983.[9]

The main reason for the downward revision of receipts from March 1981 to January 1983 is the downward revision of the real GNP assumption. Table 3 divides the total change in receipts into price level

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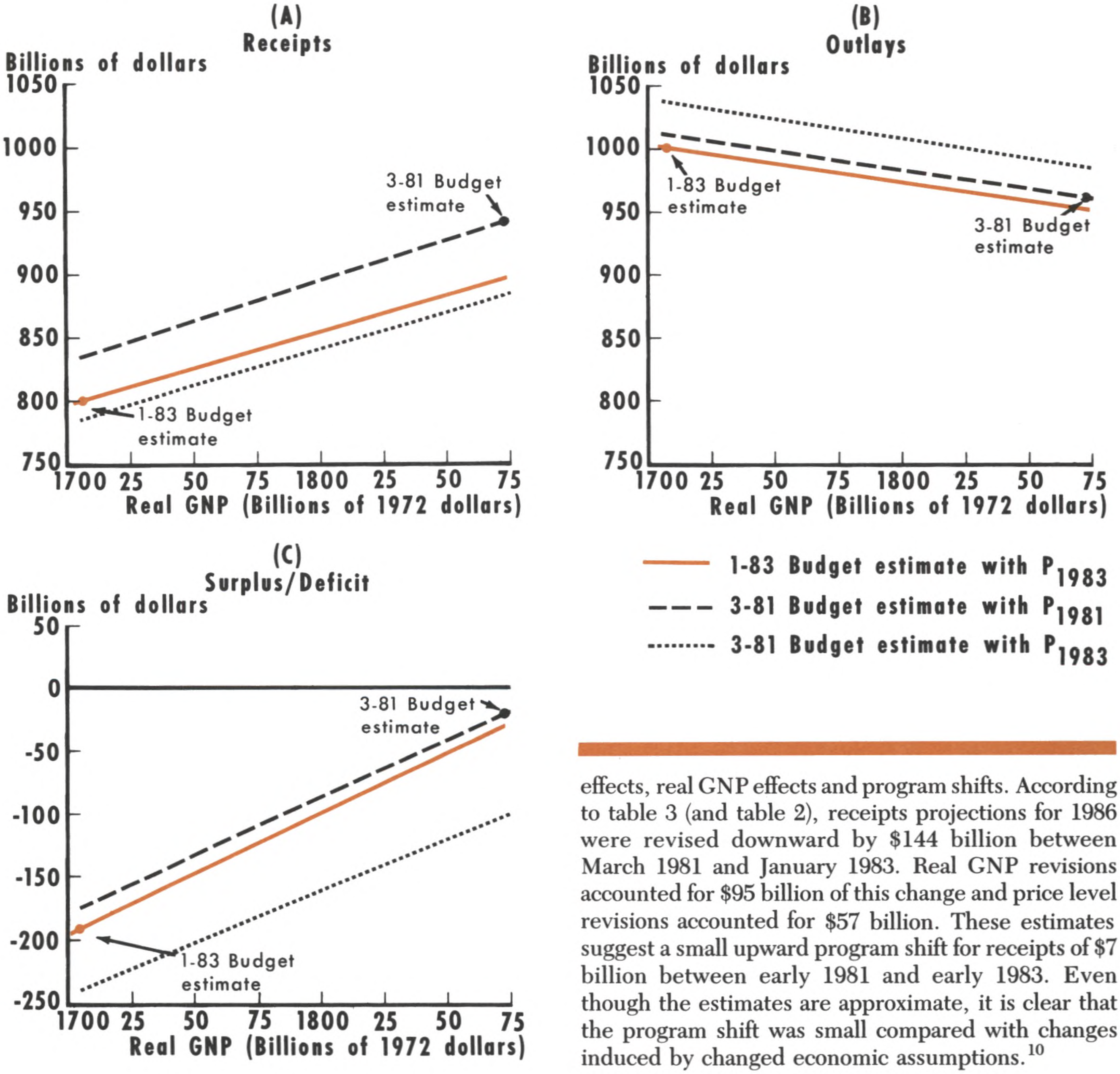
[8] Office of Management and Budget, *Budget of the United States Government: Fiscal Year 1984* (January 1983). Also see the appendix to this article. It should be noted that these estimates are approximate and, in the case of outlays, include only the effect of indexed programs.

[9] Even though figure 2 shows little change in the receipts program from 1981 to 1983, this does not imply that little has changed. The original Reagan tax plan was modified somewhat in the legislative embodiment of that plan, the Economic Recovery Tax Act of 1981. The other two major tax acts since 1981 are the Tax Equity and Fiscal Responsibility Act of 1982 and the Highway Revenue Act of 1982.

Figure 3

Economic Activity and the Federal Budget: March 1981 vs. January 1983

Estimates for fiscal 1986



effects, real GNP effects and program shifts. According to table 3 (and table 2), receipts projections for 1986 were revised downward by $144 billion between March 1981 and January 1983. Real GNP revisions accounted for $95 billion of this change and price level revisions accounted for $57 billion. These estimates suggest a small upward program shift for receipts of $7 billion between early 1981 and early 1983. Even though the estimates are approximate, it is clear that the program shift was small compared with changes induced by changed economic assumptions.[10]

Outlays — The outlay panel of figure 3 summarizes the effect on fiscal 1986 outlays of revised assumptions

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[10] Recall that this analysis is being conducted in the absence of the proposed contingency tax. Including that tax would show a sharp upward shift of the receipts line from 1981 to 1983.

Table 3

Decomposition of Changed Budget Estimates for Fiscal 1986 (billions of dollars)

	Total change 1981 to 1983	Change due to price level	Change due to real GNP	Change due to program shift
Receipts	$ − 144.3	$ − 56.7	$ − 95.0	$ 7.4
Outlays	37.8	24.7	44.2	− 31.1
Surplus/deficit	− 182.1	− 81.4	− 139.2	38.5

and program shifts from March 1981 to January 1983. A comparison of the solid and dotted lines indicates that the outlay line has shifted down significantly since 1981. According to these estimates, the fiscal 1986 outlay program has been reduced by $31 billion since March 1981.

The effect of changed price level assumptions on the March 1981 estimates requires further explanation. Compared to 1981, price level assumptions were reduced in January 1983. The effect of these revisions was to reduce outlays other than net interest.[11] However, with the assumed response coefficients, the effect of reduced price level assumptions lowered receipts more than outlays. As a result, deficits were larger and more interest would have to have been paid to finance these deficits. The indirect effect of a lower price level operating via net interest dominates the direct effect on outlays over a five-year period.

The numerical summary in table 3 indicates that changed assumptions about real GNP and the price level "overexplained" the $38 billion upward revision of the 1986 outlay projection. In other words, changed economic assumptions indicated an increase of outlays of $69 billion, whereas the outlay projection was actually increased by $38 billion. Within this framework of analysis, this implies a downward program shift for outlays of $31 billion between early 1981 and early 1983.

Surplus/deficit — Figure 3 shows that the budget line shifted upward from March 1981 to January 1983.[12] As summarized in table 3, the 1986 budget line shifted upward by $39 billion. On the surface, this shift appears quite large, but relative to the changes attributable to revised economic assumptions, it is quite small.

CONCLUSIONS

This article has focused on the critical role that economic assumptions play in projections of the federal budget. As an example, estimates for fiscal year 1986 from the Reagan budgets of March 1981 and January 1983 were compared. The analysis indicates that the changes in budget estimates for fiscal 1986 that occurred between March 1981 and January 1983 were primarily influenced by revised economic assumptions and economic developments in 1982 that were considerably different than foreseen. Changes in discretionary fiscal policy played a minor role in accounting for the sizable jump in the projected deficit for 1986 that occurred between the two budget proposals.

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[11] Note that the discussion is with reference to the effect of changed price level assumptions on the March 1981 estimates of outlays for fiscal 1986.

[12] Note that this shift is still in the planning stage. Realization of the shift requires legislation by the Congress of administration proposals.

Appendix
Estimating the Response of the Budget to Alternative Economic Assumptions

To estimate the effect on budget projections of an alternative set of economic assumptions, the budget was categorized as follows:

1) total receipts excluding earnings of the Federal Reserve System;
2) total outlays (including off-budget) excluding net interest and earnings of the Federal Reserve System;
3) net interest.

The basic source for estimates of the relevant elasticities was the *Budget of the United States Government: Fiscal Year 1984* (January 1983), pp. 2-19–2-24.

Total receipts excluding FRS earnings

The elasticity of receipts with respect to GNP was calculated from the example in the fiscal 1984 budget. The implied coefficients were

$$\Delta\dot{R}_t = .49\Delta\dot{Y}_t + .39\Delta\dot{Y}_{t-1} + .12\Delta\dot{Y}_{t-2} + .08\Delta\dot{Y}_{t-3} + .07\Delta\dot{Y}_{t-4},$$

where

$\Delta\dot{R}_t$ = change in percent change of receipts in fiscal year t;

$\Delta\dot{Y}_t$ = change in percent change in nominal GNP in fiscal year t.

Total outlays excluding net interest and FRS earnings

Outlays are responsive to both real growth and inflation. The implied coefficients for the elasticity of outlays with respect to real growth were

$$\Delta\dot{O}_t = -.08\Delta\dot{X}_t - .13\Delta\dot{X}_{t-1} - .05\Delta\dot{X}_{t-2} - .06\Delta\dot{X}_{t-3} - .04\Delta\dot{X}_{t-4},$$

where

$\Delta\dot{O}_t$ = change in percent change of outlays in fiscal year t;

$\Delta\dot{X}_t$ = change in percent change in real GNP in fiscal year t.

The implied coefficients for the elasticity of outlays with respect to inflation were

$$\Delta\dot{O}_t = .01\Delta\dot{P}_t + .06\Delta\dot{P}_{t-1} + .09\Delta\dot{P}_{t-2} + .05\Delta\dot{P}_{t-3} + .02\Delta\dot{P}_{t-4} + .02\Delta\dot{P}_{t-5},$$

where

$\Delta\dot{P}_t$ = change in percent change in the GNP deflator in fiscal year t.

These estimates are for indexed program outlays only; excluded are changes that might result from congressional or executive action to maintain real program or benefit levels for discretionary programs.

Net interest, surplus/deficit and debt

To estimate net interest, the surplus/deficit and debt held by the public, the following three-equation system was solved:

$$1)\ I_t = I_{t-1} + (i_t - i_t^m)\left(\frac{1}{2}\alpha_t D_{t-1}\right) + i_t\left[\frac{1}{2}(D_t - D_{t-1})\right]$$

$$2)\ D_t = D_{t-1} - S_t + \Delta C_t$$

$$3)\ S_t = R_t - O_t - I_t,$$

where

t = fiscal year (flows are during the year and stocks are end of year);
I_t = net interest in fiscal year t (excluding FRS earnings);
D_t = debt held by the public (including FRS) at the end of fiscal year t;
S_t = budget surplus;
ΔC_t = change in Treasury cash balance;
R_t = receipts as calculated above;
O_t = outlays as calculated above;
i_t = average of 3-month Treasury bill and 10-year Treasury note rates;
i_t^m = average interest rate on debt maturing during period t;
α_t = proportion of debt maturing in period t.

Concentration in Local Commercial Banking Markets: A Study of the Eighth Federal Reserve District

PATRICK J. WELCH

CONCENTRATION measures indicate the extent to which some specific magnitude, such as total deposits, sales or capacity, is controlled by one or a few decision-making units in a market. At the firm level, which is the focus of this study, concentration depends on the number of firms in the market and their relative sizes.[1] Accordingly, the fewer the banking organizations in a local commercial banking market or the more unevenly deposits are distributed among a given number of organizations within a market, the higher the concentration in that market.

The degree of market concentration is important because it may affect the overall "performance" of the market — the extent to which firms in the market act independently, aggressively adopt new technologies, provide desired types and levels of services and carry out other activities that benefit buyers, suppliers and others. While the existence of a systematic link between concentration and performance is open to debate, there are many, including the U.S. Department of Justice, who believe that a high level of concentration in a market will affect the market's performance adversely.[2] Thus, if a market is characterized as being highly concentrated, some form of policy intervention may be proposed to monitor or modify market performance.

The concentration of total deposits among banking organizations in 176 Eighth District local commercial banking markets is described in this study.[3] Also described is the distribution of observed levels of concentration according to a recently published Department of Justice criterion for classifying markets as highly concentrated, moderately concentrated and unconcentrated. Finally, the effects on concentration due to

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[1] Concentration also can be measured at the plant level.

[2] The Department of Justice, in its June 1982 merger guidelines, noted that:

> Other things being equal, concentration affects the likelihood that one firm, or a small group of firms, could successfully exercise market power. The smaller the percentage of total supply that a firm controls, the more severely it must restrict its own output in order to produce a given price increase, and the less likely it is that an output restriction will be profitable. Where collective action is necessary, an additional constraint applies. As the number of firms necessary to control a given percentage of total supply increases, the difficulties and costs of reaching and enforcing consensus with respect to the control of that supply also increase.

U.S. Department of Justice, "Merger Guidelines," *Federal Register* (June 30, 1982), p. 28497.

For more on the concentration-performance relationship, see Donald R. Fraser and Peter S. Rose, "Banking Structure and Performance in Isolated Markets: The Implications for Public Policy," *The Antitrust Bulletin* (Fall 1972), pp. 927–47; Arnold A. Heggestad and John J. Mingo, "Prices, Nonprices, and Concentration in Commercial Banking," *Journal of Money, Credit and Banking* (February 1976), pp. 107–17; Almarin Phillips, "Competition, Confusion, and Commercial Banking," *The Journal of Finance* (March 1964), pp. 32–45; and Thomas R. Saving, "Concentration Ratios and the Degree of Monopoly," *International Economic Review* (February 1970), pp. 139–46.

[3] Banking organizations included in the study are unit banks, multibank holding companies and branch banking organizations. Chain banking relationships arising through common ownership or management interlocks are not considered due to data limitations. Thus, observed levels of concentration may understate the effective degree of control in particular markets.

For other studies of the relationships among banking organizations in the Eighth District, see Gerald P. Dwyer, Jr., and William C. Niblack, "Branching, Holding Companies, and Banking Concentration in the Eighth District," this *Review* (July 1974), pp. 11–23; Ross M. Robertson, "The Structure of Banking in the Eighth District: Branches and Mergers," this *Review* (April 1956), pp. 45–51; and Ross M. Robertson, "The Structure of Banking in the Eighth District: Chains, Groups and Interindustry Competition," this *Review* (October 1956), pp. 113–21.

demand in local commercial banking markets, differences in state laws allowing branching and multibank holding companies, and physical space within local markets are considered.

The study is divided into three sections: First, definitions and the measure of concentration are introduced. Second, the concentration of total deposits among banking organizations in local commercial banking markets is reported and analyzed.[4] A summary and conclusions are then presented.

THE MEASUREMENT OF CONCENTRATION

Concentration and the Definition of Relevant Commercial Banking Markets

Market boundaries separate sellers who compete directly from those with whom there is no direct competition. Consequently, the measure of concentration in a market depends in a critical way on the manner in which the boundaries of the market are defined. All else equal, the more narrowly defined the market, the higher the measured concentration for a specific number of firms.

The definition of a market's boundaries depends on two considerations: the products that are judged to be close substitutes and the geographic space over which the producers of those products compete for the same buyers.[5] In this study, the product analyzed is commercial banking services. While this specification is narrower than if thrifts were included, it is chosen because commercial banking, considered as a separate line of commerce, is the point of reference in court decisions and Federal Reserve System guidelines that affect bank market concentration.[6]

The geographic boundaries of markets in this study are those established by the Federal Reserve Bank of St. Louis in its analysis of bank holding company and bank merger applications. A frequent alternative to this approach is to define banking markets along county or Standard Metropolitan Statistical Area (SMSA) lines.[7] This alternative, however, is rejected under the assumption that market boundaries need not coincide with political boundaries.[8]

The Selection of a Concentration Measure

Once the relevant markets are defined, the concentration measure must be selected and its quantitative value obtained for each market.

Because concentration measures are based on the behavior of a single variable, such as capacity, value added or sales, the results and rankings obtained using one variable may differ from those obtained using another. This is especially a problem when dealing with commercial banks, which are multiproduct firms

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[4] Deposits in banking organizations in the 176 observed markets are evaluated as of June 30, 1981, and come to \$51.31 billion, or 86.99 percent of the \$58.98 billion total deposits in the Eighth District on that date. The balance of the deposits is from areas within the Eighth District where specific markets were not defined. Foreign deposits are not included in the calculation of total deposits.

Total deposit data are from "Report of Condition," June 30, 1981, and "Summary of Deposits," June 30, 1981, compiled by the Federal Deposit Insurance Corporation. Data on multibank holding companies and branch relations are from "Bank and Branch Structure File," June 30, 1981, compiled by the Board of Governors of the Federal Reserve System from secondary sources.

[5] For studies treating market definition criteria, see Deane Carson and Paul M. Horvitz, "Concentration Ratios and Competition," *The National Banking Review* (September 1963), pp. 105–10; Stephen A. Rhoades, *Structure-Performance Studies in Banking: A Summary and Evaluation*, Staff Economic Studies 92 (Board of Governors of the Federal Reserve System, 1977); Michael E. Trebing, "The New Bank-Thrift Competition: Will It Affect Bank Acquisition and Merger Analysis?" this *Review* (February 1981), pp. 3–11; and David D. Whitehead, "Relevant Geographic Banking Markets: How Should They Be Defined?" Federal Reserve Bank of Atlanta *Economic Review* (January/February 1980), pp. 20–28.

[6] For example, in a Board of Governors memo on the consideration of thrifts in competitive analysis, it was concluded that:

> The present general framework of competitive analysis should continue, with initial consideration always of competitive effects on the structure and performance of commercial banking alone. . . .

Letter, William W. Wiles, Associate Director, Division of Banking Supervision and Regulation, Board of Governors of the Federal Reserve System, to the officers in charge of Examinations, Legal, and Research Departments at all Federal Reserve Banks, June 25, 1980.

For examples and explanations of the courts' definition of commercial banking as a separate line of commerce, see *United States v. Philadelphia National Bank*, 374 U.S. 321, 355–57 (1963); *United States v. Connecticut National Bank*, 418 U.S. 656, 660–66 (1974); and *United States v. First National State Bancorporation*, 499 F. Supp. 793, 799-801, 810–11 (D.N.J. 1980).

[7] For a summary of alternative geographic market definitions in banking structure-performance studies, see Rhoades, *Structure-Performance Studies*, appendix table.

[8] The distinction between the county/SMSA market definition and the definitions used in this study may be more important in principle than in effect. Of the 176 banking markets examined, 99 (56.25 percent) coincide with single counties, 24 (13.64 percent) coincide with two or more whole counties, and 53 (30.11 percent) coincide with parts of individual counties, whole counties plus parts of other counties or Ranally Metropolitan Areas.

and thus offer a wide range of variables as potential candidates for evaluation. This study focuses on total deposits in commercial banks because of its importance in Federal Reserve Board policy decisions that affect concentration in commercial banking markets.[9]

The concentration of total deposits in each local market is calculated using a Herfindahl index (H-index), which is the sum of the squared market shares of the organizations in the market.[10] Each banking organization's share of a market is equal to the percentage of total deposits in the market that it controls.

The H-index is chosen over other concentration measures for three reasons. First, the recently published Department of Justice merger guidelines rely primarily on the H-index to measure concentration.[11] Second, unlike other widely used concentration measures, the H-index is explicitly sensitive to the impact on concentration of the number of sellers in a market and their relative sizes.[12] Third, H-index numbers translate conveniently into "numbers-equivalents," which are useful for making intermarket comparisons of concentration. The numbers-equivalent is the number of equally sized sellers that would generate an H-index value equal to the observed value.[13]

ANALYSIS OF LOCAL MARKET CONCENTRATION

Summary of Concentration in Local Commercial Banking Markets

On the basis of its H-index value, each local commercial banking market in the Eighth District is placed into one of 15 concentration categories. These categories, along with their respective H-index value ranges and the numbers-equivalents indicating the least concentrated market consistent with placement in each category, are listed in table 1. Also listed in table 1 is the distribution of all 176 markets among H-index categories, the distribution among categories of markets in each state, and the distribution among categories of markets that cross state lines. For all markets taken together, the mode category is H4 (the equivalent of from 3 to 2 equal-sized banking organizations in a market), and the median is in category H5 (the equivalent of from 4 to 3 equal-sized banking organizations in a market).

The extent of concentration in the observed banking markets can be further categorized according to the Department of Justice guidelines for evaluating horizontal mergers. Markets with H-index values less than 0.10 are considered to be "unconcentrated," markets with H-index values greater than 0.18 are considered to be "highly concentrated," and markets with H-index values between 0.10 and 0.18 are considered to be "moderately concentrated."[14] This categorization is listed in the right-hand column of table 1.

Generally, as illustrated in table 1, local commercial banking markets in the Eighth District are highly concentrated by the Department of Justice criterion: over 80 percent of the markets studied fall into the highly concentrated group. Several factors that help explain why concentration is higher in some markets than in others are discussed below.

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[9] See, for example, orders on bank holding company cases published in the *Federal Reserve Bulletin*.

[10] H-index = $\sum_{i=1}^{n} \left(\frac{td_i}{TD}\right)^2$, where td_i is total deposits in the ith commercial banking organization in a market, TD is total deposits in all commercial banking organizations in that market, and n is the number of banking organizations in that market. The H-index can assume a value of from 1/n through 1. As a market becomes more concentrated, either through a decrease in the number of sellers or a widening inequality among a given number of sellers' market shares, the H-index number approaches 1.

For discussions of concentration measures, see "Measures of Banking Structure and Competition," *Federal Reserve Bulletin* (September 1965), pp. 1212–22; and Christian Marfels, "A Bird's Eye View to Measures of Concentration," *The Antitrust Bulletin* (Fall 1975), pp. 485–503.

[11] U.S. Department of Justice, "Merger Guidelines," p. 28497.

[12] Top level concentration measures (e.g.: three-firm, four-firm or eight-firm concentration ratios and curves) focus primarily on the market shares of the largest firms with passing, if any, consideration of smaller sellers in a market. Lorenz curves measure inequality in the distribution of market shares, with no particular reference to the number of sellers in a market.

It should be noted that the greater sensitivity of the H-index does not necessarily make it superior to other measures of concentration. The appropriateness of any measure must be judged according to the theoretical relationship it is describing.

[13] The numbers-equivalent is the reciprocal of the Herfindahl index number: 1/H-index.

[14] The "unconcentrated," "moderately concentrated" and "highly concentrated" distinctions are based on post-merger H-index values. The Department of Justice has indicated that it is unlikely to challenge mergers in markets where the post-merger H-index value is less than 0.10; unlikely to challenge mergers that increase the H-index value by less than 0.01 in markets where the post-merger H-index value is between 0.10 and 0.18; and unlikely to challenge mergers that increase the H-index value by less than 0.005 in markets where the post-merger H-index value is greater than 0.18. The Department of Justice also has identified other factors that are of consequence in evaluating the effects of horizontal mergers. See U.S. Department of Justice, "Merger Guidelines," pp. 28496–99.

Table 1

Distribution of Local Commercial Banking Markets Among Herfindahl Index and Department of Justice Concentration Categories

Category	H-Index Value Range	Numbers-Equivalent (maximum number of equal-sized firms)	All Markets	States AR	IL	IN	KY	MS	MO	TN	I.M.[1]	Dept. of Justice Categories
H1	1.0	1	2						2			Highly concentrated (147 markets)
H2[2]	0.55556 to 1.0	1.8	3	1			1		1			
H3	0.5 to 0.55556	2	14	7		2	2		3			
H4	0.33333 to 0.5	3	50	6	6	1	9	9	15	3	1	
H5	0.25 to 0.33333	4	40	6	3	3	8	4	11	4	1	
H6	0.2 to 0.25	5	34	5	8		3	5	9	1	3	
H7	0.18 to 0.2	5.556	4	2			1				1	
H8	0.16667 to 0.18	6	5		1		1		2	1		Moderately concentrated (24 markets)
H9	0.14286 to 0.16667	7	10	1	1	2			3	1	2	
H10	0.125 to 0.14286	8	5	1	2			1			1	
H11	0.11111 to 0.125	9	2							1	1	
H12	0.1 to 0.11111	10	2		1				1			
H13	0.08333 to 0.1	12	4	1	2						1	Unconcentrated (5 markets)
H14	0.07143 to 0.08333	14										
H15	0.0625 to 0.07143	16	1								1	
Totals			176	30	24	8	25	19	47	11	12	

[1]Interstate markets

[2]H-index = 0.55556 is the Herfindahl value associated with a two seller market, where one seller is twice as large as the other.

What Factors Influence the Extent of Concentration?

Concentration and Demand — One factor that can influence concentration is the level of demand in a market. All other things equal, lower demand would be expected to lead to fewer sellers and greater concentration in a market. Such a relationship can be explained on efficiency grounds. Operation below some specified level of output prevents a seller from fully exploiting the scale economies that allow unit costs to fall as output increases. Such scale economies result, for example, from the utilization of specialized inputs, or efficiencies from consolidating previously separate activities. The level of output at which scale economies are exhausted (i.e., at which unit costs are minimized) is termed the "minimum efficient scale," and the number of sellers that can achieve that level of output is influenced by the size of the market as measured in terms of demand: the greater the demand in a market, the greater the number of sellers achieving minimum efficient scale it can accommodate. As a result of this interaction between scale economies and demand, there is an upper limit on the number of sellers which can operate at or above a minimum efficient level of output in a market.

In this study, total population in the market is used as a proxy for market demand: the greater the population, the greater the demand.[15] The distribution of Eighth District local commercial banking markets according to total population is shown in table 2.

To test for the effect of demand on concentration, a simple statistical procedure is used. One hypothesis,

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[15] Population and related data are from *1982 Commercial Atlas and Marketing Guide* (Rand McNally and Co., 1982), pp. 94–95, 130–31, 194, 320, 374–75, 377; *Rand McNally Road Atlas* (Rand McNally and Co., 1982), pp. 26–27; Bureau of the Census, *1980 Census of Population*, Vol. 1, Characteristics of the Population (U.S. Government Printing Office, 1982), Part 5, Arkansas, pp. 5-8, 5-33; Part 15, Illinois, pp. 15-8, 15-23; Part 16, Indiana, p. 16-8; Part 19, Kentucky, p. 19-8; Part 26, Mississippi, p. 26-8; Part 27, Missouri, p. 27-8; Part 38, Oklahoma, p. 38-8; and Part 44, Tennessee, p. 44-8.

It is necessary to estimate the populations of markets that include parts of counties. For these markets, it is assumed that population is distributed evenly across each relevant county, so that the proportion of a county's physical space included in a market is equal to the proportion of that county's population included in the market.

Table 2

Distribution of Local Commercial Banking Markets by Total Population

Total Population (in thousands)	Number of Banking Markets
0 to 25	84
25 to 50	54
50 to 75	22
75 to 100	2
100 to 125	3
125 to 150	1
150 to 175	3
175 to 200	2
200 to 300	1
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400 to 500	1
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800 to 900	2
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2000 to 3000	1

Table 3

Distribution of the 88 Least Populated and 88 Most Populated Local Commercial Banking Markets by Herfindahl Index Category

Herfindahl Index Category[1]	88 Least Populated Markets	88 Most Populated Markets
H1	2	
H2	3	
H3	11	3
H4	36	14
H5	22	18
H6	13	21
H7		4
H8	1	4
H9		10
H10		5
H11		2
H12		2
H13		4
H14		
H15		1

[1] See table 1.

termed the null hypothesis, states that H-index values in the 88 smallest (least populated) markets are essentially the same, on average, as those for the 88 largest (most populated) markets. The alternative hypothesis is that H-index values in the 88 least populated markets are higher, on average, than those for the 88 most populated markets. Table 3 lists the distributions among the 15 H-index categories of markets in the 88 least populated and 88 most populated groupings.

The null hypothesis is evaluated and rejected using the chi-square approximation of the Kolmogorov-Smirnov two-sample test.[16] This result suggests that relatively higher levels of concentration can be expected in markets with smaller populations.

Concentration, State Banking Laws and Market Space — In any given market, a reorganization of sellers that reduces their number or increases the market share of one large firm generally increases the H-index value for that market. In commercial banking, the merging of two or more previously competing banks into a multibank holding company generally would increase concentration. Similarly, an increase in the number of branches in a market by a large bank would increase concentration if it draws deposits away from smaller banks. Thus, in principle, legislation allowing multibank holding companies or branching would be expected to increase concentration.

On June 30, 1981, there were several different legislative environments within which Eighth District banking organizations operated. Illinois allowed neither branching nor multibank holding companies;

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[16] The chi-square approximation of the Kolmogorov-Smirnov two-sample test is $\chi^2 = \frac{4D^2(n_1n_2)}{n_1 + n_2}$, where n_1 and n_2 are sample group sizes, and D is the maximum difference between the cumulative frequencies of the sample groups, as indicated by inspection of each of the categories in which the sample groups are compared. When the calculated test statistic is compared with values from the chi-square distribution with two degrees of freedom, the null hypothesis can be rejected at a particular level of confidence when the calculated statistic exceeds the appropriately defined chi-square value. See Sidney Siegel, *Nonparametric Statistics for the Behavioral Sciences* (McGraw-Hill Book Company, 1956), pp. 127–36.

The value of the test statistic, using a one-tailed test, is 34.57 for the 88 least populated vs. 88 most populated markets comparison. At the 0.1 percent level, this exceeds the chi-square statistic with two degrees of freedom of 13.82.

Arkansas, Indiana, Kentucky and Mississippi allowed limited branching but not multibank holding companies; Missouri allowed multibank holding companies but not branching; and Tennessee allowed both limited branching and multibank holding companies.[17]

To test for the effect of state banking laws on local market concentration, three market groupings are evaluated using multiple regression analysis. In the first grouping, the H-index values for the 164 markets that do not cross state lines are regressed on market population, a multibank holding company dummy variable and a branching dummy variable. In the second and third groupings, the H-index values for local markets are regressed on market population, the multibank holding company dummy variable, the branching dummy variable and a "square miles" variable, introduced to capture the effect on concentration of physical space within a market. All else equal, it is expected that the greater the geographic size of a market, the larger the number of firms it can accommodate, and the lower the concentration.

The space variable is measured in terms of square miles of county rather than square miles of market as defined by competitive relationships. Therefore, the second grouping is limited to the 120 Eighth District local commercial banking markets that do not cross state lines and that are made up of one or more whole counties. The third grouping is composed of 598 single counties in the states encompassing the Eighth District, except Mississippi, for which there are inadequate data.[18] Market areas within these states but outside the Eighth District are included in this grouping. It is implied in the third grouping that, in all instances, the relevant market is equal to a single county. This grouping is introduced to test the effects of state banking laws, population and space on local market concentration using an alternative criterion for defining relevant markets.

The regression equation for each grouping is calculated in its natural log form, and the results are presented in table 4. As illustrated, the explanatory variables have the expected signs. For each grouping, local market concentration increases with decreases in population and with the introduction of state banking laws allowing multibank holding companies and limited branching. In the second and third groupings, where size of county is introduced, concentration increases as the space within the relevantly defined markets decreases.

Unfortunately, there is some variation in the statistical significance attached to these variables in explaining levels of local market concentration. Population within the relevantly defined market area is a significant explanatory variable irrespective of the market grouping chosen. This supports the conclusion of the nonparametric test of population and concentration presented in the preceding section.

The presence or absence of state branching laws also is significant in explaining local market concentration using each market grouping. Its statistical significance declines somewhat, however, when applied to the 120 Eighth District markets that cover one or more whole counties, compared with its impact in the other two groupings.

The performance of the size of county and multibank holding company variables is mixed. Size of county is significant for the 598 county markets grouping, but not for the 120 Eighth District markets covering one or more whole counties. Likewise, while multibank holding company laws are statistically significant in explaining concentration where markets are defined to be single counties, they lose their explanatory power when applied to the two groupings derived from the Federal Reserve Bank of St. Louis market definitions.

Thus, the results of the evaluations suggest that branching laws tend to significantly increase local market concentration. The impact of multibank holding company laws is unclear; its significance depends upon how the market is defined.

The results in table 4 indicate the problems inherent in determining useful definitions of banking markets. While the explanatory variables perform best when the markets are defined along single county lines, the categorical definition of a county as a market is conceptually empty. It takes no account of the actual state of interseller rivalry; yet, the notion of interseller rivalry represents the underlying reason for measuring market concentration in the first place.

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[17] Arkansas, Indiana, Kentucky and Tennessee allowed county-wide branching. Mississippi allowed branching within 100 miles of a bank's home office.

[18] The observation date for the third grouping of markets is December 31, 1981. Total deposit data are from "Report of Condition," December 31, 1981. Total deposits for each banking organization in Mississippi on this date are listed according to the location of the organization's main office and are not disaggregated according to branches in different counties. Population and square miles of county data are from the *1980 Census of Population* sources listed in footnote 15. When a market equals a single county, the size of the market is equal to the square miles of the county. For those markets in the second grouping that equal two or more whole counties, the size of the market is equal to the sum of the square miles of the relevant counties.

Table 4
Evaluation of Factors Affecting Local Market Concentration

Grouping One: 164 Eighth District Local Commercial Banking Markets That Do Not Cross State Lines

$$\ln \text{HERF} = \underset{(1.46)}{-\,0.1928} - \underset{(9.99)^{**}}{0.3748} \ln \text{POP} + \underset{(1.28)}{0.0861}\, \text{MHC}_D + \underset{(3.92)^{**}}{0.2570}\, \text{BRN}_D$$

$$R^2 = 0.4015$$

Grouping Two: 120 Eighth District Local Commercial Banking Markets That Do Not Cross State Lines and That Consist of One or More Whole Counties

$$\ln \text{HERF} = \underset{(5.47)^{**}}{2.8828} - \underset{(6.57)^{**}}{0.3497} \ln \text{POP} - \underset{(1.24)}{0.1009} \ln \text{SQM} + \underset{(1.21)}{0.0932}\, \text{MHC}_D + \underset{(2.42)^{*}}{0.1785}\, \text{BRN}_D$$

$$R^2 = 0.3811$$

Grouping Three: 598 Counties in Eighth District States, Excluding Mississippi

$$\ln \text{HERF} = \underset{(10.48)^{**}}{2.5602} - \underset{(19.50)^{**}}{0.3170} \ln \text{POP} - \underset{(3.45)^{**}}{0.1289} \ln \text{SQM} + \underset{(3.56)^{**}}{0.1177}\, \text{MHC}_D + \underset{(13.92)^{**}}{0.4742}\, \text{BRN}_D$$

$$R^2 = 0.5559$$

Absolute values of t-ratios shown in parentheses.

** = significant at the one percent level.

* = significant at the five percent level.

HERF = H-index value in each market.
POP = Population within each market.
SQM = Square miles per county or counties.
MHC_D = 1, if market is located in a state which allows multibank holding company acquisitions,
= 0, otherwise.
BRN_D = 1, if market is located in a state which allows limited branching,
= 0, otherwise.

SUMMARY AND CONCLUSIONS

The majority of Eighth District local commercial banking markets are highly concentrated, as the term is defined by the Department of Justice. Also, relatively higher levels of concentration can be expected in local markets with smaller populations of users, and located in states that allow limited branching. The effects on concentration of state multibank holding company laws and the physical size of a market, however, are ambiguous.

In 1982, banking and finance ranked first among 50 industries for merger activity.[19] This, coupled with the extent to which local banking markets fall into the "highly concentrated" category, suggests that future bank mergers and acquisitions may well be likely candidates for closer scrutiny by the Department of Justice. If this becomes the case, it will underscore the need for a clearer understanding of the impact on measured concentration in a market of state branching and multibank holding company laws, population and physical space and alternative criteria for defining that market.

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[19] John Morris, "Banking Had More Mergers In '82 than Any Other Group," *American Banker*, January 19, 1983, p. 2.

Forecasting the Money Multiplier: Implications for Money Stock Control and Economic Activity

R. W. HAFER, SCOTT E. HEIN and CLEMENS J. M. KOOL

ONE approach to controlling money stock growth is to adjust the level of the monetary base conditional on projections of the money multiplier. That is, given a desired level for next period's money stock and a prediction of what the level of the money multiplier next period will be, the level of the adjusted base needed to achieve the desired money stock is determined residually. For such a control procedure to function properly, the monetary authorities must be able to predict movements in the multiplier with some accuracy.[1]

This article focuses, first, on the problem of predicting movements in the multiplier. Two models' capabilities in forecasting the M1 money multiplier from January 1980 to December 1982 are compared. One procedure is based on the time series models of Box and Jenkins.[2] The other model, a more general one, is based on the technique of Kalman filtering.[3] Although the Box-Jenkins type of model has been used in previous studies to forecast the M1 multiplier, this study is the first to employ the Kalman filtering approach to the problem.

The second purpose of this study is to use the multiplier forecasts in a simulation experiment that implements the money control procedure cited above. Given monthly money multiplier forecasts from each of the forecasting methods, along with predetermined, hypothetical M1 growth targets, monthly and quarterly M1 growth rates are simulated for the 1980–82 period.

Finally, the importance of reduced volatility of the quarterly M1 growth is examined in another simulation experiment. Using a reduced-form "St. Louis" GNP equation estimated through IV/1979, nominal GNP is simulated for the 1980–82 period using actual M1, desired M1 and the M1 growth rates derived from our forecast/control procedure simulation. The outcome shows that the volatility of simulated GNP growth during the 1980–82 period is halved when the M1 growth simulated from our forecast/control procedure is used in place of actual M1 growth. This finding indicates that, other things equal, reducing the

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[1] One of the earlier attempts to develop a multiplier forecasting model is presented in Albert E. Burger, Lionel Kalish III and Christopher T. Babb, "Money Stock Control and Its Implications for Monetary Policy," this *Review* (October 1971), pp. 6–22. More recent attempts, which almost exclusively have used some form of time-series model, are represented by Eduard J. Bomhoff, "Predicting the Money Multiplier: A Case Study for the U.S. and the Netherlands," *Journal of Monetary Economics* (July 1977), pp. 325–45; James M. Johannes and Robert H. Rasche, "Predicting the Money Multiplier," *Journal of Monetary Economics* (July 1979), pp. 301–25; H.-J. Buttler, J.-F. Gorgerat, H. Schiltknecht and K. Schiltknecht, "A Multiplier Model for Controlling the Money Stock," *Journal of Monetary Economics* (July 1979), pp. 327–41; and Michele Fratianni and Mustapha Nabli, "Money Stock Control in the EEC Countries," *Weltwirtschaftliches Archiv* (Heft 3: 1979), pp. 401–23.

[2] For an in-depth discussion of these models, see George E. P. Box and Gwilym M. Jenkins, *Time Series Analysis, Forecasting and Control* (Holden-Day, Inc., 1970).

[3] Kalman filtering was introduced first in the field of engineering. See R. E. Kalman, "A New Approach to Linear Filtering and Prediction Problems," *Journal of Basic Engineering* (1960), pp. 34–45; and R. E. Kalman and R. S. Bucy, "New Results in Linear Filtering and Prediction Theory," *Journal of Basic Engineering* (1961), pp. 95–108. For an introduction to Kalman filtering, see Richard J. Meinhold and Nozer D. Singpurwalla, "Understanding the Kalman Filter," *The American Statistician* (May 1983), pp. 123–27.

quarterly volatility of money growth would tend to produce more stable economic growth.

THE MULTIPLIER FORECASTING MODELS

Box-Jenkins Model

The first forecasting strategy considered is based on the techniques of Box and Jenkins (hereafter BJ). This approach requires the identification and estimation of the appropriate model before predicting the money multiplier. A consideration of the autocorrelation and partial autocorrelation function suggested an ARIMA (0, 1, 1) process. Estimating this model for the period January 1959 to December 1979 yields the following relationship:

$$(1)\quad m_t - m_{t-1} = \underset{(-4.40)}{-0.002} + \underset{(4.31)}{0.263}\varepsilon_{t-1} + \varepsilon_t,$$

$$SE = 0.011 \qquad Q(30) = 41.5$$

where m_t is the M1 multiplier (M1 divided by the adjusted monetary base), ε_t is the unforeseen current shock to the change in the multiplier, ε_{t-1} is the unforeseen shock to the change in the multiplier last period, and the value -0.002 is a negative drift in the level of the multiplier.[4]

Equation 1 suggests that changes in the multiplier can be explained partially by the error in the multiplier process last month (ε_{t-1}). The reported t-statistic, which appears in parentheses below the respective coefficient estimate, reveals that last month's error exerts a statistically significant effect on the current change in the multiplier. Moreover, the constant term reveals a slight negative, but statistically significant, trend in the level of the multiplier. Finally, the Q-statistic indicates that the model's residuals pass the test for white noise.[5] The moving-average model given by equation 1 will be used subsequently to forecast the M1 multiplier.

Kalman Filter Model

Multiplier forecasts also are derived from a general Kalman filtering model, the so-called Multi-State Kalman Filter (MSKF) method.[6] This technique is described in more detail in the insert.

The MSKF model used here is a set of four parallel models, each equivalent to a different ARIMA (0, 1, 1) specification with the coefficients fixed *a priori*. These models are used to simultaneously distinguish among four types of shocks to the multiplier: small or large, temporary or permanent. Thus, unlike the BJ procedure, the MSKF technique tries to identify the nature of the different shocks and use this information in forecasting. Given this period's prediction error and given the "state" of the system represented by all former information, the MSKF algorithm determines the probability that the shock was large or small, the proportion of this forecast error that should be viewed as temporary, and the portion that is likely to be permanent. Once this evaluation is made, the probabilities associated with the four different states are revised, and the weights associated with each are adjusted accordingly. In this way, the MSKF method allows the forecaster to reassess the structure of the forecasting model as new data become available.

Since the BJ method has been shown to work well and the MSKF procedure appears more flexible in evaluating new information, the MSKF method should be useful in forecasting the multiplier.

FORECASTING THE MULTIPLIER USING BOX-JENKINS AND MSKF METHODS

The M1 multiplier was forecast, *ex ante*, for the period January 1980 to December 1982 using the BJ and MSKF models. In each case, the forecasts are

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[4] This model was identified from an examination of the autocorrelation derived from the level and first difference of the multiplier. The first-difference specification was chosen because the autocorrelations of the level series did not display the stationarity characteristic necessary to properly analyze time series.

[5] The Q-statistic is used to determine if the estimated model has transformed the error series into white noise. Since the reported Q-statistic is less than the critical χ^2 value at the 5 percent level (43.8), one cannot reject the hypothesis of white noise residuals and, therefore, the appropriateness of the estimated model.

[6] Development of this method is presented in D. J. Harrison and C. E. Stevens, "A Bayesian Approach to Short-Term Forecasting," *Operational Research Quarterly* (4:1971), pp. 341–62, and "Bayesian Forecasting," *Journal of the Royal Statistical Society* (3:1976), pp. 205–47. Applications are found in Eduard J. Bomhoff, "Predicting the Price Level in a World that Changes All the Time," in Karl Brunner and Allan H. Meltzer, eds., *Economic Policy in a World of Change*, Carnegie Rochester Conference Series on Public Policy (Autumn 1982), pp. 7–38; Eduard J. Bomhoff and Clemens J. M. Kool, "Learning Processes and the Choice Between Abrupt and Gradual Counter-Inflation Policies," unpublished manuscript, Erasmus University (May 1982); and Eduard J. Bomhoff and Pieter Korteweg, "Exchange Rate Variability and Monetary Policy Under Rational Expectations: Some Euro-American Experience, 1973–1979," *Journal of Monetary Economics* (March 1983), pp. 169–207.

Exposition of the MSKF Model

The MSKF model used to describe the behavior of the M1 multiplier is of the form

(A1) $m_t = \overline{m_t} + \varepsilon_t$

and

(A2) $\overline{m_t} = \overline{m_{t-1}} + \gamma_t$.

This model suggests that the time series of the multiplier's growth rate (m_t) is subject to two kinds of shocks: one is a temporary level shock, represented by ε_t, the other a permanent level shock, given by γ_t.[1] Thus, the model shows that the unobservable expected value of the multiplier ($\overline{m_t}$) — sometimes referred to as the "permanent" value — behaves as a "random walk" over time, where γ_t represents once-and-for-all shifts in this expectation. Equation A1 indicates that the actual multiplier (m_t) will fluctuate randomly about this permanent value, since ε_t only affects the realization of the multiplier but not the underlying expectation.

Equations A1 and A2 yield an ARIMA (0, 1, 1) representation by shifting equation A1 one period backward in time and subtracting the result from the original equation. This transformation along with equation A2 results in

(A3) $\Delta m_t = \varepsilon_t - \varepsilon_{t-1} + \gamma_t$.

The ARIMA (0, 1, 1) model can be written as

(A4) $\Delta m_t = (1 - \phi B)\, \alpha_t$.

Writing out the autocorrelation function of both equations A3 and A4 reveals a unique correspondence between the specification of the variance of ε_t and γ_t on the one hand, and of the moving average parameter ϕ and the variance of α_t on the other. Specification of equation A3 in terms of pinning down the values of the two model parameters var(ε_t) and var(γ_t) uniquely determines the values of ϕ and var(α_t) in equation A4 and vice versa. So there is an equivalence in functional form between the ARIMA (0, 1, 1) model that is used in the Box-Jenkins estimation technique and the model we use in our Kalman filter algorithm. In methodology, estimation and forecasting, however, there is a substantial difference between the Box-Jenkins technique and the Kalman filter approach.

The application of the Box-Jenkins technique to equation A4 essentially reduces to estimating the parameter ϕ and the variance of α_t, both of which are assumed to be constant for the whole sample period.[2] Even a recursive Box-Jenkins technique combined with the weighting of past observations would not really change the characteristics of the methodology, although the ability to detect and describe slow movements of ϕ and var(α_t) over time would increase. The MSKF method goes beyond this because it allows for feedback from the data to the forecasting procedure. In this way, the MSKF model can cope with changes in the mixture of permanent and transitory shocks over time by changing the probabilities associated with the occurrence of these shocks.

Table A1
Model Specification

Model	d	Var(ε_t)	Var(γ_t)	Var(α_t)
Small temporary	0.95	0.95	0.0025	1
Small permanent	0.05	0.05	0.9025	1
Large temporary	0.99	15.84	0.0016	16
Large permanent	0.01	0.16	15.6816	16

The MSKF method is implemented by using four separate representations of equations A1 and A2. For each model, the ratio between the variances of ε_t and γ_t is specified *a priori*. This is equivalent to determining the parameter ϕ in equation A4. During the estimation the level of the variance of ε_t and γ_t or, correspondingly, the variance of α_t is computed adaptively from the forecast errors by means of a robust method. The specific procedure used is discussed in more detail by Kool.[3]

Table A1 presents the correspondence between equations A3 and A4. As can be seen from the table, each of the four alternative Kalman filter models can be viewed as having a fixed parameter (ϕ) that corresponds to a certain time series process. Using equation A4, the expectations of m_t at time $t-1$ can be written as

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[1] The terms ε_t and γ_t are assumed to be mutually independent and serially uncorrelated error terms.

[2] Applications of the Box-Jenkins approach to forecasting the multiplier can be found in Bomhoff, "Predicting the Money Multiplier;" Johannes and Rasche, "Predicting the Money Multiplier;" and R. W. Hafer and Scott E. Hein, "The Wayward Money Supply: A Post-Mortem of 1982."

[3] See Clemens J. M. Kool, "Statistical Appendix A: The Multi-State Kalman Filter Method," and "Statistical Appendix B: A Recursive Prediction Error Method," both appended to Bomhoff, "Predicting the Price Level in a World that Changes All the Time," pp. 39–51.

$$\text{(A5)}\quad E_{t-1}[m_t] = m_{t-1} - \phi[(m_{t-1} - E_{t-2}(m_{t-1})] = (1 - \phi)m_{t-1} + \phi E_{t-2}(m_{t-1}).$$

Thus, for each model the expectation of next period's m_t is a weighted average of the last observed value (m_{t-1}) and the prediction for m_{t-1}, made at time $t-2$. The *lower* the value of ϕ, the more weight is given to the observed value m_{t-1} and the more probable it is that the difference between m_{t-1} and its prediction is caused by a permanent shift. A *high* value of ϕ, on the other hand, indicates that there is a high probability that differences between m_{t-1} and its expectation are of a more temporary nature. In this case, it is best to largely ignore these prediction errors and not to incorporate them into next period's prediction. The first model in the table A1, the small temporary shock model, is such a representation. It has a ϕ parameter value of 0.95, indicating that only 5 percent of this period's prediction error is incorporated in next period's forecast.[4]

At first glance, the simultaneous use of four ARIMA (0, 1, 1) models, each with an *a priori* fixed coefficient, does not seem to be a great improvement compared with a free estimation of that moving average parameter by means of the Box-Jenkins method. There is room for improvement, however, as the actual forecast of m_t in the next period is a weighted forecast of the four Kalman filter models used. The weight attached to each of individual models for next period's prediction is equal to the (posterior) probability that the multiplier process at that moment in time is indeed described by that model. These weights can vary considerably over time and even from period to period. Moreover, the Kalman filter composite forecast can be described as the forecast of a single ARIMA model with the parameter free to change from period to period.[5] In this respect, the use of four fixed models in fact increases the flexibility of the method in describing the multiplier process.

The feedback from data to the forecasting models provides us with a tool to aid in forecasting a given time series. The data provide information on both the posterior weights of the respective models and on the current value of the parameter ϕ, which is relevant for forecasting next period's multiplier. The data also contain information concerning the probabilities that each model will adequately describe the multiplier's behavior in the future. In general, it is true that the probability — posterior to the observation of the multiplier value in period t — that model j is describing the multiplier process correctly, is calculated as a combination of the *a priori* probability at time $t-1$ that model j will be the right model to describe the process in period t and the information contained in observation m_t. This combination determines the posterior probability for each model and at the same time the weight of each model in next period's forecast.

The feedback from data to the model can take place by using the data a second time looking back at period $t-1$ after the observation of the multiplier value in period t. It is highly probable that the combined information of observations of periods $t-1$ and t will give a better evaluation of the state of the process in period $t-1$ than the observation of period $t-1$ alone. So the posterior probabilities for period $t-1$ are recalculated, using the observation at time t. These recalculated probabilities then are used to adjust the prevailing prior probabilities. The prior probabilities for the various models can be said to be updated adaptively over time as new observations become available, thereby influencing future forecasts.

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[4] For ease of exposition, we present the level of the different variances instead of their ratios by normalizing with respect to the variance of α_t, which in fact is updated adaptively as argued above. Observations more than two standard deviations away from the expected value of a variable are defined to be outliers. We choose the variance of the two large error models 16 times as large as the variance of the normal error models.

[5] The weighted sum of a specified number of moving average processes is again a moving average process under relatively loose conditions, whereby the moving average parameter of the resulting process is a non-linear function of the weights and the parameters of the various models. See David E. Rose, "Forecasting Aggregates of Independent ARIMA Processes," *Journal of Econometrics* (May 1977), pp. 323–45.

one-step-ahead predictions of the multiplier, based on data through the most recent month.[7] Specifically, suppose a forecast for the June 1981 money multiplier is desired. Given the parameter estimates in, say, equation 1, the data through May 1981 are used to construct the June forecast. This data set is then updated to include June to construct the July forecast, and so on. By continually updating the information set available to the forecaster, the procedure used here closely imitates the process by which a policymaker actually would generate multiplier forecasts.

Chart 1 plots the multiplier forecast errors (actual minus predicted multiplier) for each of the two procedures. As shown there, the errors follow a similar pattern during the sample. The forecast error derived

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[7] This procedure is used in R. W. Hafer and Scott E. Hein, "The Wayward Money Supply: A Post-Mortem of 1982," this *Review* (March 1983), pp. 17–25. See also Anatol B. Balbach, "How Controllable is Money Growth?" this *Review* (April 1981), pp. 3–12.

from the MSKF procedure is closer to zero, on average, than using BJ. The largest forecast errors for both models come in March-April 1980. During this period, when special credit controls were enacted by the Carter administration, the actual multiplier fell sharply from 2.603 in February 1980 to 2.578 in March and 2.524 in April. This decline, though small in absolute magnitude, is quite large compared with other changes in the multiplier.

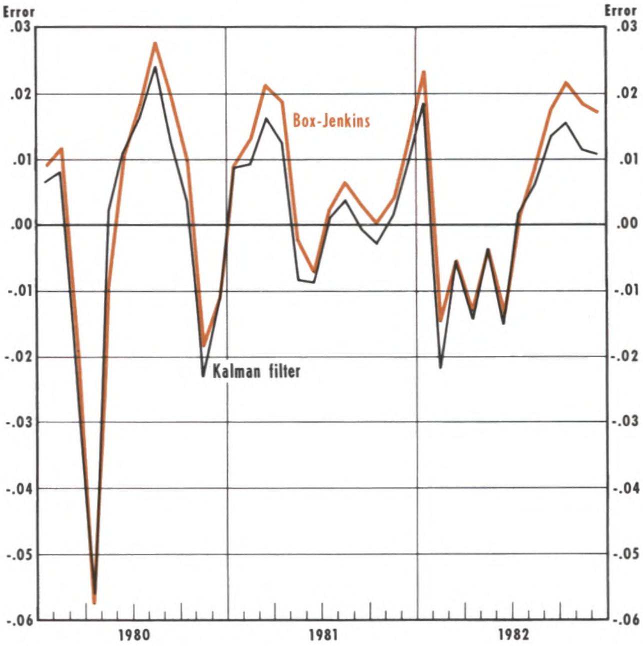
To assess further the relative capabilities of the two forecasting procedures, summary forecast statistics for 1980 to 1982 are presented in table 1. Turning first to the full-period results, the notion that the MSKF procedure, on average, produced better forecasts than the BJ model is corroborated statistically: the mean error (ME) from the MSKF model is 75 percent smaller than the mean error from the BJ model. In both cases, however, the mean error is quite small, indicating very little bias in either forecasting procedure. Indeed, the Theil decomposition statistics indicate that less than 5 percent of the forecast error is due to bias (B). Further, there is a 13 percent reduction in the mean absolute error (MAE) and a 9 percent reduction in the root-mean-squared error (RMSE) for the MSKF procedure relative to the BJ approach. Thus, the evidence in table 1 demonstrates the relative superiority of the MSKF procedure over the BJ method in forecasting the multiplier.

The full-period results indicate that an improvement in the multiplier forecasts can be attained by using the MSKF procedure. This improvement, gauged on a year-by-year basis, varies. For example, in 1980 the reduction in RMSE gained by using the MSKF model is 4 percent; in 1981 it is 26 percent; in 1982, 15 percent. The characteristics of the forecast errors also vary from year to year. For example, in 1981 bias accounted for 42 percent of the BJ forecast error, compared with only 17 percent for the MSKF model. While in 1982 the fraction of error due to bias was reduced for the BJ model from the previous year, this fraction is still higher than that of the MSKF model and, as chart 1 indicates, the BJ procedure underpredicted the actual multiplier more often than the MSKF model.

Given the behavior of the money multiplier, the improved relative performance of the MSKF model in 1981 and 1982 is not too surprising. As indicated in chart 2, 1981 and 1982 were the first years since 1959 in which the money multiplier grew. Over the previous years, there was a consistent negative trend in the multiplier. As we saw before, this trend is significant in the BJ model (−0.002), and its assumed continuation marks this forecast procedure. Because the multiplier did not continue to decline, the BJ forecast underpredicted quite frequently.

Chart 1

Box-Jenkins and Multi-State Kalman Filter



As suggested, the MSKF model adapts more easily and more rapidly to changing conditions. Thus, it is not too surprising that the MSKF model tends to underpredict the money multiplier less than the BJ model. Probably the most striking feature of the forecasts, given the sharp break in the multiplier trend, is the small degree of bias derived from either forecast procedure.

The forecast evidence on the whole indicates that the MSKF model provides relatively more accurate one-step-ahead forecasts of the money multiplier than the BJ model. It should be noted, however, that this improvement is small relative to the absolute forecast errors. Even so, the evidence suggests that more accurate forecasts of the multiplier can be made; we now consider the policy relevancy of this finding.

MONEY GROWTH: 1980–82

The growth of the money stock during the past few years has been the subject of heated debate. Some have argued that the large swings in money growth

Table 1

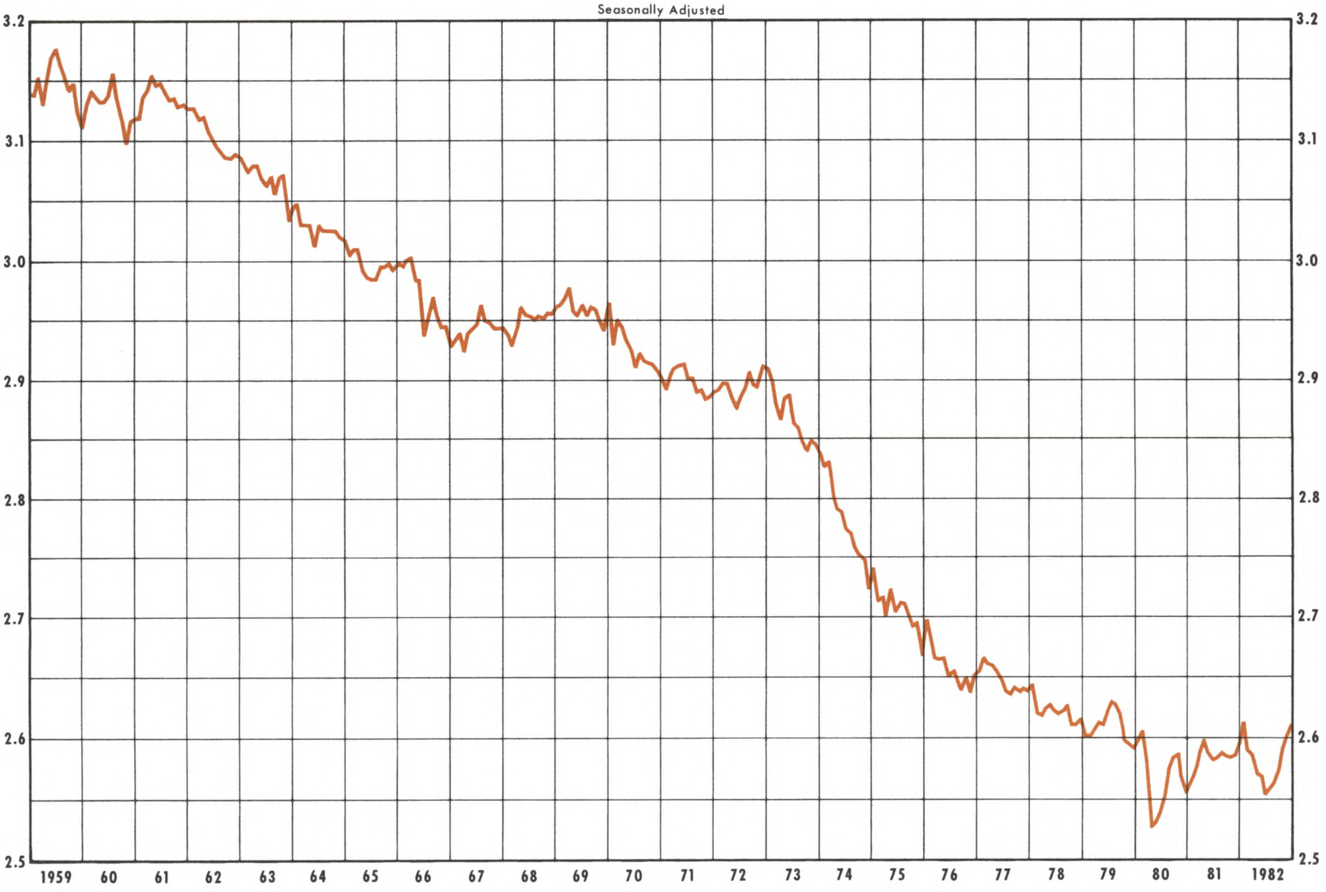
Summary Statistics for One-Step-Ahead Multiplier Forecasts: January 1980–December 1982

Summary statistics[1]	1/1980 – 12/1982		1/1980 – 12/1980		1/1981 – 12/1982		1/1982 – 12/1982	
	BJ	MSKF	BJ	MSKF	BJ	MSKF	BJ	MSKF
ME	–0.0036	–0.0009	0.0009	0.0023	–0.0068	–0.0035	–0.0048	–0.0015
MAE	0.0134	0.0116	0.0185	0.0165	0.0083	0.0069	0.0132	0.0115
RMSE	0.0168	0.0153	0.0226	0.0216	0.0106	0.0084	0.0148	0.0129
U	0.0065	0.0059	0.0088	0.0084	0.0041	0.0033	0.0058	0.0050
B	0.0459	0.0035	0.0015	0.0112	0.4200	0.1741	0.1049	0.0132
V	0.0228	0.0021	0.0061	0.0009	0.0332	0.0954	0.0549	0.0262
C	0.9314	0.9944	0.9924	0.9879	0.5468	0.7305	0.8402	0.9606

[1] ME is the mean error; MAE is the mean absolute error; RMSE is the root-mean-squared error; U is the Theil inequality coefficient; B, V and C represent the amount of forecast error due to bias, variation and covariation, respectively, between actual and forecasted series.

Chart 2

Level of the M1 Money Multiplier



resulted from erratic changes in the public's demand for money.[8] Others have suggested that certain technical changes, such as implementing contemporaneous reserve accounting, revising discount rate policy and the restructuring of reserve requirements, must be made in order to better control the money stock.

Table 2 reports the monthly and quarterly growth rates of M1 for the period January 1980 to December 1982. The monthly growth rates indicate a significant degree of variability in the series. During 1980, for example, the average monthly growth rate for M1 was 7.18 percent with a standard deviation of 12.50 percent. This relatively high degree of variability is due primarily to the large downturn in money growth during the February-April period when the special credit controls were implemented.

The years 1981 and 1982 show a reduction in money growth variability. In 1981, the average monthly growth of M1 declined to 6.56 percent with a standard deviation of 5.97 percent. In 1982, average monthly money growth and variability, although smaller than 1980, showed some increase over 1981: money growth averaged 6.56 percent with a standard deviation of 6.80 percent.

The quarterly growth rates in table 2 also indicate an erratic pattern to money growth. During the three years examined, the standard deviations of quarterly M1 growth are 8.60 percent in 1980, 2.85 percent in 1981 and 4.71 percent in 1982.

Table 2

M1 Growth Rates: 1980–82

Period	Monthly growth rate	Period	Quarterly growth rate
1/1980	7.66%		
2/1980	13.66	I/1980	7.03%
3/1980	−1.81		
4/1980	−21.53		
5/1980	6.38	II/1980	−3.84
6/1980	17.27		
7/1980	15.98		
8/1980	23.56	III/1980	16.94
9/1980	17.17		
10/1980	10.69		
11/1980	4.12	IV/1980	9.77
12/1980	−6.97		
1/1981	7.80		
2/1981	9.62	I/1981	4.97
3/1981	13.97		
4/1981	15.73		
5/1981	0.00	II/1981	9.25
6/1981	0.56		
7/1981	6.02		
8/1981	5.41	III/1981	3.17
9/1981	−1.01		
10/1981	−0.55		
11/1981	7.44	IV/1981	3.24
12/1981	13.73		
1/1982	21.47		
2/1982	0.54	I/1982	10.99
3/1982	1.62		
4/1982	1.89		
5/1982	8.60	II/1982	3.22
6/1982	2.68		
7/1982	2.68		
8/1982	10.80	III/1982	6.28
9/1982	13.61		
10/1982	15.22		
11/1982	14.45	IV/1982	13.74
12/1982	11.17		

SIMULATING MONEY GROWTH

It has been argued that policymakers could achieve a more stable pattern of quarterly money growth by implementing the following control procedure:

1) In period t, using all available information, a forecast of the money multiplier for period t + 1 is made.
2) Given this forecast and the level of M1 desired in t + 1, the amount of adjusted monetary base to support that money stock is determined, and the base is changed to achieve this new desired level. Thus, any deviation of the money stock from the desired level is the result solely of a money multiplier forecast error.
3) In period t + 1, the forecast of the multiplier is recalculated for t + 2, taking into account money multiplier information available through period t + 1.
4) Again in t + 1, the adjusted base necessary to achieve the desired money stock in t + 2 is calculated.

The process continues month by month, always attempting to achieve the desired level of money stock. Clearly, an accurate money multiplier prediction is important for this control procedure to achieve the

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[8] This view is disputed in Scott E. Hein, "Short-Run Money Growth Volatility: Evidence of Misbehaving Money Demand," this *Review* (June/July 1982), pp. 27–36; Kenneth C. Froewiss, "Speaking Softly But Carrying a Big Stick," *Economic Research* (Goldman Sachs, December 1982); and John P. Judd, "The Recent Decline in Velocity: Instability in Money Demand or Inflation?" Federal Reserve Bank of San Francisco *Economic Review* (Spring 1983), pp. 12–19.

Table 3

Simulating M1 Growth Using Box-Jenkins Multiplier Forecast: January 1980–December 1982 (seasonally adjusted)

Period	Targeted M1[1]	Actual multiplier	Forecasted multiplier	Simulated base[1]	Simulated M1[1]	Simulated M1 growth rate	
						Monthly	Quarterly
1/1980	$390.7	2.5955	2.5866	$151.0	$392.0	9.67%	
2/1980	392.3	2.6026	2.5909	151.4	394.1	6.63	5.32%
3/1980	394.0	2.5783	2.5973	151.7	391.1	−8.70	
4/1980	395.7	2.5235	2.5811	153.3	386.9	−12.35	
5/1980	397.4	2.5266	2.5364	156.7	395.8	31.76	2.11
6/1980	399.1	2.5373	2.5270	157.9	400.7	15.77	
7/1980	400.8	2.5508	2.5324	158.3	403.7	9.32	
8/1980	402.5	2.5715	2.5437	158.2	406.9	9.95	12.15
9/1980	404.2	2.5812	2.5620	157.8	407.2	1.02	
10/1980	406.0	2.5837	2.5739	157.7	407.5	0.72	
11/1980	407.7	2.5605	2.5789	158.1	404.8	−7.70	0.65
12/1980	409.4	2.5514	2.5632	159.7	407.5	8.52	
1/1981	416.1	2.5612	2.5523	163.0	417.6	10.50	
2/1981	418.1	2.5698	2.5566	163.6	420.3	8.15	5.10
3/1981	420.2	2.5853	2.5641	163.9	423.6	9.99	
4/1981	422.2	2.5964	2.5775	163.8	425.3	4.83	
5/1981	424.3	2.5870	2.5892	163.9	423.9	−3.87	4.19
6/1981	426.3	2.5789	2.5854	164.9	425.3	3.90	
7/1981	428.4	2.5806	2.5784	166.2	428.8	10.41	
8/1981	430.5	2.5843	2.5778	167.0	431.6	8.11	6.09
9/1981	432.6	2.5834	2.5804	167.6	433.1	4.32	
10/1981	434.7	2.5807	2.5804	168.5	434.8	4.66	
11/1981	436.8	2.5824	2.5784	169.4	437.5	7.81	6.29
12/1981	439.0	2.5918	2.5791	170.2	441.1	10.37	
1/1982	442.0	2.6096	2.5862	170.9	446.0	15.85	
2/1982	443.5	2.5866	2.6012	170.5	441.0	−12.73	6.64
3/1982	444.9	2.5826	2.5882	171.9	444.0	8.42	
4/1982	446.4	2.5689	2.5819	172.9	444.2	0.46	
5/1982	447.9	2.5661	2.5701	174.3	447.2	8.44	2.20
6/1982	449.3	2.5515	2.5649	175.2	447.0	−0.49	
7/1982	450.8	2.5542	2.5528	176.6	451.1	11.51	
8/1982	458.3	2.5603	2.5516	177.2	453.8	7.62	7.20
9/1982	453.8	2.5733	2.5558	177.5	456.9	8.36	
10/1982	455.2	2.5881	2.5665	177.4	459.1	5.93	
11/1982	456.7	2.5987	2.5802	177.0	460.0	2.47	5.58
12/1982	458.2	2.6088	2.5916	176.8	461.3	3.37	

[1] Billions of dollars.

desired money stock objective. In this regard, the MSKF approach should yield a quarterly money stock series of lower variability than the BJ model.

Before examining the simulation results, it must be noted that the control procedure discussed here is not designed to reduce the monthly variability in M1 growth. The objective is to achieve a monthly target and, because the procedure attempts to correct errors in money growth each month, the month-to-month variability in the simulated growth rates may be large. An important feature of this control procedure, however, is that it alters the distribution of monthly growth rates in such a way that growth rate variability over quarterly or longer time horizons is likely to be reduced. Given existing empirical evidence on the relationship between real economic activity and quarterly money growth, success can be measured in terms of the reduction in the variability of both the quarterly money growth series and in economic activity.

Money Growth Simulations: Box-Jenkins Multiplier Forecasts

The money multiplier forecasts generated from the BJ model, reported in table 1, are used to simulate money growth from January 1980 to December 1982.[9] Table 3 summarizes the results using these forecasts and the control procedure described above. The posited M1 growth targets for 1980, 1981 and 1982 are 5.25 percent, 6.00 percent and 4.00 percent, respectively.

The results in table 3 indicate that, on average, the simulated level of M1 is close to the desired amount. The largest discrepancies occur in early 1980, the period of the special credit controls. For example, the simulated level of M1 in April 1980 is more than $8 billion below the targeted level. As explained, the monthly growth rates for the simulated series are expectedly erratic under this control procedure. Compared with the actual M1 growth rate data in table 2, however, the *pattern* of growth rates is quite different. For example, in 1980, actual M1 increased during the first two months at an average rate of 10.7 percent. During the next two months, it declined at an average rate of 11.7 percent. From April to August, M1 steadily increased at an average rate of 15.8 percent and, during the last of the year, increased at a 6.25 percent rate.

Table 4

Variability of Actual and Simulated M1 Growth[1]

	Monthly			Quarterly		
		Simulated using:			Simulated using:	
Period	Actual	BJ	MSKF	Actual	BJ	MSKF
1980	12.49%	12.04%	12.90%	8.62%	5.12%	4.15%
1981	5.97	4.16	4.06	2.85	0.97	1.26
1982	6.80	7.24	7.51	4.71	2.24	1.84

[1] Variability measured by standard deviation of growth rates.

Simulated M1 based on the BJ multiplier forecasts increases at a slower 8.2 percent rate in early 1980, then declines at a 10.5 percent rate from February through April. In May, the simulated M1 figure rebounds sharply as the procedure attempts to offset the errors of the previous two months: during the period April to August, simulated M1 growth averages 16.7 percent. Finally, in contrast to the 6.25 percent rate of actual M1 growth during the final four months of 1980, simulated M1 averages only a 0.64 percent rate of growth.

The volatility of the simulated monthly growth rates continues throughout the sample. For comparison, the variability of the actual and simulated money growth series are reported in table 4. In each year, the variability of the simulated growth rate series is about the same as the actual growth rate of money.

Reducing the *monthly* variability of money growth, however, is not the goal of the procedure. One aim is a reduction in quarterly growth rate variability. Judging from the evidence in table 3, the approach used here does exactly that.[10] Note that throughout the period the swings in quarterly growth rates are reduced. For instance, actual M1 growth ranges from 16.94 percent in III/1980 to −3.84 percent in IV/1980. The corresponding figures for simulated M1 growth are less volatile, varying between 12.15 percent in III/1980 and 0.65 percent in IV/1980.

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[9] It has been argued that the actual pattern of the multiplier and, therefore, the money stock would have been different had the Federal Reserve operated under a monetary control procedure like the one discussed in this study. Two points need to be made: First, this argument can be raised against all simulation experiments. Their purpose, after all, is to investigate the outcomes under different sets of conditions. There is generally no way to determine the validity or usefulness of this criticism.

Second, this argument is based on the assumption that multiplier forecasts are rendered useless by the endogeneity of the monetary base during the multiplier forecasting period. This problem has been examined by Lindsey (and others) and found to affect the reliability of the type of multiplier forecast procedures employed here. In a recent paper, however, Brunner and Meltzer have shown that these assertions are highly questionable. For alternative views, see David Lindsey and others, "Monetary Control Experience Under the New Operating Procedures," in *New Monetary Control Procedures, Vol. 2*, Federal Reserve Staff Study (February 1981); and Karl Brunner and Allan H. Meltzer, "Strategies and Tactics for Monetary Control," in *Carnegie-Rochester Conference Series, Vol. 18* (1983), pp. 59–104.

[10] It should be noted that the first-quarter growth rates of the simulated series are measured from the actual level of money in the previous quarter. This reflects the common "foregiveness principle" of adjudging money growth from its actual level as opposed to the desired level.

Table 5

Simulating M1 Growth Using MSKF Multiplier Forecast: January 1980–December 1982 (seasonally adjusted)

Period	Targeted M1[1]	Actual multiplier	Forecasted multiplier	Simulated base[1]	Simulated M1[1]	Simulated M1 growth rate	
						Monthly	Quarterly
1/1980	$390.7	2.5955	2.5889	$150.9	$391.7	8.53%	
2/1980	392.3	2.6026	2.5944	151.2	393.6	6.02	4.81%
3/1980	394.0	2.5783	2.6009	151.5	390.6	−8.74	
4/1980	395.7	2.5235	2.5796	153.4	387.1	−10.25	
5/1980	397.4	2.5266	2.5244	157.4	397.7	38.54	3.40
6/1980	399.1	2.5373	2.5260	158.0	400.9	9.87	
7/1980	400.8	2.5508	2.5345	158.1	403.4	7.74	
8/1980	402.5	2.5715	2.5475	158.0	406.3	9.06	10.59
9/1980	404.2	2.5812	2.5683	157.4	406.2	−0.14	
10/1980	406.0	2.5837	2.5799	157.4	406.5	0.86	
11/1980	407.7	2.5605	2.5834	157.8	404.1	−7.03	0.78
12/1980	409.2	2.5514	2.5626	159.8	407.6	11.14	
1/1981	416.1	2.5612	2.5524	163.0	417.5	10.44	
2/1981	418.1	2.5698	2.5605	163.3	419.6	6.24	4.62
3/1981	420.2	2.5853	2.5690	163.6	422.8	9.52	
4/1981	422.2	2.5964	2.5840	163.4	424.2	4.05	
5/1981	424.3	2.5870	2.5954	163.5	422.9	−3.74	3.87
6/1981	426.3	2.5789	2.5876	164.8	424.9	5.84	
7/1981	428.4	2.5806	2.5796	166.1	428.6	10.94	
8/1981	430.5	2.5843	2.5805	166.8	431.1	7.33	6.50
9/1981	432.6	2.5834	2.5840	167.4	432.5	3.88	
10/1981	434.7	2.5807	2.5834	168.3	434.2	4.94	
11/1981	436.8	2.5824	2.5810	169.2	437.1	8.03	6.22
12/1981	439.0	2.5918	2.5822	170.0	440.6	10.12	
1/1982	442.0	2.6096	2.5911	170.6	445.2	13.25	
2/1982	443.5	2.5866	2.6083	170.0	439.8	−13.59	6.00
3/1982	444.9	2.5826	2.5880	171.9	444.0	12.12	
4/1982	446.4	2.5689	2.5830	172.8	444.0	−0.18	
5/1982	447.9	2.5661	2.5699	174.3	447.2	9.13	2.69
6/1982	449.3	2.5515	2.5664	175.1	446.7	−1.26	
7/1982	450.8	2.5542	2.5525	176.6	451.1	12.45	
8/1982	452.3	2.5603	2.5541	177.1	453.4	6.21	6.98
9/1982	453.8	2.5733	2.5599	177.2	456.1	7.53	
10/1982	455.2	2.5881	2.5725	177.0	458.0	5.02	
11/1982	456.7	2.5987	2.5872	176.5	458.8	1.98	4.86
12/1982	458.2	2.6088	2.5981	176.4	460.1	3.64	

[1] Billions of dollars.

This reduction in quarterly money growth volatility is made clearer in table 4. There we see that the volatility of the quarterly money growth derived from the BJ multiplier forecasts is appreciably smaller than the actual. In fact, in 1981 and 1982, the volatility of simulated quarterly M1 growth is less than one-half that of actual M1 growth. Thus, in terms of reducing quarterly fluctuations in money growth, the control procedure using the BJ multiplier forecasts is quite successful.

Money Growth Simulations: MSKF Multiplier Forecasts

The outcome from using the MSKF multiplier forecasts to simulate M1 growth is reported in table 5. Similar to the results using the BJ multiplier forecasts, the simulated M1 growth rates in table 5 exhibit a large degree of monthly variation. Again, in contrast to actual M1 growth, the distribution of monthly growth rates reveals the procedure's attempt to correct deviations from the desired M1 path. As reported in table 4, the monthly money growth derived from the MSKF forecasts is more variable than either actual money growth or the BJ simulations in 1980 and again in 1982.

This monthly volatility, however, again translates into a more stable pattern of quarterly M1 growth. Recall that, during the second half of 1980, simulated M1 growth based on BJ multiplier forecasts varied from 0.65 percent to 12.15 percent. Over this period, the MSKF-based figures range from 0.78 percent to 10.59 percent. As shown in table 4, quarterly M1 simulated using the MSKF forecasts is less volatile than that using the BJ multiplier forecasts in 1980 and 1982. This suggests that the MSKF approach provides a steadier path of quarterly money growth than the BJ approach.

The evidence indicates that stable quarterly money growth can be achieved by making use of the multiplier forecasting techniques implemented here. Based on our empirical results, the simulated quarterly money growth series were, on average, about 50 percent less variable than actual M1 growth during the past few years. Moreover, the simulated series generally came quite close to hitting the desired M1 growth target. As shown in table 6, both simulated money series missed the annual growth targets by only one percentage point, on average.

MONEY GROWTH AND ECONOMIC ACTIVITY

Large fluctuations in quarterly M1 growth have led some observers to conclude that the pattern of economic activity during the 1980–82 period is attributable largely to volatile monetary policy actions. Indeed, empirical evidence for the United States and other countries suggests a close association between substantial short-run declines in money growth from its trend and the pace of economic activity.[11] During our sample, such deviations occurred in early 1980 and again in 1981. In this regard, reducing money growth fluctuations, everything else equal, should produce more stable economic growth. To examine this hypothesis, the following experiment was conducted: First, a standard, St. Louis type of reduced-form equation for nominal GNP growth was estimated over the period I/1960 to IV/1979. Then, using the estimated coefficients, GNP growth was simulated for the period I/1980 to IV/1982. Three simulation runs were made: one with actual M1 growth, one with the posited path of M1 and one based on M1 growth from the MSKF money growth simulations. (The BJ simulations are omitted because they were so similar to the MSKF.)

Table 6

Comparison of Desired and Simulated M1 Growth Rates

Period	Desired M1 growth	Simulated M1 growth using: MSKF	Simulated M1 growth using: BJ
IV/1979–IV/1980	5.25%	4.82%	4.96%
IV/1980–IV/1981	6.00	7.69	7.67
IV/1981–IV/1982	4.00	4.96	5.10

The simulated GNP growth rates for each experiment are reported in table 7.[12] The volatility of actual M1 growth is evident in the consequent fluctuations of GNP growth, especially in 1980 when GNP growth fluctuated from 6.81 percent to 12.69 percent. For the whole period, nominal GNP growth simulated with actual money growth averages 10.46 percent with a standard deviation of 1.94 percent.

The pattern of GNP growth simulated under the posited M1 path of 5.25 percent growth in 1980, 6.0

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[11] Historical evidence on this point for the United States is presented in Clark Warburton, "Bank Reserves and Business Fluctuations," *Journal of the American Statistical Association* (December 1948), pp. 547–58; Milton Friedman and Anna J. Schwartz, "Money and Business Cycles," *Review of Economics and Statistics* (Supplement: February 1963), pp. 32–78; and William Poole, "The Relationship of Monetary Decelerations to Business Cycle Peaks: Another Look at the Evidence," *Journal of Finance* (June 1975), pp. 697–712. An analysis of more recent data for the United States along with several other countries can be found in Dallas S. Batten and R. W. Hafer, "Short-Run Money Growth Fluctuations and Real Economic Activity: Some Implications for Monetary Targeting," this *Review* (May 1982), pp. 15–20.

[12] The equation used to generate the simulations is (t-statistics in parentheses):

$$\dot{Y}_t = \underset{(2.14)}{2.507} + \underset{(5.34)}{1.052} \sum_{i=0}^{4} \beta_i \dot{M}_{t-i} + \underset{(0.68)}{0.068} \sum_{i=0}^{4} \delta_i \dot{E}_{t-i}$$

$$\bar{R}^2 = 0.33 \qquad SE = 3.52 \qquad DW = 1.95$$

where $\dot{Y}$ is nominal GNP growth, $\dot{M}$ is the growth of M1 and $\dot{E}$ is the growth of high-employment government expenditures. The equation is estimated for the period I/1960–IV/1979 using a fourth-order Almon polynomial lag for each of the explanatory variables with endpoints constrained. All simulations use actual $\dot{E}$.

Table 7

Simulated Quarterly GNP Growth Rates: I/1980–IV/1982

			Simulated values derived from:
Period	Actual M1	Desired M1	MSKF
I/1980	11.06%	10.50%	10.37%
II	6.81	8.98	8.24
III	9.81	9.04	9.90
IV	12.69	9.23	9.26
I/1981	12.70	9.24	8.41
II	12.12	8.89	7.13
III	10.41	9.96	8.41
IV	9.05	10.23	9.79
I/1982	9.15	8.37	8.98
II	8.47	7.23	7.69
III	10.18	8.16	9.16
IV	13.04	8.57	9.80
Mean	10.46	9.03	8.93
Standard deviation	1.94	0.92	0.98

percent growth in 1981 and 4.0 percent growth in 1982 is very different from that simulated with actual M1 growth. For one thing, the average GNP growth simulated with actual money is almost 1.5 percentage points above that simulated with the desired path. It is only in II/1980 and IV/1981 that GNP growth based on actual money is less than GNP growth based on desired money. In addition to the difference in mean growth rates, there is also a sizeable difference in the volatility of GNP growth under the alternative simulations. As measured by the standard deviation of GNP growth, the simulations with actual money show more than twice the volatility than the simulations with desired money yield.

Comparisons between simulations using actual and desired money growth presumes that the desired money growth easily can be achieved. As we have seen, however, the Fed cannot totally control money growth from one quarter to the next. How serious a problem is this? Would this lack of precise control make it difficult to achieve a less volatile GNP growth objective?

To examine this issue, the GNP equation was simulated using the M1 growth rates that resulted from the MSKF money multiplier forecasting control procedure. These simulated GNP growth rates are shown in the third column of table 7. There is surprisingly little difference between the GNP growth simulated using desired M1 growth and M1 growth resulting from the forecast/control procedure. The average level of GNP growth under the desired M1 growth scenario is 9.03 percent, compared with 9.08 percent under the MSKF procedure. The standard deviation of simulated GNP growth is less than one percent in both cases — about one-half that associated with actual M1 growth. In addition, the simulated GNP path using the quarterly growth of money derived from the MSKF forecast procedure usually is within one percentage point of the simulated GNP path using desired M1 growth.

SUMMARY AND CONCLUSION

This paper has examined two alternative procedures to forecast the M1 multiplier. The multiplier was forecast one period ahead for the 1980–82 sample period using both a Box-Jenkins and a Multi-State Kalman Filter forecast procedure. The evidence from the multiplier forecasts shows the MSKF procedure to be an improvement over the BJ procedure. For example, the MSKF yielded a root-mean-squared error about 9 percent smaller than the BJ procedure for the whole period, with even greater reduction in forecast error in 1981 and 1982.

Both forecasts of the multiplier then were used to simulate M1 growth. These simulations resulted in volatile monthly growth rates, but relatively stable quarterly growth rates. There was, in fact, little difference between the simulated M1 growth rates, suggesting that forecasting the multiplier with great accuracy may not be as important as aiming for a steady long-run growth rate.

The paper also examined the importance of money stock control by simulating GNP growth under the hypothetical desired path, as well as the M1 growth simulated under the MSKF forecast/control procedure. There was only a minor difference in these simulations; quarterly GNP growth usually did not differ by more than one percentage point. This indicates that the money multiplier forecast/control procedure used in this article could be successful in achieving more stable GNP growth.

Predicting Velocity Growth: A Time Series Perspective

SCOTT E. HEIN and PAUL T. W. M. VEUGELERS

ONE important issue involved in the choice of a monetary aggregate for policy purposes is the predictability of the relationship between the aggregate and nominal GNP growth. This article examines the predictability of recent M1 velocity growth to assess claims that the relationship between M1 and nominal GNP has deteriorated.[1]

WHY PREDICT VELOCITY GROWTH?

The quantity equation of exchange states that nominal GNP (Y) is identically equal to the product of the money stock (M) and its velocity (V), or rate of turnover. Expressed in terms of growth rates, the relationship is equally straightforward: the growth of nominal GNP is equal to the sum of the growth in the money stock and the growth in its velocity.

If we take the ability to achieve a desired money growth objective as given, the success in achieving a nominal GNP goal is based simply on the precision with which velocity growth can be forecast. For example, if monetary authorities know that M1 velocity growth will be 3.0 percent next year, a goal of 8.0 percent nominal GNP growth simply requires M1 growth of 5.0 percent. The uncertainty attached to the GNP objective then depends on the uncertainty attached to predicting velocity growth.

FOUR WAYS TO PREDICT VELOCITY GROWTH

This paper evaluates four different time series techniques used to predict future velocity growth over the period II/1975–I/1983, roughly the last two full business cycles. These techniques use only information available at the time the forecast is made, the same constraint facing a policymaker. Because of this constraint, we have restricted the class of forecasting models to time series models, whose forecasts are determined solely on the past behavior of velocity growth itself.[2]

It is important to note that the four techniques differ with respect to the relative weights attached to velocity growth behavior in the recent and distant past. Some techniques' forecasts of velocity are influenced more heavily by recent trends in velocity growth, while other techniques use longer trends. In addition, the techniques differ in terms of their computational ease and statistical sophistication.

Sample Mean Forecast

The technique that attaches the greatest weight to the more distant past and is one of the simplest is the sample mean forecasting technique. With this technique, next quarter's velocity growth is forecast to equal the average of velocity growth from II/1959 to the period immediately preceding the forecast (see box on opposite page, equation 1).[3]

Thus, for example, the forecast of velocity growth in I/1983 is simply the average of velocity growth from II/1959 to IV/1982. We refer to this forecast as the sample mean forecast and use the superscript (SM) to distinguish it from others.

The sample mean forecasting procedure is not as naive as it may appear on the surface. If velocity growth

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[1] For an alternative analysis of this issue, see John A. Tatom "Was the 1982 Velocity Decline Unusual?" this *Review* (August/September 1983), pp. 5–15.

[2] This information constraint limits the usefulness of econometric models that utilize contemporaneous observations of other determining variables, because forecasting velocity growth in such a framework necessitates that forecasts of these determining variables also be made. As a result of this complication, we ignore this class of models.

[3] The paper uses the new M1 measure, which is only available since 1959. Also, because this study was completed before July 1983, the GNP series used does not include the latest revisions.

Alternative Velocity Forecast Procedures[1]

Sample Mean Forecast (SM)

(1) $\hat{\dot{V}}_T^{(SM)} = \sum_{t=1}^{T-F} \dot{V}_t / T-F$, t = 1 in II/1959

Triple Exponential Smoothing Forecast (XS)

(2) $\hat{\dot{V}}_T^{(XS)} = \beta_{0,T} + \beta_{1,T}(F) + \beta_{2,T}(F^2)$

Kalman Filter Forecast (KF)[2]

(3) $\hat{\dot{V}}_T^{(KF)} = \dot{V}^P_{T-F}$

Random Walk Forecast (RW)

(4) $\hat{\dot{V}}_T^{(RW)} = \dot{V}_{T-F}$

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[1] $\hat{\dot{V}}_T^{(i)}$ = forecast of velocity growth for time T. F is the number of periods into the future over which the procedure forecasts. Information on velocity growth is presumed to be available only through period T − F.

[2] $\dot{V}^P_{T-F}$ = estimate of permanent velocity growth at time T − 1 using Kalman filter approach.

fluctuates randomly about a fixed mean, then it is said to be white noise. In this case, the best forecast for velocity growth at any point in the future is simply the sample mean.[4] There is evidence to suggest that velocity growth was white noise in the I/1959–I/1975 period.[5]

Exponential Smoothing Forecast

The second forecasting technique considered is a more complicated procedure called triple exponential smoothing (XS). Forecasters frequently use smoothing procedures to improve upon mean forecasts. When the mean of the underlying series is subject to change,

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[4] A series is said to be white noise if it has virtually no discernible pattern to it. If such a series is denoted by ε_t, then this series is white noise if correlation $(\varepsilon_t, \varepsilon_s) = 0$ for all $t \neq s$ and if the expected value of ε_t is constant for all t. See C. W. J. Granger, *Forecasting in Business and Economics* (Academic Press, 1980), esp. pp. 41–42.

The long-run properties of the "St. Louis equation" also suggest that velocity growth will be constant in the long-run steady state. Recent variations of this equation are represented by:

$$(4)\ \dot{Y}_t = \beta_0 + \sum_{i=0}^{J} \beta_i' \dot{M}_{t-i} + \sum_{i=0}^{K} \beta_i'' \dot{E}_{t-i} + \varepsilon_t,$$

where $\dot{Y}_t$ is GNP growth, $\dot{M}_t$ is money stock (M1) growth, $\dot{E}_t$ is high-employment expenditure growth, the β coefficients are constants and ε_t is a random term. Statistical estimation of this equation generally has supported the long-run propositions that

$$\sum_{i=0}^{J} \beta_i' = 1 \text{ and } \sum_{i=0}^{K} \beta_i'' = 0.$$

Placing these steady-state restrictions in equation 4 yields the steady-state result (for $\dot{M}_t = \dot{M}_{t-i} = \ldots$)

$$(4')\ \dot{Y}_t = \beta_0 + \dot{M}_t,$$

or rearranging,

$$(4'')\ \dot{Y}_t - \dot{M}_t \equiv \dot{V}_t = \beta_0.$$

In the long run, then, the St. Louis equation suggests velocity growth will be constant, in which case the best forecast is again the average level of velocity growth. For a recent discussion of this equation, see Dallas S. Batten and Daniel L. Thornton, "Polynominal Distributed Lags and the Estimation of the St. Louis Equation," this *Review* (April 1983), pp. 13–25.

[5] The conclusion that velocity growth is white noise is consistent with the evidence in John P. Gould and Charles R. Nelson, "The Stochastic Structure of the Velocity of Money," *American Economic Review* (June 1974), pp. 405–18. They find that the log of the level of velocity is a random walk,

$$\ln V_t = \ln V_{t-1} + \delta + \mu_t.$$

Thus, the difference in log levels, which is a multiple of *growth rate* of velocity — the variable in our study — can be expressed as a white noise series:

$$\ln V_t - \ln V_{t-1} = \delta + \mu_t.$$

They found, using annual data over a longer time period, that δ was not different from zero. Our evidence for quarterly data after 1959 suggests this is not true. In either case, velocity growth fluctuates randomly about a fixed value.

Triple Exponential Forecast Technique

Exponential smoothing procedures are widely used by economic and business forecasters. These procedures do not require the statistical sophistication that a Box-Jenkins or Kalman filter forecasting approach do. Yet, they generally are felt to yield forecasts superior to sample mean or moving-average forecasts.

The triple exponential smoothing procedure employed in forecasting velocity growth starts by calculating three smoothed statistics:

$$S_t^1 = \alpha \dot{V}_t + (1-\alpha) S_{t-1}^1$$

$$S_t^2 = \alpha S_t^1 + (1-\alpha) S_{t-1}^2$$

$$S_t^3 = \alpha S_t^2 + (1-\alpha) S_{t-1}^3.$$

Two pieces of information are required to calculate these statistics. First, a value for α must be specified by the forecaster. There is no fixed rule one can use to select the appropriate value. It is usually recommended, however, that the forecaster experiment with values of $\alpha = 0.1$, $\alpha = 0.4$ and $\alpha = 0.7$, selecting the α with the best forecast record for subsequent use. In our case, velocity growth was forecast over the period 1967–1973 using these three values. Based on a superior forecast record among values of α for this period, $\alpha = 0.1$ was selected. Note that from the first equation above this low value of α indicates a low weighting given to current velocity growth developments and a high weighting given to the more distant past.

In addition to the selection of α, the initial values for S^1, S^2 and S^3 are required. These values were all set equal to the average of velocity growth in the two quarters just before the forecasting procedure was initiated, which is II/1973 in our case.

The next step requires the calculation of three forecasting coefficients that are based on the smoothing statistics:

$$a_t = 3\, S_t^1 - 3\, S_t^2 + S_t^3$$

$$b_t = \left[\frac{\alpha}{2(1-\alpha)}\right] \left[(6-5\alpha)\, S_t^1 - (10-8\alpha)\, S_t^2 + (4-3\alpha)\, S_t^3\right]$$

$$c_t = \left[\frac{\alpha}{(1-\alpha)}\right]^2 (S_t^1 - 2S_t^2 + S_t^3).$$

Finally, these three coefficients are used to forecast F periods ahead of period t, based on the following relationship:

$$\hat{\dot{V}}_{t+F}^{(XS)} = a_t + b_t F + (1/2)\, c_t (F)^2.$$

This forecasting equation indicates that the hypothesized relationship is allowed to change over time, as the coefficients a_t, b_t and c_t change. The equation also makes it clear that the time horizon over which the forecast is being made will have an effect on the forecast. For example, if forecasts are being made for a given t, say t = I/1975, the one-quarter-ahead forecast (F = 1) will be different from the two-quarter-ahead forecast (F = 2). This forecast horizon dependency is not true of the other forecasting procedures used in this article.

these procedures, which give more weight to recent observations, are felt to be superior to mean or moving-average forecasts, because such procedures more quickly recognize changing conditions. Yet the procedure is not statistically derived and, for that reason, is somewhat ad hoc (see above for more detailed description). The particular smoothing procedure employed here postulates that velocity growth is related to time in the specific fashion shown on page 35, equation 2.

The coefficients from the triple exponential smoothing procedure are allowed to change through time in a way that incorporates past velocity behavior, though it allows for the influence of past effects to decay rapidly. Once coefficients are calculated, they are simply plugged into the forecast equation (page 35, equation 2) to obtain a forecast of future velocity growth.

Kalman Filter Forecast

The third forecasting scheme considered is the Kalman filter (KF) technique.[6] This procedure postulates that velocity growth is subject to two kinds of "shocks": temporary and permanent.[7] The Kalman filter tech-

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[6] The procedure is explained in Clemens J. M. Kool "Statistical Appendix A: The Multi-State-Kalman Filter Method," appended to Eduard J. Bomhoff, "Predicting the Price Level in a World that Changes all the Time," in Karl Brunner and Allan H. Meltzer, eds., *Economic Policy in a World of Change*, Carnegie-Rochester Conference Series on Public Policy, Vol. 17 (1982), pp. 39–46.

[7] It can be represented as two equations:

$$(5)\quad \dot{V}_t = \dot{V}_t^P + \varepsilon_t$$

$$(6)\quad \dot{V}_t^P = \dot{V}_{t-1}^P + \mu_t,$$

where $\dot{V}_t^P$ is the permanent level of velocity growth at time t. The ε_t term represents a transitory shock to the level of velocity growth, and the μ_t represents a permanent shock to the level of velocity growth.

nique further differentiates between small and large shocks, so that four states are possible: (1) small and temporary, (2) large and temporary, (3) small and permanent and (4) large and permanent. Based on the past history of the growth of velocity, the Kalman filter technique estimates the probability of each of the four states and forecasts future velocity growth based on a weighted average of the estimated permanent level of velocity growth under each of the four various states. The result is shown in the box on page 35, where $\dot{V}^{P}_{T-F}$ represents the permanent level of velocity growth immediately prior to the forecast.

This model of velocity behavior can be shown to correspond to an integrated moving-average model of the form IMA (1,1). This correspondence indicates that recent velocity growth information is used more heavily in the development of this forecast than either of the two forecasting techniques considered thus far.

Random Walk Forecast

As a fourth alternative, a random walk model (RW), which places even greater weight on recent developments, is assessed. This model holds that the change in velocity growth is completely random, implying that the best forecast of velocity growth in the future is the current level of velocity growth (as shown in equation 4, page 35). The random walk model stands in sharp contrast to the sample mean model. It suggests that knowledge of velocity growth in the distant past is irrelevant in forecasting the future because all relevant information is already contained in the most recent observation. The sample mean model, on the other hand, weights observations from the distant past equal to the most recent ones.[8]

THE FORECASTS

These four models were used to forecast velocity growth from II/1975 to I/1983 over two alternative time horizons. The first forecasts were simply one-quarter forecasts of velocity growth. The other forecasts were for velocity growth over the next four quarters. For the latter forecasts, no information from the intervening four quarters is used in any of the forecast procedures.[9] The forecast of velocity growth over the next four quarters made at time t = T-4 is denoted by $\hat{\dot{V}}4^{(i)}_{T}$, where i = (SM, KF, XS, RW).

The One-Quarter Forecasts of Velocity Growth

Table 1 lists actual quarterly velocity growth and the forecast errors (predicted minus actual) from the four alternative forecasts for II/1975–I/1983, where each forecast was developed conditionally on information pertaining to velocity growth up to the period being forecast. For example, the sample mean forecast ($\hat{\dot{V}}^{(SM)}_{T}$) for II/1975 was 2.79 percent, the average level of velocity growth from II/1959 to I/1975. Since velocity growth was actually 3.77 percent in II/1975, the mean forecast underestimated velocity growth by 0.98 percentage points. The triple exponential smoothing procedure ($\hat{\dot{V}}^{(XS)}_{T}$) and the Kalman filter technique ($\hat{\dot{V}}^{(KF)}_{T}$) use these same observations of velocity growth to obtain forecasts of 1.31 percent and 1.45 percent, respectively.[10] Both underestimated velocity growth in II/1975 by larger magnitudes than the sample mean forecast. The random walk forecast ($\hat{\dot{V}}^{(RW)}_{T}$) of a 1.36 percent decline for II/1975 simply reflects the fact that velocity fell at a 1.36 percent rate in I/1975. As shown in table 1, the random walk model yielded the largest forecast error in II/1975 (5.12 percentage points).

Table 1 lists statistics that summarize the different forecasting performances of the different models: the mean absolute forecast error and the root-mean-squared error.[11] The closer the forecast is on average to

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[8] The random walk model of velocity growth, or variations that emphasize more recent velocity growth, seem to have gained wider acceptance because velocity growth recently has been "abnormally" sluggish. As an example of forecasters who heavily weight recent velocity behavior, consider this statement in Robert A. Brusca *Financial Markets*, Irving Trust (July 15, 1983) ". . . M1's velocity might even increase in the second quarter [of 1983]. If this happens, the Fed is more likely to be concerned with M1's growth." This statement suggests that velocity growth developments in the second quarter of 1983 will heavily influence velocity growth in the third quarter.

[9] In the case of the four-quarter horizon, we forecast velocity growth over the next four-quarter period, *not* the quarterly velocity growth four quarters hence. That is, if t is the period from which the forecast is made, we forecast $(\ln V_{t+4} - \ln V_t) \times 100$, not $(\ln V_{t+4} - \ln V_{t+3}) \times 400$. For later reference, it is useful to recognize that velocity growth over the next four quarters is equal to average velocity growth over the next four quarters:

$$\begin{aligned}(\ln V_{t+4} - \ln V_t) \times 100 &= [(\ln V_{t+4} - \ln V_{t+3}) + (\ln V_{t+3} \\ &\quad - \ln V_{t+2}) + (\ln V_{t+2} - \ln V_{t+1}) + (\ln V_{t+1} - \ln V_t)] \times 100 \\ &= [\dot{V}_{t+4} + \dot{V}_{t+3} + \dot{V}_{t+2} + \dot{V}_{t+1}]/4.\end{aligned}$$

[10] The triple exponential smoothing technique was initiated in II/1973 using the average of velocity growth in IV/1972 and I/1973. (See box on opposite page for more details.)

[11] Let ε_t be a forecast error for period t. Then, the mean absolute forecast error is $\sum_{t=1}^{N} |\varepsilon_t|/N$; and the root-mean-squared error is $(\sum_{t=1}^{N} (\varepsilon_t)^2/N)^{1/2}$.

Table 1

One-Quarter Velocity Growth Forecasts and Summary Statistics

	Actual	Forecast Errors			
Period	$\dot{V}_t$	$(\hat{\dot{V}}_T^{(SM)} - \dot{V}_t)$	$(\hat{\dot{V}}_T^{(XS)} - \dot{V}_t)$	$(\hat{\dot{V}}_T^{(KF)} - \dot{V}_t)$	$(\hat{\dot{V}}_T^{(RW)} - \dot{V}_t)$
II/1975	3.77%	−0.98%	−2.46%	−2.32%	−5.12%
III/1975	8.64	−5.84	−6.93	−6.04	−4.87
IV/1975	7.83	−4.93	−4.30	−2.98	0.81
I/1976	6.49	−3.53	−1.74	−0.04	1.33
II/1976	−0.34	3.35	5.67	6.90	6.83
III/1976	2.84	0.12	0.91	0.55	−3.18
IV/1976	2.52	0.45	0.92	0.57	0.33
I/1977	4.49	−1.53	−1.41	−1.73	−1.98
II/1977	5.81	−2.83	−2.41	−2.24	−1.32
III/1977	5.70	−2.67	−1.63	−1.08	0.12
IV/1977	−1.37	4.43	5.93	6.55	7.06
I/1978	0.71	2.29	2.13	1.22	−2.08
II/1978	11.72	−8.75	−9.63	−10.89	−11.01
III/1978	3.94	−0.85	0.86	4.25	7.78
IV/1978	6.92	−3.82	−2.27	−3.02	−2.98
I/1979	4.27	−1.13	1.13	1.13	2.64
II/1979	−2.65	5.80	7.87	7.49	6.92
III/1979	3.54	−0.46	−0.56	−0.89	−6.19
IV/1979	3.30	−0.21	−0.25	0.43	0.25
I/1980	4.78	−1.69	−1.74	−1.21	−1.48
II/1980	2.84	0.27	0.63	1.14	1.94
III/1980	−3.03	6.14	6.28	6.66	5.87
IV/1980	3.27	−0.23	−1.96	−0.73	−6.30
I/1981	13.40	−10.36	−11.74	−10.16	−10.13
II/1981	−4.04	7.20	9.03	7.47	17.44
III/1981	10.51	−7.43	−8.07	−7.53	−14.55
IV/1981	−2.71	5.87	7.46	6.13	13.22
I/1982	−11.28	14.37	13.92	13.44	8.57
II/1982	3.29	−0.35	−4.91	−2.28	−14.57
III/1982	−0.40	3.34	−0.25	3.04	3.69
IV/1982	−10.29	13.20	9.34	11.44	9.90
I/1983	−5.06	7.83	0.93	5.85	−5.23
		Summary Statistics			
Mean Absolute Error		4.13	4.23	4.29	5.80
Root-Mean-Squared Error		5.58	5.63	5.64	7.40
Fraction of Error Due to:					
(A) Bias		0.01	0.00	0.03	0.00
(B) Variance		0.95	0.36	0.47	0.00
(C) Covariance		0.04	0.64	0.50	1.00

the actual growth rate, the smaller each of these summary measures will be. Thus, the size of each statistic provides a criterion by which to judge the respective abilities to forecast velocity growth.

In general, the models that place greater weight on the more recent observations perform worse. Compare, for example, the extremes represented by the sample mean and random walk models. The sample mean attaches the smallest relative weights to recent observations; its forecast record is generally the best. The random walk model, which attaches the greatest weight to recent developments, has the worst forecasting record with by far the largest mean absolute and root-mean-squared errors.

The table shows little difference in the forecast records of the sample mean, the triple exponential smoothing and the Kalman filter procedures, however. While the sample mean forecast generally does slightly better than the other two, the difference is not great at all.[12] Thus, it appears that knowing how velocity growth behaved this quarter provides no more information about how it will behave next than its behavior in the distant past.

Table 1 shows that the decomposition of the forecast error due to bias is less than 5 percent for each of the separate forecast procedures.[13] Forecasts yield a large fraction of the error due to bias when the mean of the forecast series is different from the mean of the actual series being forecast. The small fraction of the error due to bias in table 1 is evidence that, regardless of the forecast procedure, the mean of the velocity growth forecasts is quite close to the mean of actual velocity growth over the period II/1975–I/1983.[14] The fraction of the error due to variance increases when the series to be forecasted and the forecasts themselves have very different variances. The large fraction of error due to variance for the sample mean forecast ($\hat{\dot{V}}_T^{(SM)}$) confirms that the variance of quarterly velocity growth is much greater than the variance of the mean of velocity growth.

Regardless of which forecast model is considered, the quarterly prediction record is not impressive. Both the mean absolute error and the root-mean-squared error are quite large for each model. The root-mean-squared error for the sample mean forecast, for example, suggests a 95 percent confidence range of plus or minus 11.2 percent. Thus, based on these different forecasting procedures, it appears that forecasting quarterly velocity growth with precision is quite difficult. This suggests that the precision that monetary policymakers have in achieving short-run nominal GNP growth objectives is not great.[15]

The lack of precision in achieving short-run GNP growth objectives stands in sharp contrast to recent efforts to require the Federal Reserve to announce GNP growth targets. For example, a recent Business Week editorial urged that, "Chairman Volcker should be required to say what the Fed expects the *quarterly* growth of nominal GNP to be, especially how its forecast relates to money growth targets. . . . No one knows better than Volcker that the economy is much too complex to be guided simply by monitoring movements in monetary aggregates alone" (emphasis added).[16]

The evidence provided here suggests that little would be added by adopting an explicit GNP growth objective. M1 velocity growth apparently fluctuates randomly around a level of 2 to 3 percent, so that a monetary target for M1 can easily be translated into a GNP objective by adding 2 to 3 percent to it. The difficulty with adopting such an objective is that the random velocity growth fluctuations are quite large, indicating that the Federal Reserve alone cannot closely achieve a particular short-run GNP target that it or anyone else would choose. In this regard, "attempts to targt GNP within a narrow range would, deliberately or not, provide an unwarranted sense of omnipotence for monetary policy."[17]

Velocity Growth Since 1982

For the period as a whole, the sample mean forecast works as well as any other procedure, an observation consistent with the notion that velocity growth fluctuates randomly about a fixed value. The table does show large forecast errors for the sample mean model over the recent period I/1982–I/1983, however. For instance, while velocity contracted at a substantial 2.28 percent rate over this period, the sample mean model

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[12] We tested whether any one forecast procedure could improve upon another by regressing the forecast errors from one model on the difference in the forecasts (see C. W. J. Granger and Paul Newbold, *Forecasting Economic Time Series* (Academic Press, 1977), esp. pp. 268–78.) In general, we found nothing to statistically differentiate the sample mean, triple exponential and Kalman filter forecasts. None of these forecast procedures could improve statistically upon the others. Each of these three forecast procedures, however, was found to improve upon the random walk model, whereas the random walk model could not aid in explaining the other forecasts. In sum, there is little statistical evidence to differentiate among the sample mean, triple exponential and the Kalman filter forecasts; yet, all are superior to the random walk model.

[13] On the decomposition of forecast error, see C. W. J. Granger and P. Newbold, "Some Comments on the Evaluation of Economic Forecasts," *Applied Economics* (1973), pp. 35–47.

[14] The mean forecast errors for the sample mean, triple exponential smoothing, Kalman filter and random walk forecasts are 0.53, 0.34, 0.97 and 0.12, respectively. This indicates that all of the models slightly overpredicted velocity growth on average for the period II/1975–I/1983.

[15] In this vein, Karl Brunner, "Has Monetarism Failed?" *The Cato Journal* (Spring 1983), p. 42, has stated that ". . . discretionary policies attempting to offset observed or anticipated changes in velocity most probably raise, on average, the variability of changes in nominal GNP."

[16] "More Details from the Fed," *Business Week*, August 1, 1983, p. 104.

[17] Statement by Paul Volcker, Chairman of the Board of Governors of the Federal Reserve System, before the Subcommittee on Domestic Monetary Policy of the House Committee on Banking, Finance and Urban Affairs, August 1983, processed.

was forecasting growth of about 3.00 percent. This anomalous pattern of velocity growth resulted in a very large root-mean-squared error of 9.52 percent for this period — almost twice that of the full period. While this may seem sufficient grounds to question the usefulness of such a model of velocity growth, a number of considerations suggest that it is premature to conclude that the sample mean characterization has become invalid.

To begin with, the other forecasting procedures also have deteriorated significantly over this period. The root-mean-squared errors for the triple exponential smoothing, Kalman filter and random walk forecasting models are 7.84 percent, 8.44 percent and 9.40 percent, respectively. All of these measures indicate much larger forecast errors than for earlier periods, as all of the models have had less success in forecasting recent developments. Velocity growth has become more volatile recently and the performance of the four forecast techniques has deteriorated accordingly.[18]

Moreover, even though the sample mean model performed worse than the other models since I/1982, this period is too short to attach great significance to such a finding. There have been other periods of similar length in the past, in which the sample mean did an inferior job; over the period II/1975–I/1976, for example, both the Kalman filter and random walk models resulted in root-mean-squared errors considerably below that of the sample mean. Yet, as we have seen, for the full period the random walk model is clearly inferior and the Kalman filter is slightly worse than the sample mean model.

Four-Quarter Forecasts of Velocity Growth

Because policy generally is concerned with periods longer than one quarter, the relevant issue for policy is prediction errors over longer time horizons, for example, four-quarter periods.[19] How do the different models generate such longer-run velocity predictions? The sample mean, Kalman filter and random walk forecast models yield forecasts that are *independent* of the forecasting horizon. At any specific point in time, each of these models project velocity growth to be a given value for the indefinite future. For example, the mean of velocity growth from II/1959 to I/1975 was 2.79 percent. Thus, the forecast for II/1975 based on the sample mean model is 2.79 percent. Because this same growth is forecast to continue over the indefinite future, the sample mean forecast of velocity growth from II/1975 to I/1976 also is 2.79 percent.

The triple exponential smoothing forecasts — unlike the other three techniques — are not independent of the forecast horizon, however. The forecast of velocity growth two quarters ahead is not the same as the forecast of velocity growth one quarter ahead. Thus the forecast of velocity growth for the next four-quarter period is defined to be the average of the one-period-ahead, two-period-ahead, three-period-ahead and four-period-ahead quarterly velocity growth forecasts. In this way, all the models essentially are forecasting velocity growth over the next year based only on information available today.

Table 2 lists the actual velocity growth rates over the previous four quarters and the respective forecast errors for the same period. The forecast error at time t is simply the difference between the velocity growth predicted at t-4 and the actual velocity growth at t. A comparison of tables 1 and 2 indicates, not surprisingly, that actual four-quarter velocity growth is much less volatile than one-quarter growth rates. The standard deviation of the quarterly growth rate is 5.54 percent; it is only 2.70 percent for the four-quarter velocity growth rate.

Irrespective of the forecast technique, the mean absolute error and the root-mean-squared error in table 2 also are both much smaller than their counterparts in table 1. For example, the root-mean-squared error from the sample mean forecast technique for the four-quarter velocity growth rate forecast is 50 percent smaller than the root-mean-squared error for the one-quarter ahead forecast, decreasing the 95 percent confidence range from plus or minus 11.2 percent to plus or minus 5.5 percent. Similar reductions in the root-

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[18] The standard deviation of velocity growth is 6.26 percent for the I/1982–I/1983 period — almost twice what it was for the period II/1975–I/1979, for example. This increased volatility makes it impossible to test statistically whether the mean of velocity growth has changed in the recent period, because the small sample tests used to test such a hypothesis require assumptions of normality and *equal variance*. Thus, while the mean of velocity growth for the I/1982–I/1983 period is smaller than it was in the earlier period, one cannot determine whether it is statistically different. It is thus too early to argue that the mean model is invalid. What may have changed is that the random shocks to velocity growth have simply gotten larger.

It is interesting to note that if one compares the mean of velocity growth over the period II/1975–I/1983 with that of the preceding 32 quarters, no assumption of equal variance is required because it is a large sample test. Comparing the means across these two sample periods, however, indicates that there is no statistical difference in the means. This suggests that the sharp contraction in velocity growth since I/1982, has simply offset more rapid velocity growth for the period II/1975–IV/1981.

[19] Recall footnote 9 that shows that velocity growth over the next four quarters is equal to average quarterly velocity growth for the next four quarters.

Table 2

Four-Quarter Velocity Growth Forecasts and Summary Statistics

Period	Actual Four-Quarter Growth[1]	Forecast Errors			
	$\dot{V}4_t$	$(\hat{\dot{V}}_T^{(SM)} - \dot{V}_t)$	$(\hat{\dot{V}}_T^{(XS)} - \dot{V}_t)$	$(\hat{\dot{V}}_T^{(KF)} - \dot{V}_t)$	$(\hat{\dot{V}}_T^{(RW)} - \dot{V}_t)$
II/1975	2.01%	0.85%	1.16%	2.74%	4.60%
III/1975	3.12	−0.24	0.17	1.55	1.09
IV/1975	4.72	−1.87	−2.30	−1.40	−3.31
I/1976	6.68	−3.89	−5.88	−5.24	−8.04
II/1976	5.66	−2.85	−4.35	−3.05	−1.89
III/1976	4.71	−1.81	−0.78	0.14	3.93
IV/1976	2.88	0.09	1.97	3.57	4.95
I/1977	2.38	0.64	3.14	4.19	4.11
II/1977	3.92	−0.95	−0.23	−0.52	−4.25
III/1977	4.63	−1.66	−1.31	−1.54	−1.79
IV/1977	3.66	−0.70	−0.73	−0.89	−1.14
I/1978	2.71	0.27	0.60	0.86	1.78
II/1978	4.19	−1.17	−0.11	0.43	1.62
III/1978	3.75	−0.69	0.91	1.44	1.95
IV/1978	5.82	−2.82	−3.15	−3.89	−7.19
I/1979	6.71	−3.74	−4.90	−5.88	−6.00
II/1979	3.18	−0.10	1.84	5.01	8.54
III/1979	3.02	0.07	1.75	0.88	0.91
IV/1979	2.12	1.02	3.53	3.29	4.80
I/1980	2.24	0.91	3.17	2.61	2.03
II/1980	3.62	−0.53	−0.79	−0.96	−6.26
III/1980	1.97	1.12	0.94	1.76	1.57
IV/1980	1.96	1.13	0.94	1.61	1.33
I/1981	4.12	−1.01	−0.70	−0.14	0.66
II/1981	2.40	0.71	0.77	1.23	0.44
III/1981	5.78	−2.75	−4.84	−3.24	−8.82
IV/1981	4.29	−1.25	−2.93	−1.05	−1.02
I/1982	−1.88	5.04	7.11	5.30	15.28
II/1982	−0.05	3.12	2.32	3.02	−4.00
III/1982	−2.77	5.93	7.72	6.19	13.28
IV/1982	−4.67	7.76	7.18	6.83	1.96
I/1983	−3.11	6.05	0.72	4.13	−8.16
		Summary Statistics			
Mean Absolute Error		1.96	2.45	2.64	4.27
Root-Mean-Squared Error		2.75	3.28	3.25	5.59
Fraction of Error Due to:					
(A) Bias		0.01	0.02	0.08	0.00
(B) Variance		0.89	0.10	0.12	0.16
(C) Covariance		0.10	0.88	0.80	0.84

[1] Actual four-quarter growth rate is: $(\ln V_t - \ln V_{t-4}) \times 100$.

mean-squared error and the mean absolute error also are evident for the other forecast techniques.

In the case of four-quarter growth rate predictions, the sample mean forecast model still has the smallest root-mean-squared error and mean absolute error. Whereas there were hardly any differences in the root-mean-squared errors among the first three models for the one-quarter-ahead forecasts, the sample mean forecast has a root-mean-squared error for the yearly forecasts that is 15 percent smaller than either the exponential smoothing or the Kalman filter procedure. Thus, there is no longer-run forecasting gain associated with using these more sophisticated models. Moreover, the sample mean forecast continues to be much superior to the random walk forecast.[20]

Finally, while velocity growth forecast errors for four-quarter growth rates during 1982 are the largest in the sample period, large forecast errors of the opposite sign were experienced earlier. For example, four-quarter velocity growth was very strong through 1975 and early 1976, resulting in sizeable underpredictions. Similar developments occurred in late 1978 and early 1979.[21]

POLICY IMPLICATIONS FROM FORECAST RESULTS

The evidence presented here is consistent with the hypothesis that quarterly velocity growth fluctuates randomly about a fixed mean. If this characterization is correct, then next quarter's velocity growth is best predicted by the sample mean. This is indeed what was found. None of the alternative time series models significantly improved upon the sample mean forecast. The fact that the sample mean forecast procedure itself did not do very well in forecasting one-quarter velocity growth does not discredit such a model, but suggests that the random short-run shocks are quite large in nature.

What can be inferred from large variations in random shocks to velocity growth or their growing in magnitude in recent years? Some have concluded from this observation that monetary aggregate (especially M1) targeting is a quite hopeless policy.[22] Even recognizing the sizeable volatility in quarterly velocity growth, however, it is difficult to see how this is true. The results do suggest that policymakers will find it difficult to stabilize quarter-to-quarter fluctuations in nominal spending. Such fine-tuning of the economy, however, has seldom, if ever, been the basis for recommending a monetary aggregate targeting procedure. Instead, monetary targeting procedures almost always have been advocated on the basis of achieving long-term economic goals.

While the sizeable volatility in quarterly velocity growth does imply a great deal of uncertainty about next quarter's GNP growth even if next quarter's money growth is known with certainty, it does not follow that it is particularly difficult to achieve longer-term GNP growth objectives. In fact, as a comparison of tables 1 and 2 indicates, the accuracy of velocity growth forecasts, in terms of root-mean-squared or mean absolute errors, *improves* as the length of time over which velocity growth is measured increases.

The ability to forecast velocity growth better over longer periods is related directly to the fact that quarterly velocity growth fluctuates randomly about a fixed value. Forecasting the individual fluctuations is impossible. Over time, however, these random fluctuations partially offset each other, which means that longer-term forecasting is possible, because forecasters can "hone in" on the fixed value. The longer the time horizon over which the forecasts are generated, the more accurate the forecast is likely to be.[23]

As an example of this phenomenon, let us put ourselves back in I/1975 and forecast nominal GNP growth from II/1975 through I/1983. In I/1975, we observed an average velocity growth of 2.79 percent from I/1959 to I/1975. Suppose we took this estimate of velocity growth as our forecast for quarterly velocity growth into the indefinite future, as the sample mean model suggests. Our forecast of velocity growth over the interval II/1975–I/1983 then would be 2.79 percent. Actually, velocity growth over this period was 2.48 percent. Our projection of velocity growth would have been in error by only 0.31 percentage points. Thus, our forecast of nominal spending growth would have been only 0.31 percentage points above what

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[20] There is no evidence that any of the other forecasting procedures can aid in improving upon the sample mean forecast. When the sample mean forecast error is regressed against the difference between forecasts, none of the coefficients on the difference are significantly different from zero. On the other hand, the sample mean forecast significantly reduced forecast errors associated with the other models for the four-quarter forecasts, indicating in this case that it is a superior forecast procedure.

[21] Note also that large forecast errors in one direction, again, are offset by large forecast errors in the other, so the mean error for all models remains quite small. The mean forecast errors for the sample mean, triple exponential smoothing, Kalman filter and random walk forecasts are 0.21, 0.41, 0.90 and 0.41, respectively.

[22] For example, see John D. Paulus, vice president and economist, Goldman, Sachs & Co., "Statement in Alternative Targets for Monetary Policy, Hearings before the Subcommittee on Domestic Monetary Policy of the Committee on Banking, Finance and Urban Affairs," U.S. House of Representatives 97 Cong. 2 Sess. (Government Printing Office, July 14, 1982), pp. 36–71.

[23] This statement has a statistical foundation: suppose that quarterly velocity growth is independent and identically distributed $N(\mu, \sigma^2)$. Then, in this case average velocity growth over N periods is distributed normally with a mean μ and a variance σ^2/N. (See Gouri Bhattacharyya and Richard Johnson, *Statistical Concepts and Methods* (John Wiley & Sons, 1977), esp. pp. 210–13.) The variance of the average declines as the number of periods in calculating the average increases.

actually took place had we known the actual course of M1 growth.

The reader is reminded that this period — II/1975 to I/1983 — is one in which monetary aggregate targeting has been discredited because of: (1) supposed shifts in money demand and, most important, (2) financial innovations such as the introduction of ATS accounts, NOW accounts, money market mutual funds, all-savers certificates and money market deposit accounts, which supposedly altered the relationship of M1 to GNP. Yet, over this full period, a knowledge of average money growth plus a crude projection of velocity growth would have yielded a fairly accurate picture about the longer-term course of spending growth.[24]

SUMMARY AND CONCLUSIONS

This paper examined the predictability of velocity growth using several time series methods. The results are consistent with the notion that quarterly velocity growth fluctuates randomly about a fixed mean. The evidence suggests that forecasting next quarter's velocity growth using average velocity growth over some extended period of time is as effective as any other, more sophisticated, forecasting approaches. For one-quarter forecasts analyzed here, this method performed as well as the more sophisticated techniques.

In addition, the accuracy of average velocity growth forecasts was found to *improve* with the time horizon over which the forecast is made. For example, forecasts of average velocity growth over four-quarter periods were significantly more accurate than those over one-quarter periods. This suggests that monetary policy is likely to be more successful in achieving long-term than short-term GNP growth objectives. Indeed, attempts to fine-tune could well result in greater, rather than less, economic volatility.

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[24] The reader should not conclude from this analysis that the economic determinants of velocity growth are unimportant. These factors have been ignored here because they presumably would be difficult to forecast ex ante. For an analysis of these determinants, see Tatom, "Was the 1982 Velocity Decline Unusual?" and Milton Friedman, "Why a Surge of Inflation Is Likely Next Year," *Wall Street Journal*, September 1, 1983.