Review

Vol. 66, No. 9 November 1984

THE FEDERAL RESERVE BANK of ST. LOUIS

The Review *is published 10 times per year by the Research and Public Information Department of the Federal Reserve Bank of St. Louis. Single-copy subscriptions are available to the public free of charge. Mail requests for subscriptions, back issues, or address changes to: Research and Public Information Department, Federal Reserve Bank of St. Louis, P.O. Box 442, St. Louis, Missouri 63166.*

Federal Reserve Bank of St. Louis
Review
November 1984

In This Issue . . .

The recent and prospective rise in the federal debt-GNP ratio has given rise to concern among economic analysts. In the first article of this *Review*, "Money Growth and the Size of the Federal Debt," Keith M. Carlson examines the importance of money growth assumptions in the assessment of this ratio. Simulations of a modified version of the St. Louis model are used to determine the effect of alternative growth paths of M1 on federal deficits and the federal debt-GNP ratio. The conclusion derived from these simulations is that faster money growth makes it easier to reduce budget deficits. Therefore, plans to reduce deficits over time must be coordinated with monetary policy actions if they are to achieve their desired results. Further, the usefulness of reducing deficits via faster money growth must be weighed against the resulting associated inflationary costs.

In the second article, "Depreciation, Inflation, and Investment Incentives: The Effects of the Tax Acts of 1981 and 1982," Mack Ott examines the relation between the value of additions to business capital equipment and plant and the Accelerated Cost Recovery System (ACRS) enacted in 1981. ACRS has been controversial since its enactment because it reduced effective corporate tax rates; it is a central issue in the administration's current tax reform proposal.

Proponents of ACRS have argued that the lowered tax rates on capital income have raised the rate of investment and thus contributed to faster U.S. economic growth, but critics claim that investment actually has been less rapid since ACRS was enacted. Ott finds that ACRS has provided enhanced investment incentives, reduced the bias against long-term investment in commercial and industrial structures and sharply raised investment since the end of the 1981–82 recession. However, he concludes that a major force explaining the recent strong rate of business investment in the United States has been the significant decline in the expected inflation rate. Under either ACRS or prior tax law, the massive decline in inflation would have had a significant positive impact on U.S. investment.

The growth rate of the money stock was much more variable in 1980–83 than in the previous 27 years. This greater variability increased business cycle risk, which was reflected in a rise in the variability of long-term interest rates. In the third article in this *Review*, John A. Tatom explains the links between the variability of money growth and the variability of interest rates and between the latter and economic performance.

Tatom describes the theoretical channels through which an increase in risk affects the economy, including how it reduces both the demand for and the supply of current goods and services. He examines the effects of the variability of interest rates on GNP, the price level and real output using a small reduced-form model of the economy and finds that increased risk reduces spending and output and raises price levels. Moreover, the evidence indicates that changes in anticipated, rather than unanticipated risk, influence spending, output and prices.

Specifically, Tatom finds a substantial negative effect from increased risk on both GNP and output growth over the 1980–83 period. In addition, changes in risk in 1980–83 account, in part, for temporarily higher inflation in 1980–81 and temporarily lower observed inflation in late 1982 and 1983.

Money Growth and the Size of the Federal Debt

Keith M. Carlson

FEDERAL debt held by the public (including the Federal Reserve System) has risen relative to GNP over the past 10 years, with most of the increase occurring since 1981 (see chart 1). This recent increase in the federal debt-GNP ratio reverses a downward trend that had prevailed from the end of World War II. Furthermore, as of early this year, the Congressional Budget Office (CBO) projected that a continuation of current budget policies would lead to further rises in the debt-to-GNP ratio through 1989.

This change in trend is viewed with concern by most economic analysts. According to the CBO:

> Historical experience suggests that increases and decreases in federal debt relative to GNP have been accompanied by approximately offsetting changes in non-federal debt as a percentage of GNP. Similarly, growth trends in the federal debt-GNP ratio appear to have been mirrored by opposite trends in the capital-output ratio.[1]

Should history repeat itself, the rising federal debt-GNP ratio will produce slower economic growth and a lower standard of living than would otherwise occur.

The accuracy of the CBO's projections depends, of course, on how accurately it is able to predict both deficits and future GNP.[2] Two problems make it difficult to obtain accurate projections of these two variables. First, these variables are interrelated; consequently, their feedback effects must be taken into account. Second, assumptions about the future course of monetary policy are crucial to the analysis; different assumptions will produce widely varying projections of both future deficits and future GNP.

The purpose of this article is to examine the importance of monetary policy assumptions in the assessment of the federal debt-GNP ratio. To aid in this examination, simulations from a modified version of a St. Louis-type model are used in conjunction with a model of budget and debt determination. Because this model is sensitive to changes in money growth, it can be used to determine the effect of alternative monetary policies on the federal debt-GNP ratio.

A FRAMEWORK FOR ANALYSIS

The role for monetary policy in the determination of strategic budget variables can be described with the aid of a schematic diagram (see page 6). For a given tax structure and set of outlay programs, the economic variables — real GNP, unemployment, the price level and interest rates — impinge strongly to determine the budget outcome in a given period.[3] These variables, in turn, are affected by the growth of the money stock. The size of the federal debt held by the public

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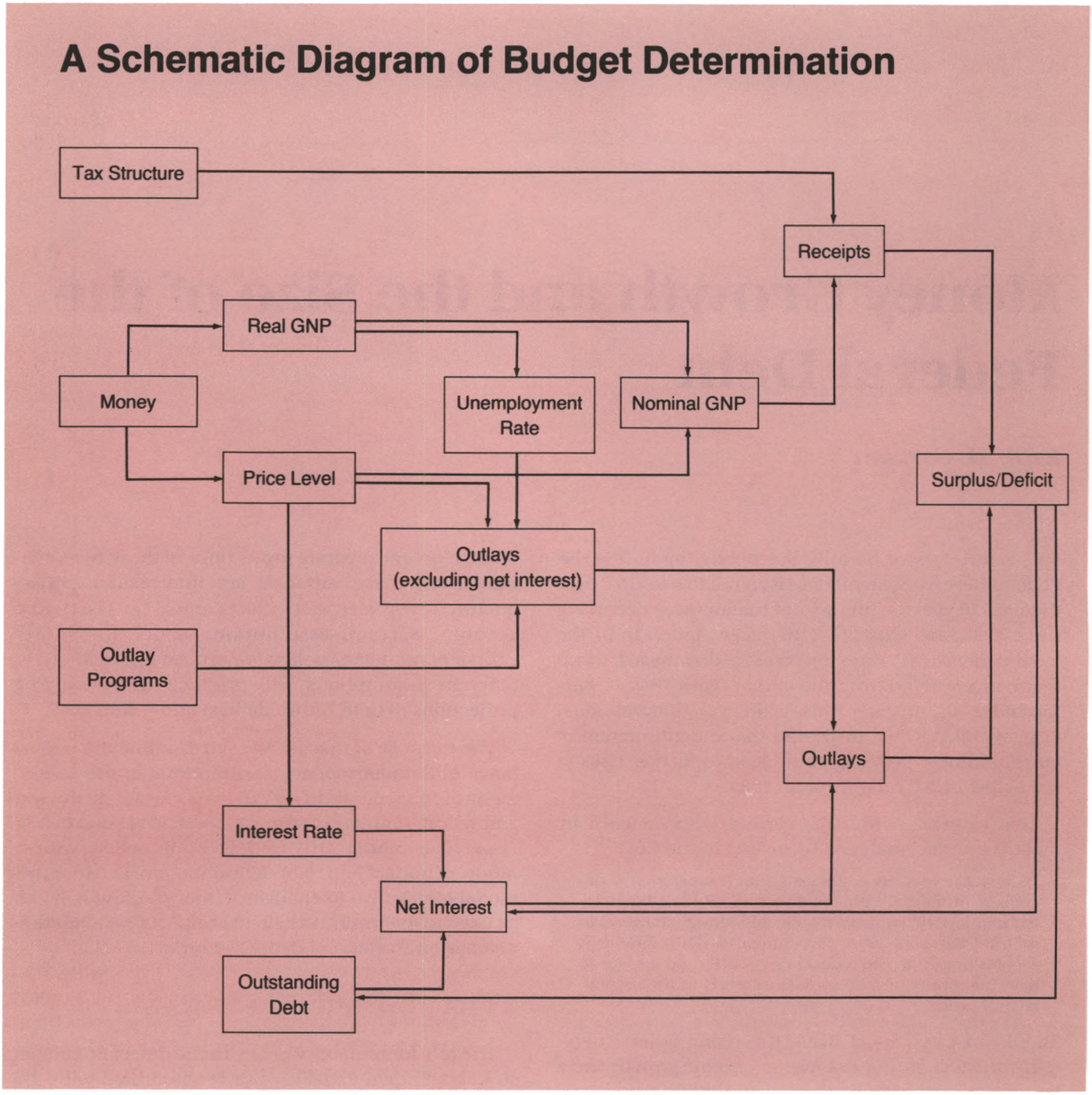
[1]CBO (February 1984), part I, p. 75.

[2]For a critique of the procedures used by the CBO and the Office of Management and Budget, see Klein (1984).

[3]In this diagram, the connection between economic variables and budget variables is predominantly in one direction, reflecting primarily the results of previous econometric studies.



relative to GNP is a convenient way of summarizing budget policy under a set of economic assumptions over a period of years.

With the aid of this schematic diagram, the key variables can be identified easily. The model must be capable of tracing a path through time for real GNP, the price level (GNP deflator) and interest rates. Given the responses of receipts and outlays, a time path for the federal debt can be derived. Then, to explore whether the federal debt grows explosively over time, the size of the debt can be compared with GNP.

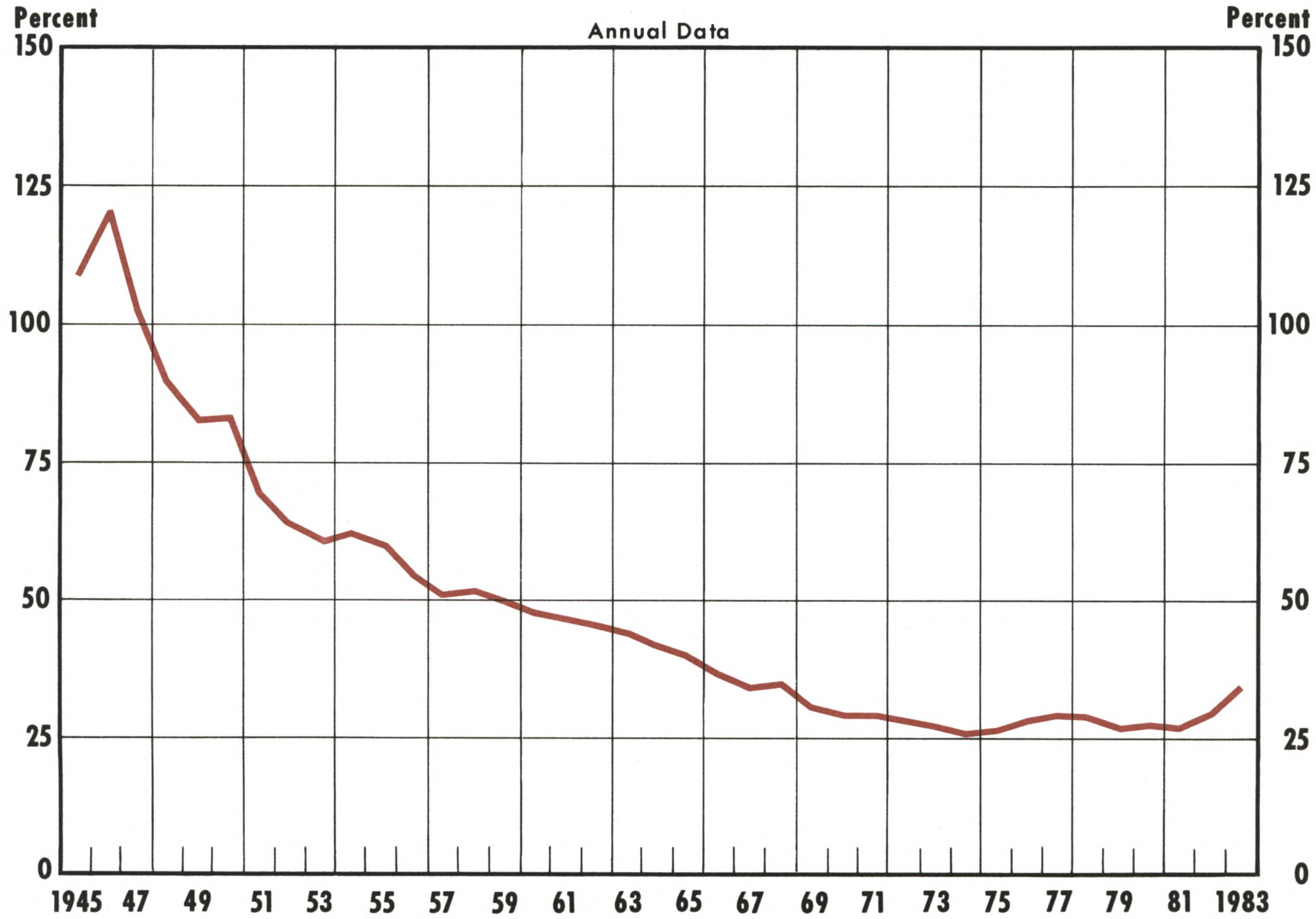
Summary of the Model

The model used in this article is an augmented monetary model.[4] (For details, see appendix A.) The key feature of the model is that nominal GNP is deter-

[4]For further details on its properties, see Carlson and Hein (1983).

Chart 1

Federal Debt Held by the Public as a Percent of GNP



mined by current and lagged values of the money stock (M1); in other words, fiscal variables were not found to be significant in the determination of GNP.[5] GNP is then divided between output and prices via a price equation. The GNP deflator is specified as a function of current and lagged values of the relative price of energy, demand pressure and anticipated price change. The 10-year Treasury bond rate is a function of past inflation. The 3-month Treasury bill rate is a function of current and lagged values of changes in output and prices.

The budget portion of the model consists of an outlays equation and a receipts equation.[6] These equations depend on a given outlay program and a set of tax laws, respectively, as well as the growth of real GNP and inflation. Interest payments are specified as a function of the two interest rates in the model, the portion of the budget deficit financed by the public, the size of the federal debt and the amount of debt maturing within a year. Several other budget identities are specified to generate additional variables and to close the model so that it can be solved.

Properties of the Model

The properties of the model are monetarist. Changes in the growth rate of money change the growth of nominal GNP quickly, with the full effect achieved within five quarters. Initially, this change in nominal GNP is translated into a change in output (real GNP) because prices respond to changes in

[5]This specification contrasts with that used in Carlson and Hein in that federal expenditures are omitted. For empirical support, see Hafer (1982).

[6]For further detail, see appendix B. See Carlson (1983) for further discussion of these equations.

money growth with a much longer lag than nominal GNP does. The 3-month Treasury bill rate responds to a change in money via its effects on output and prices.[7] The Treasury bond rate, on the other hand, responds more slowly to money because it depends only on past prices.

Over the longer run, the effects of a change in monetary growth are reflected only in nominal variables, that is, nominal GNP, inflation and nominal interest rates. The achievement of full adjustment to a steady-state growth path takes about 30 years. For the five-year time horizon used by the government for budget analysis, output growth is still influenced by money growth; that is, the steady-state equilibrium has not yet been attained. To gain more insight into the future prospects for the budget, the model is simulated to its steady-state equilibrium, which occurs around 2015. This longer-run perspective yields conclusions that differ from those that result from focusing on the conventional five-year budget horizon.

THE BUDGET EFFECTS FOR ALTERNATIVE MONETARY POLICIES: 1984–89

Each year the CBO provides a set of estimates that it calls "baseline projections." These are projections of what federal receipts and outlays would be if current laws and programs were to continue for the next five years. In other words, despite the use of the term "projections," these are not forecasts of the budget; they are meant to be used as baseline estimates against which proposed changes in tax laws and spending programs can be measured and assessed.

In the process of preparing these estimates, the CBO develops a set of economic assumptions.[8] This is a necessary part of the process because receipts and outlays depend crucially on economic conditions. Receipts depend, of course, on taxable income and sales which, in turn, depend on inflation and real growth. Similarly, outlays also are influenced by real growth, mainly via unemployment, and inflation, since a large number of programs are now indexed to the cost of living. Interest on the federal debt obviously depends on the level of interest rates as well as the size of the deficit and the amount and maturity structure of outstanding debt.

The CBO's 1984 report on the budget is particularly bleak.[9] According to the CBO's baseline estimates, the federal deficit will continue to grow in dollar terms throughout the 1984–89 period. Even when scaled against a growing GNP, the CBO concludes that the "deficit projections are obviously alarming."[10] As summarized in the ratio of federal debt to GNP, the baseline projections indicate that the sharp increase in the ratio in 1982–83 will continue through the 1984–89 period.

Economic Assumptions

To assess the validity of the CBO's conclusions, the monetary model was simulated using three different monetary scenarios — 4, 6 and 8 percent growth of M1. These three alternative money growth assumptions produced alternative paths for real growth, inflation and interest rates.

Table 1 summarizes the CBO's baseline projections and the simulations by the monetary model. Although the CBO's projections are derived under the assumption that money growth will be 6 percent, their results are not generally consistent with those obtained from the monetary model using 6 percent growth in money. In particular, the CBO's estimate of the dollar level of nominal GNP in 1989 falls about halfway between the results from simulations using 4 percent and 6 percent money growth.

The difference between the CBO's projections and the monetary model's simulations translates primarily into a difference in the projections for output. The CBO's projected level of real GNP for 1989 lies below that generated by the model using 4 percent money growth. Their relatively low projections of output tend

[7]Normally a third effect is included — a liquidity effect. However, using quarterly data the effect of contemporaneous changes in the growth rate of money was not found significant.

[8]For further discussion of the role of economic assumptions in the budgeting process, see Carlson.

[9]CBO (February 1984), part II. The analysis in this article (for both the CBO and the administration) is based on reports prepared in February 1984. Since then the CBO has prepared new baseline estimates (CBO, August 1984) and the administration has released its Mid-Session Review of the Fiscal Year 1985 Budget (OMB, August 15, 1984). The February estimates are used here because of their comparability; both the baseline estimates and the administration estimates are prepared on the basis of common CBO assumptions. Such comparability is not available for the August estimates. However, examination of the CBO's revised baseline estimates indicates that the conclusions are not materially affected. The estimates developed in this article are meant to serve as illustrations rather than precise projections.

[10]CBO (February 1984), part II, p. 6.

Table 1

Economic Variables: Model Simulations vs. CBO Baseline[1]

	1984	1985	1986	1987	1988	1989
GNP (billions of dollars)						
$\dot{M}=4\%$	$3763	$3968	$4254	$4563	$4893	$5247
	(13.9)	(5.4)	(7.2)	(7.3)	(7.2)	(7.2)
$\dot{M}=6\%$	3778	4045	4430	4852	5313	5819
	(14.3)	(7.1)	(9.5)	(9.5)	(9.5)	(9.5)
$\dot{M}=8\%$	3793	4123	4609	5153	5761	6441
	(14.8)	(8.7)	(11.8)	(11.8)	(11.8)	(11.8)
CBO	3651	3995	4339	4704	5084	5481
	(10.3)	(9.4)	(8.6)	(8.4)	(8.1)	(7.8)
Real GNP (billions of 1972 dollars)						
$\dot{M}=4\%$	$1669	$1707	$1762	$1823	$1882	$1937
	(8.7)	(2.3)	(3.2)	(3.5)	(3.2)	(2.9)
$\dot{M}=6\%$	1675	1737	1817	1891	1952	1998
	(9.2)	(3.7)	(4.6)	(4.1)	(3.2)	(2.4)
$\dot{M}=8\%$	1682	1768	1874	1964	2031	2072
	(9.6)	(5.1)	(6.0)	(4.8)	(3.4)	(2.0)
CBO	1618	1685	1744	1805	1866	1927
	(5.4)	(4.1)	(3.5)	(3.5)	(3.4)	(3.3)
GNP Deflator (1972=100)						
$\dot{M}=4\%$	225.5	232.5	241.5	250.3	259.9	270.8
	(4.7)	(3.3)	(3.9)	(3.6)	(3.8)	(4.2)
$\dot{M}=6\%$	225.5	232.9	243.8	256.5	272.2	291.2
	(4.7)	(3.3)	(4.7)	(5.2)	(6.1)	(7.0)
$\dot{M}=8\%$	225.5	233.2	245.9	262.3	283.7	310.8
	(4.7)	(3.4)	(5.4)	(6.7)	(8.2)	(9.6)
CBO	225.8	237.3	248.9	260.6	272.3	284.0
	(4.7)	(5.1)	(4.9)	(4.7)	(4.5)	(4.3)
Treasury Bill Rate (percent)						
$\dot{M}=4\%$	9.6%	8.8%	7.5%	6.6%	6.2%	6.1%
$\dot{M}=6\%$	9.8	9.4	8.6	8.2	8.2	8.4
$\dot{M}=8\%$	9.9	10.0	9.8	9.8	10.1	10.6
CBO	8.9	8.6	8.4	8.2	8.0	7.8
Treasury Bond Rate (percent)						
$\dot{M}=4\%$	12.4%	11.1%	9.7%	8.9%	8.4%	8.1%
$\dot{M}=6\%$	12.4	11.1	9.9	9.5	9.6	9.8
$\dot{M}=8\%$	12.4	11.2	10.2	10.1	10.6	11.4
CBO	11.7	11.2	11.0	10.9	10.8	10.6

[1]Percent change in parentheses. Simulations begin in III/1984; thus, 1984 reflects actual economic performance in the first half.

to increase their estimates of the baseline deficit; their estimates of outlays are higher and their estimates of receipts are lower. The CBO's projections of the price level, on the other hand, are quite close to the model's simulation using 6 percent money growth.

The differences in interest rate projections are compared at the bottom of table 1. The CBO's projections of the Treasury bill rate are consistent with the model's simulations using 6 percent money growth. The CBO's projections of the Treasury bond rate, on the other hand, are not; instead, they resemble more closely the model's result using 8 percent money growth. Even using that comparison, however, the

Table 2

Budget Variables: Model Simulations vs. CBO Baseline (billions of dollars)

	1984	1985	1986	1987	1988	1989
Receipts						
$\dot{M}=4\%$	$ 678	$ 749	$ 788	$ 852	$ 921	$ 987
$\dot{M}=6\%$	680	761	822	914	1017	1122
$\dot{M}=8\%$	682	773	857	979	1121	1273
CBO	663	733	795	863	945	1016
Outlays						
$\dot{M}=4\%$	$ 860	$ 930	$ 998	$1071	$1157	$1245
$\dot{M}=6\%$	860	928	997	1075	1172	1281
$\dot{M}=8\%$	859	926	995	1078	1185	1309
CBO	866	941	1025	1125	1240	1355
Surplus						
$\dot{M}=4\%$	$–182	$–182	$–210	$–219	$–235	$–259
$\dot{M}=6\%$	–180	–168	–174	–161	–155	–159
$\dot{M}=8\%$	–177	–153	–138	–98	–64	–36
CBO	–203	–207	–229	–261	–294	–338
Debt						
$\dot{M}=4\%$	$1306	$1487	$1696	$1914	$2148	$2406
$\dot{M}=6\%$	1303	1470	1643	1803	1957	2115
$\dot{M}=8\%$	1301	1453	1590	1688	1750	1785
CBO	1327	1533	1761	2021	2314	2652

CBO's projections are generally higher throughout the period.[11]

Higher interest rate estimates will produce higher estimates of the deficit. Furthermore, there is a crucial cumulative effect — higher interest rates add to the current deficit, which carries over to future years in the form of larger debt that must be financed.

Simulating the Monetary Model with CBO's Baseline Estimates

Table 2 summarizes the model's simulation of receipts and outlays and compares them with the CBO's estimates. The CBO's estimated receipts are slightly more than the model's estimates using 4 percent money growth. By 1989, the CBO's estimate of receipts is $106 billion below that generated by the model using 6 percent money growth. The composition of GNP is instrumental in producing this result. Because the CBO has a relatively low estimate of real growth, their estimate of the growth of receipts is also lower.

The CBO's estimated outlays are well above the highest estimate derived from the model. This difference again reflects the relatively low level of output that the CBO projects. As a result, outlays for unemployment compensation and the amount of deficit to be financed are higher as is the CBO's estimate for the interest rate on Treasury bonds. Differences in forecasts for interest rates can accumulate quickly into higher deficits via their effect on outlays. The model simulates interest payments using an equation esti-

[11]The CBO projects a continuation of the large disparity between interest rates and inflation rates that has been observed recently. The monetary approach assumes implicitly that interest rates eventually will return to levels consistent with past relationships with inflation.

mated over a sample period of 1955–83 (see appendix B). The CBO does not estimate a single-interest payments equation; instead, its estimates are based on a detailed analysis of the components of the federal debt.[12]

When the model's estimates of receipts and outlays are combined, the resulting budget picture is less bleak than the CBO's projections indicate. The model's surplus/deficit projections show clearly that the size of the projected deficit is very sensitive to the rate of monetary growth assumed. With 4 percent money growth, the deficit increases in dollar amounts through 1989; however, the rise is smaller than what the CBO projects. When 6 percent money growth is assumed, the budget deficit slowly declines. With even more rapid money growth, the budget moves toward surplus after 1989, but, of course, inflation also is more rapid.

Perhaps the most dramatic difference between the CBO's projections and those obtained from the model appears when the time paths for federal debt held by the public are compared. The cumulative effect of deficits over six years generates a public debt of $2,406 billion with 4 percent money growth, $2,115 billion with 6 percent money growth, and $1,785 billion with 8 percent money growth. Because the CBO projects higher deficits for every year than does the model, federal debt held by the public rises to $2,652 billion in 1989 under the CBO projections.

Simulating the Monetary Model with the Administration's Budget

Given the model's simulations, either the budget situation or the outlook for inflation is bleak. Although the situation projected by the monetary model is not quite as bad as that seen by the CBO, the broad conclusions about continuing large budget deficits are generally the same. To determine what might be required to prevent continued large deficits, the administration's budget, as prepared in February 1984 and recalculated with the CBO's economic assumptions, is subjected to the same exercise used in the previous section.[13]

The administration's budget for 1985–89, summarized in table 3, can be compared with the CBO baseline estimates in table 2. Note that the administration proposed modest increases in revenues, amounting to only an additional $23 billion in 1989. According to the CBO's analysis of the administration's budget, the proposed revenue increases stem from the following:

(1) taxation of health insurance premiums;

(2) "structural reform" proposals, mainly in the form of limitations on tax-exempt leasing and on private-purpose tax-exempt bonds; and

(3) restrictions on tax shelters and on accounting and corporate tax abuses.

The proposals are not major; the CBO estimates that by 1987–89 primary revenues would be increasing only at a slightly faster rate than the CBO baseline estimates, 8.8 percent vs. 8.5 percent.

With regard to outlays, the administration program is somewhat more ambitious; outlays are projected to be $62 billion less than the CBO's baseline estimate by 1989. The administration's program proposes considerable change in the composition of federal spending. For 1989, relative to the CBO's baseline projections, defense spending would be $11 billion higher, entitlement programs would be $15 billion lower, nondefense discretionary spending would be $17 billion lower, "offsetting receipts" would be higher by $6 billion and net interest would be lower by $10 billion. Although these differences do not appear large, the administration's estimate for primary outlays for the 1987–89 period would be increasing at a 7.1 percent rate, which compares with the CBO's baseline estimate of an 8.9 percent rate of increase.

The simulation results for the model using administration estimates are summarized in table 3. When compared with table 2, the contours of the deficit to GNP appear little different, especially in the early years. Closer inspection reveals that, for a given money growth, the administration program moves either toward surplus or toward a smaller deficit by 1989. This shows how relatively small changes in the growth rates of receipts and outlays can alter significantly the outlook for the deficit and the federal debt, even by 1989. It is to be noted, however, that the prospects for the debt improve in conjunction with an inflationary monetary policy.

[12]For further discussion of the CBO's procedures, see CBO (September 1984).

[13]OMB (February 1984), and CBO (February 1984), *An Analysis of the President's Budgetary Proposals for Fiscal Year 1985.*

Table 3

Budget Variables: Model Simulations vs. Administration Budget (billions of dollars)[1]

	1984	1985	1986	1987	1988	1989
Receipts						
$\dot{M}=4\%$	$ 680	$ 757	$ 800	$ 866	$ 940	$1009
$\dot{M}=6\%$	682	769	835	929	1037	1147
$\dot{M}=8\%$	684	781	870	995	1143	1301
Admin.	665	741	807	878	964	1039
Outlays						
$\dot{M}=4\%$	$ 858	$ 937	$1002	$1067	$1132	$1193
$\dot{M}=6\%$	857	935	1000	1070	1148	1227
$\dot{M}=8\%$	857	933	999	1073	1160	1254
Admin.	866	947	1028	1119	1212	1293
Surplus						
$\dot{M}=4\%$	$–178	$–181	$–202	$–200	$–192	$–184
$\dot{M}=6\%$	–176	–166	–166	–141	–110	–80
$\dot{M}=8\%$	–173	–152	–129	–78	–17	47
Admin.	–201	–206	–221	–241	–248	–254
Debt						
$\dot{M}=4\%$	$1302	$1482	$1682	$1882	$2073	$2255
$\dot{M}=6\%$	1300	1465	1629	1769	1879	1958
$\dot{M}=8\%$	1297	1448	1576	1653	1669	1622
Admin.	1326	1529	1749	1990	2237	2490

[1]Administration's February budget as estimated using CBO's economic assumptions.

THE BUDGET EFFECTS FOR ALTERNATIVE MONETARY POLICIES: THE LONGER-TERM

The previous comparisons demonstrate that the monetary model yields smaller deficit estimates than those using the CBO baseline projections. The chief conclusion from the simulations derived from the model is that faster money growth will produce smaller deficits up to 1989.[14]

Because public discussion of the effects of future deficits suggests that they are concerned with periods of time longer than five years, and because the model does not reach its full equilibrium in five years time, it is informative to carry on with the simulation through time. To make a comparison possible between the CBO's analysis and the model's simulations for this longer period, both the CBO's baseline estimates for primary receipts and outlays and the administration's estimates were extended beyond 1989 at their average growth rates for the 1987–89 period. This provided sufficient input for the model to continue the simulations past 1989. The model was simulated through 2015, when it reaches steady-state equilibrium.

Long-Term Simulations of CBO Baseline Estimates

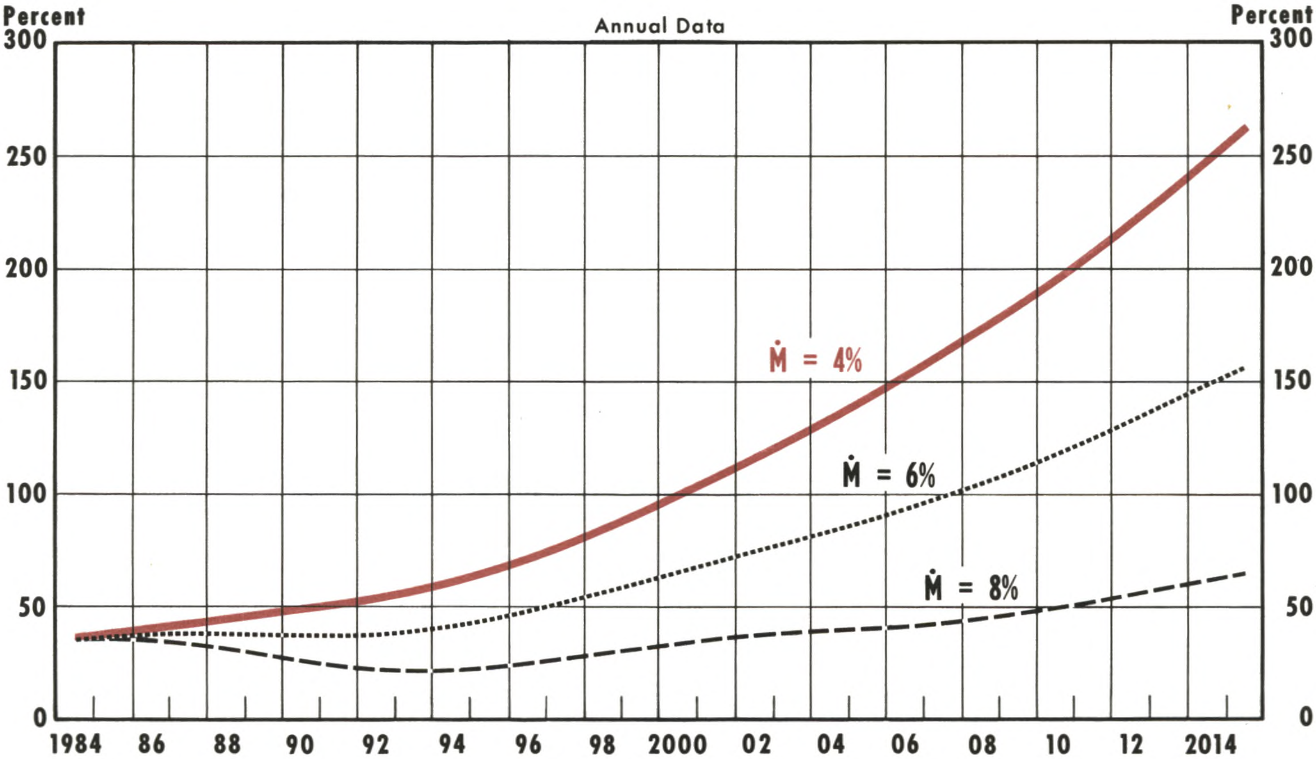
Chart 2 summarizes the simulation results using the model and the CBO baseline projections for the full period. Because dollar amounts are generally dif-

[14]This result suggests that a goal of a balanced budget is meaningless unless there is an explicit accounting for monetary growth. No attempt is made here to assess the costs and benefits of aiming toward a balanced budget. What is clear is that the specification of such an objective requires a consideration of the possible accompanying inflation and variations in the rate of real growth.

Chart 2

Federal Debt Held by the Public as a Percent of GNP

Simulation Results Using CBO Baseline Estimates



ficult to interpret meaningfully when considered over long time periods, the results for the federal debt are presented relative to GNP.

Chart 2 yields a surprising result. Here, federal debt held by the public, expressed relative to GNP, rises without limit for 4 and 6 percent money growth. Only with 8 percent money growth does the debt appear to eventually decline relative to GNP.

Why the difference in the short-run and long-run results? Isolating the reasons for this difference requires detailed examination of the time response of receipts and outlays to real growth, inflation and interest rates. The nature of the long-term results reflects primarily that outlays respond more slowly to inflation than receipts do. In addition, because it takes time for the debt to build up in response to deficits, the cumulative effect of deficits takes the form of increased outlays. These delays are further compounded because inflation responds more slowly to money growth than output does.

Long-Term Simulations of the Administration's Budget

Chart 3 summarizes the long-term simulations of the administration's budget. Here the differences from the 1984–89 horizon are also striking.

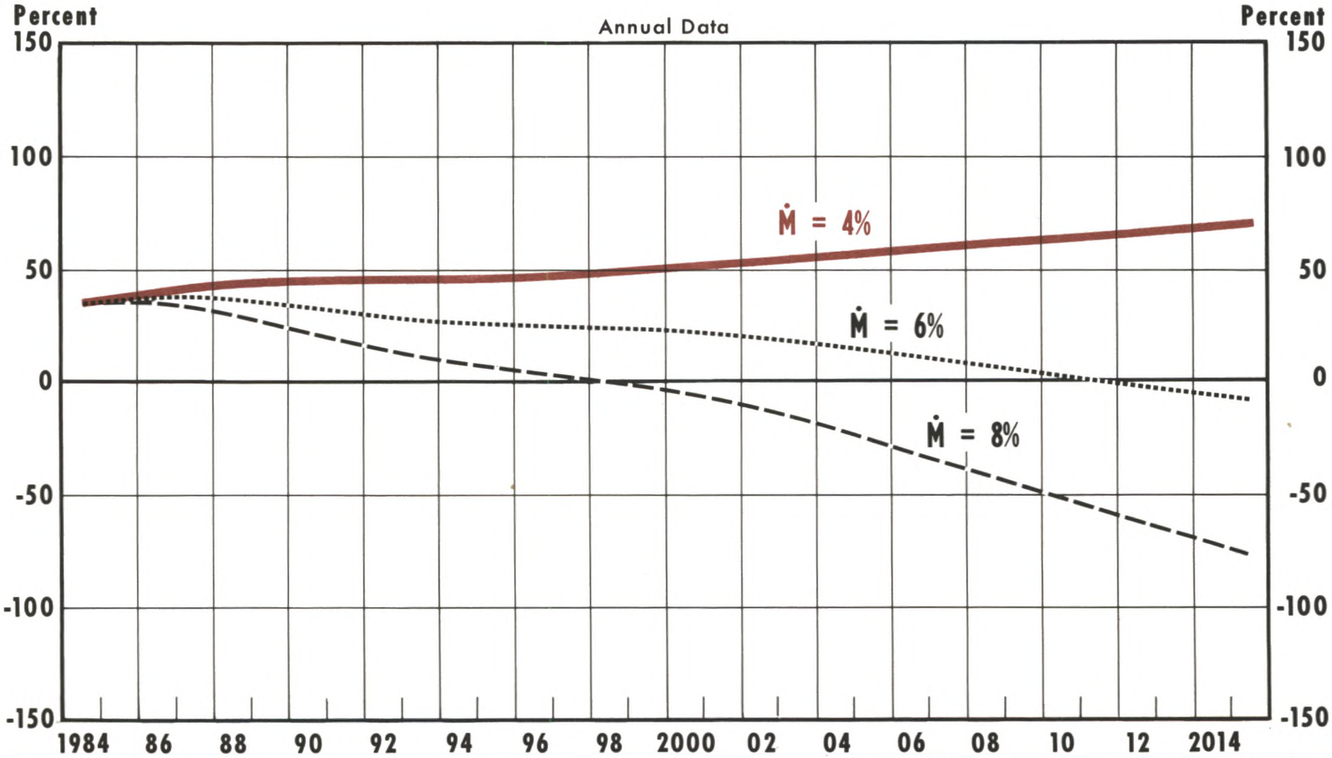
Using 4 percent money growth, the simulations show only a modest upward drift in the federal debt as a percent of GNP over the 30-year period. With 6 and 8 percent money growth, debt declines relative to GNP and is eventually eliminated, resulting in a net creditor position for the federal government.[15]

[15]Currently, because the federal government borrows more than it lends, it is a net debtor. Simulations showing the government as a net creditor are only meant to be illustrative. They should not be construed as forecasts.

Chart 3

Federal Debt Held by the Public as a Percent of GNP

Simulation Results Using Administration Budget



SUMMARY

There is a developing consensus that budget deficits are growing at disquieting rates. To examine the likelihood of future deficits, a monetary model was expanded to include the determination of budget variables. Key budget variables were recalculated using the CBO's baseline estimates and the administration's February 1984 budget. These simulation results indicate that the prospects for a balanced budget depend on the time path of monetary growth. In particular, achieving a balanced budget is facilitated by faster money growth.

Another conclusion that derives from this study is that a five-year planning horizon seems too short to judge whether a particular set of policies is really reducing the sequence of future deficits. Because of the lag structure between policy variables and economic variables, a decade or more might be necessary before the full impact on deficits can be discerned.

The charts and tables in this article should not suggest that considerable precision is possible in the preparation of budget estimates — especially those for a far distant period. The simulations are meant to be illustrative; they are conditioned by a large number of assumptions, not the least of which is the model chosen to derive the simulations. Nevertheless, the major conclusion stands: the long-term process of reducing budget deficits is difficult, but possible. In particular, receipts and outlays depend on key economic variables like real growth, inflation and interest rates; these, in turn, depend crucially on the rate of monetary expansion. Thus, fiscal plans to reduce deficits over time must be coordinated with monetary policy actions if they are to be successful; any choice of deficit reduction via faster money growth must be assessed in conjunction with the possible inflationary costs involved.

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Appendix A
A Monetary Model

The model used for simulations of the economic variables is summarized below. A dot over a variable indicates compounded annual rate of change. Most equations are estimated with Almon constraints on the coefficients. Absolute values of t-statistics are in parentheses.

(1) GNP equation

Sample period: I/1960–IV/1981

$$\dot{Y}_t = \underset{(2.60)}{2.67} + \underset{(6.30)}{1.14} \sum_{i=0}^{4} \dot{M}_{t-i}$$

$\bar{R}^2 = .36$ SE = 3.65   DW = 2.11

(2) Price equation

Sample period: I/1960–IV/1983

$$\dot{P}_t = \underset{(2.30)}{.87} + .14 \sum_{i=1}^{4} \dot{PE}_{t-i} + \underset{(5.80)}{.09} \sum_{i=0}^{5} (\dot{X}_{t-i} - \dot{XF}^*_{t-i}) + \underset{(12.35)}{1.11}\ \dot{PA}_t$$

$\bar{R}^2 = .72$ SE = 1.41   DW = 2.01 $\hat{\rho} = .15$

(3) Treasury bill rate equation

Sample period: I/1960–IV/1983

$$RS_t = \underset{(3.28)}{.55} \sum_{i=0}^{10} \dot{X}_{t-i} + \underset{(6.45)}{.99} \sum_{i=0}^{10} \dot{P}_{t-i}$$

$\bar{R}^2 = .15$ SE = .90   DW = 1.90 $\hat{\rho} = .91$

(4) Treasury bond rate equation

Sample period: I/1960–IV/1983

$$RL_t = \underset{(1.96)}{2.88} + \underset{(3.75)}{.96} \sum_{i=0}^{20} \dot{P}_{t-i}$$

$\bar{R}^2 = .13$ SE = .51   DW = 1.77 $\hat{\rho} = .95$

(5) GNP identity

$$Y_t = (P_t/100)\ X_t$$

(6) Demand pressure definition

$$\dot{XF}^*_t = (\ (XF_t/X_{t-1})^4 - 1)\cdot 100$$

(7) Price anticipations definition

$$\dot{PA}_t = .96 \sum_{i=1}^{21} \dot{P}_{t-i}$$

Y = nominal GNP
M = money stock (M1)
P = GNP deflator (1972 = 100)
PE = relative price of energy
X = output in 1972 dollars
XF = potential output (Rasche-Tatom)
RL = Treasury bond rate
RS = Treasury bill rate

Appendix B
Budget Model

To estimate the effect on budget projections of an alternative set of economic assumptions, the following budget variables were estimated:

1) primary receipts: total receipts minus earnings of the Federal Reserve System
2) primary outlays: total outlays minus net interest
3) net interest

The basic source for estimates of the relevant elasticities were estimates published by the CBO (February 1984), Part I. Net interest was estimated using fiscal year data for 1955–83.

Primary receipts

The implied coefficients for receipts as derived from estimates prepared by the CBO were:

$$\Delta \dot{R}^P_t = .75\,\Delta \dot{X}_t + .81\,\Delta \dot{X}_{t-1} - .01\,\Delta \dot{X}_{t-2} + .26\,\Delta \dot{X}_{t-3} + .14\,\dot{X}_{t-4} + .21\,\dot{X}_{t-5} + .75\,\Delta \dot{P}_t + .36\,\Delta \dot{P}_{t-1} + .02\,\Delta \dot{P}_{t-2} + .16\,\Delta \dot{P}_{t-3} - .06\,\Delta \dot{P}_{t-4} + .13\,\Delta \dot{P}_{t-5}$$

where

$\Delta \dot{R}^P_t$ = deviation of percent change in primary receipts from baseline estimate in fiscal year t

$\Delta \dot{X}_t$ = deviation of percent change in real GNP from baseline estimate in year t

$\Delta \dot{P}_t$ = deviation of percent change in GNP deflator from baseline estimate in year t

Primary outlays

The implied coefficients for outlays as derived from estimates prepared by the CBO were:

$$\Delta \dot{O}^P_t = .25\,\Delta \dot{X}_t + .06\,\Delta \dot{X}_{t-1} + .03\,\Delta \dot{X}_{t-2} - .03\,\Delta \dot{X}_{t-3} + .01\,\Delta \dot{X}_{t-4} - .02\,\Delta \dot{X}_{t-5} + .00\,\Delta \dot{P}_t + .39\,\Delta \dot{P}_{t-1} + .21\,\Delta \dot{P}_{t-2} + .14\,\Delta \dot{P}_{t-3} + .00\,\Delta \dot{P}_{t-4} + .15\,\Delta \dot{P}_{t-5}$$

where

$\Delta \dot{O}^P_t$ = deviation of percent change in primary outlays from baseline estimate in fiscal year t

Net interest

The estimation form of the net interest equation was derived from the following equation:

$$I_t = i_t[-(S^T_t + S^O_t)] + (i_t - \frac{I_{t-1}}{D_{t-1}})\frac{D_{t-1}}{M_{t-1}} + I_{t-1}$$

where

I_t = net interest in fiscal year t

i_t = average yield on 3-month Treasury bills and 10-year Treasury bonds in year t

S^T_t = budget surplus in fiscal year t = $S^P_t - I_t + \pi^{FR}_t$

S^P_t = primary surplus in fiscal year t

π^{FR}_t = earnings of the Federal Reserve System in fiscal year t

S^O_t = financing from other than borrowing from the public in fiscal year t

D_t = federal debt held by the public in fiscal year t

M_t = average length to maturity of federal debt (in years) at end of fiscal year t

The first term on the right-hand side represents borrowing from the public in the current fiscal year. The second term is an approximation of the change in interest cost due to refinancing maturing debt. This equation was solved for I_t in the form shown below. Since it is an approximation, the equation was estimated using data from 1953–83:

$$I_t = \underset{(2.02)}{.47}\left[\frac{i_t}{1-i_t}(-S^P_t - \pi^{FR}_t - S^O_t)\right] + \underset{(7.19)}{.92}\left[\frac{i_t}{1-i_t}\left(\frac{D_{t-1}}{M_{t-1}}\right)\right] + \underset{(10.88)}{.91}\left[\frac{1}{1-i_t}\left(1-\frac{1}{M_{t-1}}\right)I_{t-1}\right]$$

$\bar{R}^2 = .99$ SE = 2.05 DW = 1.95 $\rho_1 = -.34$ $\rho_2 = .17$

Depreciation, Inflation and Investment Incentives: The Effects of the Tax Acts of 1981 and 1982

Mack Ott

THREE years after its enactment, controversy still surrounds the Economic Recovery Tax Act of 1981 (ERTA) and its successor, the Tax Equity and Fiscal Responsibility Act of 1982 (TEFRA). On the one hand, the Reagan administration claims that the 1981 tax reductions substantially increased U.S. business investment and contributed to the strong recovery from the 1981–82 recession[1]. On the other hand, some commentators argue that the tax reductions have failed to increase business investment.[2] Moreover, other critics of ERTA argue that, although investment has increased, it has done so in an unbalanced fashion: too few resources are going into plant, while too many are going into producers' durable equipment.[3] Omitted almost entirely from the debate over the effectiveness of the tax reductions has been the independent impact of the recent disinflation. That is, to what extent would investment have been increased simply by the decline of the inflation rate and how does such an influence come about?

This article develops the foundation for assessing these issues. First, the economics of depreciation deductions is discussed. Second, depreciation accounting is reviewed. Third, the legislatively enacted effects of ERTA and TEFRA are set forth. Following this, the relation of U.S. capital investment to distortions in depreciation and inflation during the last three decades are reviewed. In each of these steps, the particular impact of a declining inflation rate is examined to weigh its relative importance in changing the investment incentives due to depreciation deductions from taxable income.

THE ECONOMICS OF DEPRECIATION DEDUCTIONS

In the course of any business activity, equipment and plant gradually are consumed: equipment wears out from use or becomes obsolete and must be replaced; structures deteriorate, ultimately requiring renovation or demolition and reconstruction. Consequently, depreciation is a normal expense of business activity and, like other normal expenses — wages and salaries, insurance premiums, utilities and material costs — is deducted from gross revenues to determine taxable income.[4]

Two Types of Depreciation: Physical Deterioration and Economic Obsolescence

An inherent difference between depreciation and other deductible business expenses, however, is that depreciation can be determined only implicitly; other

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[1]*Economic Report of the President* (1984), p. 34.

[2]For example, see Editorial, *Washington Post*, April 22, 1984.

[3]Greenhouse (1984).

[4]From the institution of the federal income tax with the sixteenth amendment to the Constitution in 1913, depreciation has been an allowable deduction in computing taxable income. Under the Revenue Act of 1913, taxpayers were allowed to deduct "a reasonable allowance for the exhaustion, wear and tear of property arising out of its use or employment in the business." Internal Revenue Service (Vol. 1971-2), C.B. 504.

expenses can be substantiated explicitly by such positive documentation as invoices.

Two distinct types of economic value loss are covered by depreciation: First, there is the obvious deterioration due to use which lessens the remaining value in producers' durable equipment and structures. The rate of such deterioration is difficult to establish objectively because wear and tear on a given type of equipment or structure may occur at different rates in different applications. Second, there is the economic value that is lost when either an improved machine is developed — that is, better quality of output, faster rate of output or more frugal in its input use for a given output rate — or a change in the relative prices of an input (such as energy) occurs that requires a change in production techniques and equipment design. Although the economic loss due to obsolescence is obviously difficult to predict, it has been a tenet of business income tax procedures resulting in the acceleration of depreciation since well before the explicit adoption of accelerated depreciation accounting systems in 1954.[5]

To establish an explicit basis for depreciation expenses, then, the taxing authority could either allow each firm to estimate its own current depreciation expenses or provide guidelines in the form of somewhat arbitrary schedules of allowable percentage deductions. For the first 20 years of the federal income tax, individuals were given the freedom to determine their own depreciation allowances subject to IRS review. The U.S. tax code now primarily takes the second approach.[6]

Elements of Depreciation

There are three elements of depreciation expensing implied by the foregoing discussion, only two of which are explicit in the depreciation schedules: First, there is the length of time, the asset's *tax life*, over which the asset, for tax purposes, is assumed to deteriorate.[7] Second, there is the pattern of deductions; this component determines the *acceleration* of the depreciation schedule, which varies from equal deductions in each period — no acceleration — to proportionally large initial-period deductions, which decline according to specified accounting patterns over the asset's tax life. Third, there is the problem of how to treat *scrap* or salvage value. Given the differences in deterioration that exist in different applications, this problem would exist even if tax life and useful life were equal.

In general, tax lives are shorter than the durability implied by the rate of physical deterioration so that scrap value — more particularly, after-tax scrap value — is a problem for all capital users. Moreover, the longer the physical life of an asset, the more uncertain its scrap value; technological advance, changes in relative prices of inputs or evolution in use patterns may make the market value at disposal much less than the value implied by its remaining physical life given its original purchase price. For example, a 30-year-old industrial building may be physically sound but of little value because of a change in regional industrial use, demographic changes or a shift in transportation methods.

Therefore, both the shortening of tax lifetimes and the acceleration of depreciation deductions can be economically rationalized as approximating the actual wear and obsolescence patterns of assets. Moreover, as discussed in the next section, acceleration may offset an asset's rising replacement cost due to inflation, though the more pragmatic rationalization usually advanced is that acceleration or shortened tax lives provide inducements to investment.[8] In any case,

[5]See Internal Revenue Service, p. 505.

[6]For example, the original IRS Bulletin F of 1920, which set forth depreciation guidelines, clearly allowed the freedom to choose (and imposed the burden to substantiate) depreciation deductions both for deterioration and obsolescence:

> The Bureau does not prescribe rates to be used in computing depreciation and obsolescence, as it would be impractical to determine rates which would be equally applicable to all property of a general class or character. For this reason, no table of rates is published. The rate applicable and the adjustment of any case must depend upon the actual conditions existing in that particular case. (Internal Revenue Service, p. 505, note 13.)

From 1934 onward, however, this procedure was tightened in large part due to the declining prices of replacement capital. In response to criticism (and proposed legislative action), the Treasury switched to a procedure requiring substantial documentation to support the operational as opposed to the procedural validity of depreciation deductions. *Ibid*, p. 505.

[7]At least since 1956 (and perhaps as early as 1942), the Internal Revenue Code's provisions for depreciation have been moving from a physical concept of asset life to a useful life, where the latter is intended to accord with business practice rather than a potential period of use. *Ibid.*, p. 506. In general, the useful life would be shorter than physical life due to obsolescence, optimizing of salvage value and the benefits of replacing the asset when its net economic value of output, while still positive, declines below that of a replacement asset.

[8]For example, President Kennedy argued that the shortening of tax lives by 30–40 percent in 1962 (by an administrative not a legislative procedure) was justified in spite of the large revenue loss because of the investment impact:

> Business spokesmen who have long urged this step estimate that the stimulus to new investment will be far greater — perhaps as much as four times greater — than the $1.5 billion [revenue loss] made available. In any event, it is clear that at least an equal amount will go into new income producing investment and eventually return to the Government in tax revenues most, if not all, of the initial costs. *Ibid.*, p. 507.

Depreciation Accounting Methods

Straight line — Annual deduction of 1/N of original value of asset, where N is tax life of asset.

Declining balance — Annual deduction of a specified (α) multiple of 1/N of remaining (i.e., undepreciated asset value). Most common forms are 150 percent, 175 percent, and 200 percent declining balance. Since this formulation of the depreciation deduction takes a fraction of the declining balance each period, its deductions would never accumulate to the total value of the asset. Hence, the tax code allows a switch over to straight line at any time; the maximizing switchover point (N*) is

$$N^* = 1 + [N(\frac{\alpha - 1}{\alpha})];$$

when N* is not an integer, the switchover occurs at the next year. Thus, the optimal switchover for a 15-year asset under 200 percent declining balance is year 8, for 175 percent declining balance it is year 7, and for 150 percent declining balance it is year 5.

To illustrate the changeover to straight line, consider a 10-year asset with an original purchase price of $1,000. The deductions under 150 percent declining balance would be as shown in the table.

Note that if the straight-line deduction were used in the fourth year, it would be smaller than the 150 percent declining balance deduction — (1/7)($614.12) = $87.73 vs. $92.12; conversely, if the 150 percent declining balance deduction were taken in year 5, it would be smaller than the straight-line — (1.5)(1/10)($522.00) = $78.30 vs. $87.00.

Annual Deductions for Depreciation for a $1,000, 10-Year Asset under Various Depreciation Methods

Year	SL	150 DB	200 DB	SYD
1	$ 100.00	$ 150.00	$ 200.00	$ 181.81
2	100.00	127.50	160.00	163.63
3	100.00	108.38	128.00	145.45
4	100.00	92.12	102.40	127.27
5	100.00	87.00	81.92	109.09
6	100.00	87.00	65.54	90.91
7	100.00	87.00	65.54	72.73
8	100.00	87.00	65.54	54.54
9	100.00	87.00	65.54	36.36
10	100.00	87.00	65.54	18.18
Total	$1,000.00	$1,000.00	$1,000.00	$1,000.00

NOTE: Columns may not add to total due to rounding.

Sum of the years' digits — Annual deduction is a declining fraction of the asset's value; this fraction is the ratio of the number of years remaining in the asset's tax life at the beginning of the tax year to the sum of the years (1 + 2 + 3 + ... + N) in the asset's tax life. For assets with a tax life of six years or more, SYD was the most accelerated depreciation schedule allowed in the tax code prior to the enactment of ERTA in 1981.

the concomitant gain at disposition of the fully depreciated asset, scrap value, is treated as ordinary income to the taxpayer.[9]

DEPRECIATION ACCOUNTING

The 1954 tax code explicitly authorized a variety of accelerated depreciation accounting methods: sum of the years' digits and variations on declining balance methods.[10] These methods are described in the accompanying insert. Assuming that tax life and useful life are equal, the impact of accelerated depreciation accounting is to return the invested capital to the firm earlier in the asset's life than under straight-line depreciation, thereby reducing the impact of inflation. As a result of the higher depreciation deductions, the taxable proportion of the asset's income is reduced.

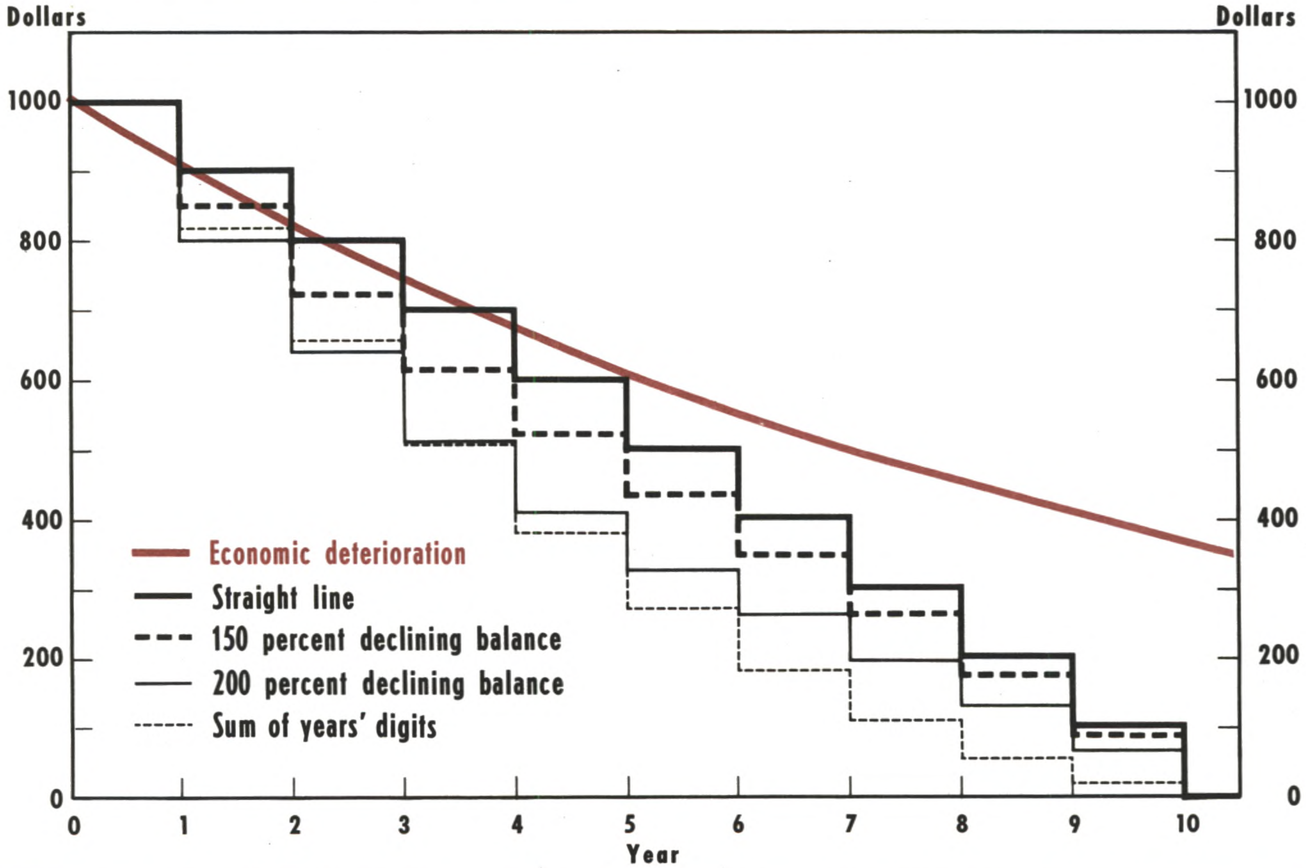
[9] *Economic Recovery Tax Act of 1981*, p. 188.

[10] As early as 1946, there was recognition that declining balance depreciation could bring accounting practice closer to the deterioration and obsolescence rates implicit in business organization; however, in contrast to the 1954 tax code which allowed the taxpayer to use declining balance methods, the 1946 IRS ruling imposed the burden of proof on the taxpayer:

> The declining balance method of computing depreciation would be approved for federal tax purposes, provided it accorded with the method of accounting regularly employed in the books of the taxpayer *and resulted in reasonable depreciation allowances and proper reflection of net income for the taxable year or years involved.* [Emphasis added], Internal Revenue Service, p. 505, note 14.

Chart 1

Remaining Depreciable Value Compared with Remaining Economic Value



This raises the present value of the asset's anticipated after-tax income stream relative to its price. Consequently, increasing depreciation deductions should induce a higher rate of investment, all other things the same.[11]

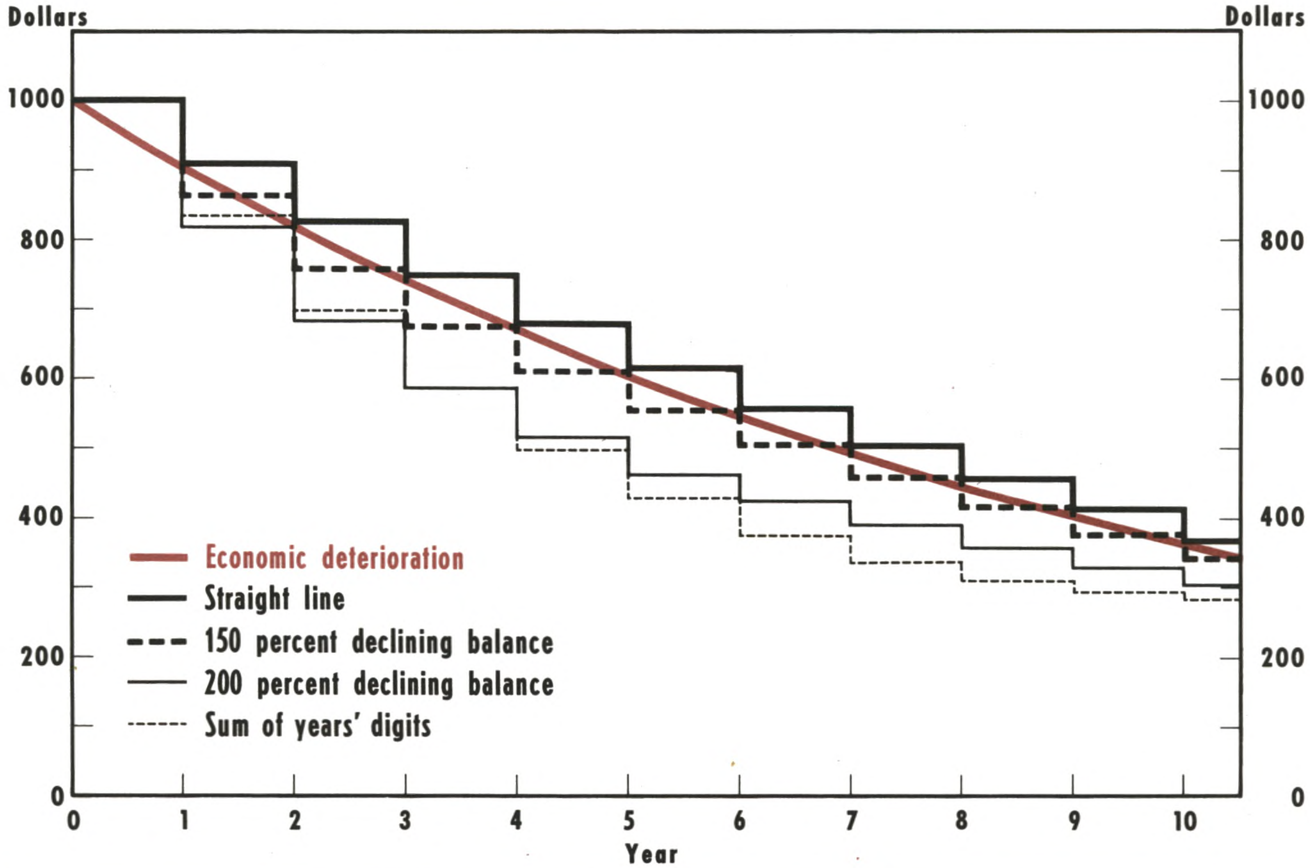
Graphically, this early return of capital can be seen in chart 1 where the remaining undepreciated value of an asset with a 10-year tax life is displayed. The undepreciated or remaining value is shown for four depreciation accounting methods: straight line (SL), 150 percent declining balance (150 DB), 200 percent declining balance (200 DB) and sum of the years' digits (SYD). As a benchmark, the remaining economic value — the asset's initial value less cumulated deterioration — is also plotted; economically, the asset is assumed to deteriorate at an exponential 10 percent rate — that is, in inverse proportion to its original useful life. Note that the depreciation schedules all provide for an earlier return of capital than warranted by physical deterioration alone. This occurs for two reasons: First, since the physical deterioration is a fraction of the declining balance, it will never consume the asset; there will always exist a positive scrap value.[12] In con-

[11]The theoretical foundations for this exist in a variety of sources: Hall and Jorgenson (1967) is the classic reference and Nelson (1976) provides a clear exposition of the issues most germane to this article. Auerbach (1983) surveys the literature on corporate finance as it relates to taxation and the cost of capital. Kopke (1981) addresses the choices confronting tax policymakers regarding the most effective form of tax reductions to stimulate investment.

[12]If an asset's economic deterioration is proportional — e.g., geometric or exponential — it will always have a scrap or salvage value at the end of any finite period. For example, if the asset's output deteriorates at a rate δ, $0 < \delta < 1$, and has a tax life $N = 1/\delta$, then the

Chart 2

The Impact of Inflation on Remaining Economic Value



trast, depreciation schedules are designed to exhaust the asset's value over its tax life. Second, the accelerated schedules take a larger portion of depreciation earlier than does the asset's decay rate.

Despite the apparent excess of depreciation over economic decay depicted in chart 1, accelerated depreciation accounting is insufficient to provide for replacement if the rate of inflation is high enough. Chart 1 implicitly assumes a zero inflation rate in that economic decay is displayed relative to a historical purchase price.

Chart 2, drawn with the remaining value adjusted for an inflation rate of 9 percent, illustrates the impact of inflation on the relation of economic and accounting measures of depreciation. This has the effect of pivoting each of the accounting depreciation profiles counter-clockwise around the zero-time intercept due to the rising nominal price of the replacement asset relative to its historical nominal purchase price. At a 9 percent inflation rate, the $1,000 purchase price of the asset will rise to $2,367 over its 10-year tax life. Consequently, at any point in the asset's 10-year tax life, a smaller portion of the real replacement cost (the economic remaining value) is recovered with a high

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scrap value per dollar of initial value (S) will be about 3/8:

$$S = 1 - \int_0^N \delta_e^{-\delta t} dt$$

$$= 1 - (-e^{-\delta t}\Big|_0^N), \delta = 1/N$$

$$= e^{-\delta N} = e^{-1}$$

$$= .368.$$

This inverse relation of depreciation and tax life holds for a variety of assets under the ADR system — for example, autos ($\delta = .333$, $N = 3$), railroad equipment ($\delta = .066$, $N = 15$) and metal working equipment ($\delta = .1225$, $N = 7.8$). Gravelle (1982), table 1, p. 8. Even when $\delta > 1/N$, however, there will be a positive scrap value. For example, aircraft ($\delta = .1818$, $N = 9.2$) and office, computing and accounting equipment ($\delta = .2729$, N-7.0) have δs about twice the reciprocal of their respective Ns for which S would be about 1/8: $S = e^{-\delta N} = e^{-2} = .135$.

inflation rate (chart 2) than with a zero inflation rate (chart 1).[13]

INFLATION DISTORTIONS IN DEPRECIATION SCHEDULES AND THE CHANGES DUE TO ERTA AND TEFRA

To evaluate the combined effects of accelerated depreciation, inflation, scrap value and shortened tax lifetimes, we first examine the depreciation schedules applied to assets under the assumption that tax lives and economically useful lives are equal. In this examination, presented in table 1, the relative adequacy of depreciation deductions is assessed for assets of 3-, 5-, 10-, 15- and 30-year durabilities. The table also incorporates one final complication — the investment tax credit.

Since 1962, the investment tax credit (ITC) has been, in effect, a second form of accelerated capital return in the tax code. In principle, because it is a return of capital at the end of the asset's initial tax year, ITC augments the depreciation deduction; adjusting for its being a credit rather than a deduction can be accomplished by dividing by the tax rate.[14]

Each entry in table 1 is the sum of the real present discounted value of the tax-deduction equivalent of the investment tax credit plus the depreciation deductions plus the after-tax anticipated proceeds from the sale of the asset (scrap value) in ratio to the present discounted value of the replacement cost of the asset. A real after-tax interest rate of 3 percent was used in the computations.[15] The entries are computed over a range of inflation rates typical of those experienced during the last three decades. The higher the inflation rate, the lower the real value of the depreciation deductions since the deductions are based on a fixed nominal value — the historical purchase price of the asset. In contrast, the denominator is unaffected by inflation since it is cast in real terms to measure the declining value in production of the asset. Note that these are actual, not expected, inflation rates. It is the actual inflation rate that determines whether depreciation deductions will be adequate to provide for the replacement asset; however, as this implies, the higher the expected inflation rate over the asset's life, the lower the value of the asset.

These ratios determine whether there is adequate provision in the tax code for the anticipated net cost of asset replacement (net of scrap value). The fund is exactly adequate if the ratio equals 1.0. Ratios less than 1.0 indicate that the fund is inadequate, and implicit subsidies are present in ratios that exceed 1.0. The ratios are computed for a variety of depreciation schedules, both straight-line and accelerated. The Accelerated Cost Recovery System (ACRS) mandated by ERTA and modified by TEFRA also is included in the table; ACRS-ERTA is based on the 150 DB method. ACRS-TEFRA is ACRS-ERTA with the reduction in depreciation base — 50 percent of the investment tax credit — mandated by TEFRA.[16]

The table suggests that, even at an inflation rate as high as 9 percent, the present value of depreciation deductions is sufficient to provide for replacement of assets with tax lives up to 10 years under any of the schedules; with two exceptions, this also holds for 15-year assets. While the ratios are lower under current law (TEFRA) than under prior law, they remain adequate for replacement funding. In marked contrast, for the most durable assets — those with 30-year lifetimes which are, generally, structures and other plant — the deductions are inadequate even at an inflation rate as low as 3 percent. While the more accelerated depreciation schedules, 200 DB and SYD, appear to overcome this shortfall, structures and plant were restricted, before ERTA, to using 150 DB. Consequently, for investment in plant, depreciation deductions were woefully inadequate to provide for replacement at the inflation rates experienced in the United States over the

[13]The inflation effect is symmetric: rising prices lower the value of depreciation deductions and falling prices raise it. Consequently, it is not surprising that in 1934, during a period of sustained deflation, legislation was introduced in Congress to *lower* depreciation allowances. Internal Revenue Service, p. 505, note 10.

[14]For the first two years after its introduction, the depreciable base of an asset was reduced by the credit; from 1964 to 1982, no such reduction was required. In 1982, the enactment of TEFRA has restored a reduction in the depreciation base — by 50 percent of the credit. ITC is currently 10 percent of the asset's price in the case of equipment with a tax life of five years or more and 6 percent for shorter-lived equipment; structures, generally, are not eligible for ITC, although some equipment associated with structures and certain low-income housing does qualify. *Tax Equity and Fiscal Responsibility Act of 1982*, pp. 41–43.

[15]This is the commonly used rate in the literature, going back to Hall and Jorgenson (1967) and continuing through Kopke (1981). Gravelle (1982) uses 5.5 percent following Hendershott and Hu (1981); all of the ratios reported in this article were also recomputed with a 5.5 percent real rate, and neither the qualitative nor quantitative results using 5.5 percent were appreciably different.

[16]More accelerated versions of ACRS were mandated by ERTA for 1985 (175 percent declining balance) and for 1986 and beyond (200 percent declining balance); however, these later changes were repealed by TEFRA. See *Tax Equity and Fiscal Responsibility Act of 1982*, pp. 40–43.

Table 1

Ratio of Present Value of Depreciation Deductions to Replacement Cost with Scrap Value

Tax Life (years)	π (%)	Prior Tax Law SL	Prior Tax Law 150 DB	Prior Tax Law 200 DB	Prior Tax Law SYD	ACRS ERTA	ACRS TEFRA
3	0	1.323	1.330	1.339	1.333	1.319	1.289
3	3	1.262	1.276	1.293	1.280	1.255	1.227
3	6	1.204	1.224	1.249	1.231	1.194	1.168
3	9	1.151	1.176	1.207	1.184	1.138	1.114
5	0	1.424	1.433	1.445	1.444	1.420	1.370
5	3	1.333	1.351	1.373	1.370	1.327	1.281
5	6	1.251	1.276	1.306	1.301	1.242	1.200
5	9	1.176	1.207	1.245	1.238	1.165	1.127
10	0	1.453	1.468	1.489	1.499	1.460	1.408
10	3	1.300	1.327	1.363	1.378	1.311	1.266
10	6	1.173	1.208	1.255	1.274	1.187	1.148
10	9	1.067	1.109	1.163	1.183	1.083	1.049
15	0	1.483	1.505	1.535	1.556	1.497	1.445
15	3	1.274	1.309	1.359	1.390	1.296	1.253
15	6	1.114	1.159	1.220	1.255	1.142	1.106
15	9	0.991	1.042	1.110	1.144	1.021	0.991
30	0	1.223	1.265	1.325	1.379	N/A	N/A
30	3	0.889	0.949	1.033	1.096	N/A	N/A
30	6	0.688	0.755	0.846	0.904	N/A	N/A
30	9	0.561	0.630	0.719	0.767	N/A	N/A

NOTE: Each entry in the table is computed as

$$\frac{(ITC/\tau)e^{-(r+\pi)} + (1-\Theta ITC)\sum_{t=1}^{N} D(t)e^{-(r+\pi)t} + (1-\tau)e^{-(r+\delta)N}}{\frac{\delta}{r+\delta} + e^{-(r+\delta)N}\left(1-\frac{\delta}{r+\delta}\right)}$$

where ITC = Fraction of asset's purchase price received as investment tax credit, 6 percent for three-year assets and 10 percent for longer-lived assets, except structures for which it is zero; in the table, 30-year assets are assumed to be structures

τ = Corporate tax rate, .46

Θ = .5 for ACRS-TEFRA; for other schedules, $\Theta = 0$

D(t) = Depreciation deduction under the specified schedule in year t

π = inflation rate

r = Real after-tax discount rate, assumed to be 3 percent

N = Tax life of asset; assumed equal to useful life in table 1

δ = Real economic rate of deterioration, assumed to be 1/N

15 years preceding ERTA. As we shall see below, one of ERTA's clearest impacts has been to rectify this shortfall for structures.

The Uncertain Effect of Anticipated Salvage Value

For assets with tax lives under 15 years, the entries in table 1 suggest that the present value of depreciation deductions combined with the investment tax credit have been sufficient to provide for replacement. Yet, included in these entries is the after-tax portion of the asset's anticipated scrap or salvage value. That is, for example, the replacement of an electric typewriter is in part financed by the anticipated sale of the old, used typewriter. Yet, the inclusion of such anticipated scrap value in the investment decision entails significant risks: technological obsolescence, economic obsolescence due to changes in relative prices and (in the case of structures) locational obsolescence. The first of these is exemplified by the widespread use of word-processing machines, which has reduced the value of even the most sophisticated electric typewriters. The second can be appreciated by considering the effect of the mid-1970s' run-up in oil and gas prices on the value of standard-sized American used cars. The third is an obvious risk entailed in purchasing any commercial, industrial or residential structure. Moreover, each of these risks rises with the durability of the asset.[17]

Because scrap value is so uncertain, especially for longer-lived assets, it is informative to recompute the ratios in table 1 without scrap value. The results are shown in table 2. Without scrap value, the most accelerated depreciation schedules under prior law were adequate for replacement except for assets of 10- or 15-year tax lives at 9 percent inflation and 30-year assets at any inflation rate. Under current tax law (TEFRA), however, even three-year assets in the face of moderate inflation, say 6 percent, could not have their replacement financed through depreciation deductions alone.

Nonetheless, the shorter is the asset life, the smaller is the risk entailed in the anticipated scrap value; thus, a three-year asset (for example, an automobile or light truck according to the tax code) surely does have a more secure resale market than, say, an asset with a seven-year life (for example, accounting, computing or other office equipment). Consequently, the ratios presented in tables 1 and 2 should be interpreted as defining a range of uncertainty within which the specific values of particular assets can be considered in relation to their depreciation allowances and scrap values.

Shortened Tax Lives under ACRS and the Impact on Specific Asset Types

Although ERTA contains a bewildering array of features, the principal changes to prior tax law are lower personal income tax rates, changes to gift and estate tax rules, incentives for saving and the ACRS depreciation deduction schedules. In the context of depreciation, the primary impact of TEFRA was to repeal the more accelerated ACRS schedules, which would have become effective in 1985 and 1986, and to reduce the depreciable asset base by one-half of the ITC. ACRS under either ERTA or TEFRA, as tables 1 and 2 show, is not as accelerated for a given tax life as were some options available earlier — for example, 200 DB and SYD. The major impact of ERTA, however, was in shortening the tax life of assets, an impact not revealed by either of these tables.

Under ERTA, four ACRS schedules replaced the various options available to asset owners under prior law.[18] The older system was based on surveys conducted by the U.S. Treasury Department from which asset life distributions were computed. The system based on these distributions, called the Asset Depreciation Range system (ADR), was the basis for determining the tax life over which an asset could be depreciated using the various deduction formulas.[19]

The new system, ACRS, replaced more than 100 classes of asset lives with four: 3-year, 5-year, 10-year and 15-year. The 3-year class primarily contains automobiles, light trucks and research equipment. Most equipment is included in the 5-year class. The 10-year class primarily comprises specialized machinery of the public utility industry. All structures and some other utilities' capital are in the 15-year class.[20] Thus, the acceleration of the depreciation allowance under ERTA relative to prior tax law is not due to the formula applied.[21] Rather, the saving is primarily due to a pro-

[17]That is, suppose that there is a 1 percent likelihood that during any single year an innovation in technology will make an existing asset's value decline due to the improvements in newer machines. Then, the probability that an investment will *not* have its scrap value lowered is 97 percent for a three-year asset, 90 percent for a 10-year asset and 74 percent for a 30-year asset.

Further, consider the uncertainty associated with relative prices. Every manufacturing process makes use of a variety of inputs — labor, various raw materials and energy — so that the optimal design based on existing technology of a machine used in that process will depend on the relative prices of the inputs. Suppose that the likelihood during any single year of a significant change in relative input prices (sufficient to induce an alteration in capital design) is 1 percent and is independent of the likelihood of technological innovation. Then, the probability that an asset's salvage value will *not* be lowered by either event is 94 percent for a three-year asset, 82 percent for a 10-year asset and only 55 percent for a 30-year asset.

Finally, if we add a third source of obsolescence, the problem of neighborhood decline or a change in locational use patterns, also an independent likelihood of 1 percent, this final obsolescence risk which is peculiar to structures causes the 30-year asset probability of *no decline* in salvage value to plummet to 40 percent.

[18]See *Economic Recovery Tax Act of 1981*, pp. 6–7, 67–68, and 75–85.

[19]In particular, the 30th percentile of the survey responses was the minimum allowable tax life.

[20]Certain manufactured housing and tank cars also fall into the 10-year class. See *Economic Recovery Tax Act of 1981*, pp. 78–80.

[21]The schedules for equipment are based on 150 DB with a switch to straight line at the deduction optimizing point (see insert). There is a half-year convention in these schedules — the asset is assumed to be acquired at mid-year so the initial year's depreciation is one-half of the 150 DB schedule in the insert. The ACRS schedule for structures is 175 DB with a switch to straight line at year 8; the structures' schedules are specific to the month of asset acquisition. See *Economic Recovery Tax Act of 1981*, pp. 40–41.

Table 2

Ratio of Present Value of Depreciation Deductions to Replacement Cost without Scrap Value

Tax Life (years)	π (%)	Prior Tax Law				ACRS	
		SL	150 DB	200 DB	SYD	ERTA	TEFRA
3	0	1.131	1.138	1.147	1.141	1.127	1.097
3	3	1.069	1.084	1.101	1.088	1.063	1.035
3	6	1.012	1.032	1.057	1.039	1.002	0.976
3	9	0.959	0.984	1.015	0.992	0.946	0.922
5	0	1.236	1.246	1.258	1.256	1.233	1.182
5	3	1.145	1.163	1.185	1.182	1.139	1.093
5	6	1.063	1.088	1.119	1.114	1.054	1.012
5	9	0.989	1.020	1.057	1.050	0.978	0.939
10	0	1.276	1.292	1.312	1.322	1.283	1.231
10	3	1.123	1.150	1.186	1.201	1.134	1.090
10	6	0.996	1.031	1.078	1.097	1.010	0.972
10	9	0.890	0.932	0.987	1.006	0.906	0.872
15	0	1.317	1.338	1.369	1.390	1.331	1.278
15	3	1.108	1.143	1.193	1.224	1.130	1.087
15	6	0.948	0.993	1.054	1.089	0.976	0.940
15	9	0.825	0.876	0.943	0.978	0.855	0.825
30	0	1.088	1.129	1.190	1.243	N/A	N/A
30	3	0.754	0.814	0.898	0.961	N/A	N/A
30	6	0.553	0.620	0.711	0.768	N/A	N/A
30	9	0.426	0.494	0.584	0.632	N/A	N/A

NOTE: Entries in the table are computed as in table 1 except the present value of anticipated scrap value does not appear in the numerator:

$$\frac{ITC\,(1/\tau)\,e^{-(r+\pi)} + (1-\theta\,ITC)\sum_{t=1}^{N} D(t)\,e^{-(r+\pi)t}}{\frac{\delta}{r+\delta} + e^{-(r+\delta)N}\left(1-\frac{\delta}{r+\delta}\right)}$$

nounced shortening of the tax lives of each asset class. The mean reductions in asset tax lives from ADR to ACRS for equipment and for structures were, respectively, 44 percent and 49 percent.[22] The reductions in tax lifetimes varied widely. The tax life of the three-year class was shortened by only half a year from ADR to ACRS, but for longer-lived assets, the reductions included 22.5 years for commercial structures (15-year category), 4.7 years for aircraft (five-year category) and 5.5 years for railroad equipment (10-year category).

Thus, in evaluating the adequacy of depreciation deductions in providing for replacement of any specific asset, there are six elements to be considered: the depreciation schedule, the anticipated inflation rate, the asset's tax life, its investment tax credit, economic life and scrap value. The effects of these elements are revealed in the ratios of depreciation to replacement cost for specific assets in table 3.

Column a of table 3 lists the specific asset types analyzed; the nine assets were selected to cover a variety of economic depreciation rates, durability and ACRS tax lives, which are reported in columns b, c and d, respectively, for each asset. Column e lists the inflation rate assumed in each ratio, the range of rates being the same as in tables 1 and 2. In the next three columns, the ratio of the present values of depreciation, ITC and after-tax salvage value to economic depreciation and scrap value are reported; the ratios are computed under prior tax law in column f, under ERTA in column g and under TEFRA in column h. Columns i and j display the ratio of the entries in columns g and h to column f; if the ratio is greater (less) than 1.0, then the tax treatment under ERTA or

[22]Computed from ADR data by producers' equipment and structures classes in table 1 of Gravelle (1982).

Table 3

Comparison of Present Values of Depreciation Tax Deductions with ITC and Scrap Value to Replacement Cost for Selected Assets

Asset Type (a)	Economic Depreciation Rate[1] (b)	Tax Life (years)[2] ADR (c)	Tax Life (years)[2] ACRS (d)	π (%) (e)	Ratios of Present Value of Depreciation Deduction to Replacement Cost[3] ADR[4] (f)	ACRS-ERTA (g)	ACRS-TEFRA (h)	Ratios of Present Value of Deductions ACRS-ERTA/ADR (i)	ACRS-TEFRA/ADR (j)
Automobiles, light trucks	.3333	3.0	3	0	1.339	1.319	1.289	0.985	0.963
				3	1.293	1.255	1.227	0.970	0.949
				6	1.249	1.195	1.168	0.956	0.935
				9	1.207	1.138	1.114	0.943	0.923
Office, computing and accounting equipment	.2729	7.0	5	0	1.305	1.301	1.251	0.997	0.959
				3	1.215	1.207	1.162	0.994	0.956
				6	1.135	1.123	1.081	0.990	0.953
				9	1.062	1.047	1.008	0.985	0.949
Aircraft	.1818	9.2	5	0	1.389	1.365	1.314	0.983	0.946
				3	1.276	1.268	1.221	0.994	0.957
				6	1.178	1.181	1.137	1.003	0.966
				9	1.091	1.101	1.062	1.009	0.973
Mining and oilfield machinery	.1650	9.2	5	0	1.415	1.391	1.339	0.983	0.946
				3	1.301	1.293	1.245	0.994	0.957
				6	1.202	1.205	1.161	1.003	0.966
				9	1.114	1.125	1.085	1.009	0.973
Communications equipment	.1179	11.5	5	0	1.511	1.464	1.409	0.969	0.933
				3	1.371	1.362	1.312	0.993	0.957
				6	1.251	1.269	1.224	1.014	0.978
				9	1.150	1.186	1.144	1.031	0.995
Ships and boats	.0750	16.0	5	0	1.501	1.594	1.534	1.062	1.022
				3	1.331	1.483	1.428	1.114	1.073
				6	1.193	1.382	1.333	1.158	1.117
				9	1.082	1.291	1.246	1.194	1.152
Railroad equipment	.0660	15.0	10	0	1.559	1.570	1.514	1.007	0.971
				3	1.393	1.407	1.359	1.010	0.975
				6	1.258	1.272	1.230	1.011	0.978
				9	1.147	1.158	1.131	1.010	0.978
Industrial structures[5]	.0330	36.0	15	0	1.192	1.495		1.254	
				3	0.853	1.239		1.452	
				6	0.660	1.045		1.584	
				9	0.540	0.895		1.657	
Commercial structures[5]	.0230	37.0	15	0	1.361	1.713		1.259	
				3	0.981	1.427		1.456	
				6	0.766	1.210		1.580	
				9	0.634	1.042		1.644	

[1]See Gravelle (1982), table 1.

[2]Actual tax lives for equipment under ACRS are .5 years less than shown due to an assumption, implicit in the schedules, of acquisition at mid-year; for structures, the ACRS schedules explicitly allow for actual month of acquisition.

[3]Entries are as in table 1 except ADR uses ADR tax life and ACRS uses ACRS tax life for numerator of ratios; denominator for both ADR and ACRS use ADR tax life as proxy for useful life.

[4]For structures, the depreciation schedule utilized is 150 DB with a switch to SL after 12 years (for industrial structures) or 13 years (for commercial structures). For autos, 200 DB was used (200 DB is more accelerated than SYD for assets with tax lives less than 6 years); all other assets used SYD.

[5]Note that TEFRA did not change the ERTA tax schedules for structures.

TEFRA has increased (decreased) the value of depreciation for that asset. Notice that for structures, columns g and h are combined as are columns i and j; this reflects the fact that investments in structures do not qualify for ITC, and, thus, the 50 percent of ITC reduction in the depreciable base mandated by TEFRA does not affect structures.

Scanning down the columns of ratios in columns f–j of table 3 provides an overall assessment of the impact on depreciation adequacy under ERTA and TEFRA relative to prior tax law. Column f reiterates the general message of table 1 for specific assets — namely that equipment, especially shorter-lived equipment such as automobiles, was more than adequately provided for under the prior tax law, while structures' depreciation deductions were inadequate at even low inflation rates. Columns g and h show that the new tax laws have reduced the benefits of fast depreciation for short-lived equipment, but sharply raised these benefits for structures at all inflation rates. For example, at a 6 percent inflation rate, the depreciation ratio for office, computing and accounting equipment declines from 1.135 under prior tax law to 1.081 under TEFRA, while for industrial structures it rises from 0.660 to 1.045. Finally, the entries in columns i and j affirm that longer-lived assets have had their depreciation ratios reduced less or increased more than shorter-lived assets. For example, comparing the ratios in column j at a 6 percent inflation rate, communications equipment has 0.978 of its prior tax law depreciation ratio under TEFRA, while the shorter-lived asset aircraft has 0.966 and the longer-lived asset commercial structures has 1.580.

In summary, the ratios in column h reveal that the shift to ACRS has provided inducements to purchase new capital equipment that rise with the durability of the equipment. Moreover, relative to prior law (column j), the additional incentives are especially strong for nonresidential structures, particularly at low inflation rates. Compared with prior tax law, ACRS diminishes the deleterious effects of inflation on the value of depreciation deductions for long-lived assets and reduces the attractiveness of investments in equipment relative to structures. For example, the present value of the depreciation deductions plus scrap for industrial structures under ACRS is greater than the present value of the replacement cost at inflation rates up to 6 percent; moreover, the deductions are increased massively relative to prior tax law at all inflation rates.[23] In particular, the ratios for industrial structures in column h exceed those for automobiles and aircraft at low inflation rates where, as column f shows, the ranking was the reverse under prior law.

The Combined Effects of Tax Changes and Disinflation in the 1980s

To focus only on the changes in the depreciation schedules and their effects on various assets at any specific inflation rate understates the investment incentives provided by the changes in the 1980s. The reduction in the observed inflation rate and, presumably, the anticipated inflation rates over the investment term provide another strong impetus. For example, the rate of inflation measured by the implicit GNP deflator has been falling over the past four years — from an average rate of over 9 percent during 1978–81 to between 3 and 4 percent during 1982–84. Consequently, the most pertinent assessment of the impact on investment incentives afforded by this substantial decline in the inflation rate is to compare (using the data in table 3) the ratio of depreciation to replacement cost under pre-ERTA schedules at 9 percent inflation with the ratios for 6 percent inflation under TEFRA. These inflation rates approximate the expected inflation rates, based on survey data, which prevailed in late 1980 and late 1984, respectively.[24] When this comparison is made for communications equipment, the ratio rises from 1.150 to 1.224 instead of declining. In the case of automobiles, this enhanced comparison shows a slight decline — from 1.207 to 1.168 — while in the case of industrial structures it reveals a near doubling — from 0.540 to 1.045.

THE HISTORICAL RELATION BETWEEN DISTORTIONS IN DEPRECIATION DEDUCTIONS AND INVESTMENT

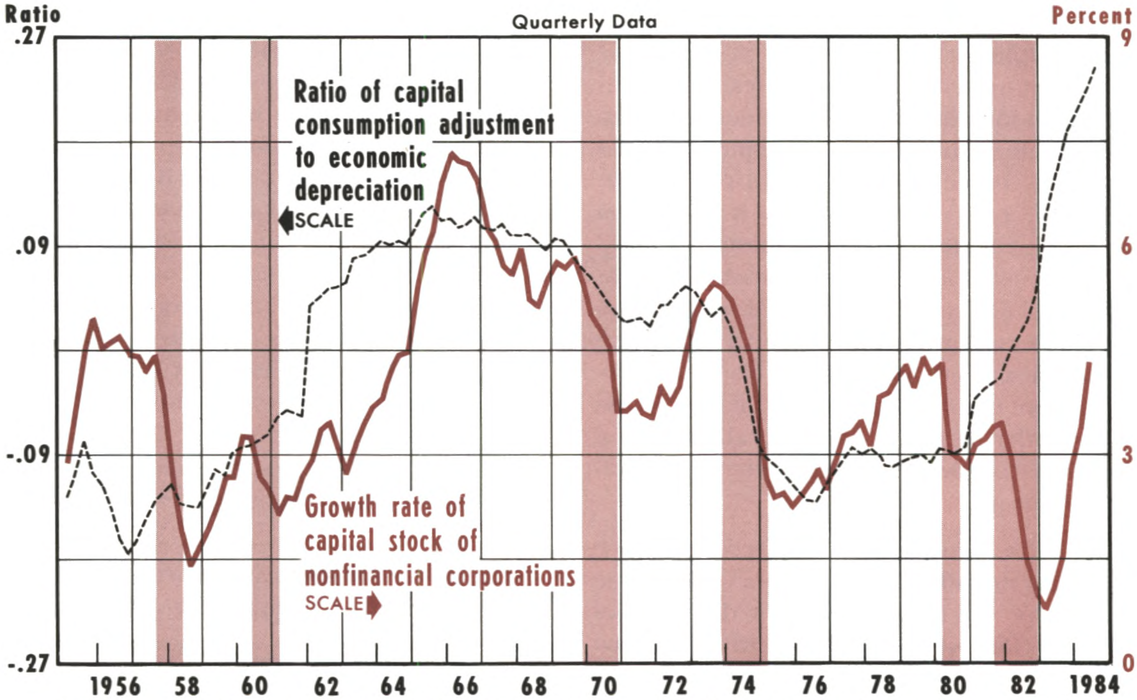
As shown above, there are two sources of distortion in depreciation deductions: On the one hand, they may provide more expense deduction than required for the eventual replacement of the used-up asset. This can result either from a shortening of the tax life below the span of its economic usefulness, or from an acceleration of the deductions. On the other hand, they may be inadequate to provide for the purchase of the replacement asset given a rise in its nominal price due to inflation. That is, since the deductions are based on the purchase price — its historical cost — inflation will progressively make the depreciation allowance inadequate for the purchase of the replacement.

As shown in tables 1 and 2, these two distortions work in opposition. For example, in table 1 consider

[23]In part, this higher present value of depreciation deductions is offset by the lack of investment tax credit on investment in nonresidential structures. Moreover, the tax act of 1984 has lengthened the depreciation term for structures from 15 to 18 years, which will slightly reduce the impetus. See *Tax Reform Act of 1984*, p. 178.

[24]The short-term (one-year period) expected inflation rate in June 1980 was 10.22 percent and 5.47 percent in June 1984; these estimates are from a semi-annual survey of economists conducted by Joseph Livingston of *The Philadelphia Inquirer*, as revised by Carlson (1977). The long-term (10-year period) expected inflation rate in October 1980 was 8.82 percent and had fallen to 5.79 percent in October 1984; these estimates are from a decision-makers poll conducted by Richard B. Hoey of Drexel Burnham Lambert, Incorporated.

Chart 3
Depreciation Distortion and the Growth Rate of the Corporate Capital Stock



Sources: Board of Governors of the Federal Reserve System and U.S. Department of Commerce
Shaded areas represent periods of business recessions.

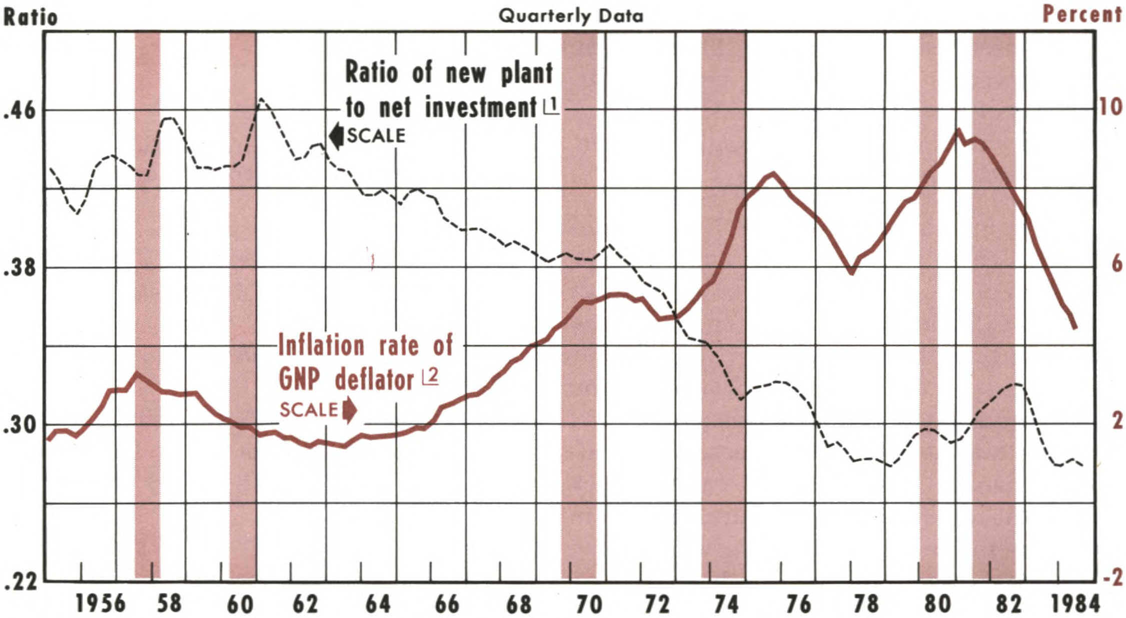
the effect of increasing acceleration on the ratio of depreciation to replacement cost for a 10-year asset at a 6 percent inflation rate: as the depreciation schedule is accelerated from SL to 150 DB to 200 DB, the ratio rises from 1.173 to 1.208 to 1.255, an increase of nearly 7 percent. Conversely, consider the impact of rising inflation on the 10-year asset's ratio under 200 DB: as inflation rises from 3 percent to 9 percent, the ratio falls from 1.362 to 1.163, a decrease of over 17 percent. Consequently, the rate of investment should vary positively with the net distortion of depreciation — that is, the difference between these two opposing distortions.

This association, in fact, can be seen in chart 3 which displays the growth rate of the capital stock and the ratio of the Capital Consumption Adjustment (CCA) to estimated economic depreciation for U.S. nonfinancial corporations beginning 1955. CCA, as estimated by the Commerce Department, is the difference between depreciation claimed by corporations on their tax returns and the estimated "economic depreciation" of their capital equipment; the Commerce Department defines economic depreciation as straight-line depreciation with an adjustment (an increase in the depreciable base) for inflation. By computing the ratio of CCA to economic depreciation, we obtain a proportional measure of depreciation distortion.

Chart 3 reveals important characteristics of the last 30 years' capital stock growth rates. First, the interval of highest capital stock growth over the period coincided with the interval during which the CCA ratio was highest — from late 1961 through early 1974.[25] From mid-1973 through early 1982, CCA was negative, hence its ratio was below zero, and capital growth was

[25]The simple correlation coefficient between the variables in chart 3 is .42, significant at the .0001 level. However, the association appears to have changed during the 1981–82 recession: from 1955–80, the correlation was .65, significant at .0001, but from 1981–84 it was −.08 and insignificant. Yet the sharp rise of CCA during the 1981–82 recession, due to disinflation and ERTA, is out of keeping with its behavior in the earlier recessions shown in chart 3. During the 1969–70 and 1973–74 recessions, CCA fell sharply and during the 1980 recession it was roughly constant. The other two recessions, 1957–58 and 1960–61, during which CCA rose moderately, had, like the current recovery, much sharper upturns in capital growth than the recoveries following the recessions with declining or unchanged CCA.

Chart 4
Investment in Structures and the Rate of Inflation



Sources: Board of Governors of the Federal Reserve System and U.S. Department of Commerce
1 Two-quarter moving average.
2 Twelve-quarter moving average.
Shaded areas represent periods of business recessions.

correspondingly slower. Second, capital stock growth appears to follow the growth rate of real output: it rises throughout expansions and plummets in recessions, ceteris paribus. Thus, the two pronounced non-recession declines in capital growth in chart 3 — 1955–56 and 1966–67 — each occurred in years when substantial slowdowns in the growth rate of real output occurred — year-over-year declines of 4.6 percent and 3.3 percent, respectively. Third, the sharpest rise in capital stock growth in any single year occurred in 1983 coincident with the largest rise in the proportion of CCA to economic depreciation.

A second qualitative indication of the effects of distortion in depreciation deductions is its impact on the relative share of investment devoted to structures. As is clear from tables 1 or 2, under prior tax law, investment in structures was penalized — in the sense of lowering the ratio of depreciation deductions to replacement cost — by sustained inflation relatively more than investment in shorter-lived assets. As a consequence, it is not surprising that periods of sustained high inflation are also periods in which investment in structures is relatively low.[26] Chart 4 depicts the proportion of total U.S. nonresidential investment in nonresidential structures and the rate of inflation since 1955. As expected, investment in plant has been proportionally lowest during periods of relatively high and sustained inflation. The enhanced incentives for investment in structures displayed in table 3 and the drop in the inflation rate suggest that the structures' share of investment should rise from its currently low proportion.

CONCLUSIONS

Elementary capital theory implies that lowering taxes on capital by increasing the acceleration of de-

[26]Nelson (1976), pp. 928–30, develops the simple analytics of this proposition, which are that the present values of shorter-lived projects rise relative to longer-lived ones, as implied by the data in tables 1, 2 and 3. The simple correlation between the variables in chart 4 during 1955–84 is −.89, significant at the .0001 level. Moreover, a regression of the plant share variable on the Livingston 6-month expected inflation rate yields a coefficient of −1.81, significant at the .0001 level.

preciation deductions or shortening the term over which depreciation is taken raises the value of capital and, other things the same, raises the rate of investment. The tax reductions in ERTA consisted primarily of a shortening of the tax lifetimes over which assets are depreciated; the changes in TEFRA, while repealing the more accelerated depreciation schedules that would have followed in 1985 and 1986, left intact the basic shortening of asset tax lives. This lowered the portion of net proceeds on which corporations would pay taxes and raised the value of capital.

Yet, the rise in investment occurring since the enactment of ERTA cannot be attributed solely to faster acceleration of deductions or shorter tax lives. In large part, the rise in CCA since 1980 has been due to the sharp decline in the inflation rate from about 9 percent to about 3 to 4 percent and the associated decline in inflation expectations. Previously, sustained shifts in the inflation rate also have been associated, inversely, with changes in the rate of capital stock growth. Part of the rapid rise in capital stock growth in 1983 may be due to the proximity and severity of the 1980 and 1981–82 recessions. In no other recovery, however, has capital growth risen as rapidly or as long as in the current expansion.

Since, in the case of most intermediate-lived capital equipment, the ACRS-TEFRA depreciation schedules are actually less accelerated than those allowed under prior tax law, ACRS could explain neither the recent rise in CCA nor in capital growth in chart 3. Yet, if the decline in inflation expectations continues to follow the decline in observed inflation, then the value of depreciation deductions will have been raised by 10 to 20 percent for most equipment and by more than 100 percent for structures.[27] Thus, the impacts of the 1981 and 1982 tax acts have been augmented by the substantial decline in the inflation rate since 1980 and, more important, the change in investors' expectations about what inflation rate policymakers will bring about in the future. Without question, the renewed vigor of corporate investment is due to both sources of effective tax reductions — ACRS and the lower rate of inflation.[28]

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[27]Specifically, the increases in the ratios of depreciation and scrap to replacement cost as inflation declines from 9 percent to 3 percent (from table 3, columns f and h) are: autos, 1.7 percent; office equipment, 9.4 percent; aircraft, 11.9 percent; mining and oil field equipment, 11.8 percent; communications equipment, 14.1 percent; ships and boats, 32.0 percent; railroad equipment, 18.5 percent; commercial structures, 125.1 percent; industrial structures, 129.4 percent.

[28]The *Economic Report of the President* (1984) is also clear on this apportioned credit:

> The tax climate for business investment has also been substantially improved in the past 3 years. During the 1970s the rising rate of inflation combined with the old depreciation rules to raise very substantially the tax rate on the income from investment in business plant and equipment. The 1981 changes in the tax rules governing depreciation, as modified in the Tax Equity and Fiscal Responsibility Act, and the sharp reduction in inflation reduced this effective tax rate substantially. (p. 34).

Interest Rate Variability: Its Link to the Variability of Monetary Growth and Economic Performance

John A. Tatom

SINCE 1979, interest rate volatility has been unusually high, subjecting investors to increased risk on their returns. When investment is riskier, risk-averse investors demand a higher rate of return as an incentive to continue investing. Evans (1984) shows that the rise in the volatility of interest rates in 1980–81 had a significant negative effect on output in the United States, which he attributes to the policy of monetary stock control implemented in 1979.[1] Other investigators have noted that money growth volatility increased substantially after 1979 and have attributed many of the unusual features of economic performance since 1980 to this increase.[2]

The purpose of this paper is to examine both the link between money growth and interest rate variability and the effects of interest rate variability on U.S. economic performance. This examination is conducted using a model in which money growth is exogenous, and past interest rate and money growth variability are taken to be exogenous for the determination of current economic performance.

The article first examines the recent experience with unusually high variability of both money growth and interest rates. This section clarifies why variability matters, and describes the type of interest rate variability that, in theory, affects economic decision-making. Other measures of interest rate variability that were examined in the course of this research are also indicated. A specific measure of variability that has the desired theoretical property is then shown to be positively influenced by the level of money growth variability. This relationship is demonstrated using the experience of the past 60 years.

Next, the article turns to the link between interest rate variability and economic performance. The theoretical channels of influence of both money and interest rate variability on economic performance are explained. These hypotheses are tested using a small reduced-form model of the economy. These tests also delineate whether it is anticipated or unanticipated interest rate volatility that accounts for the observed effects. Finally, empirical estimates of the economic effects of interest rate variability over the past four years are presented.

The empirical results point to several difficulties in implementing tests of the interest rate variability hypothesis. Only a few measures of interest rate variability strongly support the hypotheses tested. While these few have desirable theoretical and statistical properties, other standard measures of variability provide mixed results, at best, in the tests of their effects on economic performance. This study focuses on only one measure of interest rate variability. This measure has significant effects on the levels of GNP, prices and real output during the periods examined; it is also

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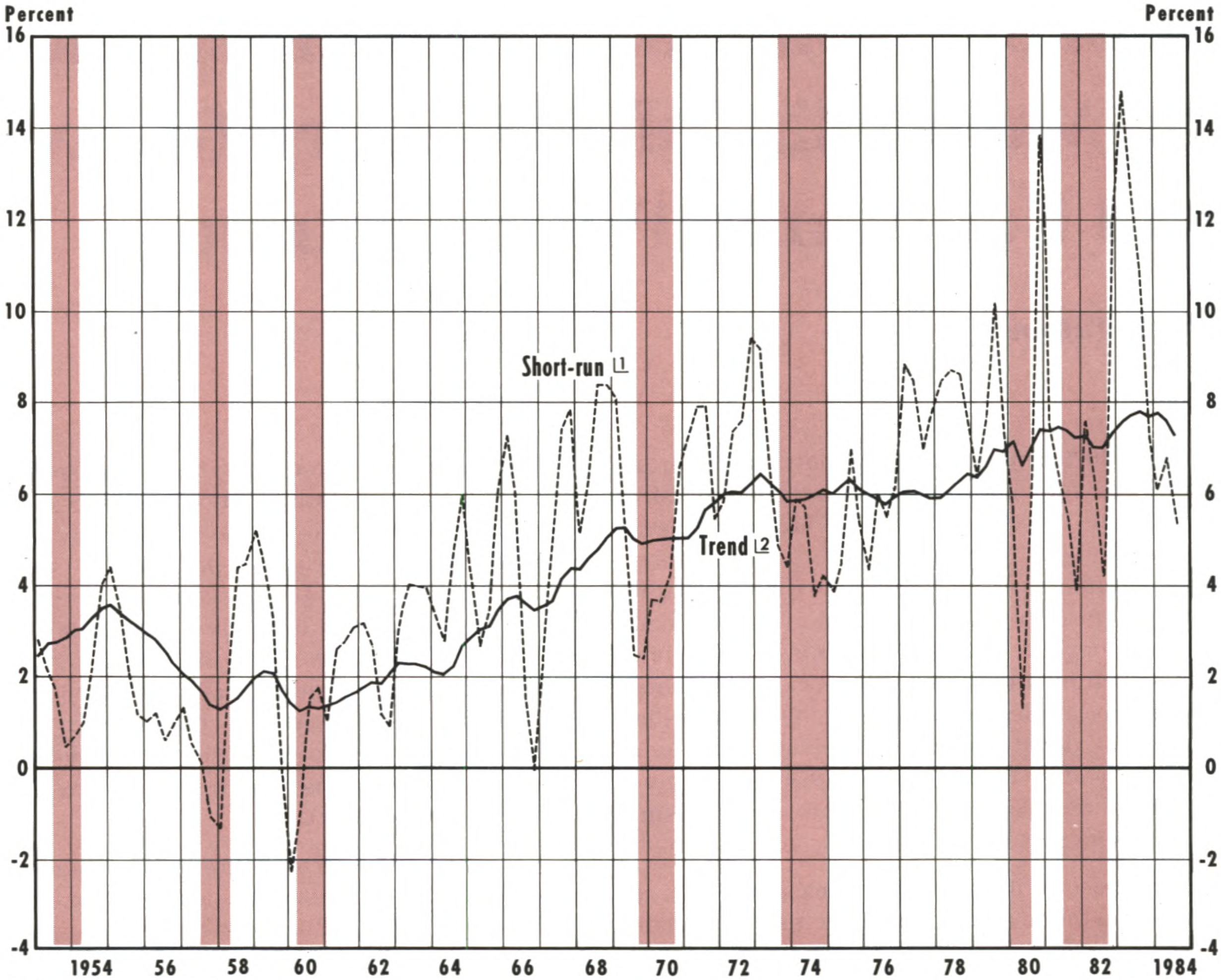
[1] See Evans (1984). The 1979 policy change is discussed by Lang (1980) and Gilbert and Trebing (1981). Subsequent policy alterations are discussed by Thornton (1983) and Wallich (1984). For an extensive set of criticisms of central bank policy aimed at money stock control, especially the policies of the Federal Reserve from 1979–82, see the citations in Batten and Stone (1983), p. 5.

[2] See Friedman (1983), Bomhoff (1983), Tatom (1983), Bodie, Kane and McDonald (1983), Mascaro and Meltzer (1984) and Belongia (1984).

Chart 1
Short-run and Trend Money Growth



[1] Two-quarter rate of change of M1.
[2] Twenty-quarter rate of change of M1.
Shaded areas represent periods of business recessions.

shown to be influenced by the variability of money growth.[3]

THE RECENT EXPERIENCE IN PERSPECTIVE

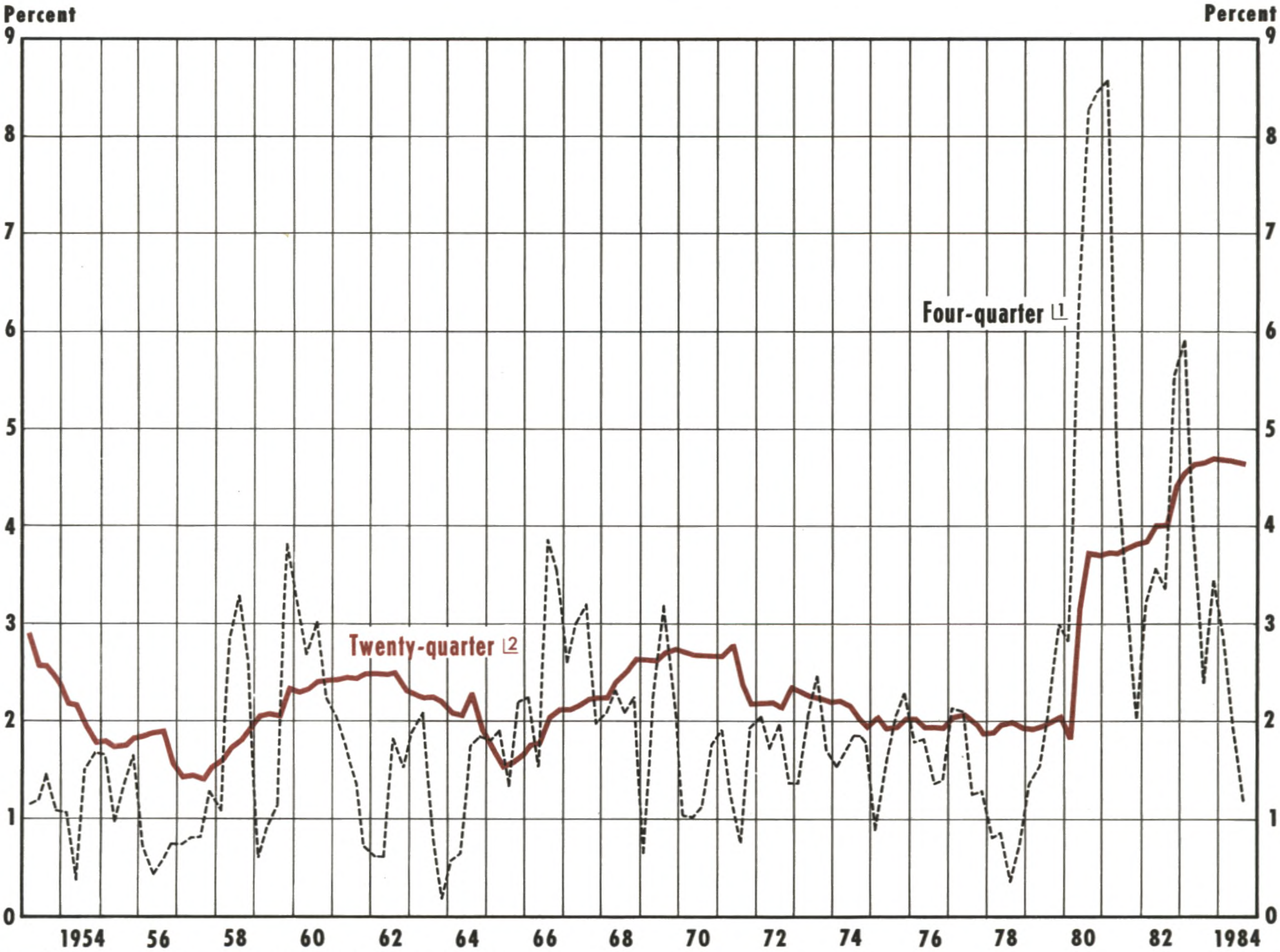
The growth rate of the money stock (M1) has been more volatile since 1979 than in the previous 27 years.

[3]The link between money growth variability and these other measures of interest rate variability was not examined because these other measures do not appear to systematically affect economic performance.

Chart 1 shows the annual rate of growth for two-quarter periods and the longer-term trend rate of expansion (five years) since 1953. Economic theory and empirical evidence indicate that sharp swings in the two-quarter growth rate of the money stock temporarily affect the growth rate of output and employment. The shaded areas in the chart, which indicate periods of business recession, are associated with relatively sharp slowings in short-run money growth relative to the trend growth rate.

Chart 1 also shows that the gyrations of money growth about trend have been unusually wide since

Chart 2
Standard Deviations of Quarterly M1 Growth



1 Four-quarter standard deviation of M1 growth (400Δln).
2 Twenty-quarter standard deviation of M1 growth (400Δln).

1979. Statistical measures of money growth variability strongly support this visual evidence. Chart 2 shows the standard deviations for the growth rate of the quarterly money stock measured over the most recent four and 20 quarters since 1953. Both measures show relatively high levels of volatility since 1979.[4]

[4]There are several reasons for increased variability of money growth since 1979. For example, Weintraub (1980), Tatom (1982), Hein (1982) and Board of Governors of the Federal Reserve System (1981) emphasize the effect of the credit control program on the currency ratio and, hence, on the link between reserves and monetary aggregates in mid–1980. This factor contributed to the rise in the variability of money growth in 1980. Others have emphasized problems associated with financial innovations, especially late in 1982 and early in 1983, that led to the temporary abandonment of M1 targeting in October 1982.

The Variability of Interest Rates

The variability of expected returns affects decisions because it influences the variability of wealth (the present value of expected income streams). For example, the present value of real income expressed as a perpetuity is inversely proportional to the expected yield. That is, wealth (W) is the flow of income per year (Y) discounted by the rate of interest paid on a perpetuity (i), $W = Y/i$.

Wealth holders are concerned with the likelihood of *percentage variations* in interest rates rather than absolute percentage point changes. The wealth effect of a 100 basis-point change in the expected interest rate is greater when the expected interest rate is 3 percent than when it is 15 percent. In the former case, wealth can change by about one-third; in the latter case, wealth changes by about 6 percent. If risk is measured relative to the expected return, the variability of returns should be measured relative to the mean return. The logarithm of the interest rate provides such a mean-adjusted measure. The variability of the logarithm of wealth is directly related to the variability of the logarithm of the expected yield.[5] Risk is measured here using the yield on Aaa bonds, since it is the long-term yield that is most important for capital accumulation and has the greatest impact on wealth.

The expected volatility of rates of return is an important determinant of investment decisions. It is not possible, however, to directly measure this risk.[6] If assessments of this risk are reflected in the actual variability of yields, then the variability of interest rates in the recent past can be used as an indicator of risk. Even then, the length of the relevant past is essentially an empirical issue.

Chart 3 shows the standard deviation of the logarithm of the quarterly Aaa bond yield, measured for the four and 20 quarters ending in each quarter shown, respectively, for the period from 1924 to 1983. These measures summarize the riskiness of yields during the respective past period. Both measures indicate a sharp jump to record levels in the variability of interest rates after 1979. In 1984, the 20-quarter measure declined sharply from its peak in early 1982, but it remained near previous peaks achieved in the mid-1930s, early 1960s and early 1970s.

Other Measures of Interest Rate Variability

There are a variety of other ways to measure the variability of interest rates. For example, Evans (1984) uses the standard deviation of monthly interest rate changes over a one-year period. The list of standard deviation measures examined for this article includes, besides the two measures in chart 3, the standard deviations of: the level of the quarterly interest rate, the change in the quarterly interest rate and the change in the logarithm of the quarterly interest rate. To test the effects of variability on economic performance, each standard deviation measure, as well as the logarithm of each measure, was used. Two other measures were examined as well: the average absolute change in the level of the quarterly interest rate and the coefficient of variation of the quarterly interest rate. All measures were computed for four-, 12- and 20-quarter periods.

The best results (judged by robustness across periods of time and relative explanatory power for economic performance) were found using the 20-quarter standard deviation of the logarithm of the interest rate; this measure is called VR here. Virtually the same results are obtained using the 20-quarter coefficient of variation, which is simply an alternative way of adjusting the variability of the interest rate for different mean levels over time. As emphasized above, it is such mean-adjusted measures of variability that, in principle, should matter. Other measures generally do not have significant economic effects; in those cases where significant economic effects are observed, relationships usually are either not robust or are statistically inferior in terms of explanatory power. These exceptions are noted below.

Interest rate variability measures inherently depend on past interest rates. For example, a rise or fall in interest rates from one level that has persisted for a considerable time to another that will persist for a long time to come, will lead to a transitory rise in the variability of interest rates during the transition from the former to the latter and for some period subsequently. The Aaa bond yield has broadly followed a pattern of three level shifts from 1955 to 1983; it rose from about 3 percent during 1950–55 to near 4.5 percent during 1960–65, then rose to about 8 percent from 1970 to early 1977, and finally surged upward to an average of 13 percent in 1980–83.

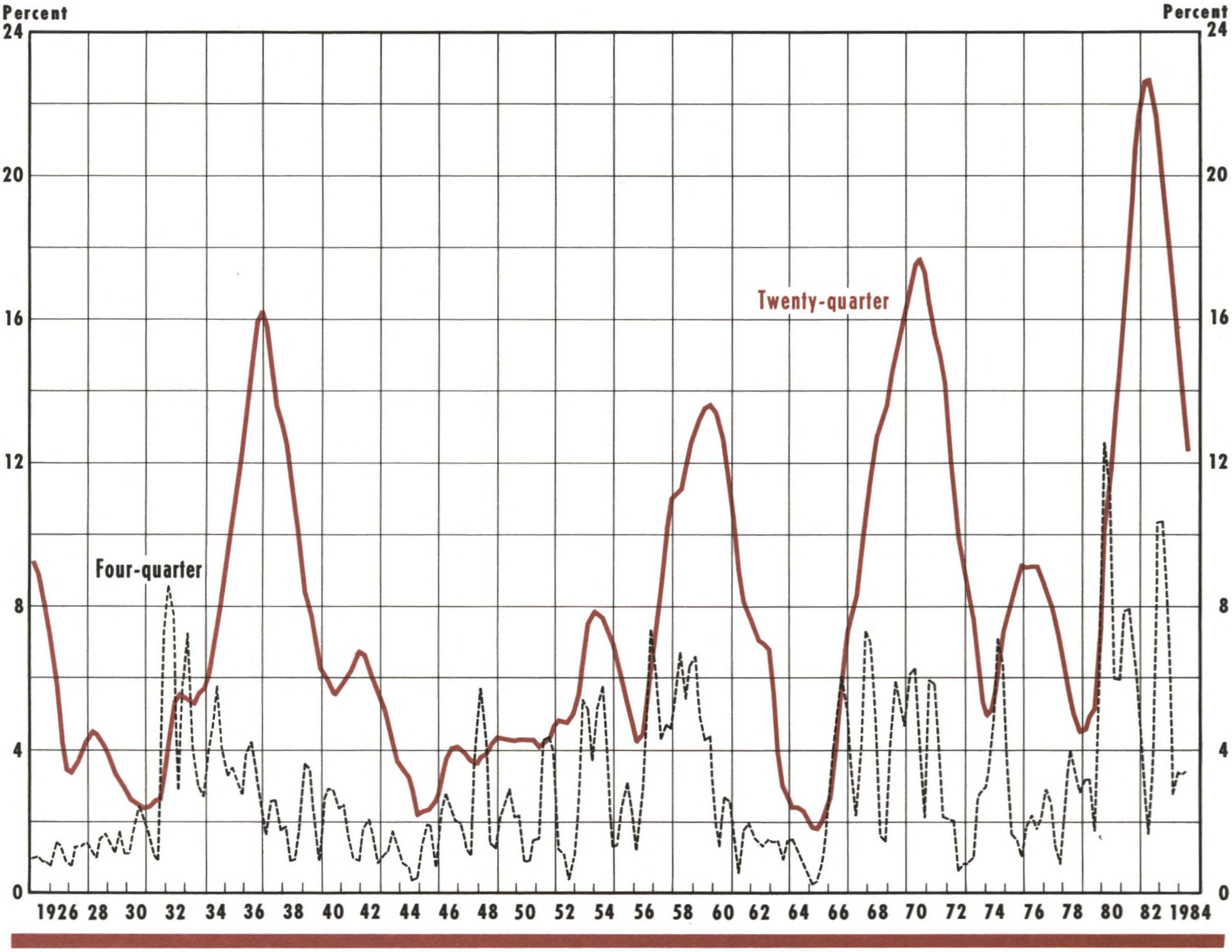
The three major spikes for the 20-quarter measure in chart 3 are consistent with such level shifts in interest rates. There are two ways to interpret this rise in variability. One way would suggest that the rise is purely arithmetic with no economic consequences for perceived investment risk. The alternative view is that the rise in interest rate variability associated with such level shifts in interest rates mirrors the increased risk perceived from such unforeseen changes. Moreover, this risk, like the variability measure, is reduced slowly over time. This article assumes that the second inter-

[5]Given expected income, $(\bar{Y})$, wealth is $W = \bar{Y}/i$ and the logarithm (ln) of wealth is $\ln \bar{Y} - \ln i$. Thus, $\ln W$ is inversely related to $\ln i$ and the variance of $\ln W$ is proportional to the variance of $\ln i$. Note also that the variance of $(\ln i)$ is independent of the level of the interest rate since $\text{Var}[\ln (k\,i)] = \text{Var}(\ln i)$, where k is a scalar multiple.

[6]It would be most useful to measure the variability of the expected after-tax real rate of return and that of the expected rate of inflation separately. Makin and Tanzi (1983) argue that an increase in both factors account for the increased volatility of interest rates in 1980–82. Since both have qualitatively the same effect on investment, production and money demand incentives, the distinction is ignored here.

Chart 3

Standard Deviations of the Logarithm of the Quarterly Average Aaa Bond Yield



pretation is more accurately descriptive of risk perceptions following such level shifts in interest rates.

The Link Between Variable Money Growth and Variable Interest Rates

Both measures of the variability of money growth shown in chart 2 rose sharply beginning in 1980 and remained well above their previous average during 1980–83. The variability of interest rates rose similarly, as chart 3 shows. An empirical investigation of the link between the variability of money growth and that of interest rates was conducted for the 20-quarter standard deviation measures shown in charts 2 and 3.[7] Lags of the 20-quarter standard deviation of quarterly money growth shown in chart 2, VM, were introduced to test whether money growth variability influences interest rate variability, VR. The results for the period I/1955–IV/1983 are shown in table 1.

There is a significant positive link between a rise in the variability of money growth and the variability of interest rates.[8] When one controls for the past two quarters of the variability of interest rates (longer lags

[7]The best univariant time series model for VR is a second-order autoregressive and second-order moving average process during the periods I/1955–IV/1978 and I/1955–IV/1983.

[8]These tests, including past information on interest rate and money growth variability, use the Granger causality test specification. However, unidirectional causality is not asserted, necessary, or tested here. Also, interest rate variability may be a function of other sources of increased risk including increased variability of fiscal policy variables. The importance of other factors is apparent over the 1955 to 1978 period, when VR showed considerable variation, but VM was essentially unchanged.

Table 1

The Effect of Money Growth Variability on the Variability of Interest Rates

Dependent Variable: VR_t[1]

	I/1955–IV/1983		III/1924–IV/1954	
	Coefficient	t-statistic	Coefficient	t-statistic
Constant	0.245	1.96	0.117	1.62
VR_{t-1}	1.877	51.52	1.763	34.86
VR_{t-2}	−0.920	−24.53	−0.790	−15.59
VM_{t-1}[1]	0.827	3.87	0.153	3.09
VM_{t-2}	−0.762	−3.41	−0.147	−2.87
$\bar{R}^2$	0.996		0.993	
S.E.	0.394		0.282	
Q(12)	7.74		11.62	
ρ_1	−0.185	−2.15	—	—
ρ_2	0.380	4.42	—	—

[1]VR_t is the standard deviation of the logarithm of the Aaa bond yield over the 20 quarters ending in quarter t; VM_t is the standard deviation of money growth measured over the same period.

are not significant) and for statistically significant second-order autocorrelation, the variability of money growth over the previous two quarters has significant effects on the current level of the variability of interest rates.[9] A rise in money growth variability initially has a significant and positive effect on interest rate variability; this effect is offset in the next quarter.[10] According to table 1, the significant positive effect of the variability of money growth on interest rate variability is transitory.[11]

Attempts to replicate the table 1 results from I/1955–IV/1978 were unsuccessful; the variability of money growth did not significantly affect the variability of interest rates over this earlier period. A principal reason for this result is that the variability of money growth over the period I/1955–III/1979 was relatively constant; the standard deviation of VM over this period is 0.3 percent, only 15.3 percent of the mean level of money growth variability over the period. The variability of money growth from 1955 to 1979 was too small and steady to provide information on the potential impact of changes in money growth variability on interest rate variability.[12]

Earlier Evidence: 1924 to 1954

Prior evidence of a systematic relationship between the variability of money growth and interest rates does exist, however. Friedman and Schwartz (1963) have shown that money growth variability was much greater before World War II than it was from the end of World War II to the early 1960s.[13] The variability of money growth also fluctuated much more before World War II. The average level of VM from I/1924–IV/1954 is 7.5 percent, and its standard deviation is 3 percent; the former is more than three times as large,

[9]The Q-statistic indicates that the residuals in the equation estimate are not significantly correlated with their own past for up to 12 past quarters, although the same results holds for one to 24 past values of the residuals.

[10]The results do not arise from the computational relationship arising from the use of moving standard deviations. Virtually identical results are obtained by relating changes in VR to ΔVR_{t-1}, VR_{t-2}, and either VM_{t-1} and VM_{t-2}, or ΔVM_{t-1}. First-differences of VM or VR are not computationally related.

[11]The steady-state response of VR to a rise in VM involves the lagged adjustment of VR to its own past values. This response is 1.52, but its standard error, found from the variance-covariance structure of the coefficients on the lags of VM and VR, is 2.00. Thus, the effect of a change in VM is transitory. Whether a rise in money growth variability, in theory, has a permanent or transitory effect on interest rate variability is a question that is not resolved here. The empirical evidence clearly indicates that the effect is transitory.

[12]The mean of ΔVM from I/1955–III/1979 is 0.0021 and its standard deviation is 0.1101. Over this period, ΔVM is an independently distributed random variable with a Q-statistic, Q(12), of 7.34, which indicates that ΔVM is not correlated with its past history. Over the longer period to IV/1983, ΔVM is described by a first-order moving average process.

[13]Friedman and Schwartz (1963, pp. 592–638). Their M1 data until 1947 is used to compute VM below.

and the latter measure is about 10 times as large as that observed from 1955 to 1979. Thus, this earlier period should provide useful information on the effect of monetary growth variability on interest rate variability.

Over the period III/1924–IV/1954, there is a statistically significant positive relationship between VR and VM (see table 1). The results are similar to those for the 1955–83 period. In particular, for this earlier period, increases in the volatility of money growth temporarily and significantly raised the volatility of interest rates. Autocorrelated errors are not significant in the earlier period according to the Q-statistic. The dynamic structure for interest rate volatility is about the same as in the later period.[14] The difference in the magnitude of the money growth variability effect in the two periods is not meaningful; the money stock data used in the early period are largely based on end-of-month data, while those in the later period are based on averages of daily figures.

VARIABILITY OF MONEY GROWTH AND INTEREST RATES: THE AGGREGATE DEMAND CHANNELS

Mascaro and Meltzer (1984) have attributed part of the substantial jump in interest rates and the decline in real GNP growth in 1980–81 to the increased uncertainty arising from greater variability of money growth. They attribute a 1.3 percentage-point rise in the average long rate and a 3.3 percentage-point rise in the average short rate over the nine quarters, IV/1979–IV/1981, to a rise in monetary uncertainty.[15]

Mascaro and Meltzer emphasize a money demand channel for the effect of monetary uncertainty on the economy. A rise in monetary uncertainty increases the demand for money. They indicate that an increase in the demand for money raises the interest rate and reduces aggregate demand. In addition, they argue, prices and real output fall because of the reduction in aggregate demand. Furthermore, they suggest that the growth rates of output, prices and GNP are likely to be further affected by the reduced demand for capital. Their empirical analysis focuses on the rise in interest rates on both short- and long-term debt due to the risk premium.[16]

There is a second demand channel, however, through which money growth variability lowers investment. When money growth is more variable, the variability of the output of goods and services, employment and earnings will rise. There will also be greater risk associated with the expected returns from both existing capital and prospective investments. If stockholders and lenders are risk averse, and if existing expansion plans and sources of financing are to be maintained market rates of return must rise to compensate for increased risk. Of course, with higher costs of capital funds and greater risk associated with prospective investment projects, investment managers will both reduce investment and enhance the flexibility of their asset portfolios.[17] Thus, because it contributes to more volatile investment returns, erratic money growth raises the level of observed market rates and retards and redirects the desired stocks and usage of plant and equipment.

At unchanged interest rates and costs of funds for firms, a rise in the variance of expected returns from investment in plant and equipment reduces the incentive to invest. The portfolio shifts emphasized by Mascaro and Meltzer, and Gertler and Grinols (1982), involve an increase in money demand that raises interest rates. Investment demand in their analysis declines along a given investment demand curve. But even at an unchanged cost of capital, firms faced with riskier expected incomes will reduce investment.

[14]Over this period, the t-statistic for the steady-state response of VR to VM is 0.12; the response of VR to VM is transitory.

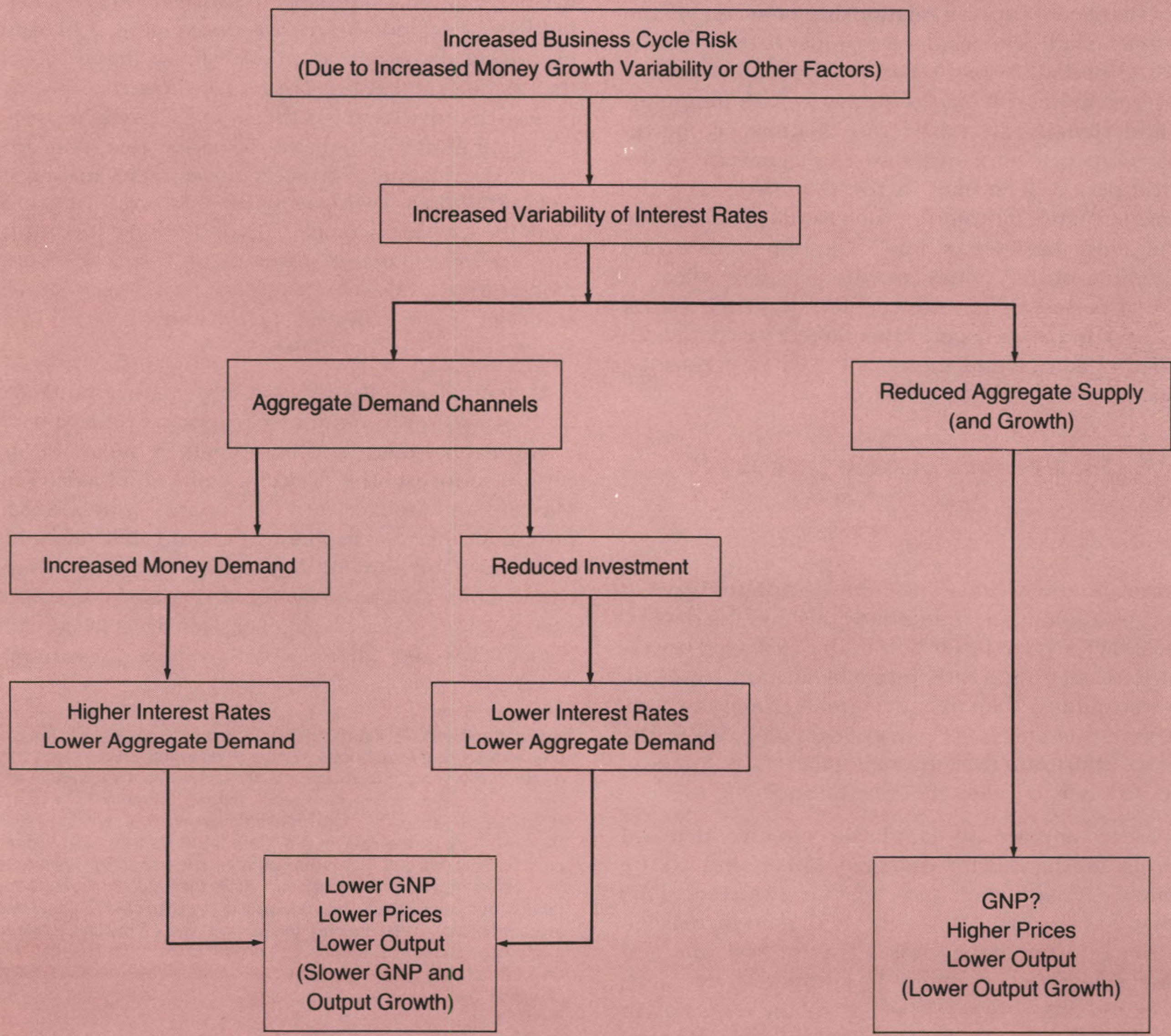
[15]Belongia has argued that nominal GNP growth was depressed by the rise in monetary uncertainty in 1980. Both Mascaro and Meltzer and Belongia use a measure of the variability of unanticipated money growth rather than that of actual money growth.

[16]Bodie, Kane and McDonald (1983) find evidence of a rise in the risk premium on long-term bonds. Gertler and Grinols (1982) show that a rise in monetary growth uncertainty raises money demand and reduces investment, but their result follows primarily from an increase in the variability of expected inflation, not from an increase in the variability of the real rate of interest. If variations in money growth affect real output and employment in the short run, as monetary explanations of the business cycle indicate, then monetary randomness also affects the variability of the expected real rate and investment incentives. Indeed, this is more likely if the link between money and prices has long lags as shown in the model used below or in Barro (1981). A rise in monetary variability raises the variability of yields on capital and reduces investment, either through increased variability of expected inflation or of real rates of return (both of which are captured in the variability of nominal interest rates), or both.

Makin and Tanzi attribute the high volatility of interest rates from 1980 to the end of 1982 to increased volatility of both expected inflation and after-tax real rates of return. Their evidence for the former, however, is survey data on expected inflation for a six-month horizon during a period in which substantial price level shocks were occurring.

[17]Obviously a rise in risk tends to reduce both the supply of saving and investment demand at given market interest rates. Thus, the effect on observed market rates is not as straightforward as it may appear in the text. If suppliers of credit are more risk averse than firms that invest in plant and equipment, then market rates (not risk-adjusted) will tend to rise. This result also depends on relative interest elasticities of supplies and demands for credit and equities.

Figure 1
The Channels of Influence of Increased Risk



Such a decline in the demand for goods and services is accompanied by a reduction in the demand for credit, so that interest rates tend to fall along with aggregate demand.

The left side of figure 1 summarizes the two aggregate demand channels. These effects arise in this instance through increased money growth variability. Other changes that raise risk assessments about future economic conditions or business cycle risk could alter interest variability as well, however. There appear, then, to be at least two channels through which monetary growth variability affects aggregate demand: increased money demand and reduced investment. Of course, the two channels have opposite implications for interest rates; both, however, imply reduced aggregate demand and, hence, lower nominal GNP, real output and prices. The Mascaro-Meltzer evidence on interest rates suggests that the rise in money demand dominates risk-related reductions in the demand for goods and services.

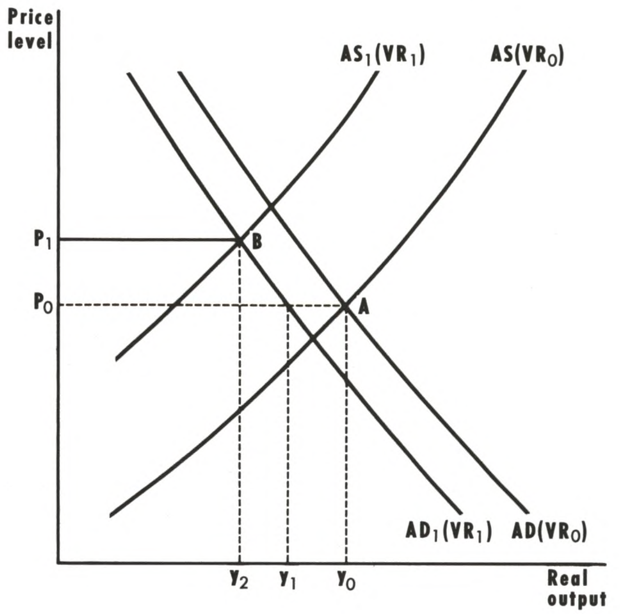
Evans (1984) and Tatom (1984a) show that a rise in the variability of interest rates has a significant negative effect on the level of annual output. This effect is consistent with the two aggregate demand channels shown on the left side of figure 1, but it encompasses other sources of a rise in such variability besides a rise in monetary variability. To the extent that such variability arises from monetary variability, it simply reflects the channels through which money growth variability affects the levels of interest rates, spending, output and prices.

VARIABILITY OF INTEREST RATES AND MONEY GROWTH: AGGREGATE SUPPLY

A rise in risk implies, at the producer level, increased variability of expected sales, real cash flows or profits. A rise in the variability of returns to production may be viewed as either an increased cost of using the firm's capital to produce output or a reduction in the value of given expected income. In either case, exposure to the increased risk can be lessened by reducing expected output, production and capital employment in production. Thus, an increase in risk reduces desired supply, given expected prices of inputs and output.[18] This effect is summarized in the third channel of influence shown in figure 1. Whether supply is reduced more than demand is not obvious. Thus, while the consequences of increased risk for spending and output are unambiguous, given the price level, the consequences for the price level are not.

Figure 2 shows the effect of a rise in risk, VR, on aggregate demand and supply. Initially, the economy is assumed to operate at point A where, at price level P_0, the quantities of goods and services demanded and supplied (y_0) are equal. An increase in risk reduces aggregate demand to AD_1; at (P_0, y_1), market interest rates, which are implicit in AD and AD_1, are higher than at (P_0, y_0). Aggregate supply is reduced as well, however. As drawn in figure 2, AS shifts leftward more than AD, so the price level rises to P_1. Thus, the economy operates at point B. Of course, the price outcome depends on the relative magnitude of the supply and demand shifts.

Figure 2
The Effect of an Increase in Risk on Output and Price



Earlier studies of monetary uncertainty and interest rate variability have focused primarily on their effects on nominal and real GNP and on the interest rate. The common assumption appears to be that the effects on spending and output arise from an unanticipated shift in aggregate demand, so that the price level changes in the same direction as spending or output. The model used below to assess the effects of interest rate variability is a reduced-form model for GNP, price and output growth that permits all three effects to be examined; this model is shown in table 2.

In the model without interest rate variability, GNP growth depends on current and past growth rates of the money stock, cyclically adjusted federal expenditures, energy prices and a strike variable.[19] Inflation

[18]De Vany and Saving (1983) provide a model of the firm in which greater variability of demand will yield higher pecuniary prices, the substitution of inventory for plant and equipment at a given expected output rate to the extent the product is storable, and, a reduction in expected output relative to capacity. Such reductions in the efficiency of firms indicate an overall loss in economic capacity or, for a given stock of plant and equipment and employment, less expected output. The firm in their model can be risk-neutral. Sandmo (1971) and Holthausen (1976) show that risk-averse firms reduce capacity and output in response to increased uncertainty, yielding similar price and output implications.

Table 2

The Reduced-Form Model

$$(1)\ \dot{GNP} = \beta_0 + \sum_{i=0}^{4} \beta_{i+1} \dot{M}_{t-i} + \sum_{j=0}^{4} \beta_{j+6} \dot{E}_{t-j} + \sum_{k=0}^{6} \beta_{k+11} \dot{p}^e_{t-k} + \beta_{18} \Delta S_t$$

$$(2)\ \dot{P} = \sum_{i=0}^{20} \gamma_i \dot{M}_{t-i} + \sum_{j=1}^{4} \gamma_{j+21} \dot{p}^e_{t-j} + \gamma_{26} D1 + \gamma_{27} D2$$

$$(3)\ \dot{X} = \dot{GNP} - \dot{P}$$

where

GNP = gross national product

P = GNP deflator

X = real GNP

M = money stock (M1)

E = cyclically adjusted federal expenditures

p^e = the producer price index for fuel and related products and power deflated by the business sector price deflator

ΔS_t = the quarterly change in the ratio of days lost due to strikes to the civilian labor force

A dot over a variable, for example a, represents 400 Δln a

depends on current and past growth rates of the money stock, energy prices and dummy variables for the wage-price control and decontrol periods of the early 1970s.

Introducing interest rate variability into this model permits its effects on GNP and the price level to be examined directly. The real output growth effect simply equals the difference between the GNP growth and inflation effects. In addition, the equation in table 1 (I/1955–IV/1983) can be used to delineate anticipated and unanticipated interest rate variability. Thus, the issue of whether interest rate variability effects arise from unanticipated or anticipated changes in variability can be examined.

INTEREST RATE VOLATILITY AND ECONOMIC PERFORMANCE

To examine whether recent changes in interest rate variability affected total spending or GNP, the modified version of the Andersen-Jordan equation shown in table 2 was used for GNP. Since interest rate variability rose sharply beginning in 1979, tests were conducted for two periods: I/1955–IV/1978 and I/1955–IV/1983.[20]

The results for GNP growth are given in table 3. In both periods, a rise in the variability of interest rates in

[19]The model estimation uses quarterly data for growth rates. Evans and Tatom (1984a), use annual data for the level of output and, in the latter, the level of prices.

The strike variable, S, is based on days lost due to work stoppages. The details for its construction are available upon request from the author. The coefficients for money and expenditure growth were estimated using a fourth-degree polynomial with head and tail constraints. The energy price coefficients were estimated using a third-degree polynomial and were constrained to sum to zero. This constraint cannot be rejected in either period.

[20]The level of interest rates can be controlled for in tests such as these, but this raises an identification problem; a change in interest rate variability affects the level of interest rates and vice versa. Such an attempt to control for interest rates would capture variability effects in the interest rate effects, or vice versa. The interest rate specification in Tatom (1983), the contemporaneous and five lagged values of the changes in the logarithm of the Aaa bond yield, was added to the GNP equation in table 3 to check for their importance. The lagged variability of interest rate measure remains significant in both periods, despite the inclusion of these interest rate controls, so that the results reported do not arise from changes in the level of interest rates. Similar controls were examined for the price equation; see footnote 28 below.

Table 3

Interest Rate Variability and GNP

Dependent Variable: $\dot{GNP}_t$

Independent Variables	I/1955–IV/1983 Coefficient	I/1955–IV/1983 t-statistic	I/1955–IV/1978 Coefficient	I/1955–IV/1978 t-statistic
Constant	5.389	6.02	3.992	4.01
$\dot{M} \quad \sum_{i=0}^{4} \beta_{i+1}$	1.061	8.10	1.142	7.99
$\dot{E} \quad \sum_{j=0}^{4} \beta_{j+6}$	−0.000	−0.00	−0.006	−0.08
ΔS_t	−0.520	−3.98	−0.497	−3.93
$\dot{p}^e_t$	−0.041	−1.66	−0.035	−1.18
$\dot{p}^e_{t-1}$	0.005	0.28	0.011	0.52
$\dot{p}^e_{t-2}$	−0.005	−0.36	−0.004	−0.23
$\dot{p}^e_{t-3}$	−0.031	−2.12	−0.038	−2.18
$\dot{p}^e_{t-4}$	−0.033	−1.93	−0.046	−2.28
$\dot{p}^e_{t-5}$	0.029	0.99	0.015	0.38
$\dot{p}^e_{t-6}$	0.075	2.68	0.097	2.85
VR_{t-1}	−0.297	−4.85	−0.152	−2.09
$\bar{R}^2$	0.52		0.57	
SE	3.099		2.892	
DW	1.88		2.05	

the previous quarter significantly and permanently reduces the growth rate of GNP.[21] Longer lags (up to eight quarters) on the variability of interest rates were examined, but none added significantly to the table 3 equation, with or without an insignificant contemporaneous term. In the more recent period, the effect is larger than in the pre-1979 sample period, but both results indicate that variability matters. The equation in table 3 was also estimated to the third quarter of 1981, the previous cyclical peak. The coefficient on interest rate variability, VR_{t-1}, is about the same as in the pre-1979 case, –0.138 (t = –2.03); thus, the change in the volatility coefficient occurred as a result of the experience from mid-1981 to the end of 1983.[22]

The variability measure VR_t can be decomposed into an anticipated component, $\hat{VR}_t$, the predicted value from the I/1955–IV/1983 estimate in table 1, and an unanticipated component, VRE_t, the residual from the equation. The tests of the GNP effect can be conducted using each of these measures to clarify the source of the interest rate variability effect. While either effect is consistent with the theory, the importance of monetary variability as a major source of the GNP effect is strengthened if it is found that the anticipated compo-

[21]For the longer period (I/1955–IV/1983), the coefficient of a contemporaneous four-quarter standard deviation of interest rate changes is significantly negative in the GNP growth equation. The lagged value of the average absolute change in the level of interest rates also significantly and negatively affects GNP whether measured over four, 12 or 20 quarters, and in both periods. None of the latter measures provide as much explanatory power as VR in the text.

[22]The equation estimated to the end of 1978 is stable when extended to III/1981. The F-statistic for the additional 11 observations is $F_{11,83}$ = 0.93. When the equation ending in III/1981 is extended to IV/1983, it is not stable; the F-statistic for the additional nine observations is $F_{9,94}$ = 2.89. The critical F is 1.98 (5 percent) or 2.60 (1 percent). The instability of the equation during late 1981 and 1982 is also discussed in Tatom (1984b).

nent of variability, which depends, in part, on money growth variability, is responsible for the GNP effect.

Tests of current and lagged values of both $\hat{VR}$ and VRE were conducted. It might seem that only the anticipated and unanticipated components of VR_{t-1} should be examined because it is the significant variable in table 3. But VR_t and lagged VR terms beyond one lag are constrained to zero in table 3, a result that may only have been supported in the lag search over VR by constraining the anticipated and unanticipated component to be equal in each of the omitted periods. Thus, it is useful to examine all of lags of $\hat{VR}$ and VRE, regardless of the actual VR lags selected above. Current or lagged values of unanticipated volatility, VRE, are not statistically significant in either period, whether anticipated interest rate variability is included or not. The current or first lag of anticipated volatility, $\hat{VR}_t$ or $\hat{VR}_{t-1}$, are significant, in both periods; additional lags are not significant for either specification in either period.

The results using either $\hat{VR}_t$ or $\hat{VR}_{t-1}$ are virtually identical; those using $\hat{VR}_t$ are reported here. The coefficient on $\hat{VR}_t$ is –0.158 ($t = -2.18$) in the I/1955–IV/1978 period and –0.289 ($t = -4.75$) in the longer period. Both estimates are essentially identical to those shown for VR_{t-1} in table 3. Further, none of the other coefficients in table 3 are affected when $\hat{VR}_t$ is used and the standard error of the estimates compare favorably. In the period ending in IV/1983, the standard error is 3.111; in the earlier period it is 2.886. The adjusted R^2s are the same as in table 3. Thus, the source of the interest rate variability effect in table 3 is anticipated variability.[23] The results indicate that the effect of interest rate variability on GNP growth since 1979 discussed below is the same whether the measure chosen is the actual past level of volatility, VR_{t-1}, or contemporaneous or lagged anticipated volatility ($\hat{VR}_t$ or $\hat{VR}_{t-1}$).

Some Problems with the GNP Estimates

It should be noted that the interest rate variability measure, either VR_{t-1} or $\hat{VR}_t$, enters the GNP equation in level form. Thus, a rise in the level of VR permanently affects the growth rate of nominal GNP. Tests of additional lags, especially VR_{t-2} and $\hat{VR}_{t-1}$, respectively, indicate that they are insignificant. This result suggests that a permanent rise in the variability of interest rates reduces both the level of GNP in the short run and the growth rate of spending permanently.

The latter effect is theoretically implausible; the capital stock eventually should be adjusted to its lower desired level. Once this has occurred, the permanent effect on the growth of nominal spending and real output should disappear. The dynamic structure of VR indicates, however, that interest rate volatility tends to revert to its mean following changes in money growth variability or random shocks. Thus, because changes in interest rate volatility are transitory, changes in the GNP growth rate arising from interest rate variability are transitory as well.

A second concern with the GNP evidence is that variability measured over two shorter time horizons (four and 12 quarters) does not have a significant effect on GNP growth, nor do a few other measures of variability for any horizon. There are two ways to interpret the GNP results. One interpretation is that changes in interest rate variability are only important when viewed from a longer time horizon and, even then, only certain measures of variability (such as VR, the coefficient of variation of the interest rate or average absolute changes in the interest rate) capture the relevant risk. The other alternative is that the GNP results are spurious. The consistent results from the tests for prices below suggest that the latter interpretation is not valid.

The Effect of Interest Rate Variability on Prices

The theoretical discussion indicates that the effect of increased interest rate variability on prices is an empirical issue; it depends on whether aggregate supply is affected more or less than aggregate demand. To assess this relationship, a standard price equation which emphasizes the link between money growth and prices, controlling for shocks such as wage and price controls and energy price changes, is employed. The price equation used for the test of an interest rate variability effect is the second equation in table 2.[24] Again, both permanent and transitory effects of interest rate variability were examined.

As with the GNP experiments, the five-year measure

[23]The significance of $\hat{VR}$ in both periods indicates that, given past interest rates, VM significantly reduces GNP. When VM and its lags are added alone to the table 1 equations, however, they are not significant.

[24]The coefficients on money growth are estimated to lie along a third-degree polynomial.

[25]A 12-quarter measure of the standard deviation of the logarithm of the interest rate has a positive and statistically significant effect at one lag in the period ending in IV/1983, but the equation has a higher standard error than the same estimate using the 20-quarter variability measure. The 20- and 12-quarter average absolute change in the interest rate also significantly raises then lowers inflation at lags one and two, respectively, over the longer period, but no effect is significant in the earlier period. See also footnote 31 below.

Table 4
Interest Rate Variability and Prices

Dependent Variable: $\dot{P}_t$

Independent Variables	I/1955–IV/1983 Coefficient	I/1955–IV/1983 t-statistic	I/1955–IV/1978 Coefficient	I/1955–IV/1978 t-statistic
$\dot{M} \sum_{i=0}^{20} \gamma_i$	0.939	20.41	1.010	24.05
D1	−1.442	−2.07	−1.942	−3.37
D2	1.419	1.97	1.306	1.93
$\dot{p}^e_{t-1}$	0.008	0.74	0.012	0.80
$\dot{p}^e_{t-2}$	0.051	4.19	0.041	2.59
$\dot{p}^e_{t-3}$	−0.017	−1.01	−0.018	−1.15
$\dot{p}^e_{t-4}$	0.031	2.40	0.030	2.11
ΔVR_{t-1}	1.275	4.80	1.093	3.38
ΔVR_{t-2}	−0.951	−3.62	−0.963	−2.84
$\bar{R}^2$	0.80		0.81	
SE	1.179		1.112	
DW	2.11		2.00	
$\hat{\rho}$	0.37		0.16	

of variability (VR) is significant and provides the greatest explanatory power of the alternative measures.[25] Tests for statistically significant lags of VR indicate that the past three quarters of interest rate volatility affect inflation. The effects of VR sum to zero, implying that there is no permanent effect of a change in VR on inflation.[26] Thus, the appropriate expression includes ΔVR_{t-1} and ΔVR_{t-2}. The price equation results for the two periods are summarized in table 4. In addition, these results indicate that there is no permanent effect of a change in VR on the level of prices, since the coefficient on ΔVR_{t-1} is opposite in sign and statistically not significantly different from that for ΔVR_{t-2}.

According to these results, a rise in VR initially raises inflation and the price level one quarter later, then depresses inflation and the price level in the subsequent quarter. After two quarters, both inflation and the price level are unaffected.[27] The sum of the coefficients on the change in interest rate variability in table 4 is positive, but not significantly different from zero. In the I/1955–IV/1978 period, the sum is 0.130 ($t = 0.62$), while in the I/1955–IV/1983 period it is 0.283 ($t = 1.27$).[28]

The anticipated/unanticipated variability distinction was also employed to isolate the inflation effect. When VR_{t-1}, VR_{t-2} and VR_{t-3} are decomposed into anticipated and unanticipated components using the table 1 equation, only the lagged unanticipated component,

[26]The F-statistics for this constraint are $F_{1,84} = 0.85$ for the I/1955–IV/1978 period and $F_{1,105} = 0.00$ in the I/1955–IV/1983 period.

[27]This result is at odds with that found using annual data where interest rate variability appears to have a permanent positive impact on the price level. See Tatom (1984a). It is shown below, however, that a distinction between anticipated and unanticipated variability yields results that are consistent with the annual result for the price level.

[28]The price equation is stable across the two periods in table 4. The F-statistic for the last 20 observations is $F_{20,83} = 1.66$, which is below the critical value of 1.69 (5 percent significance level). The equation is not stable without the interest rate variability term. See Tatom (1984b), where tests of other variables (such as shifts to other checkable deposits or unusual recent movements of exchange rates, the volatility of money growth, unemployment or interest rates) that might affect prices indicate that, since mid-1981, only unemployment and the previous quarter's change in the ln of the Aaa bond rate significantly affect the price level. The unemployment result does not hold before IV/1981 and disappears even in the later period when the past interest rate change is included. The bond yield result is robust across the periods. When either of these variables is added to the estimates in table 4, however, it is not significant in either period, and the interest rate variability result is unaffected. This also indicates that controlling for the level of interest rates in table 4 does not affect the result there.

VRE_{t-1}, is significant, and in both periods. Tests of lags of VRE or $\hat{VR}$ yielded the same conclusion for VRE and indicated that both $\hat{VR}_t$ and $\hat{VR}_{t-1}$ terms are statistically significant in both periods. In addition, the coefficients on the two anticipated variability terms can be constrained to sum to zero; in the I/1955–IV/1978 period, $F_{1,85} = 0.00$, while in the longer period, $F_{1,104} = 0.70$.

The inflation equations with VRE_{t-1} or $\Delta\hat{VR}_t$ are given in table 5, along with the inflation equation containing both variables.[29] The results do not discriminate between the alternative hypotheses that only anticipated ($\Delta\hat{VR}$) or unanticipated (VRE) interest rate variability matters in the I/1955–IV/1983 period. Either specification yields the same adjusted R^2 and standard error of estimate; when one of these variables is included, the other is not significant. In the earlier period, however, lagged unanticipated volatility slightly outperforms the anticipated variability specification. Moreover, the tests show that when VRE_{t-1} is included, information on anticipated variability is not statistically significant.

The effect of interest rate volatility on prices is unambiguous, according to the results in table 5. In particular, a rise in anticipated variability temporarily raises inflation, leaving the price level unambiguously higher. Although it may appear that a rise in unanticipated variability permanently raises prices *and* inflation, only the former conclusion is correct; this result is the same as that obtained when only anticipated inflation is considered. A rise in the unanticipated variability of interest rates cannot *permanently* raise inflation because, by definition, the level of unanticipated variability is only a transitory phenomenon.

The evidence supports the dominant supply-side effect of interest rate variability: a rise in interest rate variability unambiguously raises prices permanently, through a temporary rise in inflation, but it has no permanent effect on the inflation rate. The evidence, however, does not discriminate well between whether the permanent effect on prices arises from changes in anticipated variability or past unanticipated variability.

The Effect of Interest Rate Variability on Output

The growth rate of real GNP in the model in table 2 equals the difference between the growth rate of GNP and the growth rate of prices; it can be written as the right-hand-side of the GNP equation less the right-hand-side of the price equation. Consequently, the effect of interest rate volatility on output growth is the difference in the VR components in the appropriate GNP and price equations.

Since a permanent rise in interest rate variability permanently lowers the growth rate of GNP and temporarily raises the inflation rate, the permanent effects on real output and its growth rate are unambiguously negative. An estimate of the effect of interest rate variability on output growth is found using the actual variability results in tables 3 and 4. For the I/1955–IV/1983 period, the output growth effect is $(-1.572\ \Delta VR_{t-1} + 0.654\ \Delta VR_{t-2} - 0.297\ VR_{t-3})$; t-statistics for the three coefficients are –5.76, 2.42 and –4.87, respectively. When the anticipated interest rate variability measure results are combined, the real GNP growth rate effect is $(-0.937\ \Delta\hat{VR}_t - 0.289\ \hat{VR}_{t-1})$; the t-statistics for the two coefficients are –5.78 and –4.75, respectively. The long-run effect on the real GNP growth rate indicated by the last term is essentially identical for both specifications, while the timing and short-run effects are slightly different. Of course, the same effects can be estimated using the unanticipated volatility effect on prices and the anticipated volatility effect on GNP; when this is done, once again, the differences are slight.

The Estimated Effects on Economic Performance: 1980–83

To gain some insight into the magnitude of the estimated effects above, the actual levels of VR_t from I/1980 to IV/1983 are given in table 6, along with the effects on the growth rates of GNP, prices and real GNP, due to the departure of VR from its I/1955–III/1979 mean level of 8.60 percent. The effects for GNP, prices and output

[29]In table 4, the included lags of VR can be written as (VR_t, VR_{t-1}, VR_{t-2}, VR_{t-3}), where the coefficient on VR_t is constrained to zero. A more general specification includes the anticipated ($\hat{VR}$) and unanticipated component (VRE) of each of the VR effects above, where these components at each lag are not constrained to be equal. From this specification, the constraints involved in table 5 can be tested and found to hold. These constraints are that the coefficients on $\hat{VR}_{t-3}$, VRE_{t-3}, $\hat{VR}_{t-2}$, VRE_{t-2}, and VRE_t are zero; and they hold when tested jointly or separately. One cannot discriminate statistically between the hypotheses that the coefficients on $\hat{VR}_t$ and $\hat{VR}_{t-1}$ are significantly different from zero and opposite in sign while that on VRE_{t-1} is zero and the hypotheses that the coefficient on VRE_{t-1} is significantly different from zero and those on $\hat{VR}_t$ and $\hat{VR}_{t-1}$ equal zero. An implication of these results is that the apparent insignificance of VR_t in table 4 arises from the imposition of the unsupportable constraint that the effects of $\hat{VR}_t$ and VRE_t are the same. Thus, the following constraints in table 4 do not hold: that the coefficient on $\hat{VR}_t$ is zero or that the coefficients on $\hat{VR}_{t-1}$ equals that on VRE_{t-1}. When these constraints are relaxed, both components of VR_{t-2} and VR_{t-3} drop out.

Table 5

Anticipated and Unanticipated Interest Rate Volatility and Inflation

Dependent Variable: $\dot{P}_t$

I/1955–IV/1983

Independent Variables	Anticipated VR ($\hat{VR}$)		Unanticipated VR (VRE)		Both	
	Coefficient	t-statistic	Coefficient	t-statistic	Coefficient	t-statistic
$\dot{M} \sum_{i=0}^{20} \gamma_i$	0.924	20.53	0.938	20.39	0.930	20.67
D1	−1.185	−1.73	−1.765	−2.51	−1.498	−2.13
D2	1.712	2.41	1.274	1.79	1.540	2.15
$\dot{P}^e \sum_{j=1}^{4} \gamma_{j+21}$	0.065	2.93	0.081	3.70	0.071	3.18
$\Delta \hat{VR}_t$	0.648	4.32	—	—	0.372	1.69
VRE_{t-1}	—	—	1.234	4.36	0.720	1.73
$\bar{R}^2$	0.81		0.81		0.81	
SE	1.198		1.198		1.187	
DW	2.14		2.13		2.13	
$\hat{\rho}$	0.37	4.26	0.40	4.53	0.38	4.34

I/1955–IV/1978

Independent Variables	Anticipated VR ($\hat{VR}$)		Unanticipated VR (VRE)		Both	
	Coefficient	t-statistic	Coefficient	t-statistic	Coefficient	t-statistic
$\dot{M} \sum_{i=0}^{20} \gamma_i$	0.990	23.02	1.004	26.42	1.003	26.39
D1	−1.641	−2.86	−2.274	−4.46	−2.239	−3.90
D2	1.489	2.15	1.323	2.12	1.333	2.10
$\dot{P}^e \sum_{j=1}^{4} \gamma_{j+21}$	0.071	2.73	0.068	2.90	0.068	2.88
$\Delta \hat{VR}_t$	0.440	2.85	—	—	0.029	0.14
VRE_{t-1}	—	—	1.408	3.89	1.350	2.50
$\bar{R}^2$	0.80		0.81		0.81	
SE	1.125		1.090		1.096	
DW	2.01		1.97		1.97	
$\hat{\rho}$	0.19	1.85	0.10	0.94	0.10	0.97

Table 6

The Effect of Interest Rate Variability on GNP, Prices and Real GNP: 1980–83

Period	Variability of interest rates	Effect on GNP growth rate	Effect on inflation	Effect on real GNP growth rate
I/1980	10.03%	0.1%	1.9%	−1.8%
II	11.33	−1.2	2.9	−4.1
III	12.70	−1.3	0.3	−1.6
IV	14.83	−1.6	0.6	−2.2
I/1981	16.66	−2.2	1.5	−3.7
II	18.61	−2.6	1.0	−3.6
III	20.66	−3.2	1.3	−4.5
IV	21.79	−3.8	1.3	−5.1
I/1982	22.57	−3.8	0.2	−4.0
II	22.62	−3.9	0.3	−4.2
III	21.90	−3.8	−0.3	−3.4
IV	20.55	−3.4	−1.0	−2.4
I/1983	19.29	−2.9	−1.0	−1.9
II	18.02	−2.6	−0.8	−1.8
III	16.62	−2.2	−0.8	−1.4
IV	15.22	−1.8	−1.0	−0.8

in table 6 use the I/1955–IV/1983 estimates of the impact of anticipated variability reported above. The estimates based on actual or unanticipated variability effects are about the same for the whole period or for subperiods such as the 1981–82 recession.

Changes in risk, as measured by the five-year standard deviation of the logarithm of Aaa bond yields have had a substantial impact on the economy since 1979, generally retarding the growth rate of nominal and real GNP over the period. In 1980–81, the rise in risk temporarily raised the observed inflation rate. The subsequent fall in risk temporarily reduced inflation in 1982–83.

Table 6 indicates that greater interest rate variability reduced the growth rates of nominal spending and real GNP by an average of 2.3 and 3.8 percentage points, respectively, during the III/1981–IV/1982 recession.[30] Thus, such variability played a major role in the relatively sluggish growth of spending at a 2.8 percent rate over the period and the –2.4 percent growth rate of real GNP from peak to trough. Indeed, departures from the mean variability had a negative impact on real output growth that exceeds the observed decline, suggesting that, in the absence of increased variability, real GNP growth would have been positive.[31]

[30]Evans also reaches this conclusion. Using the estimates based on actual variability, the reduction in nominal GNP over the whole period shown in table 6 is 2.7 percentage points, while during the recession it is 3.9 percentage points; the reduction in real GNP growth over the whole period is 2.8 percentage points and 3.6 percentage points during the recession. Similar estimates are found using the unanticipated interest rate variability hypothesis for prices; real output falls 2.6 percentage points over the whole period and 3.7 percent during the recession.

[31]When the measure of variability is the 20-quarter standard deviation of the changes in the logarithm of the quarterly interest rate, similar significant effects are obtained for GNP, prices and real GNP. Over the period I/1955–IV/1983, the current and past four levels of this standard deviation measure significantly affect GNP growth. The sum effect is significantly negative. In the price equation, only the change in the standard deviation three quarters earlier is significant. For both equations, the statistical results are inferior to those presented in the text, judged by the fit of the equations. Also, the results are not as robust. In the I/1955–IV/1978 period, no lag of this measure adds significantly to the price equation; in the GNP equation, only the lagged change in the standard deviation approaches significance ($t = -1.92$). The quantitative effects of higher variability on GNP, prices and output using this measure, however, are similar to those found from tables 3 and 4 or those given in table 6. For example, over the recession period III/1981–IV/1982, nominal and real GNP growth were reduced by an average 2.7 percent, while inflation was unaffected. The anticipated/unanticipated variability tests were not conducted for this measure due to the inferiority of the actual variability results.

SUMMARY AND IMPLICATIONS

The evidence here generally supports recent studies which indicate that increased variability of money stock growth and interest rates in the early 1980s had deleterious effects on output and employment. Moreover, the evidence provides a link between the rise in money growth and interest rate variability. The rise in the variability of interest rates, in particular anticipated variability, was an important channel through which increased monetary uncertainty operated to reduce GNP, output and employment, and to first raise, then lower, inflation after 1979.

The empirical results suggest that the rise in interest rate variability after 1979 explains the severity of the 1981–82 recession. The results also shed some light on the magnitude of the swing in observed inflation from 1980–81 to 1982–83. Inflation was first pushed up temporarily in 1980–81, then down in 1982–83 due to the pattern of changes in interest rate volatility since 1979.

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