II

Federal Reserve Staff Study — Volume II

New Monetary Control Procedures

Board of Governors of the Federal Reserve System
February 1981

Federal Reserve Staff Study

New Monetary Control Procedures

VOLUME II

MONETARY CONTROL EXPERIENCE UNDER THE NEW OPERATING PROCEDURES

February 1981

Paper Written for a Federal Reserve Staff Review of Monetary Control Procedures

by

David Lindsey and Others

February 1981

MONETARY CONTROL EXPERIENCE UNDER THE NEW OPERATING PROCEDURES

CONTENTS | PAGE

CONTENTS (cont.)

February 1981

MONETARY CONTROL EXPERIENCE UNDER THE NEW OPERATING PROCEDURES*

I. Summary of Principal Findings

This study examines the record regarding monetary control and related issues for the first year after the adoption of the reserves-oriented operating procedures. A summary of our principal findings follows:

1. Observed variability of monetary and reserve aggregates and their multipliers.

   a. Using currently available seasonal factors, monthly and quarterly growth rates of the monetary aggregates are significantly more variable over the period of the new operating procedures than over the last decade. However, by smoothing pre-1980 data more than 1980 data, current seasonal factors substantially exaggerate this increase in variability.

   b. When the seasonal factors in use at the time are applied to monthly data over each of the last 10 years, the increase in variability of monthly money growth since last October is still statistically significant. (In contrast, the changes in variability of reserve measures and their multipliers in the last year--when constructed with original seasonals--are not

* David Lindsey of the Division of Research and Statistics of the Federal Reserve Board staff was reponsible for the preparation of this study with the collaboration of other staff of the Federal Reserve System. Major contributions were made by Helen Farr, Gary Gillum, Kenneth Kopecky, Eileen Mauskopf, Edward Offenbacher, and Richard Porter of the Division of Research and Statistics of the Federal Reserve Board staff; John Judd and John Scadding of the San Francisco Bank staff; and Albert Burger of the St. Louis Bank staff. Assistance also was provided by Wayne Smith and Fran Weaver of the Board staff. Thanks also are due to James Johannes and Robert Rasche of Michigan State University for providing simulation results of their model.

statistically significant.) Similar quarterly measures of the narrow monetary aggregates also display significantly higher variability in growth rates than over the previous decade, but quarterly measures of M-2 do not.

c. It may be noted that, over the last decade or so, the variability of quarterly rates of growth of the monetary aggregates in the U.S. has been well within the range observed in other major industrial countries.

2. <u>Comparative accuracy of judgmental versus econometric projection procedures and selection of the reserve instrument</u>.

a. Judgmental projections of the nonborrowed and total reserve multipliers made at the beginning of intermeeting periods were significantly more accurate than the forecasts of the Johannes-Rasche and San Francisco Bank models. They also were superior to the Board's monthly model forecasts of the nonborrowed reserves multiplier, but they were no better than the Board model forecasts of the total reserves multiplier. The judgmental multiplier errors, after incorporation of intermeeting adjustments to the narrow reserves targets, were in all cases smaller than the econometric forecast errors. In predicting the two base multipliers, the results were more even, with the Board model showing a slight edge.

b. The multiplier-prediction experiment was intentionally designed so that all the multiplier errors would include misses in reserves as well as in money. This feature provided comparability between the judgmental and model results. However, this experiment is incapable of evaluating which model could best predict money given a fixed level of reserves or which reserve aggregate could provide the closest monetary control if chosen as an exogenous operating target over the intermeeting period. This is because induced movements in actual reserves distort the true relation going from reserves to money and bias the observed multiplier errors.

c. Two alternative procedures for predicting monetary aggregates, rather than their multipliers, were designed for the Board and San Francisco models to circumvent this problem of reserve endogeneity.1/ Unfortunately, neither procedure could be

1/ Both procedures determine exogenous levels of reserve aggregates in an initial step. The first procedure assumes that actual nonborrowed reserves have been the instrument controlled exogenously by the Desk since October 1979. Hence, this procedure derives exogenous levels of the three broader reserve measures from simulations of the Board and San Francisco models given the actual level of nonborrowed reserves. Then, each reserve measure, in turn, is held at this level and, in a second step, the model is simulated in the presence of the observed errors in all of the structural equations. The model's prediction of money in this simulation is compared to its prediction in the absence of these errors, and the difference interpreted as the prediction error that would have occurred if that particular reserve aggregate had been exogenously fixed over the month.

The second, alternative procedure attempts to refine the first by correcting for the induced movements of actual nonborrowed reserves within the month that reflect Desk adjustments to the nonborrowed reserves target in response to unanticipated developments as revealed by incoming data. In this procedure, exogenous levels of all four reserve aggregates are determined in the first step by simulating the models given the staff's expected federal funds rate for the month. The last step in this procedure is identical to that of the first procedure described above.

applied to the Johannes-Rasche model, which is incapable of addressing the problem of reserve endogeneity. Nor could these procedures be applied to the judgmental method, although the actual experience of misses of monetary aggregates from their intermeeting targets may be used as a benchmark in evaluating the other two models' money forecast errors.

d. In both procedures, the model errors for the narrow monetary aggregates with nonborrowed reserves or the nonborrowed base taken as exogenous ranged from slightly to somewhat smaller than the actual misses of money from intermeeting targets. However, in most of these model simulations, even for the nonborrowed measures of reserves, the federal funds rate occasionally moved outside the FOMC's limits. The results with total reserves and the total base exogenous ranged from about the same as actual misses of money from intermeeting targets to dramatically worse in the case of the Board model forecasts given total reserves. The deterioration of total relative to nonborrowed measures in both models largely stems from the enlarged importance of misforecasts of average required reserve ratios--either implicit in the San Francisco model or explicit in the Board model. Without having the discount window operate to alter levels of total reserves and the total base when required reserves change randomly, supply-side errors in the models substantially destabilize money.

e. By contrast, when the Board model is simulated under the assumption of contemporaneous, uniform, and universal reserve requirements on demand deposits and zero reserve requirements on other bank liabilites, its money errors--given total reserves and, to a lesser extent, the total base--drop dramatically. The results given nonborrowed reserves and the nonborrowed base, however, are scarcely affected by this assumption. On the other hand, the model's money errors for the two nonborrowed reserve aggregates do show some improvement when the error in the discount borrowing equation is suppressed. These results suggest that reforms to the structure of reserve requirements--some of which are in train as requirements under the Monetary Control Act become phased in--are a prerequisite to giving more emphasis to total reserves or the total base in short-run open market operations. They also suggest that consideration might be given to a restructuring of the discount window, if nonborrowed reserves are retained as the main operating target, which seems warranted under an institutional structure similar to the present one.

f. All of the model results indicate that close monetary control is impossible in the short run of a month or so under the present institutional structure. When simulated with a federal funds rate instrument, the two models yield money errors similar to those with the nonborrowed reserve measures as the instrument. Under either instrument, the money errors, particularly in the Board model, tend to fall over longer periods, reflecting the partial averaging out of monthly errors over periods even as short as a quarter.

3. Variability in interest rates and money demand behavior.

a. In none of the seven money demand functions examined is the effect of interest rate movements, even when combined with income and price movements, sufficient to explain all of the large variability in money growth since last October.

b. The quarterly model with the largest interest rate impact-- and with the best annual forecasting record in recent years-- is one proposed by Porter and Simpson of the Board staff that incorporates a short-term interest rate and a long-term interest rate variable representing the profitability of investments in cash management. This equation indicates that interest rate movements depressed M-1A demand by 7 percent at an annual rate in the first quarter of 1980 and raised it by 2-1/2 percent in the third quarter of this year.

c. However, even with depressing effects on M-1A growth from interest rates of about 4 percent and from real income of about 3 percent in the second quarter of 1980, this equation's over-prediction in that quarter was about 6 percent, suggesting that other factors were at work.

d. Some preliminary evidence of a link from a change in bank loans to the level of money suggests that the large shortfall in M-1A growth in the second quarter of 1980 relative to most model predictions was related to the imposition of credit controls in March. However, other evidence, over a variety of sample periods prior to the mid-1970s, casts some doubt on the change in total bank loans as a reliable variable in money demand functions.

II. Observed Variability of Monetary and Reserve Aggregates and Related Measures*

The first issue examined is the observed variability of various monetary and reserve aggregates, and of their multipliers, over the October 1979 to September 1980 period. Weekly, monthly and quarterly variability over this 12-month period--measured by standard deviations of annualized growth rates--is compared to that over other October to September "fiscal years," beginning with October 1970. Results for M-1A are not reported because they are very similar to those for M-1B.

A. Monetary Aggregates

The widespread perception of increased variability in growth rates of the monetary aggregates since last October appears to be borne out in Charts 1 and 2, which indicate the variability of seasonally adjusted growth rates in M-1B and M-2 for each of the last 10 October-to-September fiscal years. These monetary aggregates have been seasonally adjusted using the current series of seasonal factors. The summary statistics plotted are standard deviations of growth rates over weekly (for M-1B only), monthly, and quarterly intervals. With these current seasonal factors, the data for M-1B in Chart 1 show an uptrend in variability since the 1977 (for quarterly data, 1978) fiscal year that has continued in 1980. The variability of M-2, shown in Chart 2, has risen since fiscal 1978, but from a rather low level. While the standard deviation for monthly

* Contributors to this section: Helen Farr, Gary Gillum, David Lindsey, and Fran Weaver of the Board staff.

M-2 growth in fiscal 1980 reached the peak level shown for this series--as is also true of the weekly, monthly, and quarterly measures for M-1B--the standard deviation for quarterly M-2 growth in fiscal 1980 only matched its previous peak level recorded in fiscal 1975.

It might be noted that substantial variability in money growth is not unique to the United States. Indeed, in comparison with the variability of quarterly money growth in other major industrial countries in the period 1973 to the present, the variability of U.S. money growth has been fairly low, as shown in Table 1. However, one should be careful in comparing the measures of variability shown in the table, for several reasons. First, the measures are biased in favor of relatively low U.S. variability because of the fact that U.S. data are averages of daily observations while in other countries the money data typically are based on only one observation per month.1/ Second, the extent to which central banks attempt to control money growth has varied across countries and over time. Third, the institutional setting, which may affect, for example, the availability of money substitutes and the interest sensitivity of the demand for money, differs across countries.

Some of the observed increase in variability in U.S. monetary growth since October 1979 can be expected to arise from the standard seasonal adjustment techniques used for the aggregates. These techniques tend to produce smoother seasonally adjusted data for earlier years than for recent

1/ The series on Canadian M-1 and M-2 and German Central Bank money also are averages of daily data.

years because, as each year recedes into the past, the change in its seasonal pattern relative to earlier years becomes better captured by its estimated seasonal factors. In order to correct for this bias in judging the relative variability of the aggregates in fiscal 1980, the monetary aggregates in earlier years were seasonally adjusted using original seasonal factors--that is, those available at the time.1/

The effects of employing the seasonal factors in use at the time are shown in Charts 3 and 4. In Chart 3, the variability of weekly growth rates for M-1B in fiscal 1980 is no larger than in 1979, and only slightly larger than the average for the 1971 to 1979 period. This result contrasts sharply with the increased weekly variability for data with current seasonal factors, shown in Chart 1. For monthly and quarterly data, however, the variability of M-1B growth rates still increases after fiscal 1978, although the increase is much less pronounced. The effects on M-2 of replacing current with original seasonal factors, shown in Chart 4 for monthly and quarterly data, are similar to those for M-1B. One important outcome is that the increase in monthly and quarterly variability since 1978 is smaller in Chart 4 than in Chart 2.

The bias implicit in the use of current seasonal factors also affects the comparison of individual monthly growth rates. Growth rates in fiscal 1980 that are large in absolute value are exaggerated in comparison to those of earlier years. For example, the 21.6 percent growth rate of M-1B in

1/ To the extent possible, the currently available data for the not seasonally adjusted money stock in any given year were adjusted, component by component, with seasonal factors originally used during that year. Changes in definitions of the money stock and its components made some *ad hoc* adjustments necessary.

August 1980, which appears to be a record high, is exceeded by a 24.0 percent growth rate in April 1979 and nearly matched by a 21.4 percent growth rate in March 1977 when the original seasonal factors are used for those earlier years.

As a check on the procedure using original seasonal factors, we employed an analogous technique for constructing seasonal factors for earlier years. In this procedure, seasonal factors were generated by the X-11 seasonal adjustment program for each fiscal year using only data for earlier years that are currently available in the not seasonally adjusted series. The results from this technique confirmed the conclusions reached using original seasonal factors. 1/

B. Reserve Aggregates

We applied a similar analysis to the variability of nonborrowed and total reserves. 2/ Standard deviations of weekly, monthly, and quarterly growth rates are shown in Charts 5 and 6. They are based upon data that were seasonally adjusted with the implied original seasonal factors, for the same reasons

1/ An analysis of not seasonally adjusted growth rates uncovered the surprising result that not seasonally adjusted M-1B and M-2 monthly growth rates have varied over a significantly smaller range since October 1979 than in most earlier years. The lower standard deviations for not seasonally adjusted monthly data in fiscal 1980 than in several recent fiscal years may simply be a historical accident. The seasonal factor for M-1B, for example, called for an enormous not seasonally adjusted increase in April 1980, which did not materialize. In addition, in August, the not seasonally adjusted growth rate of M-1B was near the average for the year, rather than showing a drop in the level called for by the seasonal factor. Of course, the adoption of the new procedures may have affected the seasonal pattern, and the System's attempt to reinforce the existing seasonal factors may be imparting a new policy seasonal to the data.

2/ Table 2, in subsection D, contains results for the nonborrowed and total monetary base.

discussed above with regard to the monetary aggregates. The implied seasonal factors were derived by dividing the not seasonally adjusted reserve measure by the seasonally adjusted reserve measure, both as originally published during that year. The variability of monthly growth rates for nonborrowed reserves in fiscal 1980 shown in Chart 5 is near the high levels recorded in the fiscal years 1973 to 1975. However, the jump of this monthly variability from fiscal 1979 to 1980 is only half as large as would be evident if current seasonal factors were used instead. In contrast, the weekly and quarterly growth rate data for nonborrowed reserves decline in variability from fiscal 1979 to 1980. The variability in the growth rate of total reserves, presented in Chart 6, declines from fiscal 1979 to 1980 with all three data frequencies and is not as high as the variability in several earlier years.

C. Reserve Multipliers

Multipliers defined as the ratio of M-1B to either nonborrowed or total reserves have been constructed from data that have been seasonally adjusted with the original factors.1/ As shown in Chart 7, month-to-month variability of the nonborrowed reserves multiplier, as with nonborrowed reserves themselves, increased in fiscal 1980 to near the highs attained in the mid-1970s. In contrast, weekly and quarterly variability of the nonborrowed reserves multiplier declined in 1980, to a level below the average variability for the past decade.

1/ Table 2, in subsection D, contains results for the nonborrowed and total monetary base multipliers.

The monthly and quarterly variability of the total reserves multiplier, shown in Chart 8, evinces only slight increases in fiscal 1980. Monthly variability in 1980 was well below past peaks, but quarterly variability was at a relatively high level. In contrast, weekly variability of this multiplier declined sharply to its lowest level of the decade.

D. Relationships of M-1B, M-2, Reserve Aggregates, and Multipliers

The relationships among the results for M-1B and M-2, the reserve aggregates, and their multipliers are presented in Table 2. Summary statistics of monthly and quarterly growth rates for fiscal 1980 are compared both to those for fiscal 1979 and to those of the average of the fiscal years 1971-79. In addition, tests of statistical significance of the change in variability in 1980 from 1979 and from the average of the 1970s are reported.

The variation in monthly and quarterly M-1B and M-2 growth rates over the 1970s is smaller than the growth-rate variation both for the narrow reserve aggregates and for their associated multipliers because of substantial negative correlation between reserve and multiplier growth-rate variability. In other words, there was a strong tendency for narrow reserve aggregates to move in the opposite direction to changes in their multipliers. For the nonborrowed and total monetary base, a negative correlation with their multipliers does appear over the entire 1971-79 period for both monthly and quarterly data, but it is not large enough to make M-1B and M-2 growth variability smaller than that for these reserve measures themselves. Although a comparable pattern generally emerges over monthly intervals in fiscal 1980, the attenuation of the negative correlation between the monetary base and its multiplier makes the variability of its multiplier changes smaller than money-growth variability. For quarterly data in fiscal 1980, both base measures and their multipliers were positively correlated, causing the variation in M-1B and M-2 growth to be larger than the variation in growth of either the multiplier or the base measure.

Tests have been made of the statistical significance of the changes in variability in fiscal 1980 from earlier periods. Changes in variability that are significant at the 10 percent level (for a two-tailed test) are indicated by three special symbols in Table 2. Only M-2 monthly growth rates show a statistically significant increase in variability in fiscal 1980 when compared both with fiscal 1979 and with the fiscal 1971-79 period as a whole. However, variability in quarterly average growth rates for M-2 in fiscal 1980 is not significantly higher than in either earlier period. For M-1B, variability in both monthly and quarterly average growth rates for 1980 is significantly higher than for the 1971-79 average, but not significantly higher than for 1979 taken alone. Statistically significant decreases were recorded for nonborrowed reserves and its multipliers with M-1B and M-2, but only for quarterly average rates of change. Despite these indications of significantly higher variability for the monetary aggregates and significantly lower quarterly variability for nonborrowed reserves and its multipliers in fiscal 1980, some years in the 1970s also registered statistically significant changes in variability of these measures.

Lagged reserve accounting appears to be a major factor explaining the high variability of the reserve multipliers reported in Table 2. To estimate approximately the impact of lagged reserve accounting, multipliers were constructed in two ways from four-week averages of not seasonally adjusted levels of M-1B and the various reserve measures. In the first, nonborrowed and total reserves were measured over the same weeks as the monetary aggregates, representing the present lagged accounting system. In the second, nonborrowed and total reserves were measured over a four-week period ending two weeks after the corresponding period for the aggregates, representing a system of contemporaneous reserve accounting. For both the nonborrowed and total monetary base, the currency and nonmember bank vault cash components were not shifted forward, although reserve components were.

Table 3 reports the measured reduction in multiplier variability due to the two-week forward shift of reserves. The variability of the total reserve multiplier is decreased going from column (1) to column (2) by an amount ranging from 12 to 14 percentage points (depending on the period), roughly half of the measured variability under lagged reserve accounting. The other reserve measures, especially the nonborrowed and total monetary base, show less improvement. Also, the adjustment for contemporaneous reserve accounting produces much less of an improvement in the nonborrowed reserve multiplier in fiscal 1980 than in earlier years, particularly when viewed as a fraction of the variability of the multiplier in column (1). This oddity of 1980 should be kept in mind in interpreting certain results in the next section.

The procedure embodied in Table 3 probably overestimates the reduction in multiplier variability that would have obtained had contemporaneous reserve accounting been in existence during these years. Under contemporanous accounting the variability of excess reserves might have risen and, in any event, the outcome of interest rates and the quantity of money demanded would have differed from that actually observed.

III. Comparative Accuracy of Judgmental Versus Econometric Projection Procedures and Selection of the Reserve Instrument*

The departures of the monetary aggregates from longer-run and interim targets as well as wide swings in short-term interest rates since last October have given rise to criticisms of various aspects of the operating procedures. In one way or another, all the criticisms involve the techniques used in selecting and adjusting target paths for the reserve aggregates.

Under the new procedures, initial intermeeting levels for a family of reserve measures are derived, largely judgmentally, from intermeeting targets for the money aggregates and from associated projections of separate components of the aggregates, other liabilities subject to reserve requirements, excess reserves, vault cash, and discount window borrowings. The intermeeting money stock target reflects the FOMC's desired speed of return to the longer-run objective following observed deviations. This target represents the FOMC's chosen average growth rate for the entire interim period of several months, adjusted for lagged effects of policy actions and special factors, both of which give rise to expected temporary variations of money demand around that average growth rate. After the intermeeting average money stock targets and related projections are converted to weekly paths over the intermeeting period, the associated weekly levels of total reserves and the total

* Contributors to this section: Helen Farr, Gary Gillum, Kenneth Kopecky, David Lindsey, Richard Porter, and Wayne Smith of the Board staff; John Judd and John Scadding of the San Francisco staff; and Albert Burger of the St. Louis Bank staff.

base are derived. The initial intermeeting targets for these reserve aggregates are simply the averages of these weekly levels. The FOMC's stated assumption for discount window borrowings is then used to derive the nonborrowed reserves target and associated nonborrowed base level.[1/]

The implicit money/reserve multipliers built into the initial intermeeting targets for reserves can, of course, be derived by dividing the targeted levels of the monetary aggregates by the targeted levels of reserves. During intermeeting periods, the staff typically adjusts the reserve targets in light of incoming information about unexpected changes in the multipliers. These adjustments are made cautiously, either to avoid overreaction to transitory, self-correcting changes in the multiplier or because the multiplier variation is recognized too late in the intermeeting period for a change in reserve targets to have a perceptible effect on the intermeeting average level of the monetary aggregates.

While many observers, including market participants, have objected to the enlarged variability of interest rates since October 1979, others, particularly those in the monetarist camp, have complained that the operating procedures still embody excessive emphasis on smoothing movements in short-term interest rates. Some monetarists argue that the Federal Reserve should make adjustments to the reserve targets more aggressively, both within

1/ For a detailed discussion of the establishment of reserve target paths, see Appendix B of the Federal Reserve's Monetary Policy Report to the Congress, February 1980. Also see Stephen Axilrod and David Lindsey, "Federal Reserve System Implementation of Monetary Policy: Analytical Foundations of the New Approach," Federal Reserve Board, processed; presented at the Denver Meeting of the American Economic Association, September 6, 1980; forthcoming in American Economic Review, Papers and Proceedings, May 1981.

intermeeting periods and from one intermeeting period to the next, regardless of interest rate consequences. Other monetarists suggest instead that the Desk should simply maintain a predetermined growth rate of some reserve measure from one intermeeting period to the next, or even over a considerably longer time, and accept whatever interest rate movements result.

This section first addresses a somewhat narrower, more technical criticism that originates with those who have recommended econometric, rather than judgmental, techniques for forecasting the various multipliers. The Shadow Open Market Committee, besides proposing the monetary base as either an operating or intermediate target, also suggests replacing judgmental projections of the multiplier with a statistical time-series method devised by Professors James M. Johannes and Robert H. Rasche of Michigan State University.1/ This committee advocates maintaining over the control period a level of the reserve instrument equal to the long-run money stock target divided by this multiplier estimate. (Professor James Pierce of the University of California at Berkeley makes a somewhat different criticism. He argues that modern methods of statistical "filtering" and "optimal" forecasting should supplement judgmental procedures.)2/

1/ For the most recent description of this technique, see James M. Johannes and Robert H. Rasche, "Can the Reserves Approach to Monetary Control Really Work?" April 1980.

2/ James L. Pierce, "Making Reserves Targets Work," in Controlling the Monetary Aggregates III, (Federal Reserve Bank of Boston, forthcoming). It may be noted that both the money demand side of the Board staff's monthly money market model and Banking Section time series models of the monetary aggregates have been considered in preparing the initial intermeeting money targets. In addition, the Banking Section is engaged in a long-term project to integrate time-series models and filtering methods into the judgmental projections made between FOMC meetings.

In order to assess the gains, if any, that would have resulted if econometric models had replaced judgmental methods in October 1979, we conducted two experiments drawing on the evidence accumulated since that time. First, we compared the accuracy of judgmental projections of multipliers for nonborrowed reserves, total reserves, the nonborrowed monetary base, and the total monetary base with the accuracy of one-month-ahead postsample forecasts of three monthly econometric models.1/ The purpose of this test was to see whether the various multipliers could have been better predicted by econometric techniques. Second, we contrasted the misses of the monetary aggregates from their intermeeting and monthly targets with the prediction errors of the models when each of the four reserve measures was treated in turn as the exogenous control instrument. Because the second test corrects for induced movements in the reserve aggregates, we believe it is a more reliable indicator of the potential value of the econometric models in helping to derive reserve targets than the first procedure. Another purpose of this test was to see whether money could have been better controlled by hewing to an operating target other than nonborrowed reserves. Thus, these results also suggest the degree of monetary control that would have been attained if each of the four reserve measures had been used as the primary operating target.

1/ The advent of the new reserve-oriented operating regime no doubt has altered the coefficients of the various models' equations. Practical ways of mitigating this drawback of econometric procedures, other than judgmental adjustments to the equations, have not been advanced.

A. The Nature of the Multiplier-Prediction Tests

The multiplier predictions of the three models were compared with three conceptually distinct judgmental projections of the multiplier. The first is the initial projection of the average multiplier over the intermeeting period. It is simply the targeted average level of the relevant monetary aggregate divided by the initially targeted average level of the relevant reserve measure. These projections were made at the beginning of the intermeeting period just after the FOMC meeting; in cases of a long interval between FOMC meetings, the intermeeting period was divided into two subperiods for reserve targeting purposes. The error in the multiplier is calculated as the difference between the realized multiplier and its predicted value.1/ It equals the percent miss of money from its intermeeting target less the percent miss of reserves from the initial intermeeting target, both at annual rates.2/

1/ In all the calculations of forecast errors for all the procedures, the actual and predicted multiplier or money stock values were based on data that were either not seasonally adjusted or were converted to not seasonally adjusted levels using the Board's current seasonal adjustment factors. Then, the natural logs of the levels were calculated and percent errors derived as the difference beween the log of the actual and the log of the predicted level times 100. Finally, the percent errors were converted to represent annual rates of change by multiplying by 12.

2/ The multiplier errors to be reported in Table 4 are calculated as

$$1200 \cdot (\ln m^{Act} - \ln m^{IniPred}) = 1200 \cdot [\ln (M^{Act}/R^{Act}) - \ln (M^{Target}/R^{IniTar})],$$

where M is the monetary aggregate; R is the reserve measure; and Act, IniPred, Target, and IniTar represent actual, initially predicted, targeted, and initially targeted values respectively. Rearranged, this expression becomes

$$1200 \cdot (\ln m^{Act} - \ln m^{IniPred}) = 1200 \cdot (\ln M^{Act} - \ln M^{Target}) - 1200 \cdot (\ln R^{Act} - \ln R^{IniTar}).$$

Thus, the multiplier error is composed of a monetary aggregate error and a reserve aggregate error. The appendix shows the expressions for all the errors whose summary statistics are shown in Tables 4-6 of this section.

It will be important in the later analysis to keep in mind that this judgmental multiplier error incorporates misses of both money and reserves from the levels built into the multiplier projection. That is, intermeeting deviations of the monetary aggregate from its target and of the reserve measure from its initial target both contribute to a multiplier-projection error. This characteristic of incorporating both money and reserve errors will be preserved in designing comparable experiments for the econometric models.

The second judgmental multiplier projection examined is for the adjusted intermeeting-period multiplier. It is simply the same intermeeting money target divided by the "final" adjusted intermeeting reserve target. The reserve target determined at the beginning of the last statement week of the intermeeting period was considered the final one. It should be noted that reserve path adjustments do occur in the last week; in fact, about two-thirds of the misses of the final adjusted reserve path for nonborrowed reserves were intentional.1/ The error in this adjusted multiplier projection represents not only the percent miss of money from target less the percent miss of reserves from their adjusted target, but also the extent to which intermeeting adjustments to targeted reserves prior to the final week did not compensate for actual errors in the initial multiplier projection.

This latter relationship is shown formally in the appendix. Initial intermeeting-period-multiplier percent errors plus the percent reserve path

1/ See Fred J. Levin and Paul Meek, "Implementing the New Operating Procedures: The View from the Trading Desk," in this compendium.

adjustments--made as compensation for expected errors in the initial multiplier projection--equal the adjusted intermeeting-period-multiplier percent errors. Since the adjusted multiplier error equals the initial multiplier error plus the reserve target adjustment, the adjusted multiplier error will be lower than the initial multiplier error to the extent that intermeeting reserve adjustments are in the opposite direction to initial multiplier errors. In fact, adjusted multiplier errors for both nonborrowed and total reserves have been smaller, on average and ignoring sign, than the initial intermeeting period multiplier errors because reserve path adjustments have partially offset the initial multiplier errors, owing to a negative correlation between the two.

It should not be expected that reserve path adjustments would fully offset initial multiplier errors. For one thing, unexpected multiplier errors occur in the last week of intermeeting periods, after "final" reserve path adjustments have been made. For another thing, lagged reserve accounting creates certain problems for total reserves. Total reserves are predominantly determined by the amount banks need to satisfy required reserves based on deposits two weeks earlier. This permits certain recognized multiplier disturbances originating on the money-supply side that affect the intermeeting average total and nonborrowed reserves multiplier values--such as changes in the mix of demand deposits that alter required reserves given the same amount of demand deposits in total--to be fairly readily offset through adjustments to both the total and nonborrowed reserve targets. Other disturbances on the supply-of-money side, such as unexpected changes in demands for excess reserves, and even more importantly money-demand-side disturbances, pose more of a problem. For example, a permanent surge in the demand for transactions balances in the second week of a four-week intermeeting period will not raise required reserves, and hence demanded total reserves, until the last week. Thus, due to the delay in this increase of total reserves, the average total reserves multiplier over the intermeeting period would move above the initially projected level. But, in this case, total reserves also would necessarily overshoot its initially targeted average level, given the now higher demand for reserves in the last week.

Nonborrowed reserves, by contrast, are susceptible to fairly close week-to-week control, and near-term path adjustments in response to money demand shocks to its multiplier are more practicable for this reserve aggregate. Even so, adjustments to the nonborrowed reserve target can completely offset such multiplier disturbances only if the monetary aggregate is fully returned to its targeted intermeeting average level following recognized divergences. But such divergences from target, particularly those recognized late in the intermeeting period, are difficult to completely eliminate. An attempt to adjust the nonborrowed reserve path late in the period in order to compensate fully for a demand-side disturbance to its multiplier would only slightly affect the intermeeting average of money, and thus would be frustrated by a further, nearly proportional offsetting change in the observed value of the multiplier in the opposite direction. In addition, efforts made late in the intermeeting period to compensate fully for perceived multiplier disturbances through adjustments in the nonborrowed reserve target run the risk of violating the funds rate limits set by the FOMC.

The third judgmental multiplier forecast analyzed is the multiplier projection for the current month. These projections also were made just after each FOMC meeting. Since October 1979, FOMC meetings took place on average at midmonth. Accordingly, this forecast is reported in order to indicate how much the receipt of incoming data improves the quality of the judgmental projection. This projection is constructed as the average of those past weekly estimates and future weekly targets for the money aggregate that are encompassed by the current month divided by the average of those past weekly estimates and future weekly targets for the reserve aggregate that also are included in the current month. Thus, the judgmental projector of current-month multipliers typically had access to one week of first published data and one week of preliminary data for the monetary aggregates at the time the projection was made. Also, the projector typically had knowledge of interest rate developments over the first half of the month, as well as estimates of required reserves for two more weeks based on the first published and preliminary deposit data. These considerations thus mean that the judgmental projector of current-month multipliers enjoyed advantages in the tests unavailable to the monthly econometric models.

The postsample predictions of three econometric models with quite different structures also were examined: the Johannes-Rasche model; the Board staff's money market model; and the San Francisco Federal Reserve Bank staff's money market model. The basic characteristics of each of these models will be summarized here briefly and citations given for more detailed descriptions.

The Johannes-Rasche model originally was devised to predict the monetary-base multiplier but recently has been adapted by the authors to forecast the other reserve multipliers as well.1/ Their model predicts separately six component ratios of the various multiplier expressions: the ratio of reserves to demand deposits, the ratio of currency to demand deposits, and other relevant ratios comprising the multiplier.2/ Time-series equations--univariate Box-Jenkins ARIMA models--that capture the influence of history, seasonal movements, and previous errors are used to forecast these ratios.3/ Forecasts of the various multipliers are constructed from these predictions of the component ratios. In the present study, the simulations were conducted by Johannes and Rasche with the assistance of the staff at the Federal Reserve Bank of St. Louis.

The Board's monthly money market model, by contrast, develops explicit equations for the demand for and supply of demand deposits. Interest rates equilibrate the two when nonborrowed or total reserves are taken as exogenous. The demands for demand deposits and currency depend inversely on current and lagged levels of interest rates, and directly on current and lagged levels of exogenous real personal income and exogenous prices. The supply of demand deposits depends on the predicted amount of reserves available

1/ See Johannes and Rasche, "Can the Reserves Approach Really Work?", and Johannes and Rasche, "Predicting the Money Multiplier," Journal of Monetary Economics, vol. 5 (July 1979), pp. 301-25.

2/ As the reserve concept, the model used the Board's reserve measures adjusted for changes in Regulations D and M rather than the St. Louis Bank's variants. This approach assumes perfect knowledge of required reserves on nondeposit items and of changes in the marginal and supplemental reserve requirements. In the simulations of all the econometric models, special borrowings were treated as if they were known with certainty.

3/ Each successive month's multiplier was forecast after incorporating the error made in the previous month; thus, the final not seasonally adjusted values of the monetary aggregates and their components in the previous month were assumed to be known with certainty.

to support demand deposits divided by the predicted average required reserve ratio on demand deposits. With nonborrowed reserves taken as the exogenous control instrument, for example, predicted reserves available to support demand deposits equal actual nonborrowed reserves plus predicted discount window borrowings less predicted excess reserves less predicted required reserves on savings and time deposits less actual required reserves on nondeposit items. The supply of demand deposits, given nonborrowed reserves, depends directly on market interest rates because of the positive interest-rate-demand elasticity of borrowings and the negative interest-rate-demand elasticity, on balance, of savings and small time deposits.

Having determined predicted equilibrium levels of demand deposits and interest rates, the predicted levels of the monetary aggregates are derived by adding the predicted quantities demanded of currency and the other components of the aggregates to predicted demand deposits.1/ This model was originally developed by Board staff in the early 1970s and has since gone through many respecifications.2/

1/ All the Board model simulations used Board staff data and projections for real personal income and prices in current and earlier months. Thus, for example, no model simulation was based on the revisions in personal income for July-September 1980 published November 18, 1980. However, perfect knowledge of the currently published (mid-November 1980) monetary aggregates for the previous month was assumed. The actual average discount rate in the current month also was used. Except for the equations predicting required reserve ratios, the sample period for all the model's equations ended in September 1979. The equation for the required reserve ratio on demand deposits was refit after each postsample projection to include the latest month.

2/ For the original specification see Thomas D. Thomson, James L. Pierce and Robert T. Parry, "A Monthly Money Market Model," Journal of Money, Credit and Banking, vol. 7 (November 1975), pp. 411-31. For the most recent description of the model, see Helen T. Farr, "The Monthly Money Market Model," working paper (Board of Governors of the Federal Reserve System, July 1980).

The last monthly model examined was recently estimated by the staff of the Federal Reserve Bank of San Francisco. The model incorporates an equation for the demand for nominal demand deposits that depends on current and lagged values of nominal personal income and the commercial paper rate. This equation also includes as an explanatory variable the change in total loans at commercial banks, which is designed to capture the effects on the money stock of temporary shocks arising from net loan extensions or repayments that make actual money depart from the long-run demanded quantity.

In addition, the model has behavioral equations for bank demands for total reserves and for discount-window borrowings, together yielding the bank demand for nonborrowed reserves. The theoretical underpinnings of the model focus upon bank management of federal funds and RPs as substitutes for other managed liabilities, including large CDs and discount-window borrowings, and upon the effects of funds rate movements on the bank supply of demand deposits. The banking system supports more managed liabilities and fewer demand deposits at a higher federal funds rate for a given volume of assets to be financed. An increase in the volume of such assets causes increases in both managed liabilities and demand deposits, thus providing a direct supply-side link between bank loans and the quantity of demand deposits supplied. The model's implicit demand deposit supply function depends directly on the commercial paper rate and inversely on the federal funds rate.

1/ For additional discussion, see section IV of this paper and John Scadding and John Judd, "The Disequilibrium Demand for Money," forthcoming.

The interaction of this demand deposit supply function with the demand deposit demand function, together with the interaction of the actual supply of nonborrowed reserves with the bank demand for nonborrowed reserves, which is a function of the commercial paper rate and the funds rate, determines the equilibrium levels of interest rates as well as the model's predicted quantities.1/

Before explaining how the predictions of the multiplier in the Board and the San Francisco models were obtained, a digression on the "pure theory" of deriving reserve targets is warranted. The desired average growth rate for the monetary aggregates over a horizon of several months is first established by the FOMC. Then a pattern of targeted intermeeting-period growth rates is constructed. In doing so, consideration is given to any

1/ The model is actually estimated for lunar month--that is, four-week--blocks of data, with required reserves based on deposits lagged two weeks to account for lagged reserve accounting. Although actual levels of time and savings deposits for the four weeks ending two weeks earlier are used in computing required reserves, predicted levels of demand deposits and managed liabilities shifted back two weeks also enter into the computation. Lunar-month predictions were interpolated to obtain calendar-month predictions. The model's equations were fit over a mid-1976 through September 1979 sample period.

In the simulations of the model, all exogenous variables for the current month other than the reserve instrument and the discount rate were projected using time-series models. Perfect knowledge of seasonally adjusted deposits, bank loans, personal income, and so on was assumed for periods prior to the month being forecast. The Board's reserve measures adjusted for changes in Regulations D and M were used in all simulations. This approach assumes perfect knowledge of required reserves on nondeposit items and of changes in the marginal and supplemental reserve requirements. For the four months from May through August, when the federal funds rate fell below the discount rate and adjustment borrowings dropped to a frictional minimum, the model was simulated with the actual federal funds rate treated as the exogenous control instrument.

A more detailed description of the model and projection technique appears in John Judd and John Scadding, "Contribution to the Study of the Monetary Control Experience Under the New Operating Procedures," forthcoming.

expected temporary variation in money demand around the specified average growth rate--due to the operation of lags in the impact of policy actions and to known special factors, say, tax rebates. Simultaneously, an expected level of short-term interest rates is implied that is consistent with anticipated money demand relationships at the quantity of money given by the upcoming intermeeting target. Of course, the existence of such an expectation does not imply that the Federal Reserve uses the funds rate as an operating target. Unanticipated developments over the intermeeting period cause the actual interest rate outcome to differ from initial expectations. Indeed, the primary virtue of reserve targeting is that unexpected changes in money demand cause interest rates to react automatically and offset some of the miss of money from the target level. (These induced interest rate movements also will be in the appropriate countercyclical direction to the extent that the unanticipated change in money demand is related to an unwanted strengthening or weakening of aggregate spending. 1/)

The next stage of the process involves selecting an initial expectation for discount-window borrowings. This selection is conditioned by the initial expectation of money market interest rates that are thought con-

1/ To the extent that changes in money demand represent shifts in the demand function itself, the induced interest rate movements with an invariant reserve target will not be in the appropriate countercyclical direction. To the extent errors in the money supply function occur, the induced interest rate movements will neither contribute to hitting the money target nor be in the appropriate countercyclical direction, other things equal.

sistent with the public's money demand at the intermeeting target for the money stock. In light of this expectation of short-term interest rates and the level of the discount rate, an initial average level of discount-window borrowings is assumed for the intermeeting period. Then intermeeting targets for total reserves and the total base are determined from the money targets and projections of reservable items based on expected interest rate levels. Finally, subtracting the expected level of borrowings from the targets for total reserves and the base yields the targets for nonborrowed reserves and the nonborrowed base.

The manner in which the models generated multiplier forecasts may now be described. In contrast to the judgmental multiplier projections, which were based upon money and reserve targets, for the models predictions of both aggregates were used. Initially, however, we tried an alternative approach. For the multiplier prediction with the Board model, we first attempted to derive reserve predictions consistent with the monthly target for M-1A. However, these targets reflected the judgmental projector's estimates about money demand, and at times implicitly incorporated information about the model's errors unavailable to the model. The model's predictions of money demand typically were different. Even if these differences were relatively small (and even if the model's predictions of money demand were more accurate), large errors in the model forecasts of interest rates and of nonborrowed reserves would be implied. In fact, the model simulations yielded very large multiplier forecast errors.1/

Therefore, an alternative experiment was conducted that permitted the Board and San Francisco models to predict levels of the money stock, as well as reserves, that are consistent with the deterministic structure of each model. Specifically, the two models predicted money and reserves given the same staff expectation of the federal funds rate that the judgmental projector used. That is, the predictions of money and reserves in the Board and San Francisco model simulations were based on the judgmental expectation of the average federal funds rate in the current month, made around the time of the FOMC meeting. This procedure thus allowed for misses in predictions of both money and reserves. These multiplier predictions were then subtracted from the realized multiplier values, and the errors compared to the Johannes-Rasche monthly errors and the judgmental intermeeting and current-month forecast errors.

While these experiments were designed to be as even-handed as possible in comparing the different multiplier forecasting techniques, we believe on balance that the initial judgmental intermeeting multiplier projections are most handicapped, and the current-month judgmental multiplier fore-

1/ The comparable simulation with the San Francisco model was aborted when the results for the Board model became known. This problem of unrealistic interest rate variability does not arise for the Johannes-Rasche procedure because the multiplier forecasts are invariant to changes in interest rates, which do not appear in the model.

casts most advantaged.[1]

1/ Several factors put the initial intermeeting judgmental projections of the multiplier at a disadvantage in the experiments compared with the model forecasts. Since intermeeting periods (or subperiods) are, on average, shorter than calendar months, there is less automatic smoothing of the actual figures owing to reversals of transitory noise with the passage of time. As a minor compensation for this effect, the judgmental forecast errors for intermeeting periods expressed as percentages were converted to annualized rates-of-change errors by a factor of 12, rather than a factor of around 13. Moreover, the judgmental projector typically goes into intermeeting periods at midmonth having received only first published monetary aggregate data for the previous month, in contrast to the perfect knowledge of final data afforded the models. (Since these forecasts were compared with final data, the judgmental forecasts were adjusted, as necessary, for benchmark revisions, but not for other data revisions.) Furthermore, the projector does not know the final values of the previous month's measures of economic activity, such as personal income and prices--unlike the San Francisco experiment--but, like the Board model runs, only has the benefit of staff estimates. The projector also must predict reserve requirements against nondeposit items and impacts of changes in Regulations D and M, which the models were allowed to know with certainty. The funds rate expectation in the current month that was used to obtain the Board and San Francisco models' forecasts on average was based on two weeks of observed data, giving the Board and San Francisco models an advantage relative to the initial intermeeting judgmental projection. Finally, unlike these two models, the judgmental projector would not know of upcoming discount rate changes. Owing to knowledge of additional data, the adjusted intermeeting projections and current-month judgmental projections are, of course, much less disadvantaged than either the initial intermeeting projections or the three econometric approaches.

There is a difficulty with the concept of a current-month multiplier forecast. When averaged over the current month, the actual reserve measures, even nonborrowed reserves, frequently differed from the average of the weekly levels falling in the current month that comprise the initial intermeeting target path. The Desk was instructed to aim at a nonborrowed reserves target defined as an intermeeting average. Thus, the Desk did not always attempt to follow week-by-week the individual weekly components of the intermeeting average, even aside from reserve target adjustments. This reason partly explains why the actual outcome for nonborrowed reserves in the current month deviated from the current-month average of weekly target path levels. Given the strong negative correlation between nonborrowed reserves and their multipliers, particularly in the very short run, this effect enlarges the current-month judgmental errors of the nonborrowed reserves multiplier projection.

B. An Analysis of the Multiplier-Prediction Results

Table 4 presents summary statistics for the multiplier-prediction errors of the four techniques.[1] The findings may be summarized briefly:

1. M-1B results. Results for M-1B are available for all the procedures.

   a. Judgmental results.

      (1) The error dispersion statistics--mean absolute and root mean squared errors--for the adjusted judgmental intermeeting projections of nonborrowed and total reserve multipliers are consistently lower than the figures for the initial projection. This improvement, noted earlier, results from reserve path adjustments that partially compensate for recognized multiplier disturbances.

      (2) In contrast, reserve path adjustments yielded no average improvement for the nonborrowed or total base multiplier forecasts. However, because the Trading Desk was instructed to focus on nonborrowed and total reserves as operating targets, formal reserve path adjustments were made only to these two reserve targets. Thus, the only adjustments to the two base paths were these formal adjustments for nonborrowed and total reserves. In other words, the

1/ The appendix presents the expressions for the errors.

table does not include any intermeeting adjustments to the currency or vault cash components of the base, even though projections of these items also were altered as the intermeeting period progressed.

(3) The current-month judgmental projections of all the M-1B/reserves multipliers are more accurate than either of the intermeeting projections in terms of error dispersion statistics, reflecting the gains from additional information.

(4) Over the period examined the judgmental mean error statistic was negative for the total reserves measure, implying an overestimate of the total reserves multiplier, but it was positive for nonborrowed reserves, meaning the nonborrowed reserves multiplier typically was underestimated. The source of this reversal was an initial underestimate, on average, of the ratio of discount-window borrowings to deposits.1/ Part of this average underestimate typically kept the nonborrowed reserves multiplier prediction from being too low, unlike the average total reserves multiplier prediction. But the borrowing error also was, on average, sufficiently large to make the nonborrowed reserve multi-

1/ The only difference in the two multiplier expressions is the presence of a negative ratio of discount-window borrowings to transactions balances in the denominator of the nonborrowed reserves multiplier.

plier prediction higher than the observed multiplier. The tendency for discount borrowings to be higher than the FOMC's initial assumption was amplified, on average, by a reduction of nonborrowed reserves below the initial target, partly undertaken in order to offset the effects on money of higher borrowings than expected given the funds rate, discount rate, and required reserves.

b. Judgmental versus model results. The initial intermeeting judgmental projections consistently outperform the Johannes-Rasche and San Francisco model predictions for all four reserve multipliers. The edge is fairly small for the nonborrowed and total monetary base multipliers. The initial intermeeting judgmental projections and Board monthly model forecasts are more evenly matched. The measures of error dispersion of nonborrowed reserve multiplier forecasts are substantially lower for the judgmental procedure than for the Board model. For total reserves multipliers, however, the Board model has a slight edge. It may be noted that the intermeeting projection incorporating adjustments to the reserve targets reverses the relative performance of the two procedures for total reserves. For the nonborrowed and total base multipliers, error dispersion statistics are somewhat lower for the Board model than for the initial judgmental projections. The judgmental mean errors, though, are lower in all cases than the Board model with the exception of total reserves.

2. M-1A results. The Johannes-Rasche technique was not applied to M-1A. The error dispersion statistics for M-1A tend to be a bit larger than for M-1B (except for the San Francisco model) but otherwise are quite similar.

3. M-2 results. The San Francisco model does not predict M-2. Also, since no weekly data for redefined M-2 exist, there are no intermeeting judgmental results for this aggregate. However, all of the judgmental error dispersion statistics for the current-month projection are lower than those for the narrower monetary aggregates, as is the case for most of the Johannes-Rasche statistics. The reverse is true of all the comparable Board model statistics, except for the nonborrowed base.

4. Conclusions.

   a. Value of alternative procedures.

   (1) One conclusion emerging from Table 4 is that the initial intermeeting judgmental projections of multipliers for the narrow reserve measures were either superior to or about the same as econometric forecasts derived without the benefit of judgmental "add factors." Intermeeting adjustments to the judgmental projections improve their performance. Given that under the new procedures the effective operating targets have been nonborrowed and total reserves, these results do not indicate that replacing judgment with econometric multiplier forecasts in

October 1979 would have provided consistently better multiplier projections.

(2) The various model forecasts obviously contain information, however, and supplementing judgmental forecasts with model forecasts would provide some gain in precision. In principle, a weighted-average "consensus" forecast could be constructed from judgmental and econometric predictions, with the predictions of the historically more accurate procedure weighted more heavily.1/

b. Multiplier-projection techniques versus selection of money targets.

(1) It might be argued that if another procedure for predicting multipliers, say the Johannes-Rasche technique, had been used to derive reserve paths each month that were consistent with the midpoint of the longer-run ranges for the monetary aggregates, the divergences from the midpoints of the longer-run ranges since October 1979 would have been reduced.

1/ As noted earlier, the Board's monthly model already is considered in determining the particular pattern of intermeeting money targets consistent with the FOMC's average interim path.

(2) This position really boils down to a criticism of the selection of intermeeting money targets, not of how multiplier forecasts are made. Even with intermeeting money targets always determined by the midpoint of the longer-run range, the results in Table 4 suggest that a better approach would be to derive reserve paths using judgmental multiplier projections and then make intermeeting adjustments in response to new information.1/ There are, of course, good reasons why the FOMC does not attempt an abrupt return to the long-run target following observed discrepancies, but this is a separate issue altogether.2/

c. Multiplier-projection techniques versus choice of reserve aggregate.

(1) It might also be argued that the money stock could have been kept under closer control if another reserve aggregate, say the nonborrowed or total monetary base, had been used as the operating target. Indeed, at first glance, the results in Table 4 would appear to provide strong evidence in support of this view. The error dispersion statistics for all the econometric procedures consistently decline as the reserve aggregate considered is successively broadened.

1/ The extent to which the results in Table 4 bear on the question of the best technique to use in deriving reserve paths is questionable, as the next subsection will make clear.

2/ For an analysis of this issue, see Peter Tinsley, Peter von zur Muehlen, Gehard Fries, and Warren Trepeta, "Money Market Impacts of Alternative Operating Procedures," in this compendium.

(2) This position is essentially a criticism of the choice of the reserve measure for use as a target, rather than of judgmental projection methods. Table 4 shows that judgmental predictions of the multipliers for the two base measures were similar to those of all the econometric forecasts except the Board's monthly model, which were somewhat better.

(3) More fundamentally, however, Table 4 is incapable of providing reliable evidence on the question of the best reserve concept for use as an operating target or on the question of the best econometric method available for use in deriving the appropriate level of the reserve target. The reason simply is that the reported multiplier-prediction errors contain endogenous movements of reserves away from their predicted values. These error statistics are not instructive regarding the closeness of monetary control in a regime in which a model's predicted level of reserves was taken as an invariant operating target. The next subsection will address this issue in depth, and conduct alternative empirical tests.

C. The Nature of the Money Stock Prediction Tests

The error statistics of multiplier predictions shown in Table 4 are quite misleading regarding the reserve measure that could provide the closest monetary control, because they include reserve misses as well as money stock forecast errors. The design of the multiplier tests discussed in the last two subsections underscores the fact that none of the reserve measures has been truly exogenous since October 1979. In the case of nonborrowed reserves, there were intermeeting adjustments in response to recognized multiplier disturbances, as well as misses of the final adjusted path owing to noncontrolled factors affecting reserves, like float, or to other considerations. Because adjustments to nonborrowed reserves tended to be in the opposite direction to deviations of the monetary aggregates from target, the prediction errors of judgmental nonborrowed reserve multipliers suffer from an upward bias.

For example, assume that, even though nonborrowed reserves are maintained at the initial target, the money stock unexpectedly jumps in the first half of the intermeeting period to a level that, if maintained, would imply an annual growth rate for the entire intermeeting period 10 percent faster than targeted. Now suppose that the Desk in response adjusts the nonborrowed reserves target downward so that for the entire period its annual rate of change is 10 percent less than initially targeted. Assume that, as a result, growth of the money stock in the intermeeting period is reduced 2 percentage points to 8 percent above the targeted growth rate. Although the intermeeting adjustment to nonborrowed reserves brings the rate of growth of the money stock 2 percentage points closer to target, it also produces an 18 percent error in the initial prediction of the annual rate of change of the multiplier, rather than the 10 percent error that would have occurred in the absence of a reserve path adjustment. Thus, if nonborrowed reserves literally had been held at their initial target level throughout the intermeeting period, their multiplier error statistics shown in Table 4 would have been lower, although the misses of the monetary aggregates from their intermeeting targets of course would have been larger.

As a result of this inverse relationship between deviations of nonborrowed reserves from initial intermeeting targets and the prediction errors of the associated multiplier--since October 1979 the correlation coefficient between the two was -.74--the judgmental multiplier-prediction errors were considerably larger than the monetary-aggregate intermeeting target misses. For example, the mean and root mean squared errors of the initial judgmental M-1B/nonborrowed reserves multiplier projection were 2.7 percent and 14.9 percent at an annual rate respectively. But, as shown in the top row of Table 5, the comparable error statistics for the miss of M-1B from intermeeting targets built into this multiplier projection were -0.9 percent and 9.8 percent respectively.

The error statistics in Table 4 for judgmental predictions of multipliers for the other reserve aggregates and for model predictions of multipliers for all the reserve measures also are potentially quite misleading, although the direction of bias is less clear and more dependent on the particular judgmental or model technique being employed.1/ To be sure, the results of

1/ The total reserve and nonborrowed base judgmental M-1B multiplier error statistics for the initial projection are close to those for M-1B deviations from its intermeeting target, while the comparable error statistics for the total monetary base multiplier are below those for M-1B deviations. For the econometric models, the particular equations subject to the largest errors and, in the Board and San Francisco models, the various equations' interest elasticities all play a role. To illustrate how multiplier error statistics like those in Table 4 could be biased downward, consider a hypothetical example involving total reserves and abstracting from lagged reserve accounting. If the Federal Reserve held nonborrowed reserves constant over the intermeeting period but exerted little administrative pressure on banks borrowing at the window, then short-term interest rates would react little when the public unexpectedly increased its desired holdings of demand deposits. Although required reserves would rise, discount-window borrowings would increase to fill the gap between nonborrowed and required reserves, raising total reserves. The assumed muting of interest rate movements would affect other deposits only (continued on page 41)

Table 4 are intended to provide a fair test of the relative ability of the various procedures to predict the different multipliers under these circumstances of endogenous movements in various reserve aggregates. Nevertheless, these statistics are unreliable as a test of the relative attractiveness of the various reserve aggregates as potential operating targets because the multiplier errors include endogenous misses of the reserve prediction and forecast errors of money. These results also are unreliable as a test of the relative improvement in monetary control that could be obtained by relying on each particular model for determining the appropriate value of the reserve target.

We have developed two procedures for circumventing the problem of the endogeneity of reserve aggregates.1/ The first makes the working assumption

1/ (continued from page 40). little, even if Regulation Q ceilings made savings depositors quite sensitive to movements in short-term interest rates. Thus, total reserves would go up by about the same proportion as demand deposits and the M-1/total reserves multiplier would remain relatively stable.

This case can be compared with one in which the Federal Reserve maintained total reserves at a predetermined level. Now, as the assumed surge in the demand for demand deposits increased required reserves, market interest rates would rise, as discount borrowings were offset by open market sales. The rise in interest rates would, by assumption, induce large outflows of savings deposits, making more reserves available to support demand deposits. Hence, some of the increase in the demand for demand deposits would be accommodated automatically. In this latter example, holding total reserves exogenous causes the observed M-1/total reserves multiplier to increase noticeably, in contrast to the case with a nonborrowed reserves target. Examples of supply-side shocks can be constructed that give the same result.

1/ These procedures involve stochastic model simulations in which the chosen instrument is held constant at an exogenous level determined in a prior step. Selection of alternative policy instruments influences the ultimate allocation but not the total impact of random disturbances on the financial system. This conclusion is well established in control theory and has also been the subject of a number of early inquiries in macroeconomics, such as Martin J. Bailey, National Income and the Price Level: A Study in Macrotheory (McGraw-Hill, 1962); William Poole, "Optimal Choice of Monetary Policy Instruments in a Simple Stochastic Macro Model," Quarterly Journal of Economics, vol. 84 (May 1970), pp. 197-216; John H. Kareken, Thomas Muench, and Neil Wallace, "Optimal Open Market Strategy: The Use of Information Variables," American Economic Review, vol. 63 (March 1973), pp. 156-72. A more general discussion of this phenomenon with empirical illustrations and further references may be found in P. Tinsley and P. von zur Muehlen, "A Maximum Probability Approach to Short-Run Policy," Journal of Econometrics, vol. 15 (January 1981), pp. 31-48.

that the actual level of nonborrowed reserves may be treated as exogenous, since it, in fact, has been the instrument under Federal Reserve control.1/ The Board and San Francisco models were then simulated to predict money, given actual nonborrowed reserves. Obviously, no disparity between actual and predicted nonborrowed reserves is allowed to occur. Hence, the two models were permitted to generate money stock forecasts given the actual level of nonborrowed reserves provided by the Trading Desk. These predictions were compared with realized money stock levels.

If nonborrowed reserves are assumed to be determined exogenously, then the total reserve and the two base aggregates would be endogenously related to the money stock. This endogeneity would present a problem for evaluating money stock forecasts generated using actual levels of total reserves, the nonborrowed base, or the total base as if they were exogenous.2/ Hence, rather than following this approach, an alternative set of simulations of the Board and San Francisco models was conducted that explicitly treated total reserves, the nonborrowed base, or the total base as exogenous. Rather than simulating the models with the actual level of the three broader reserve measures treated as exogenous, the model was run using as the exogenous policy variable the prediction of these reserve measures derived from the simulation with the actual level of nonborrowed reserves treated as exogenous. In other words, predicted

1/ Intermeeting adjustments to the nonborrowed reserve path in response to observed money stock deviations from target represent a feedback from currently evolving errors and violate the assumption of exogeneity. The second procedure described below attempts to correct for this correlation.
2/ From the vantage point of the two monthly models and assuming nonborrowed reserves are exogenous, actual total reserves, for example, would implicitly contain information about all the structural errors in the model, except for the error in the demand for currency. If the models then were simulated by treating actual total reserves as the exogenous control variable, the resulting ex ante model prediction of money would in fact be based on ex post deposit errors implicitly captured in the level of actual total reserves. Such a procedure would violate the purpose of the comparison between an ex ante prediction and

levels of borrowed reserves and/or currency were added to actual nonborrowed reserves in order to determine in a first step the predicted levels of total reserves, the nonborrowed base, and the total base. Thus, from the viewpoint of both models, levels of these reserve measures were constructed to be internally consistent with the assumed exogenous level of nonborrowed reserves. On the assumption that the Federal Reserve maintained nonborrowed reserves at the observed level in an effort to achieve a particular monetary aggregate objective, it follows that if another reserve measure instead had been used as the operating target, the Federal Reserve would have chosen a setting of that measure consistent with the same monetary objective.

In computing monetary aggregate errors for this set of simulations, the predicted money levels were thus the same as those derived from the run with actual nonborrowed reserves exogenous in the absence of the model errors. However, the "actual" levels of the monetary aggregates used to evaluate the forecasts were not based on the actual money levels observed in the data, which reflect deviations of actual from predicted levels of total reserves and the two base measures. Instead, the respective model simulations held these reserve aggregates constant at their predicted levels, and imposed on the model the observed errors in all the structural equations in a second step. Accordingly, the predicted values of the monetary aggregates in each of these second-stage simulations represented the levels that the models suggest actually would have resulted had the reserve measure been held constant at the assumed exogenous level.

In sum, the money stock error in each simulation for the three broader reserve aggregates was defined as the difference between the model solution for the monetary aggregates given the assumed exogenous value for each reserve measure--after imposing the ex post errors in each equation--and the prediction of the monetary aggregate derived from the nonborrowed reserves exogenous simulation in the absence of these errors.1/

The basic assumption underlying this procedure--that actual nonborrowed reserves are an exogenous variable--obviously abstracts from deliberate intermeeting adjustments to the nonborrowed reserve target. An alternative procedure to correct for this effect was used with the Board and San Francisco models. It involved defining the exogenous level of all the reserve measures in the first step as the predictions of these reserve measures obtained from the simulations used to generate the multiplier predictions underlying Table 4. In that experiment the models were solved for money and reserves given the judgmental expectation of the federal funds rate in the current month. Hence, this procedure takes that predicted level of reserves as the exogenous level. The remaining step is then carried out just as in the first procedure.

This second procedure is more likely than the first to provide settings for all the reserve measures that are truly exogenous, since it eliminates the residual bias in the forecast errors for money based on actual nonborrowed reserves in the first procedure.2/ Be that as it may, we believe

1/ It should be emphasized that these monetary aggregate errors are not related to any observed levels of the aggregates. They are the errors that would have emerged according to the models if the specific reserve measure had in fact been held exogenous at the assumed level in the presence of the the same errors as actually occurred in all the equations.

2/ Our initial expectation was that the first procedure involved a residual upward bias in the errors using actual nonborrowed reserves relative to the errors using the other reserve measures. For example, a positive shock to money during the control period would at times have induced an intentional reduction in actual nonborrowed reserves, which would move the predicted level of money further below the realized level. The results of the two procedures confirmed this expectation for the San Francisco model but not for the Board model.

that both procedures--reported below in Tables 5 and 6--provide better tests than Table 4 of the relative merits of various reserve measures as potential operating targets. We also believe that either approach better indicates the usefulness of the Board and San Francisco models for deriving target reserve paths associated with near-term money stock objectives. The model prediction errors will indicate how closely the models would have come to predicting levels of the monetary aggregates if the reserve aggregate had been held at the assumed exogenous level during the course of a month.

Unfortunately, the Johannes-Rasche technique is incapable of addressing this problem of reserve endogeneity. The conclusion that the total monetary base would be the best operating target rests on results like those reported in Table 4.[1] But this conclusion must be viewed with considerable skepticism, given the endogeneity of this reserve measure, even over the period of the new reserves-oriented operating procedures. Johannes-Rasche predictions of money necessarily are based on actual, rather than exogenized, levels of the broader reserve aggregates. The results therefore are not in accordance with the spirit of the experiments reported in Tables 5 and 6, unless one makes the restrictive assumption that these multipliers would not have changed if the reserve measure had been held exogenous at a level different from that observed.[2]

Nor could this counterfactual experiment be applied directly to the judgmental projection procedure. Instead, the actual experience of misses

1/ See Johannes and Rasche, "Can the Reserves Approach Really Work?"
2/ One interpretation of this assumption is that the multiplier has a zero interest rate elasticity, and that the full adjustment of the monetary aggregate to a change in the reserve aggregate occurs in the current month so as to restore the multiplier to its predicted value.

of each monetary aggregate from its target, both for intermeeting periods and for current months, is reported for comparison with the model errors. At the risk of redundancy, a review of the selection of these targets follows. As discussed earlier, targets for the monetary aggregates are established shortly after FOMC meetings. They are based on the average growth rates selected by the FOMC over the entire interim period, which incorporate the Committee's desired speed of the attempted return to longer-run objectives following recognized deviations. As also previously noted, however, near-term growth rate targets occasionally differ from the specified average growth rate over the interim period. Regarding the monthly targets, half of the current month typically has elapsed by the time the target is established. The potential for significantly affecting the monthly average growth rate by influencing the behavior of the monetary aggregates in the last two weeks of the month is limited. The intermeeting-period targets often reflect some adjustment for anticipated temporary variations in future money growth around the FOMC's average path that is associated with lagged effects of past or current actions or with known special factors.

D. An Analysis of the Money Stock Prediction Results

Tables 5 and 6 present summary statistics both of the misses in the growth rate of each monetary aggregate from its intermeeting or monthly target, expressed at an annual rate, and of model forecast errors of annualized money growth. It should be kept in mind that these statistics represent errors over a particular period—encompassing the 15 intermeeting periods or 13 months following the adoption of the new operating procedures. Generalizations from these results about the future should be made cautiously.1/ The findings in both tables may be summarized briefly.

1. Money stock target misses.

   a. Intermeeting periods. As noted earlier, the root mean squared miss of M-1A is 11 percent and of M-1B is near 10 percent, both at annual rates.

   b. Current months. The misses from the current-month targets, which contain estimates for two weeks of realized data, are only about half as much.

   c. Various monetary aggregates.

      (1) The size of the available error dispersion statistics, expressed as growth rates, decreases as the monetary aggregate concept broadens.

      (2) The mean errors are negative for the narrow aggregates, reflecting large shortfalls in three of the four intermeeting periods from late March through early July. However, they were positive for current-month M-2 misses.

2. Money stock target misses versus econometric prediction errors.

   a. Conclusions. A comparison of the statistics in Tables 5 and 6 that summarize model money errors with those that summarize observed money target misses reveals that model predictions based on either of the nonborrowed reserve measures ranged from slightly to somewhat lower than

1/ For a study that attempts to get around this problem by looking at sets of errors in the Board model that are typical of the experience of the 1970s, see Tinsley and others, "Money Market Impacts."

misses of M-1A and M-1B from intermeeting targets.

b. Caveats. These results are misleading, however, unless properly interpreted.

(1) As indicated earlier (see p. 31), the models enjoyed certain advantages in the tests relative to actual experience. In addition, since the models were simulated without a constraint on the federal funds rate, these results ignore the FOMC's upper and lower funds rate bounds.1/ These bounds were violated for some of the predictions. Violations of the funds rate limits in the planning stage, in which the exogenous level of the reserve target level is selected, mean that these levels of the reserve measures used in the simulations would not in fact have been chosen if the models alone had been used to set the operating target. Violations of the funds rate limits in the execution stage, in which the models' errors are imposed with reserves held fixed at the exogenous level, mean that the reserve aggregate actually would not have been maintained at the exogenous target level over the control period, but would have been altered to keep the funds rate within desired limits. However, it may be noted that the San Francisco model violated the federal funds range in Table 6 by only a minimal amount for the two nonborrowed measures.

1/ As noted in the previous subsection, the San Francisco model errors summarized in Table 5 represent an exception for the four months when the actual federal funds rate, rather than actual nonborrowed reserves, was used in the first stage of the simulations.

(2) Even considering these caveats, the value of the Board and San Francisco models for use in predicting money given reserves, and hence for deriving reserve target paths, appears much greater in Tables 5 and 6 than in Table 4. We believe the results in Tables 5 and 6 are more relevant to this issue.

3. Comparison of multiplier and money stock errors for econometric models.1/

The differences between the models' typical multiplier errors, shown in Table 4, and typical money stock errors, shown in Tables 5 and 6, are instructive.

a. Nonborrowed reserves.

(1) Using actual nonborrowed reserves in the Board and San Francisco models (Table 5) or predicted nonborrowed reserves (Table 6) to forecast the monetary aggregates, rather than using the expected funds rate to predict the money/nonborrowed reserves multiplier (Table 4), resulted in a striking decline in the error statistics for both the Board and San Francisco models.

1/ The error statistics for the Johannes-Rasche approach of course would be identical in Tables 5 and 6 to those in Table 4 because this method would have to use actual levels of all the reserve aggregates, despite their evident endogeneity.

(2) This result indicates that the multiplier statistics in Table 4 suffer from a marked upward bias owing to intermeeting adjustments or other factors that involve a negative correlation between the departure of nonborrowed reserves from its path and the forecast error in the multiplier.

b. Total reserves.

(1) The Board model shows a marked deterioration in the money stock forecasts of Tables 5 and 6, which exogenize total reserves, compared with the multiplier forecasts of Table 4, which treat total reserves as endogenous.

(2) The San Francisco model statistics, in contrast, show a clear improvement in the latter two tables.

c. Nonborrowed base.

(1) The Board model improved somewhat going from Table 4 to Table 5, but changed little going from Table 4 to Table 6.

(2) The San Francisco model improved dramatically in the latter two tables, particularly Table 5.

d. Total base.

(a) The Board model worsened noticeably in Tables 5 and 6.

(b) The San Francisco model was about unchanged in the latter tables.

4. <u>Results across the econometric models</u>. The statistics are similar for both M-1A and M-1B. The San Francisco model's errors stack

up favorably in all comparisons, but the Board model also does quite well for nonborrowed reserves, except perhaps for M-1A in Table 6.

5. <u>The choice of a particular reserves instrument</u>. Concerning the important question of which reserve measure would have afforded the closest monetary control since October 1979 if held at a predetermined level over each control period, it is convenient to consider the Board and San Francisco models in turn.

a. The Board model results.

(1) In both Tables 5 and 6 this model shows the best results for nonborrowed reserves and the nonborrowed base, with the latter slightly better for the narrow aggregates and the former slightly better or about even for M-2.

(2) In contrast, the error dispersion statistics for total reserves were two to three times as high as for nonborrowed reserves. Similarly, these total base statistics were about double those of their nonborrowed base counterparts in Table 5 and also higher, although less dramatically so, in Table 6.

(3) The deterioration in the predictions of the model when the total reserves and base measures are treated as exogenous arises principally from the enlarged importance of demand deposit supply-related errors. With a given level of total reserves or the total base, the discount window is not permitted to play its role as a safety

valve in muting the impact of supply-related shocks on interest rates. With total reserves given exogenously, for example, the demand deposit supply curve becomes quite interest inelastic in the model. But prediction errors of the average required reserve ratio on demand deposits and of other reservable items cause shifts in this curve, inducing interest rate fluctuations large enough to produce changes in the quantity of demand deposits demanded of a similar size. This effect accounts for the large prediction errors for the money stock given exogenous total reserves or total base.

(4) The system of lagged reserve accounting makes the monthly average required reserve ratio by type of deposit quite unstable, as was suggested by the standard deviations of actual multipliers shown in Table 3, and quite unpredictable as well. It is inherently difficult for a monthly model to capture adequately the effects of the two-week lag in required reserve accounting.1/

1/ In the model simulations reported in these tables, the average required reserve ratio against demand deposits is forecast as an inverse function of predicted demand deposits. Alternatively, the model was simulated using time-series models of weekly reservable demand deposit data. This method reduced the root mean squared forecast errors of the monthly average required reserve ratio against demand deposits by about 30 percent, and reduced the annualized percent root mean squared errors of M-1A and M-1B shown in Table 5 in the runs with total reserves exogenous by about 2 and 4 percentage points respectively. The errors in runs with actual nonborrowed reserves, however, were little changed.

In addition, the system of graduated reserve requirements that prevailed over the period added to the difficulties of forecasting the average required reserve ratio on demand deposits because deposit distribution among banks affected the average ratio of required reserves to deposits. Finally, forecast misses of other reservable deposit and nondeposit items also made the position of the demand deposit supply function under any reserve aggregate control variable more difficult to predict. This general problem is exacerbated with a total reserves or base instrument. Accompanying these reserve instruments is a demand deposit supply function with a very low interest rate sensitivity.

(5) The first set of memo items in Tables 5 and 6 shows the money stock errors with the various reserve measures treated as exogenous at the same time that the average required reserve ratio on demand deposits and the level of required reserves against small time and saving deposits and large time deposits are assumed to be known with certainty. The resulting error statistics, compared to those in the body of Tables 5 and 6, provide an upper limit to the improvement in monetary control since October 1979 that would have arisen if legislated reserve requirements on demand deposits had been contemporaneous, uniform, and universal, and if there had been no reserve

requirements on other deposit categories. This experiment is relevant because full phase-in of the Monetary Control Act of 1980 makes reserve requirements on transactions balances more nearly uniform and universal and removes reserve requirements on all other deposit categories except nonpersonal time deposits. Moreover, the requirements on these latter deposits could be eliminated at the Board's discretion. The error statistics with total reserves and the total base exogenous reported in these memo items show a marked improvement over the comparable errors without such certain knowledge in the body of the tables. Indeed, in both tables total reserves evince quite small prediction errors for M-1A, relative both to other reserve measures and to M-1B, as might be expected with required reserves effectively applying only to demand deposits in the simulation. The M-1A error statistics for the total monetary base, however, show less improvement than those for total reserves.

(6) In contrast, the improvement in the errors for both of the nonborrowed measures shown in the first set of memo items is trivial in Table 6 and nonexistent in Table 5. In part, this result again reflects the success of the discount window in muting the effects of supply-side shocks on the money stock with a nonborrowed reserve measure as the operating target. However, these results must be interpreted with care, as

they only reflect the particular history of errors since October 1979. As noted in the last section's discussion of Table 3, the portion of variability of the M-1B/nonborrowed reserves multiplier due to lagged reserve accounting for some reason declined dramatically in fiscal 1980 relative to the experience of earlier years. Consequently, the apparently trivial impact of these institutional changes on the model's money predictions, given nonborrowed reserves or the nonborrowed base in Tables 5 and 6, may well be specific to the unusual pattern of equation errors experienced over the past year.

(7) These results suggest great caution in putting more day-to-day emphasis on a total reserves operating target until the average required reserve ratio on transactions balances and required reserves against other items become more predictable. As just noted, the Monetary Control Act, particularly after full phase-in, will certainly help in this regard.1/ However, the reinstitution of contemporaneous reserve accounting would seem

1/ The gain in monetary control would be larger still if, after the phase-in of the new reserve requirement structure under the MCA has proceeded for a few years, the Board were to impose the supplemental reserve requirement. This action would raise average reserve requirement ratios on transactions balances and bring more depository institutions under binding reserve requirements. Without the supplemental, a sizable fraction of transactions deposits will be at institutions that can meet their reserve requirements with vault cash held for day-to-day operations.

to be a prerequisite for strictly maintaining a total reserves or total base operating target, judging from the results in Tables 5 and 6 for the Board model. In addition, close short-run control over these reserve measures would become more feasible.1/

(8) The second set of memo items in Tables 5 and 6 adds certain knowledge of the function determining the ratio of discount borrowings to deposits to the certain knowledge concerning required reserves embodied in the first set of memo items. The resulting error statistics, compared with those in the first set of memo items, provide an upper limit to the improvement in monetary control since October 1979 that would have arisen if the discount-window equation had not been allowed to generate any supply-side multiplier prediction errors.2/ That is, these statistics show how closely M-1A (or M-1B) could have been controlled if the only relevant errors in the model's

1/ For discussion of the controllability of various reserve aggregates under lagged and contemporaneous reserve accounting, see Axilrod and Lindsey, op. cit.

2/ These results could be interpreted as applying to the situation prevailing without administrative pressure or arbitrage restrictions but with a graduated marginal discount rate that rises with increases in borrowings as a percent of deposits. In this case, the borrowing ratio as a function of the spread of the funds rate over the discount rate could become quite predictable. For a discussion of variants of such a proposal, see Perry D. Quick, "Federal Reserve Discount Window Reforms: Policies Without Administrative Pressure," Board paper, July 1980. For a discussion of this and other proposals to make discount borrowings more predictable, see Peter Keir, "Impact of Discount Policy Procedures on the Effectiveness of Reserve Targeting," in this compendium.

equations were for excess reserves and the demands for currency and demand deposits (or transactions balances). The M-2 statistics show the precision of control over this aggregate if, in addition to these errors, random disturbances also affected the remaining components of M-2. The results with the total reserves or total base measures held exogenous are, of course, identical in the first and second set of memo items in Tables 5 and 6. The money error is the same regardless of whether or not unexpected movements in discount borrowings occur, since any such movements would have to be fully offset by open market operations to keep total reserves or the total base on target.

(9) For the two nonborrowed measures, a slight improvement in monetary control owing to certainty about the borrowings function is evident in Table 5, but a little larger improvement appears in Table 6. These results suggest that some consideration might be given to a restructuring of the discount window. These monetary control advantages would have to be balanced against the disadvantages of any such institutional change.1/

b. The San Francisco model results. The same two procedures for exogenizing reserve aggregates are shown in the body of Tables 5 and 6 for this model. These results yield rather similar conclusions, although it may be reiterated that the error

1/ Ibid.

statistics for all reserve measures were lower than those reported for the Board model.

(1) As in the Board model, nonborrowed reserves and the non-borrowed base have the lowest error statistics in the two tables. The nonborrowed base recorded slightly smaller errors than nonborrowed reserves in Table 5, but the two measures ran a dead heat in Table 6.

(2) The error dispersion statistics for total reserves and the total base were about two to three times higher than for their nonborrowed counterparts in both tables.

(3) The money prediction errors for total reserves were much smaller for this model than for the Board model. In marked contrast to the Board model, these error statistics actually improved going from Table 4 to Tables 5 and 6.1/ The explanation for the better performance of total reserves in this model appears to involve a combination of three factors. First, the demand deposit supply function in the San Francisco model is much more interest elastic than the Board's, which reduces the effects of supply-side disturbances on the model's money stock error given total reserves in the last two tables. Second, the San Francisco model uses staggered four-week periods for reserves and deposits, affording a more successful

1/ The bulk of the San Francisco model's multiplier forecast errors given the projected funds rate in Table 4 stems from forecast errors of reserves rather than forecast errors of money. (The last set of memo items in Tables 5 and 6 indicate that the model's forecasts of money given the projected funds rate are fairly accurate.) These reserve prediction errors are eliminated going from Table 4 to Tables 5 and 6.

treatment of lagged reserve accounting. Third, the model does not make explicit predictions of required reserve ratios on demand deposits and managed liabilities. The model's implicit forecasts of these ratios appear to yield better results than attempts to model the ratios explicitly.

c. Reserves versus base measures. The total base does quite a bit better than total reserves in the Board model and just a bit better in the San Francisco model. However, under the institutional structure that has obtained since October 1979, their nonborrowed counterparts were clearly superior. In both models, the nonborrowed base does a bit better than nonborrowed reserves for M-1A and M-1B in Table 5, but this slight advantage virtually disappears in the perhaps more reliable Table 6. Although these results only apply to a 13-month period, they do not suggest that a change in day-to-day emphasis from nonborrowed reserves to the nonborrowed base would afford much, if any, improvement in monetary control.

6. A federal funds rate versus a nonborrowed reserves operating target. The third set of memo items in Tables 5 and 6 indicates the size of money errors for the Board and San Francisco models taking as given either the actual federal funds rate in the current month or the judgmental federal funds rate prediction made as of mid-month on average. The similarity of the funds rate and nonborrowed reserves error statistics for the narrow aggregates with the Board and the San Francisco model simulations in both Tables 5 and 6 is remarkable; the only real divergence appears for the Board model forecast of M-1A in Table 6.

a. This general result is broadly consistent with earlier work, done both internally and outside the System.1/

b. It may be noted that this result can only be interpreted to indicate that a fixed funds rate operating target would have provided as close monetary control as a fixed nonborrowed reserves target (in the absence of funds rate constraints) on the assumption that, at the beginning of each control period, the funds rate target would have been fully adjusted to the level thought consistent with the average money target over the period.2/

c. This result also only holds for the institutional structure prevailing since October 1979. In Table 5, the errors for the funds rate instrument with the Board model are a little larger than the errors for nonborrowed reserves in the second set of memo items, which assume institutional changes to make reserve requirements and discount borrowings more predictable. However, in Table 6, the errors for the funds rate are somewhat below those for nonborrowed reserves in the second memo item.3/

1/ This literature was initiated by James Pierce and Thomas Thomson, "Some Issues in Controlling the Stock of Money," in Controlling the Monetary Aggregates II: The Implementation, Federal Reserve Bank of Boston Conference Series 9 (September 1972). For the most recently published extension, see Charles Sivesind and Kevin Hurley, "Choosing an Operating Target for Monetary Policy," Quarterly Journal of Economics, vol. 94 (February 1980), pp. 199-203.
2/ See Axilrod and Lindsey, "Federal Reserve System Implementation," for a discussion of the realism of such an assumption.
3/ Recall the discussion (on p. 55) of the perhaps atypically large multiplier errors for nonborrowed reserves over this period, even with these institutional changes.

7. The feasibility of close short-run monetary control.

   a. The evidence from Tables 4-6. Close short-run monetary control over periods as brief as one month is not possible with either a funds rate or a reserve aggregate operating target under the current or any reasonably similar institutional structure. Even the lowest error statistics in Tables 4-6 support this conclusion.

      (1) The San Francisco model's root mean squared prediction error of M-1B monthly growth rates of 3.2 percent at an annual rate for the nonborrowed monetary base in Table 5 implies that, over the long pull, in one month out of twenty the annualized growth rate of M-1A would move outside a band of 12.5 percentage points centered on the monthly target.

      (2) The lowest root mean squared error for monthly M-1B growth in the Johannes-Rasche model, 9.0 percent, implies that, on the average, in one month out of twenty M-1B growth will vary outside a range of 36 percentage points centered on the monthly targeted growth rate.1/

   b. The averaging out of monthly errors over quarterly periods. In light of the sizable monthly errors, the degree to which such errors average out over a longer time horizon is of interest.

1/ As emphasized earlier, translating multiplier errors into money errors when the reserve measure is endogenous is potentially misleading.

(1) Table 7 displays summary statistics of quarterly prediction errors of the monetary aggregates expressed at an annual rate, based on the money errors reported in Table 5. The intermeeting-period "quarterly" misses are derived from the nonannualized intermeeting errors underlying Table 5 by grouping the errors into five sets of three adjoining intermeeting-period errors, averaging each set of errors, and then annualizing by a factor of 4. The quarterly errors derived from monthly observations are simple averages of monthly errors over calendar quarters, expressed at annual rates. A sizable reduction both in the bias and in the measures of dispersion is evident for the quarterly average misses of money from intermeeting targets. However, this largely reflects the reduction of the annualizing factor from 12 to 4, although some averaging out of the individual monthly misses is evident. The proportional declines of the San Francisco model's root mean squared errors for predictions of the narrow aggregates from monthly to quarterly intervals are no larger than actual experience. However, the Board model's quarterly statistics for M-1A and M-1B show a more sizable improvement, reflecting essentially no systematic tendency for errors to run on the same side from one month to the next. If the monthly errors were serially uncorrelated, the quarterly root mean

squared error on average would be reduced to 19 percent of the monthly root mean squared error--a result that is achieved exactly for the Board's monthly model predictions of M-1B given actual nonborrowed reserves.

(2) Table 8 presents the comparable quarterly errors for the models derived from the second procedure's monthly errors reported in Table 6. The reductions for the San Francisco quarterly errors are similar to the changes from Table 5 to 7. The reductions for the Board's quarterly errors, however, are larger than the changes from Table 5 to 7, reflecting a negative serial correlation of monthly errors.

IV. Variability in Interest Rates and Money Demand Analysis*

Many observers have noted that interest rates as well as money growth have registered enlarged variability since the new operating procedures were established. Some even have suggested that more variable interest rates have accentuated the movements of money; others have argued that the causation has worked in the opposite direction.

This section addresses these issues from the perspective of the demand for money. Several alternative money demand equations are examined. In each, movements in money demand are decomposed by source into the separate effects on the quantity of money demanded of each of the variables appearing in the equations. These individual sources include interest rates, real income, and prices, as well as other variables in several alternative equations, both for quarterly and monthly data. The size of the residual errors in these equations also is examined, and an attempt is made to explain why they occurred. The accuracy of these models' money growth predictions over various time spans--monthly, quarterly, and annually--also is asssessed.

These results serve as background for other papers in the overall project that address the issue of whether or not attempts to control money over the past year have produced either cycles or greater volatility in short-term interest rates, in real economic activity, and, through feedback effects, in the monetary aggregates themselves. One study uses the Board's monthly model to examine the variability of interest rates and

*Contributors to this section: Helen Farr, David Lindsey, Eileen Mauskopf, Edward Offenbacher, and Richard Porter, of the Board staff; John Judd and John Scadding, of the San Francisco Bank staff.

money under alternative targeted speeds of return to the longer-run money target following deviations and under alternative instruments.[1] This study holds the real sector and price level exogenous. The assumption of no feedback effects from real economic activity or prices to money is dropped in another study, where macroeconomic models allowing for various interactions between the monetary and real sectors are considered.[2]

Our paper examines predicted growth rates for M-1A derived from five quarterly and two monthly money demand equations. The quarterly money demand equations consist of the Board (MPS) equation, the Wharton and DRI equations, one proposed by Michael Hamburger of New York University and one recently developed by Richard Porter and Thomas Simpson of the Board staff. The monthly equations are taken from the Board's and the San Francisco Bank's money market models.

In their original form, the quarterly equations were estimated over somewhat different time periods and explain somewhat different monetary concepts. The properties and predictive performance of the original versions of the MPS, Hamburger, DRI, and Wharton equations have been discussed elsewhere.[3] The Porter-Simpson equation, which is not discussed in this earlier paper, is similar to the MPS equation but incorporates a five-year bond rate ratchet variable--with an increasing elasticity as

1/ Tinsley and others, "Money Market Impacts."
2/ Jared Enzler and Lewis Johnson, "Cycles Resulting from Money Stock Targeting," January 1981.
3/ See Jared Enzler, Eileen Mauskopf and Edward Offenbacher, "Other Money Demand Equations," October 1980; and Michael J. Hamburger. "Behavior of the Money Stock: Is There a Puzzle?" Journal of Monetary Economics, vol. 3 (July 1977), pp. 265-88.

the rate rises. This variable is intended to serve as a proxy for the opportunity cost of not making cash management investments. Thus, the total interest rate impact in this equation is captured by the sum of the standard interest rate term and this cash management variable.1/

For purposes of comparison, the equations were reestimated over a common sample period, 1960:4-1974:2. The results are reported for a common monetary concept, M-1A, by adding the predictions of a standard currency equation to those of the MPS, DRI, and Wharton equations, which were estimated for demand deposits only. The estimated elasticities of the various quarterly equations are given in Table 10.

Predicted values of M-1A and their decomposition in terms of explanatory variables are presented in Tables 10-15. Table 10 summarizes the results from all these equations for fiscal years 1979 and 1980. Tables 11-15 present quarter-by-quarter predictions and decompositions. Predicted M-1A growth rates are obtained by dynamically simulating the demand equations beginning in 1974:3, as shown in the "predicted M-1A" column in each table. The column labeled "pre-1977:4 values" is obtained by fixing the values of all explanatory variables for 1977:4-1980:3 at their 1977:3 values. The predicted growth of M-1A in this column represents the effects of movements in values of all the explanatory variables only up through 1977:3. In each subsequent column, a single group of explanatory variables, as labeled, is permitted to take on actual historical values for 1977:4-1980:3 rather than fixed 1977:3 values. The figures in

1/ See Thomas Simpson and Richard Porter, "Some Issues Involving the Definition and Interpretation of the Monetary Aggregates," in Controlling the Monetary Aggregates III (Federal Reserve Bank of Boston, forthcoming).

these columns represent the growth in predicted M-1A due to the actual movements in only that group of explanatory variables. In addition, as a basis for judging predictive performance, each table presents actual M-1A growth rates as well as an "adjusted M-1A" measure designed to indicate what M-1A growth would have been if other checkable deposits and related deposit substitutes had never been introduced. This adjustment is obtained by adding to M-1A two-thirds of the increase in other checkable deposits plus approximately one-fourth of business savings deposits and one-fifth of state and local government savings deposits. Prediction errors are calculated relative to growth in both actual and adjusted M-1A.

As shown in Table 10, all of the equations except Hamburger's overpredict actual M-1A growth during each of the two most recent fiscal years. Hamburger's equation makes no prediction error for actual M-1A growth during fiscal 1980, but it underestimates M-1A growth by 1.5 percentage points over fiscal 1979. Relative to the growth in adjusted M-1A, the Porter-Simpson equation has the smallest annual prediction errors--overpredicting growth rates during each of these two fiscal years by less than one percentage point. However, the quarterly results reported in Tables 11-15 indicate that, on average, even this equation does considerably worse during shorter periods, particularly the second quarter of 1980; indeed, no equation predicted that quarter's actual decline in M-1A.

The decompositions of predicted growth rates indicate that the increase of prices is by far the most important factor contributing to the high growth of predicted nominal money demand. This reflects the public's attempt to attain their desired level of real balances. In addition, differences in the equations' estimated response to price changes are an important factor in accounting for their differences in predictive performance over the past two fiscal years. The increase in prices of 9.2 percent (logarithmic change) during fiscal 1980, for example, leads to an increase in predicted M-1A of about equal magnitude in the MPS, Wharton, and Porter-Simpson equations, other things equal. By contrast, the DRI price component amounts to 7.6 percent in fiscal 1980. While this equation suggests that most of the adjustment of money holdings to price level changes is completed within a year, nominal balances will never grow by the full 9.2 percent rate of inflation because the long-run price elasticity is less than unity. The Hamburger equation implies an increase in M-1A in fiscal 1980 due to price increases since 1977:3 of 2.6 percent, owing to its glacially slow speed of adjustment. In this equation, M-1A takes 16 years to complete 90 percent of its ultimate change in response to a change in prices. Multiplying its implied coefficients on lagged inflation by the associated actual inflation rates over the last 16 years yields a price component of money growth over fiscal 1980 of 6.2 percent. The 3 percentage point shortfall from the 9.2 percent actual inflation rate arises in part because recent inflation rates have been well above the average rate over the past 16 years. Hamburger's equation will reflect a given rate of inflation to the same extent as the other equations only if that rate is sustained for several decades.

The superior forecasting results of the Hamburger equation for unadjusted M-1A also depend on the inclusion of the dividend-price ratio as an explanatory variable. The presence of the dividend-price ratio can be criticized on a number of grounds. Theoretically, the dividend-price ratio (or the earnings-price ratio) behaves more like a real rate of interest than a nominal rate but it is the nominal rate of return on an alternative asset that should properly be included in the equation. Moreover, since the alternative to holding money balances is an investment to be held for a short period of time, the appropriate yield is an earnings rate adjusted for anticipated nominal capital gains or losses over that period. On practical grounds, the difficulty in forecasting the dividend-price ratio would complicate the policymaking process if the equation were used for this purpose. In view of these deficiencies, further discussion of this equation will be limited.

The tables also show that changes in other factors exert a considerably more modest influence than changes in prices on the average growth of predicted M-1A, as opposed to its variability. The continued, but declining, real expansion of the economy through early 1980 is generally reflected in a positive, but declining, contribution to predicted money growth. The actual decline in real income later in 1980 is reflected in a negative contribution to predicted money in all equations but Hamburger's. Similarly, the impact on the average growth of M-1A stemming from changes in interest rates is, in general, considerably smaller than the estimated impact arising from changes in the price level. This outcome reflects relatively low estimated interest elasticities as well as offsetting movements in interest rates themselves, especially in 1980.

On the other hand, except in the Hamburger equation, the variability of both the real income and interest rate components have contributed to relatively sizable quarter-to-quarter movements in predicted money growth, as indicated by Tables 11-14. Movements in real income alone caused predicted quarterly M-1A growth at an annual rate to vary over a 3.1-percentage-point range in the DRI model and up to a 9.2-percentage-point range in the Wharton model. Changes in interest rates alone caused predicted M-1A growth to vary over a 3.2-percentage-point range in the DRI model and a 6.9-percentage-point range in the Wharton model. Interest rate movements cause predicted M-1A growth to vary over a 10.9-percentage-point range in the Porter-Simpson equation, when the cash management variable is included in the calculation.1/

Regarding the interest rate component, an episodic review also is warranted. The rapid rise in interest rates through the first quarter of 1980 induced a deceleration in predicted M-1A growth from 1979:3 to 1980:1 in a range from 0.3 percentage points for the DRI equation to 5.0 percentage points in the Porter-Simpson equation. The decline in rates starting in the second quarter is sufficient to offset the lagged interest rate effects in the MPS equation in that quarter, turning the overall interest rate impact positive. In the Wharton, DRI, and Porter-Simpson equations, the absolute value of the negative interest rate effect is reduced. In none of these equations does predicted M-1A growth in 1980:2 become negative. Thus, the 3.9 percent decline in actual M-1A in the second quarter of last year cannot be attributed solely to the effects of

---

1/ The interest rate impact on money growth in the Porter-Simpson model is captured by the sum of the last two columns in Table 12. With this interpretation, the pattern of interest rate effects is similar to the MPS, Wharton, and DRI models, although it is amplified.

current and lagged interest rate movements on money demand in the various equations.1/

Table 16 shows the effects of a dynamic simulation of the Board's monthly model. Movements in interest rates over this whole period are estimated to have caused considerable variation in the growth rate of money demanded. For example, the depressing effect of interest rate movements on March money growth of 7.0 percent has, by June, become a stimulating force of 18.9 percent. Even the quarterly average figures for this model, shown in the bottom panel of the table, involve considerably more variation in the interest rate effects than the quarterly models examined earlier. However, the implied response of money does not correspond very well with actual money growth. The estimated impact of interest rates on M-1A growth by the second quarter has become quite expansionary, rather than depressive, and the model thus makes a very large error in that quarter. For the year as a whole, interest rate effects average out, and the model substantially overpredicts M-1A growth.

1/ The issue of whether or not a change occurred in the variability of the quarterly interest rate component in fiscal 1980 can be examined formally. For each equation, "F" statistics were calculated to test the null hypothesis of equality between the variance of this component for fiscal 1979 and fiscal 1980. Against the alternative hypothesis of a change in the variance in either direction--that is, a two-tailed test--the null hypothesis of no change in variance could not be rejected at the 5 percent significance level in three of the five models--MPS, Porter-Simpson, and Wharton. However, in a one-tailed test of the alternative hypothesis of an increase in the variance, all but the Porter-Simpson equation rejected the null hypothesis of no change at the 5 percent level. Thus, while the evidence is mixed, there is a hint of an increase in money variability associated with heightened variability in interest rates. It should be noted that the extremely small sample size in these tests precludes definitive conclusions on this point.

The large short-fall of actual relative to predicted M-1A growth in the second quarter of 1980 in all the models discussed so far may in part reflect the imposition of credit controls in March. Evidence on the role of credit controls has recently been provided by John Judd and John Scadding of the San Francisco Bank staff. As noted in Section III, they have estimated a monthly demand equation for demand deposits in which the amount of deposits the public holds reflects not only current and lagged values of interest rates and of nominal personal income but also disequilibrium caused by shifts in the supply function of demand deposits. Such shifts act like shocks to the demand for demand deposits, causing the public temporarily to hold more or less than the amount of demand deposits desired on the basis of longer term considerations.

Judd and Scadding argue that changes in the volume of commercial bank loans constitute an important source of these demand deposit shocks. In the San Francisco model, the banking system is viewed as responding to exogenous changes in the demand for bank loans by changing either demand deposits or managed liabilities. The deposits that are created in the process of new loan extensions essentially are byproducts, held only temporarily until they are spent. Hence, Judd and Scadding include in their demand deposits equation the net change in total bank loans to proxy for deposit shocks that leave the public temporarily off its demand function.1/

1/ This specification involving the change in bank loans differs from a specification involving a level of loans variable. Earlier work by Board staff found that the level of nonfinancial business demand deposits depended significantly on the level of business loans. More recent work by the staff suggests that over some periods the level of total bank loans is a significant determinant of the aggregate demand for demand deposits.

Their equation was estimated over the sample period mid-1976 to September 1979. Table 16 displays the M-1A errors from this equation monthly, quarterly, and annually over the last fiscal year. The equation comes closer to predicting the decline in money in 1980:2 than all the other equations, lending credence to the view that the imposition of credit controls helped to reduce money in that quarter.

This conclusion, of course, is conditional on the validity of the equation itself. Although the equation predicted adjusted M-1A growth quite accurately over fiscal 1980 as a whole, it registered relatively large errors in the first and final quarters of that period. Other evidence drawn from earlier periods raises questions about the robustness of this specific variant of the Judd-Scadding hypothesis. Attempts to explain demand deposit movements using this specification in other sample periods have not met with uniform success. Using the San Francisco specification--nominal money holdings on nominal income--the approach works only in the 1970s; it performs poorly in the 1960s as well as for the period from 1960 to mid-1974. Furthermore, a specification that imposes the property of homogenity of degree one in prices gives reasonable results only in the latter half of the 1970s, from mid-1976 to 1980. On balance, the explanatory power of the loan shock variable seems limited to recent years.[1/]

1/ The San Francisco model assumes that errors in the demand for money are uncorrelated over time, whereas an alternative specification currently being examined by the Board staff allows these errors to be correlated. In all other respects, this alternative specification is essentially the same as the San Francisco model. Preliminary results from this research suggest that the San Francisco approach may substantially overestimate--even over the late 1970s--both the size of the initial impact of bank loans on the money stock and the degree of money stock disequilibrium over time caused by such loan changes.

In summary, the overall record of the various money demand equations for fiscal years 1979 and 1980 is somewhat mixed. For the most recent two-year period as a whole, the forecasting record is not too bad by recent historical standards, particularly with respect to adjusted M-1A. The Porter-Simpson equation has the best record, with annual growth rate errors of less than 1 percent in both years, while the Wharton equation averages less than 1 percent for both years together. Also as noted, the San Francisco equation shows an error of less than 1 percent during fiscal 1980 as a whole. On the other hand, no single satisfactory explanation for the spectacular overprediction in the second quarter of 1980 has emerged. Some evidence suggests that these developments may well have reflected in part the effects of the imposition of credit controls on bank lending and, in turn, on money. Thus, while it may be noted that interest rate movements induced in the various equations slightly more quarterly variability in the predicted quantity of money demanded in fiscal year 1980 than in the previous fiscal year, our analysis as a whole indicates that other influences not captured in the standard equations significantly supplemented these effects.

CHART 1

ANNUALIZED GROWTH RATES OF M-1B
STANDARD DEVIATIONS

Current Seasonal Factors

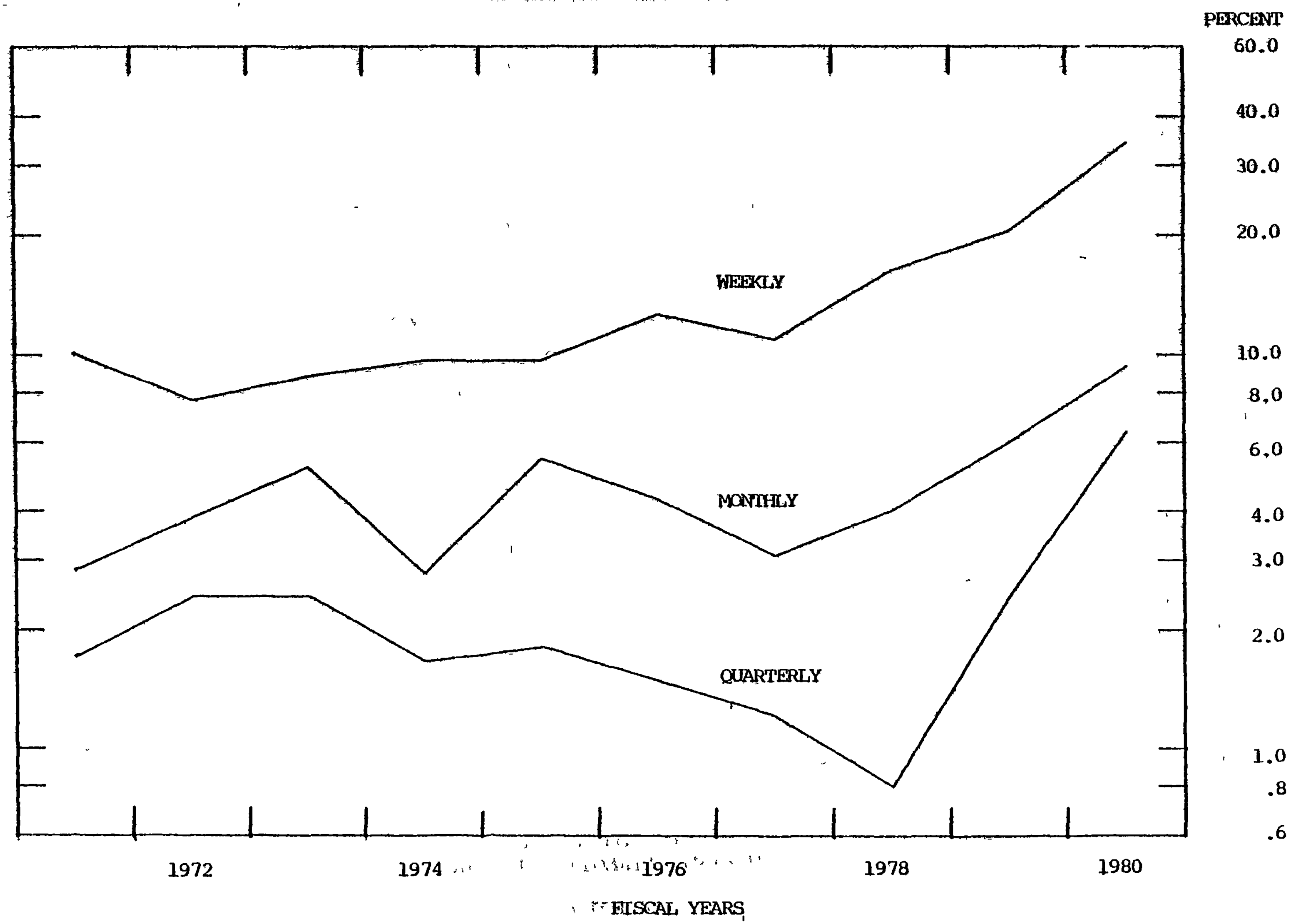


CHART 2

ANNUALIZED GROWTH RATES OF M-2
STANDARD DEVIATIONS

Current Seasonal Factors

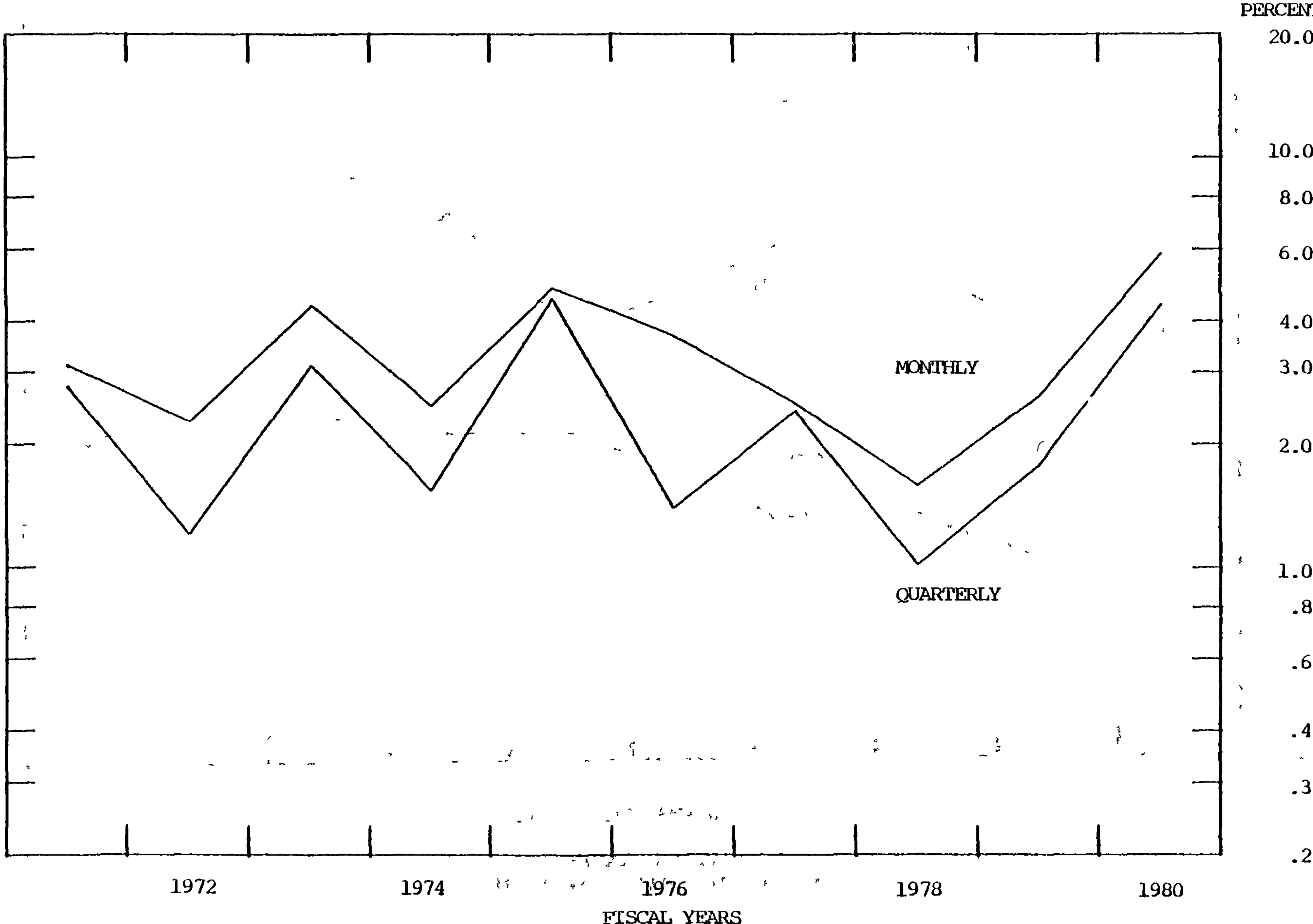


CHART 3

ANNUALIZED GROWTH RATES OF M-1B
STANDARD DEVIATIONS

Implied Original Seasonals

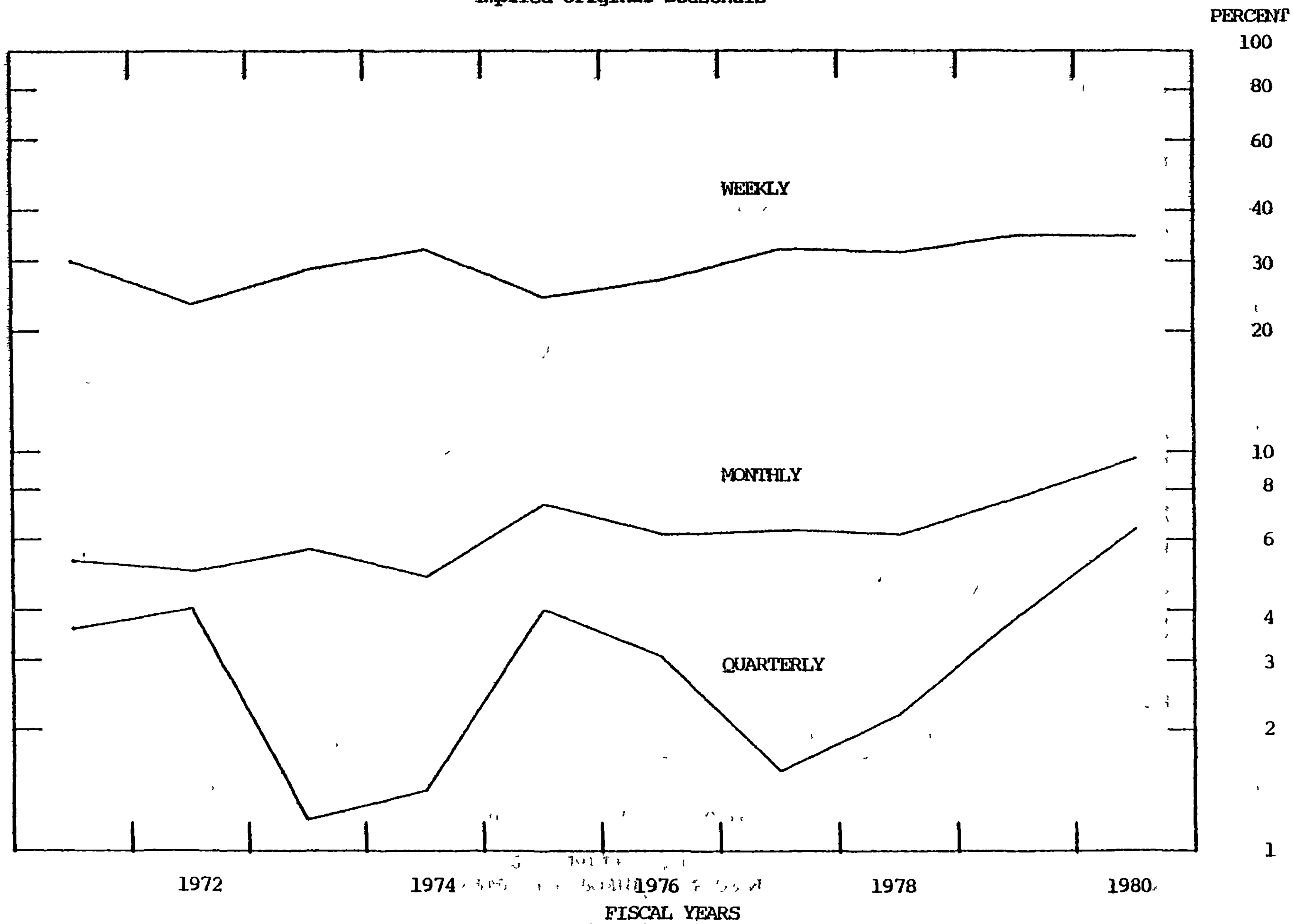


CHART 4

ANNUALIZED GROWTH RATES OF M-2
STANDARD DEVIATIONS

Implied Original Seasonals

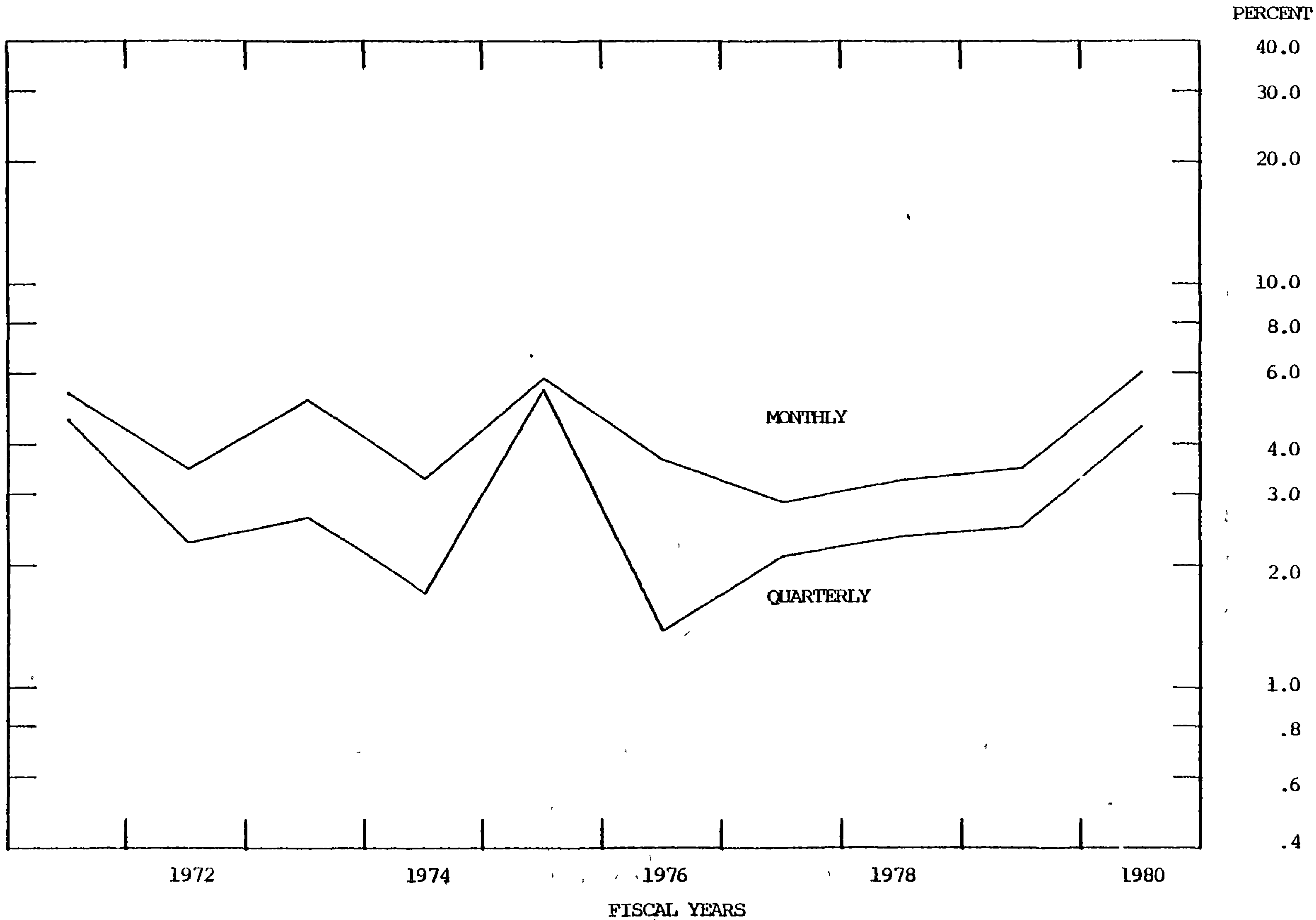


CHART 5

ANNUALIZED GROWTH RATES OF NONBORROWED RESERVES
STANDARD DEVIATIONS

Implied Original Seasonals

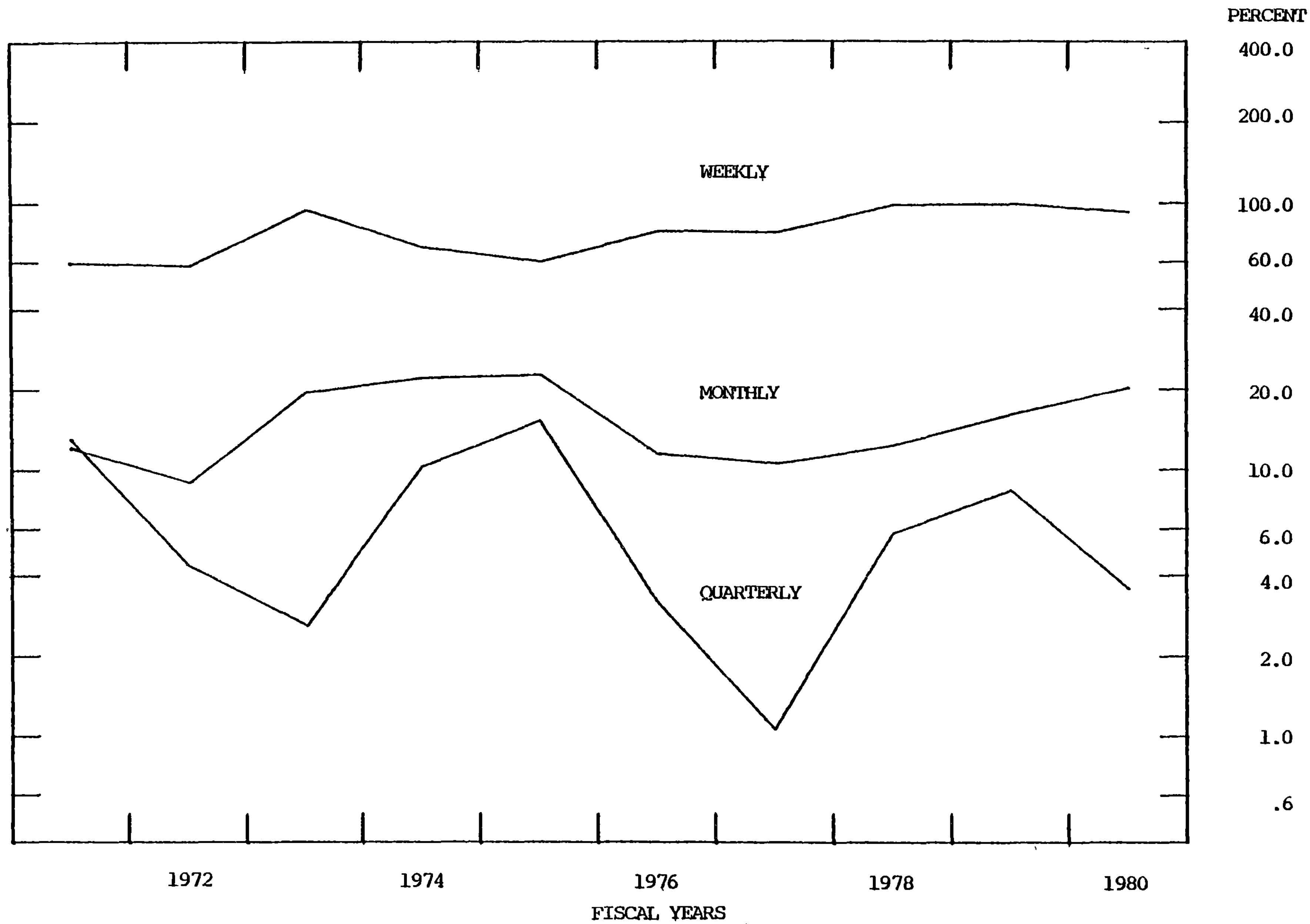


CHART 6

ANNUALIZED GROWTH RATES OF TOTAL RESERVES
STANDARD DEVIATIONS

Implied Original Seasonals

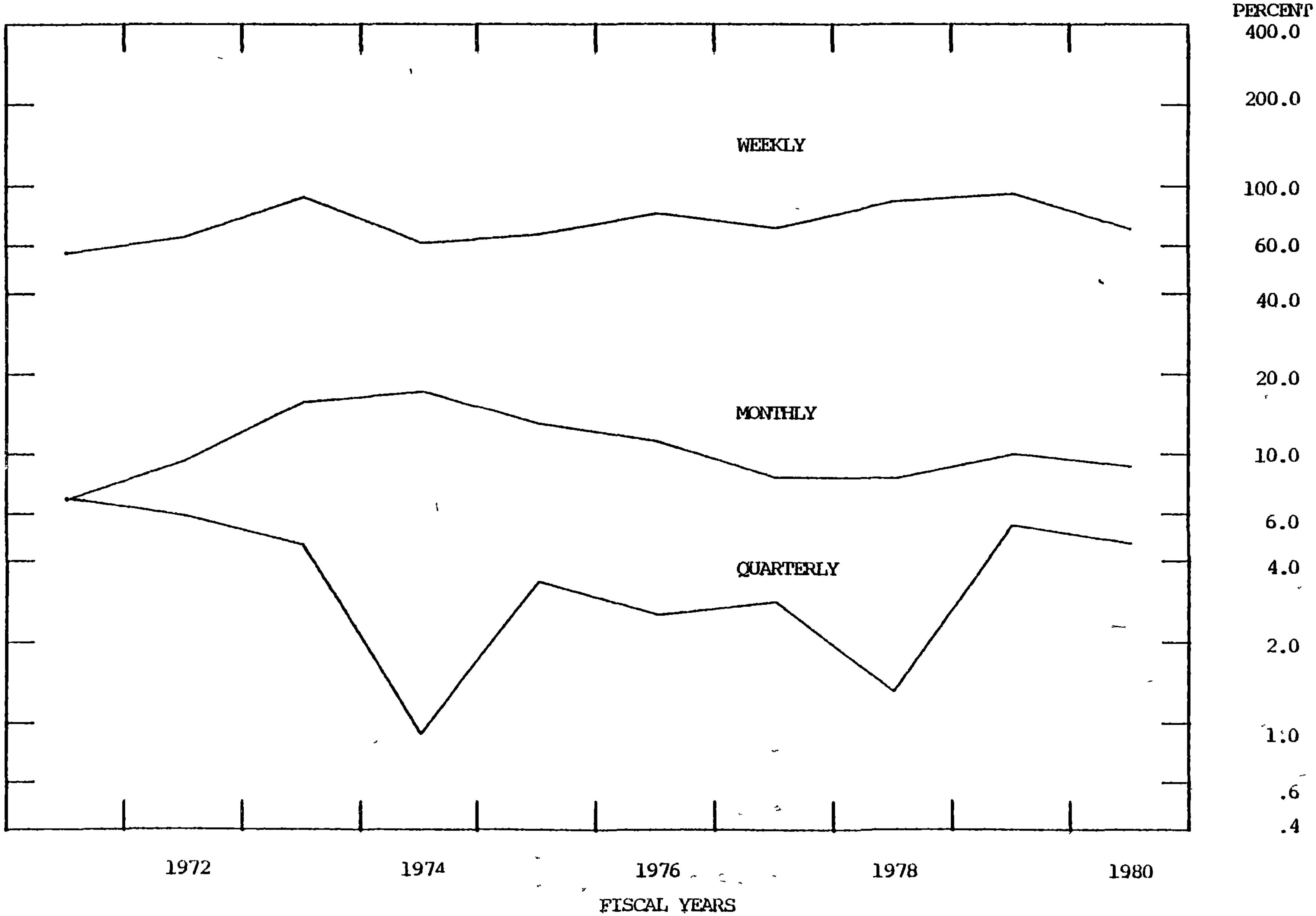
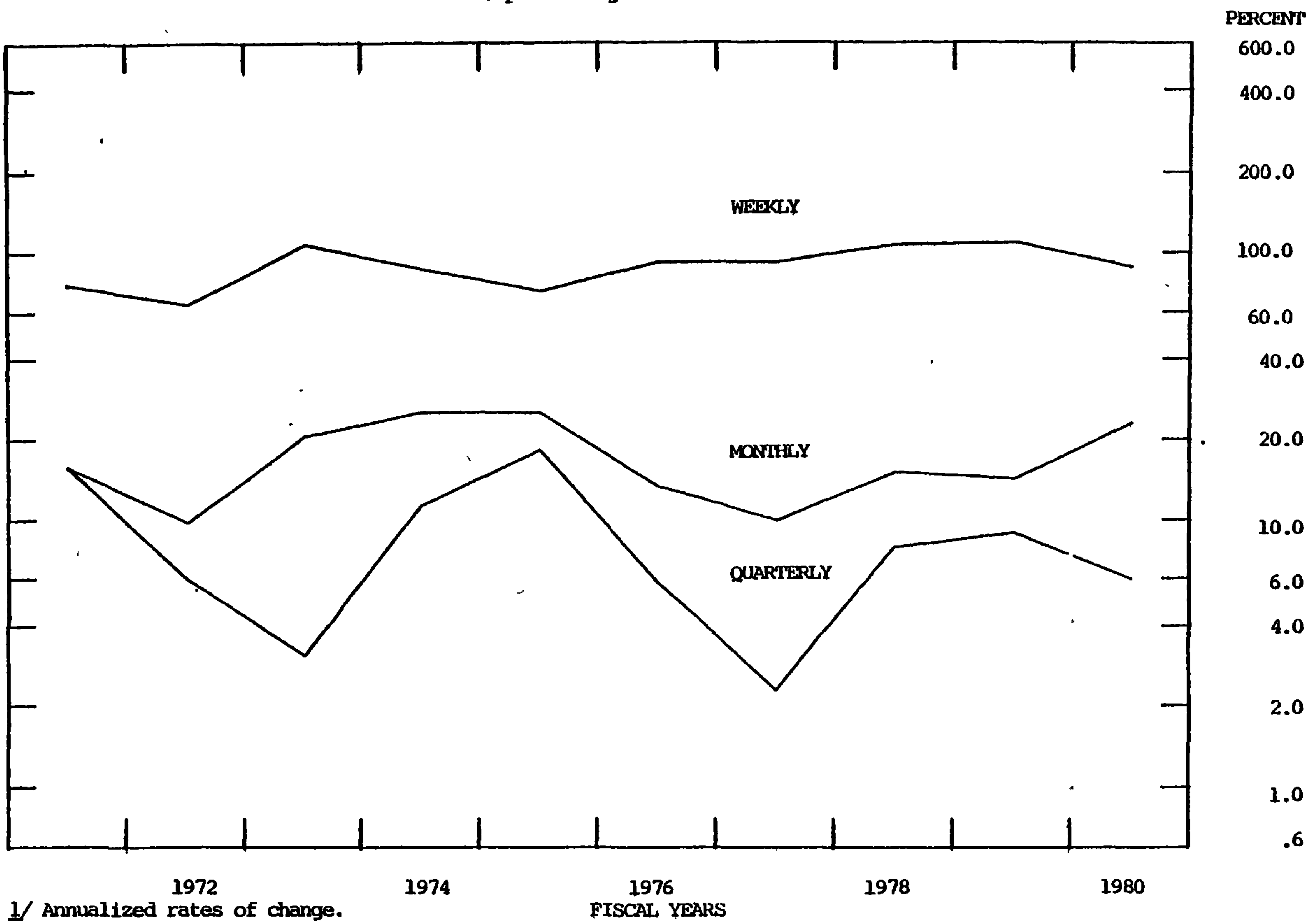


CHART 7

M-1B NONBORROWED RESERVE MULTIPLIERS 1/
STANDARD DEVIATIONS

Implied Original Seasonals

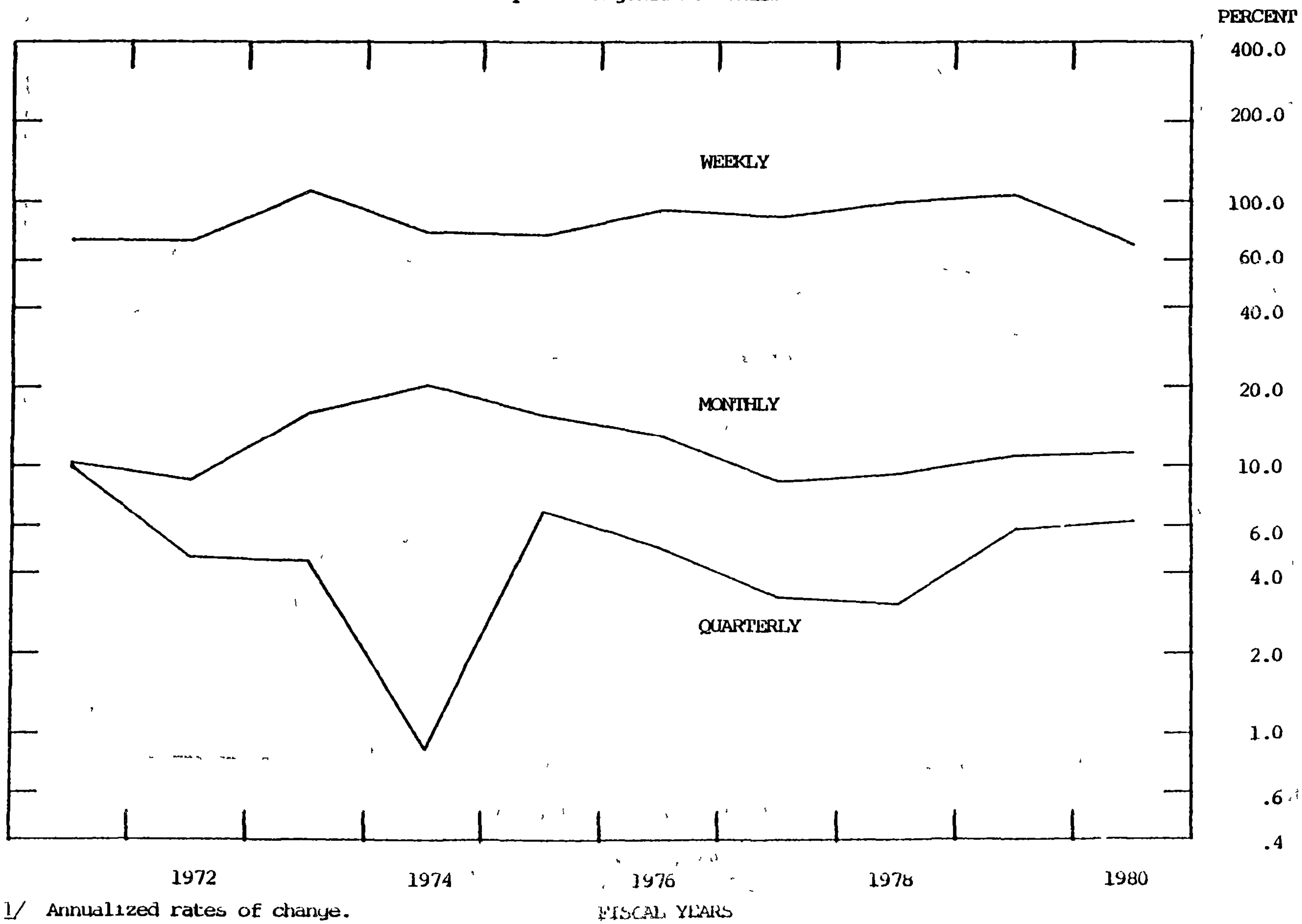


1/ Annualized rates of change.

CHART 8

M-1B TOTAL RESERVE MULTIPLIERS[1/]
STANDARD DEVIATIONS

Implied Original Seasonals



1/ Annualized rates of change.

TABLE 1

VARIABILITY OF QUARTERLY MONETARY GROWTH RATES IN MAJOR INDUSTRIAL COUNTRIES
(seasonally adjusted annual rates)

	Standard deviation	Mean	Standard deviation/Mean	Sample
Narrow Money				
Canada :ZM1	1.763	2.212	0.797	1973:Q1-1980:Q3
France : M1	1.349	2.545	0.530	1973:Q1-1980:Q3
Germany : M1	1.426	1.907	0.748	1973:Q1-1980:Q3
Japan : M1	1.976	2.483	0.800	1973:Q1-1980:Q3
Switzerland: M1	2.735	1.012	2.703	1973:Q1-1980:Q3
U.K. : M1	2.228	2.866	0.777	1973:Q1-1980:Q3
U.S. : M1A	0.690	1.369	0.504	1973:Q1-1980:Q3
Broad Money				
Canada : M2	0.931	3.501	0.266	1973:Q1-1980:Q3
France : M2	0.882	3.301	0.267	1973:Q1-1980:Q3
Germany : CBM	0.714	1.952	0.366	1973:Q1-1980:Q3
Japan : M2	0.888	3.013	0.295	1973:Q1-1980:Q3
Switzerland: M2	1.330	1.979	0.672	1975:Q4-1980:Q2
U.K. : LM3	1.879	3.151	0.596	1973:Q1-1980:Q3
U.S. : M2	0.777	2.316	0.335	1973:Q1-1980:Q3

TABLE 2

STANDARD DEVIATIONS OF M-1B, RESERVE MEASURES, AND ASSOCIATED MULTIPLIERS
MONTHLY AND QUARTERLY AVERAGE GROWTH RATES
SEASONALLY ADJUSTED USING IMPLIED ORIGINAL SEASONAL FACTORS
(in annualized percent changes)

	M-1B or M-2	Nonborrowed reserves			Total reserves			Nonborrowed monetary base			Total monetary base		
		Reserves	Multiplier	Correlation coefficient 1/	Reserves	Multiplier	Correlation coefficient 1/	Reserves	Multiplier	Correlation coefficient 1/	Reserves	Multiplier	Correlation coefficient 1/
Monthly Growth Rates													
M-1B													
1971-79 period	6.1	16.1	17.4	-0.94	11.6	13.1	-0.92	5.8	8.0	-0.65	4.7	6.9	-0.50
1979	7.6	16.0	14.1	-0.88	10.1	11.0	-0.74	5.8	7.6	-0.38	4.7	8.1	-0.39
1980	9.6#	20.2	22.8	-0.91	9.0	11.2	-0.59	6.3	10.4	-0.47	3.4	8.1	-0.17
M-2													
1971-79 period	4.2	16.1	17.4	-0.97	11.6	12.7	-0.94	5.8	7.4	-0.82	4.7	6.1	-0.73
1979	3.5	16.0	15.0	-0.98	10.1	9.3	-0.94	5.8	5.5	-0.81	4.7	4.8	-0.73
1980	6.0#*	20.2	20.3	-0.96	9.0	11.3	-0.85	6.3	6.8	-0.58	3.4	5.4	-0.13
Quarterly Average Growth Rates													
M-1B													
1971-79 period	3.0	8.5	10.2	-0.96	4.2	5.4	-0.83	3.0	4.7	-0.78	1.9	3.2	-0.40
1979	3.8	8.3	9.0	-0.91	5.4	5.8	-0.77	3.5	5.1	-0.67	2.8	4.5	-0.54
1980	6.4#	3.5#	5.9#	-0.15	4.6	6.2	-0.33	2.1	4.6	0.80	2.3	4.7	0.63
M-2													
1971-79 period	3.1	8.5	10.5	-0.97	4.2	5.6	-0.84	3.0	4.9	-0.80	1.9	3.5	-0.23
1979	2.5	8.3	7.6	-0.95	5.4	4.6	-0.89	3.5	3.5	-0.74	2.8	2.8	-0.30
1980	4.4	3.5#	2.7#	-0.01	4.6	5.7	-0.65	2.1	2.4#	0.91	2.3	3.3	0.21

1/ Correlation between reserve measure and associated multiplier.
The increased (or decreased) standard deviation for 1980 compared with that of the 1971-79 period is statistically significant at the 10 percent level.
* The increased (or decreased) standard deviation for 1980 compared with that of 1979 is statistically significant at the 10 percent level.

TABLE 3

STANDARD DEVIATIONS OF RATES OF CHANGE OF FOUR-WEEK AVERAGES OF
M-1B DIVIDED BY FOUR-WEEK AVERAGES OF RESERVE MEASURES, ALL NOT SEASONALLY ADJUSTED
(in annualized percent changes)

Reserve measure	Reserve measure not shifted forward (1)	Reserve measure shifted forward two weeks (2)	Higher variability associated with lagged reserve accounting (1) - (2)
Nonborrowed Reserves, NSA			
1971-79	26.9	16.1	10.8
1979	29.2	22.5	6.7
1980	34.8	30.7	4.1
Total Reserves, NSA			
1971-79	24.4	12.7	11.7
1979	28.0	16.2	11.8
1980	22.4	8.4	14.0
Nonborrowed Monetary Base, NSA			
1971-79	13.6	11.4	2.2
1979	13.5	11.3	2.2
1980	14.1	12.9	1.2
Total Monetary Base, NSA			
1971-79	13.5	11.3	2.2
1979	14.0	11.5	2.5
1980	13.1	11.8	1.3

TABLE 4

MONTHLY AVERAGE ERROR STATISTICS FOR MONTHLY RATE OF CHANGE OF MONEY MULTIPLIERS, NSA
JUDGMENTAL AND ECONOMETRIC FORECASTING TECHNIQUES
October 1979-October 1980
(in annualized percent)

	M-1A			M-1B			M-2		
	Mean error	Mean absolute error	RMS error	Mean error	Mean absolute error	RMS error	Mean error	Mean absolute error	RMS error
FORECASTING TECHNIQUES BY RESERVE MEASURE									
Nonborrowed Reserves									
Board Judgmental									
Initial Intermeeting Period 1/	2.6	13 7	16 2	2 7	12 7	14.9	n.a.	n a	n a
Adjusted Intermeeting Period 1/ 2/	2.8	10.7	13 5	3 0	9 9	12 0	n a	n a	n.a.
Current Month 3/	1.2	8.9	11.7	1 8	8 6	11 0	3 9	7 4	9.0
Johannes-Rasche	n.a.	n.a	n.a	-4 8	20.7	26 2	-3.4	19.4	23.4
Board Monthly Model	-9 2	19.9	25 9	-9 0	18 9	24 7	-8 5	22 6	26 3
San Francisco Model	13 8	31 0	35 8	13.6	31.4	36 0	n a	n.a.	n a
Total Reserves									
Board Judgmental									
Initial Intermeeting Period 1/	-4.4	9.0	10.7	-4 3	8 9	10 3	n a	n a.	n a
Adjusted Intermeeting Period 1/ 2/	-3 5	6 1	8 5	-3 4	6 5	8 2	n a	n a	n a
Current Month 3/	-1.9	5.0	6.1	-1 9	5 0	6 1	0.8	3 5	4 1
Johannes-Rasche	n a	n a	n.a	-3 0	14 6	16 6	-2.1	15 5	17 3
Board Monthly Model	-3.1	8 7	10 3	-2.8	8 2	9 5	-2.4	11.0	13.3
San Francisco Model	-5.4	15 6	20.0	-5 6	16 0	20.4	n a.	n a	n a.
Nonborrowed Monetary Base									
Board Judgmental									
Initial Intermeeting Period 1/	0.1	9.4	11.5	0.2	8.4	10 4	n a	n a	n a
Adjusted Intermeeting Period 1/ 2/	0 9	9 0	11 6	1.0	8 1	10 5	n a	n a.	n a
Current Month 3/	-0 3	5.1	6.5	0.3	4 5	5 6	2.4	3 1	3 8
Johannes-Rasche	n.a.	n a	n a.	-0 6	9 9	11.7	-0 2	5 8	7.0
Board Monthly Model	-3 7	6 9	9 2	-3 5	6.1	8 2	-3 1	8 0	9 0
San Francisco Model	2.6	9 0	11 0	2 4	9.4	11 2	n a	n a	n a.
Total Monetary Base									
Board Judgmental									
Initial Intermeeting Period 1/	-1.4	7 1	8 3	-1 3	6 1	7 2	n a	n a	n a.
Adjusted Intermeeting Period 1/ 2/	-0.4	7 5	9 6	-0 3	6 7	8 5	n a.	n a	n a
Current Month 3/	-1 1	4.7	5 6	-0 6	4.1	4 7	1.6	3.0	3 6
Johannes-Rasche	n.a.	n a.	n a.	-0.5	8.0	9 0	0.8	5 4	6 4
Board Monthly Model	-2 1	4 0	5 4	-1 9	4.0	5.0	-1.5	5 0	6 3
San Francisco Model	-2.3	6.3	8.3	-2 4	6.6	8.6	n a.	n a	n a

1/ From October 10, 1979 to February 6, 1980, projection errors of old M-1 are reported for M-1A and M-1B All the percent errors are annualized by 12 and include the October 29-November 19, 1980 period

2/ Error of initial multiplier forecast adjusted for intermeeting changes in targeted reserve path

3/ From October 1979 to January 1980, projection errors of old M-1 are reported for M-1A and M-1B and projection errors of old M-2 are reported for M-2.

n a.--not available

TABLE 5
FIRST PROCEDURE
ERROR STATISTICS FOR THE MONTHLY RATE OF GROWTH OF THE MONETARY AGGREGATES, NSA
ACTUAL VERSUS TARGFTED AND ACTUAL VERSUS PREDICTED FROM ECONOMETRIC MODELS
October 1979-October 1980
(in annualized percent)

	M-1A			M-1B			M-2		
	Mean error	Mean absolute error	RMS error	Mean error	Mean absolute error	RMS error	Mean error	Mean absolute error	RMS error
FOMC INTERIM MONEY STOCK TARGETS									
Intermeeting Period Path 1/	-0.9	8 6	11 0	-0.9	7 6	9.8	n a.	n a	n.a
Current Month Path 2/	-1.5	4.9	6 0	-1 0	4.2	5 0	1.2	3 1	3 4
ECONOMETRIC PROCEDURES BY RESERVE MEASURE									
Nonborrowed Reserves									
Board Monthly Model									
Given Actual Nonborrowed Reserves	-2.4	4 6	7.0	-2.1	4.8	6.5	-1.9	5 3	6.4
San Francisco Model									
Given Actual Nonborrowed Reserves	0.4	4 2	5.4	0.1	4 4	5.6	n.a.	n.a	n.a
Total Reserves									
Board Monthly Model									
Given Exogenous Total Reserves 3/	-5.6	17.3	23.1	-4.6	13.2	18.6	-6.4	20.1	24.4
San Francisco Model									
Given Exogenous Total Reserves 3/	-0 8	8 1	10 6	0.5	8.3	10 6	n a	n.a	n.a
Nonborrowed Monetary Base									
Board Monthly Model									
Given Exogenous Nonborrowed Base 3/	-2.0	4 0	6 1	-1 7	3.9	5.6	-4.5	6 8	8.4
San Francisco Model									
Given Exogenous Nonborrowed Base 3/	1.0	3 0	3.3	0.9	2 8	3 2	n a	n.a	n.a.
Total Monetary Base									
Board Monthly Model									
Given Fxogenous Total Base 3/	-3 1	10 0	12.3	-3.7	7.9	9 9	-5.1	13 4	15 5
San Francisco Model									
Given Exogenous Total Base 3/	0.4	5 5	8 5	0.4	5 3	8.1	n.a.	n a	n a.
Memo									
Board Monthly Model Required Reserve Ratio on Demand Deposits and Required Reserves Against Savings and Time Deposits Known With Certainty									
Given Actual Nonborrowed Reserves	-2.4	4.7	7 1	-2.2	4.9	6.6	-2.0	4.8	5 9
Given Exogenous Total Reserves 3/	-0.8	2.2	2.9	-1 8	5 5	7.0	-3.8	6.1	8 0
Given Exogenous Nonborrowed Base 3/	-2 0	3 8	5 9	-1.7	3.8	5.5	-4 6	6 8	8 2
Given Exogenous Total Base 3/	0.6	5 6	7.3	-0 7	4.4	5 9	-2.2	8.5	10 0
Board Monthly Model Borrowing Ratio to Deposits Function as Well as Required Reserve Ratio on Demand Deposits and Required Reserves Against Savings and Time Deposits Known With Certainty									
Given Actual Nonborrowed Reserves	-2.0	4.4	6.3	-1.8	4.7	6.1	-1.5	3.7	4.9
Given Exogenous Total Reserves 3/	-0.8	2 2	2.9	-1.8	5.5	7 0	-3.8	6 1	8.0
Given Exogenous Nonborrowed Base 3/	-1.9	3.6	5 5	-1.6	3 7	5 3	-4 3	6.0	7.6
Given Exogenous Total Base 3/	0 6	5.6	7 3	-0.7	4 4	5.9	-2.2	8 5	10.0
Federal Funds Rate									
Board Monthly Model									
Given Actual Federal Funds Rate	-2.2	4 8	6 8	-2.0	5 0	6.5	-1 5	3.4	4 8
Given Judgmental Federal Funds Rate	-2 3	4 9	6 9	-2 1	5 1	6.6	-1.6	3 6	5 0
San Francisco Model									
Given Actual Federal Funds Rate	-0.5	4.2	5.0	-0 6	4 3	5 2	n.a.	n.a	n a
Given Judgmental Federal Funds Rate	-0.5	4.0	5.2	-0 7	4.6	5 4	n.a	n.a.	n a.

1/ From October 10, 1979 to February 6, 1980, errors for old M-1 are reported for M-1A and M-1B. All the percent errors are annualized by 12 and include the October 29-November 19, 1980 intermeeting period.

2/ From October 1979 to January 1980, projection errors for old M-1 are reported for M-1A and M-1B and errors for old M-2 are reported for new M-2.

3/ The exogenous level is equal to the model's prediction of this reserve aggregate given the actual level of nonborrowed reserves.

n a.—not available

TABLE 6
SECOND PROCEDURE
ERROR STATISTICS FOR THE MONTHLY RATE OF GROWTH OF THE MONETARY AGGREGATES, NSA
ACTUAL VERSUS TARGETED AND ACTUAL VFRSUS PREDICTED FROM ECONOMETRIC MODELS
October 1979-October 1980
(in annualized percent)

	M-1A			M-1B			M-2		
	Mean error	Mean absolute error	RMS error	Mean error	Mean absolute error	RMS error	Mean error	Mean absolute error	RMS error
FOMC INTERIM MONEY STOCK TARGETS									
Intermeeting Period Path 1/	-0 9	8.6	11 0	-0.9	7.6	9.8	n a.	n.a.	n a.
Current Month Path 2/	-1.5	4.9	6.0	-1.0	4.2	5.0	1.2	3.1	3 4
ECONOMETRIC PROCEDURES BY RESERVE MEASURE 3/									
Nonborrowed Reserves									
Board Monthly Model									
Given Exogenous Nonborrowed Reserves	-2.5	6 7	9.5	-2 1	6.0	8 2	-4.9	8.4	10.9
San Francisco Model									
Given Exogenous Nonborrowed Reserves	0.1	4 2	5.2	0 0	4.0	4.9	n.a	n.a.	n.a
Total Reserves									
Board Monthly Model									
Given Exogenous Total Reserves	-5.5	17.3	23.1	-4 6	13 2	18.6	-6.0	19 6	24.0
San Francisco Model									
Given Exogenous Total Reserves	0 8	7 2	9.4	0.8	6 8	9 0	n a.	n a.	n a
Nonborrowed Monetary Base									
Board Monthly Model									
Given Exogenous Nonborrowed Base	-0.3	6.9	9 8	-0.4	5.5	7 5	-2.8	8 6	10 5
San Francisco Model									
Given Exogenous Nonborrowed Base	0 1	4.2	5 1	0.1	4.0	4.9	n.a	n.a	n.a.
Total Monetary Base									
Board Monthly Model									
Given Exogenous Total Base	-3.1	9.3	11.8	-2.5	8 4	10.4	-4 2	14.5	17.3
San Francisco Model									
Given Exogenous Total Base	-0.3	6.7	9.4	-0.3	6 4	8 9	n a	n a	n.a.
Memo									
Board Monthly Model Required Reserve Ratio on Demand Deposits and Required Reserves Against Savings and Time Deposits Known With Certainty 3/									
Given Exogenous Nonborrowed Reserves	-2.2	6.6	9.2	-1.9	5 8	7.9	-4.7	8 6	10 7
Given Exogenous Total Reserves	-0.8	2.1	2 9	-0 7	3.7	4.9	-3 3	10 2	12.9
Given Exogenous Nonborrowed Base	-0.4	6 8	9 6	-0.5	5.4	7 2	-3.0	8.3	10 2
Given Exogenous Total Base	0.2	5 0	5.8	-0.1	5.4	7.4	-2.1	9 8	12.4
Board Monthly Model Borrowing Ratio to Deposits Function as well as Required Reserve Ratio on Demand Deposits and Required Reserves Against Savings and Time Deposits Known With Certainty 3/									
Given Exogenous Nonborrowed Reserves	-0.6	5 5	7 8	-0 6	5.1	7 0	-3 4	7.5	9.7
Given Exogenous Total Reserves	-0 8	2 1	2.9	-0.7	3.7	4 9	-3 3	10.2	12.9
Given Exogenous Nonborrowed Base	-1 4	3.7	5 5	-1.2	4 0	5.4	-3.7	5.7	7 4
Given Exogenous Total Base	0.2	5.0	5.8	-0 1	5.4	7.4	-2.1	9.8	12.4
Federal Funds Rate									
Board Monthly Model									
Given Actual Federal Funds Rate	-2 2	4 8	6.8	-2 0	5.0	6 5	-1.5	3 4	4.8
Given Judgmental Federal Funds Rate	-2 3	4 9	6.9	-2.1	5.1	6 6	-1 6	3 6	5 0
San Francisco Model									
Given Actual Federal Funds Rate	-0.5	4 2	5.0	-0.6	4 3	5.2	n a.	n.a.	n a.
Given Judgmental Federal Funds Rate	-0 5	4 0	5 2	-0.7	4.6	5.4	n a	n a.	n.a.

1/ From October 10, 1979 to February 6, 1980, errors for old M-1 are reported for M-1A and M-1B. All the percent errors are annualized by 12 and include the October 29-November 19, 1980 intermeeting period.

2/ From October 1979 to January 1980, projection errors for old M-1 are reported for M-1A and M-1B and errors for old M-2 are reported for new M-2

3/ The exogenous level of each reserve measure is equal to the model's prediction of this reserve aggregate given the judgmental prediction of the federal funds rate

n a.--not available

TABLE 7

FIRST PROCEDURE

ERROR STATISTICS FOR THE QUARTERLY RATE OF GROWTH OF THE MONETARY AGGREGATES, NSA
ACTUAL VERSUS TARGETED AND ACTUAL VERSUS PREDICTED FROM ECONOMETRIC MODELS
October 1979-September 1980
(in annualized percent)

	M-1A			M-1B			M-2		
	Mean error	Mean absolute error	RMS error	Mean error	Mean absolute error	RMS error	Mean error	Mean absolute error	RMS error
FOMC INTERIM MONEY STOCK TARGETS									
Intermeeting Period Path 1/ 2/	-0.3	2 2	2.8	-0.3	1.8	2.4	n.a.	n.a.	n.a
Current Month Path 2/ 3/	-0.5	1.1	1.4	-0.4	0.9	1.1	0.4	0.7	0.8
ECONOMETRIC PROCEDURES BY RESERVE MEASURE 3/									
Nonborrowed Reserves									
Board Monthly Model									
Given Actual Nonborrowed Reserves	-0.9	0.9	1.1	-0.8	0 8	1.2	-0.6	1.0	1.1
San Francisco Model									
Given Actual Nonborrowed Reserves	0.2	1.1	1 5	0.1	1.2	1.6	n.a	n a.	n.a.
Total Reserves									
Board Monthly Model									
Given Exogenous Total Reserves 4/	-2.8	3 1	5.1	-2 3	3 1	4.4	-2.8	5.6	6.7
San Francisco Model									
Given Exogenous Total Reserves 4/	0.7	2.0	2.7	0.6	2.2	2 8	n.a.	n.a.	n.a.
Nonborrowed Monetary Base									
Board Monthly Model									
Given Exogenous Nonborrowed Base 4/	-0.7	0 7	0.9	-0 7	0.7	1.0	-1.5	2.3	2.5
San Francisco Model									
Given Exogenous Nonborrowed Base 4/	0.1	0 7	1.0	0.2	0.8	1 1	n.a.	n.a.	n.a.
Total Monetary Base									
Board Monthly Model									
Given Exogenous Total Base 4/	-0.8	1.8	2 2	-1.2	1.2	1.5	-1.5	2 6	3 1
San Francisco Model									
Given Exogenous Total Base 4/	0 5	1.7	2.1	0 4	1.6	2.1	n a.	n.a.	n a
Federal Funds Rate 3/									
Board Monthly Model									
Given Actual Federal Funds Rate	-0.8	1.0	1.3	-0.8	0.9	1.4	-0 6	0.6	0.7
Given Judgmental Federal Funds Rate	-0.9	1.0	1 2	-0.8	0.9	1.3	-0.6	0.6	0.8
San Francisco Model									
Given Actual Federal Funds Rate	0.0	1.1	1 4	-0.1	1.1	1.4	n.a.	n.a.	n.a.
Given Judgmental Federal Funds Rate	0.0	1 2	1.5	0.0	1.0	1.4	n.a.	n.a	n.a.

1/ Quarterly" errors calculated as averages of three adjoining intermeeting periods, annualized by a factor of 4. (Averages of four adjoining intermeeting periods give very similar results.)
2/ From October 1979 to January 1980, projection errors for old M-1 are reported for M-1A and M-1B and errors for old M-2 are reported for new M-2.
3/ Quarterly errors calculated as three-month averages of monthly percent errors in each calendar quarter annualized by a factor of 4.
4/ The exogenous level is equal to the model's prediction of this reserve aggregate given the actual level of nonborrowed reserves.
n.a.--not available

TABLE 8

SECOND PROCEDURE

ERROR STATISTICS FOR THE QUARTERLY RATE OF GROWTH OF THE MONETARY AGGREGATES, NSA
ACTUAL VERSUS TARGETED AND ACTUAL VERSUS PREDICTED FROM ECONOMETRIC MODELS
October 1979-September 1980
(in annualized percent)

	M-1A			M-1B			M-2		
	Mean error	Mean absolute error	RMS error	Mean error	Mean absolute error	RMS error	Mean error	Mean absolute error	RMS error
FOMC INTERIM MONEY STOCK TARGETS									
Intermeeting Period Path1/2/	-0.3	2.2	2.8	-0.3	1.8	2.4	n.a.	n.a.	n.a.
Current Month Path2/3/	-0.5	1.1	1 4	-0.4	0.9	1.1	0.4	0.7	0.8
ECONOMETRIC PROCEDURES BY RESERVE MEASURE4/									
Nonborrowed Reserves									
Board Monthly Model									
Given Exogenous Nonborrowed Reserves	-0.9	0.9	1.1	-0.8	0 8	1.0	-1.7	2.6	2.7
San Francisco Model									
Given Exogenous Nonborrowed Reserves	-0.1	1.1	1.3	-0 1	1.0	1.3	n a.	n.a.	n a.
Total Reserves									
Board Monthly Model									
Given Exogenous Total Reserves	-2.8	3.1	5.1	-2 3	3.1	4.4	-2.7	5.4	6.5
San Francisco Model									
Given Exogenous Total Reserves	0.7	1.8	2.5	0.7	1.8	2.4	n.a.	n.a.	n.a.
Nonborrowed Monetary Base									
Board Monthly Model									
Given Exogenous Nonborrowed Base	-0.1	0.8	1.0	-0.2	0.6	0.6	-0.9	2.6	2.8
San Francisco Model									
Given Exogenous Nonborrowed Base	-0.1	1.1	1 3	-0.1	1 0	1.3	n.a.	n.a.	n.a
Total Monetary Base									
Board Monthly Model									
Given Exogenous Total Base	-0.8	1 5	1.9	-0.7	1 7	2.0	-1 2	3 9	4.3
San Francisco Model									
Given Exogenous Total Base	0.0	1.7	2.3	0.0	1.6	2.2	n.a.	n.a.	n.a.
Federal Funds Rate									
Board Monthly Model									
Given Actual Federal Funds Rate	-0.8	1.0	1.3	-0.8	0.9	1.4	-0.6	0.6	0.7
Given Judgmental Federal Funds Rate	-0.9	1.0	1.2	-0.8	0.9	1.3	-0 6	0.6	0 8
San Francisco Model									
Given Actual Federal Funds Rate	0.0	1.1	1.4	-0.1	1.1	1.4	n.a.	n.a.	n.a.
Given Judgmental Federal Funds Rate	0 0	1.2	1.5	0.0	1.0	1.4	n.a	n.a.	n a.

1/ 'Quarterly" errors calculated as averages of three adjoining intermeeting periods, annualized by a factor of 4. (Averages of four adjoining intermeeting periods give very similar results.)

2/ From October 1979 to January 1980, projection errors for old M-1 are reported for M-1A and M-1B and errors for old M-2 are reported for new M-2.

3/ Quarterly errors calculated as three-month averages of monthly percent errors in each calendar quarter, annualized by a factor of 4.

4/ The exogenous level is equal to the model's prediction of this reserve aggregate given the judgmental prediction of the federal funds rate.

n.a.--not available.

TABLE 9

SUMMARY OF EQUATION ELASTICITIES FOR SELECTED VARIABLES

Equation	Prices		Real income		T-bill, federal funds, commercial paper rate		Passbook rate		Dividend-price ratio		Bond rate		Other 1/	
	Current	Past	Current	Past	Current	Past	Current	Past	Current	Past	Current	Past	Current	Past
MPS	1.000	0	.317	.642	-.050 2/	-.045 3/	-.017	-.112						
Porter-Simpson	1.000	0	.331	.205	.002	-.040	-.037	0					-.053	.026
Wharton	1.000	0	.469	-.047	-.030 4/	-.197 4/	-.030 5/	-.197 5/					-.025	.025
Hamburger	.036	.964	.036	.964			.077	.183	-.039	-1.015	-.003	-.078		
DRI	.211	.584	.128	.355	-.007	-.019	.003	.007	-.060	-.165			-.016	-1.56

1/ The other variables are as follows: MPS, time trend = -1.52 percent per year; Porter-Simpson, opportunity cost of cash management proxy with the table entry being the elasticity evaluated at the 1979:4-1980:3 mean of this proxy, 53.23; Wharton, elasticity with respect to the discount rate; DRI, sum of elasticities with respect to lagged stocks of nonfinancial corporate holdings of Treasury and agency bonds [-.012, -.033 current and past] and with respect to lagged stocks of other deposits (mainly large CDs, flow-of-funds concept) [-.004, -.123 current and past].

2/ Sum of T-bill rate elasticity (-.041) and federal funds rate elasticity (-.009).

3/ Sum of lagged T-bill rate elasticities. Lagged funds rates not in equation.

4/ Evaluated at 0.10 for commercial paper rate.

5/ Evaluated at 0.05 for passbook rate.

TABLE 10

SUMMARY OF SIMULATION DECOMPOSITIONS, 1978:3-1979:3 AND 1979:3-1980:3
(percent rate of change from preceding period based on seasonally adjusted data)1/

Equation	Actual M-1A	Adjusted M-1A 2/	Predicted M-1A	Error (actual M-1A minus predicted)	Error (adjusted M-1A minus predicted)	Predicted M-1A due to movement in: pre-77:4 3/ values	post-77:3 prices	post-77:3 real income	post-77:3 interest rates	other 4/
A. 1978:3-1979:3										
MPS	5.1	7.0	7.8	-2.7	-0.8	0.2	8.5	2.7	-2.2	-1.3
Porter-Simpson	5.1	7.0	7.9	-2.8	-0.9	0.0	8.9	1.1	-1.5	-0.4
Wharton	5.1	7.0	7.5	-2.4	-0.5	-0.5	8.5	2.2	-2.6	—
Hamburger	5.1	7.0	3.6	1.5	3.4	3.2	1.7	0.7	-1.9	--
DRI	5.1	7.0	9.3	-4.2	-2.3	0.7	6.4	1.7	-0.8	2.2
B. 1979:3-1980:3										
MPS	4.0	5.0	7.4	-3.4	-2.4	0.1	9.4	0.0	-0.7	-1.2
Porter-Simpson	4.0	5.0	5.7	-1.7	-0.7	0.0	9.3	-0.6	-1.2	-1.6
Wharton	4.0	5.0	6.2	-2.2	-1.2	-0.5	9.5	-0.6	2.0	--
Hamburger	4.0	5.0	4.0	0.0	1.0	2.7	2.6	0.6	-1.9	—
DRI	4.0	5.0	8.9	-4.9	-3.9	0.2	7.6	0.3	-0.3	1.2

1/ The percent changes are changes in natural logarithms multiplied by 100.

2/ The adjustments are based on the assumption that the introduction of ATS accounts nationwide, NOW accounts in the Northeast, and savings accounts for businesses and for state and local governments has had a depressing effect on M-1A growth. An adjusted M-1A series is constructed as an estimate of what M-1A would have been if these new deposit categories had not been created. The series added to M-1A essentially consists of two-thirds of other checkable deposits, one-fourth of business savings deposits, and one-fifth of state and local savings deposits. Since the latter two series tend to fluctuate with interest rates, the actual adjustment is made by assuming that these series grow at half the rate of increase of nominal income after the initial introductory phase for each.

3/ That is, for a given row (equation), this column represents the effects of pre-1977:4 movements in all the variables for which there are entries in subsequent columns.

4/ "Other" variables differ by equation and are as follows: MPS, time trend; Simpson-Porter, interest rate ratchet variable as proxy for the opportunity cost of cash management services; DRI, prior-period stocks of nonfinancial corporate holdings of government bonds and time deposits (primarily large CDs).

TABLE 11

BOARD'S QUARTERLY ECONOMETRIC MODEL EQUATION (MPS)[1]
(percent rate of change from preceding period, annualized, based on seasonally adjusted data)[2]

Date	Actual M-1A	Adjusted M-1A	Predicted M-1A	Error (actual M-1A minus predicted)	Error (adjusted M-1A minus predicted)	Predicted M-1A due to movement in: pre-77:4 values[3]	post-77:3 prices	post-77:3 real income	post-77:3 interest rates	time trend
1978:4	5.5	6.8	8.8	-3.3	-2.0	0.4	7.7	5.4	-3.3	-1.3
1979:1	0.2	3.3	7.3	-7.1	-4.0	0.3	8.5	2.6	-2.8	-1.3
1979:2	7.2	9.2	7.6	-0.4	1.6	0.2	8.6	1.6	-1.5	-1.3
1979:3	7.8	8.9	6.7	1.1	2.2	0.1	8.2	1.0	-1.4	-1.2
1979:4	4.5	4.7	4.3	0.2	0.4	0.1	8.2	0.9	-3.6	-1.2
1980:1	4.8	5.5	6.6	-1.8	-1.1	0.1	9.2	2.2	-3.5	-1.2
1980:2	-3.9	-2.8	8.7	-12.6	-11.5	0.0	10.1	-2.0	1.8	-1.2
1980:3	11.0	12.4	9.0	2.0	3.4	0.0	8.9	-1.1	2.4	-1.2
1978:3-79:3	5.1	7.0	7.8	-2.7	-0.8	0.2	8.5	2.7	-2.2	-1.3
1979:3-80:3	4.0	5.0	7.4	-3.4	-2.4	0.1	9.4	0.0	-0.7	-1.2

1/ The MPS equation is for demand deposits. Predicted values from a separate currency equation were added to demand deposit predicted values to obtain M-1A predicted values.
2/ The percent changes are changes in natural logarithms multiplied by 100.
3/ That is, pre-1977:4 movements in all variables that appear in subsequent columns.

TABLE 12

PORTER-SIMPSON EQUATION[1]
(percent rate of change from preceding period, annualized, based on seasonally adjusted data)[2]

Date	Actual M-1A	Adjusted M-1A	Predicted M-1A	Error (actual M-1A minus predicted)	Error (adjusted M-1A minus predicted)	Predicted M-1A due to movement in: pre-77:4[3] values	post-77:3 prices	post-77:3 real income	post-77:3 interest rates	post-77:3 cash management[4]
1978:4	5.5	6.8	9.2	-3.7	-2.4	0.0	8.3	2.6	-0.7	-1.2
1979:1	0.2	3.3	8.6	-8.4	-5.3	0.0	8.9	1.4	-1.2	-0.6
1979:2	7.2	9.2	6.2	1.0	3.0	0.0	8.9	-0.4	-2.1	-0.2
1979:3	7.8	8.9	7.0	-0.8	1.9	0.0	8.2	0.6	-2.3	0.4
1979:4	4.5	4.7	6.4	-1.9	-1.7	0.0	8.0	1.1	-0.7	-2.1
1980:1	4.8	5.5	3.0	1.8	2.5	0.0	9.1	0.8	-0.6	-6.3
1980:2	-3.9	-2.8	3.4	-7.3	-6.2	0.0	10.2	-3.1	-1.9	-1.9
1980:3	11.0	12.4	9.8	1.2	2.6	0.0	8.7	-1.4	-1.4	4.0
1978:3-79:3	5.1	7.0	7.9	-2.8	-0.9	0.0	8.9	1.1	-1.5	-0.4
1979:3-80:3	4.0	5.0	5.7	-1.7	-0.7	0.0	9.3	-0.6	-1.2	-1.6

1/ The Porter-Simpson equation is for M-1A.
2/ The percent changes are changes in natural logarithms multiplied by 100.
3/ That is, pre-1977:4 movements in all variables that appear in subsequent columns.
4/ This variable is a proxy for the opportunity cost of investment in cash management services.

TABLE 13

WHARTON MODEL EQUATION[1]
(percent rate of change from preceding period, annualized, based on seasonally adjusted data)[2]

Date	Actual M-1A	Adjusted M-1A	Predicted M-1A	Error (actual M-1A minus predicted)	Error (adjusted M-1A minus predicted)	Predicted M-1A due to movement in: pre-77:4[3] values	post-77:3 prices	post-77:3 real income	post-77:3 interest rates
1978:4	5.5	6.8	7.6	-2.1	-0.8	-0.1	7.6	4.0	-3.9
1979:1	0.2	3.3	7.7	-7.5	-4.4	-0.5	8.3	2.1	-2.3
1979:2	7.2	9.2	6.9	0.3	2.3	-0.9	8.9	0.2	-1.4
1979:3	7.8	8.9	7.0	0.8	1.9	-0.7	8.1	2.4	-2.7
1979:4	4.5	4.7	4.4	0.1	0.3	-0.6	7.5	2.4	-5.0
1980:1	4.8	5.5	5.5	-0.7	0.0	-0.6	9.0	1.3	-4.3
1980:2	-3.9	-2.8	4.4	-8.3	-7.2	-0.5	10.6	-5.2	-0.5
1980:3	11.0	12.4	9.8	1.2	2.6	-0.4	9.4	-1.0	1.8
1978:3-79:3	5.1	7.0	7.5	-2.4	-0.5	-0.5	8.5	2.2	-2.6
1979:3-80:3	4.0	5.0	6.2	-2.2	-1.2	-0.5	9.5	-0.6	-2.0

1/ The Wharton equation is for demand deposits. Predicted values from a separate currency equation were added to demand deposit predicted values to obtain M-1A predicted values.
2/ The percent changes are changes in natural logarithms multiplied by 100.
3/ That is, pre-1977:4 movements in all variables that appear in subsequent columns.

TABLE 14

HAMBURGER EQUATION[1]
(percent rate of change from preceding period, annualized, based on seasonally adjusted data)[2]

Date	Actual M-1A	Adjusted M-1A	Predicted M-1A	Error (actual M-1A minus predicted)	Error (adjusted M-1A minus predicted)	Predicted M-1A due to movement in: pre-77:4[3] values	post-77:3 prices	post-77:3 real income	post-77:3 interest rates
1978:4	5.5	6.8	3.4	2.1	3.4	3.3	1.3	0.7	-1.8
1979:1	0.2	3.3	3.5	-3.3	-0.2	3.2	1.5	0.7	-1.9
1979:2	7.2	9.2	3.3	3.9	5.9	3.1	1.8	0.6	-2.2
1979:3	7.8	8.9	4.0	3.8	4.9	3.0	2.0	0.7	-1.7
1979:4	4.5	4.7	3.4	1.1	1.3	2.8	2.2	0.7	-2.4
1980:1	4.8	5.5	3.8	1.0	1.7	2.7	2.5	0.8	-2.2
1980:2	-3.9	-2.8	3.1	-7.0	-5.9	2.6	2.8	0.4	-2.7
1980:3	11.0	12.4	5.4	5.6	7.0	2.6	3.0	0.4	-0.5
1978:3-79:3	5.1	7.0	3.6	1.5	3.4	3.2	1.7	0.7	-1.9
1979:3-80:3	4.0	5.0	4.0	0.0	1.0	2.7	2.6	0.6	-1.9

1/ The Hamburger equation is for M-1A.
2/ The percent changes are changes in natural logarithms multiplied by 100.
3/ That is, pre-1977:4 movements in all variables that appear in subsequent columns.

TABLE 15

DRI EQUATION[1]
(percent rate of change from preceding period,
annualized, based on seasonally adjusted data)[2]

Date	Actual M-1A	Adjusted M-1A	Predicted M-1A	Error (actual M-1A minus predicted)	Error (adjusted M-1A minus predicted)	Predicted M-1A due to movement in: pre-77:4 values[3]	post-77:3 prices	post-77:3 real income	post-77:3 interest rates	other[4]
1978:4	5.5	6.8	8.3	-2.8	-1.5	1.0	5.2	2.2	-1.3	1.3
1979:1	0.2	3.3	9.0	-8.8	-5.7	0.7	6.0	1.7	-1.2	1.8
1979:2	7.2	9.2	9.7	-2.5	-0.5	0.5	6.4	0.8	-1.3	3.2
1979:3	7.8	8.9	9.0	-1.2	-0.1	0.4	6.7	1.2	-0.6	1.4
1979:4	4.5	4.7	10.1	-5.6	-5.4	0.3	6.8	1.3	-1.4	3.1
1980:1	4.8	5.5	9.2	-4.4	-3.7	0.2	7.3	1.0	-0.9	1.5
1980:2	-3.9	-2.8	6.0	-9.9	-8.8	0.1	7.7	-0.9	-0.9	-0.1
1980:3	11.0	12.4	9.4	1.6	3.0	0.1	7.6	-0.2	1.8	0.1
1978:3-79:3	5.1	7.0	9.3	-4.2	-2.3	0.7	6.2	1.5	-1.1	2.0
1979:3-80:3	4.0	5.0	8.9	-4.9	-3.9	0.2	7.6	0.3	-0.4	1.2

1/ The DRI equation is for demand deposits. Predicted values from a separate currency equation were added to demand deposit predicted values to obtain M-1A predicted values.
2/ The percent changes are changes in natural logarithms multiplied by 100.
3/ That is, pre-1977:4 movements in all variables that appear in subsequent columns.
4/ Includes prior-period stocks of nonfinancial corporate holdings of government bonds and time deposits (primarily large CDs).

TABLE 16

BOARD'S MONTHLY MODEL
(percent change from preceding period, annualized)1/

	Actual M-1A	Adjusted M-1A 2/	Predicted M-1A	Error (actual M-1A minus predicted)	Error (adjusted M-1A minus predicted)	Predicted M-1A growth due to movement in: pre-77:10 values 3/	post-77:09 prices	post-77:09 real personal income	post-77:09 interest rat
A. Monthly results									
1979:10	2.2	2.2	0.4	1.8	1.8	0.0	11.8	-1.8	-9.6
1979:11	4.6	4.4	2.1	2.5	2.3	0.0	12.6	-1.0	-9.4
1979:12	5.6	6.3	5.4	0.2	0.9	0.0	13.4	-0.8	-7.3
1980:01	3.6	4.7	7.3	-3.7	-2.6	0.0	13.4	-1.5	-4.7
1980:02	9.3	9.6	6.6	2.7	3.0	0.0	13.1	-2.6	-3.9
1980:03	-1.8	-0.6	3.5	-5.3	-4.1	0.0	14.4	-3.9	-7.0
1980:04	-17.8	-15.1	2.9	-20.7	-18.0	0.0	13.4	-5.8	-4.7
1980:05	0.6	-0.6	20.4	-19.8	-21.0	0.0	14.9	-7.0	12.5
1980:06	11.5	13.4	26.7	-15.2	-13.3	0.0	15.0	-7.2	18.9
1980:07	7.7	9.9	20.2	-12.5	-10.3	0.0	9.8	-3.7	14.1
1980:08	19.4	20.8	18.7	0.7	2.1	0.0	13.2	-1.3	6.9
1980:09	12.5	14.5	11.2	1.3	3.3	0.0	10.9	0.4	-0.1
B. Quarterly results 4/									
1979:4	4.5	4.8	2.6	1.9	2.2	0.0	12.6	-1.2	-8.8
1980:1	4.8	5.5	5.8	-1.0	-0.3	0.0	13.7	-2.7	-5.2
1980:2	-3.9	-2.7	16.2	-20.1	-18.9	0.0	14.4	-6.7	8.4
1980:3	11.0	12.5	16.6	-5.6	-4.1	0.0	11.3	-1.5	6.8
C. Annual results									
1979:3-80:3	4.0	5.3	10.1	-6.1	-4.8	0.0	13.0	-3.1	0.0

1/ The percent changes in the first five columns are standard percent changes. However, in subsequent columns percentage changes are measured as a percent of the predicted M-1A (third column) level for the previous period.
2/ M-1A adjusted essentially equals M-1A plus two-thirds of other checkable deposits, one-fourth of business savings deposits, and one-fifth of state and local savings deposits. Since the latter two series tend to fluctuate with interest rates, the actual adjustment is made by assuming that each of these series grow at half the rate of increase of nominal income after the initial introductory phase for each.
3/ That is, pre-1979:10 movements in all variables that appear in subsequent columns.
4/ Growth rates computed from quarterly averages of levels.

TABLE 17

SAN FRANCISCO MONTHLY MODEL
(percent change from preceding period, annualized) 1/

	Actual M-1A	Adjusted M-1A 2/	Predicted M-1A	Error (actual M-1A minus predicted)	Error (adjusted M-1A minus predicted)	Predicted M-1A growth due to movement in: pre-77:10 values 3/	post-77:09 nom. pers. income	post-77:09 interest rates	post-77:09 changes in bank loans
A. Monthly results									
1979:10	2.3	2.2	-2.3	4.6	4.5	0.0	7.5	-4.5	-5.1
1979:11	4.6	4.4	-5.5	10.1	9.9	0.0	8.2	-4.6	-8.9
1979:12	5.5	6.3	0.5	5.0	5.8	0.0	8.4	-3.7	-4.2
1980:01	3.6	4.7	8.7	-5.1	-4.0	0.0	8.4	-2.9	3.2
1980:02	9.4	9.6	9.3	0.1	0.3	0.0	7.6	-2.9	4.7
1980:03	-1.9	-0.6	-3.2	1.3	2.6	0.0	7.3	-5.2	-5.3
1980:04	-17.7	-15.1	-5.0	-12.7	-10.1	0.0	6.1	-3.1	-8.0
1980:05	0.7	-0.6	-1.0	1.7	0.4	0.0	5.4	5.9	-12.4
1980:06	11.4	13.4	6.5	4.9	6.9	0.0	5.3	8.1	-6.7
1980:07	7.8	9.9	14.4	-6.6	-4.5	0.0	6.6	7.5	0.3
1980:08	19.3	20.8	19.0	0.3	1.8	0.0	6.6	4.9	7.5
1980:09	12.3	14.5	16.0	-3.7	-1.5	0.0	6.9	2.1	7.0
B. Quarterly results 4/									
1979:4	4.5	4.8	-2.4	6.9	7.2	0.0	8.0	-4.3	-6.1
1980:1	4.8	5.5	4.9	-0.1	0.6	0.0	7.8	-3.6	0.9
1980:2	-3.9	-2.7	0.2	-4.1	-2.9	0.0	5.6	3.7	-9.1
1980:3	11.0	12.5	16.5	-5.5	-4.0	0.0	6.7	4.9	4.9
C. Annual results									
1979:3-80:3	4.0	5.3	4.6	-0.6	0.7	0.0	7.0	0.0	-2.5

1/ The percent changes in the first five columns are standard percent changes. However, in subsequent columns percentage changes are measured as a percent of the predicted M-1A (third column) level for the previous period.

2/ M-1A adjusted essentially equals M-1A plus two-thirds of other checkable deposits, one-fourth of business savings deposits, and one-fifth of state and local savings deposits. Since the latter two series tend to fluctuate with interest rates, the actual adjustment is made by assuming that each of these series grow at half the rate of increase of nominal income after the initial introductory phase for each.

3/ That is, pre-1979:10 movements in all variables that appear in subsequent columns.

4/ Growth rates computed from quarterly averages of levels.

APPENDIX

ERROR EXPRESSIONS IN TABLES 4 - 6 1/

Table 4
Multiplier Errors

Forecasting Technique	
Board Judgmental	
Initial Intermeeting Period	$\ln m^{Act} - \ln m^{IniPred} = (\ln M^{Act} - \ln M^{Target}) - (\ln R^{Act} - \ln R^{IniTar})$
Adjusted Intermeeting Period	$\ln m^{Act} - \ln m^{adjPred} = (\ln m^{Act} - \ln m^{IniPred}) + (\ln R^{adjTar} - \ln R^{IniTar})$
	$= (\ln M^{Act} - \ln M^{Target}) - (\ln R^{Act} - \ln R^{adjTar})$
Current Month	$\ln m^{Act}_{cm} - \ln m^{IniPred}_{cm} = (\ln M^{Act}_{cm} - \ln M^{Target}_{cm}) - (\ln R^{Act}_{cm} - \ln R^{IniTar}_{cm})$
Johannes-Rasche	$\ln m^{Act}_{cm} - \ln m^{Pred}_{cm}$
Board Model and San Francisco Model	$\ln m^{Act}_{cm} - \ln m^{Pred}_{cm} = (\ln M^{Act}_{cm} - \ln M^{Pred}_{cm}) - (\ln R^{Act}_{cm} - \ln R^{Pred}_{cm})$

Tables 5 and 6
Money Stock Errors

FOMC Interim Money Stock Targets	
Intermeeting Period Path	$\ln M^{Act} - \ln M^{Target}$
Current Month Path	$\ln M^{Act}_{cm} - \ln M^{Target}_{cm}$
Board Model and San Francisco Model	$\ln M^{"Act"}_{cm} - \ln M^{Pred}_{cm}$

1/ All level errors annualized by a factor of 1200.

REFERENCES

1. Stephen Axilrod and David Lindsey. "Federal Reserve System Implementation of Monetary Policy: Analytical Foundations of the New Approach," Federal Reserve Board, processed; presented at the Denver Meeting of the American Economic Association, September 6, 1980; forthcoming in American Economic Review, Papers and Proceedings, May 1981.

2. Martin J. Bailey. National Income and the Price Level, New York, 1962.

3. Jared Enzler and Lewis Johnson. "Cycles Resulting from Money Stock Targeting," January 1981.

4. Jared Enzler, Eileen Mauskopf and Edward Offenbacher. "Other Money Demand Equations," October 1980.

5. Helen T. Farr. "The Monthly Money Market Model," FRB working paper, July 1980.

6. Michael J. Hamburger. "Behavior of the Money Stock: Is There a Puzzle?" Journal of Monetary Economics, vol. 3 (July 1977), pp. 265-88.

7. James M. Johannes and Robert H. Rasche. "Predicting the Money Multiplier," Journal of Monetary Economics, vol. 5 (July 1979), pp. 301,25.

8. __________. "Can the Reserves Approach to Monetary Control Really Work?" April 1980.

9. John Judd and John Scadding. "Contribution to the Study of the Monetary Control Experience under the New Operating Procedures," forthcoming.

10. John H. Kareken, Thomas Muench, and Neil Wallace. "Open Market Strategy: The Use of Information Variables," American Economic Review, vol. 63 (March 1973), pp. 156-72.

11. Peter Keir, and others. "Impact of Discount Policy Procedures on the Effectiveness of Reserve Targeting," January 1981.

12. Fred J. Levin and Paul Meek. "Implementing the New Operating Procedures: The View from the Trading Desk," February 1981.

13. James L. Pierce. "Making Reserves Targets Work," in Controlling the Monetary Aggregates III, Federal Reserve Bank of Boston, forthcoming.

14. James Pierce and Thomas Thomson. "Some Issues in Controlling the Stock of Money," in Controlling the Monetary Aggregates II: The Implementation, Federal Reserve Bank of Boston Conference Series 9, September 1972.

15. William Poole. "Optimal Choice of Monetary Policy Instruments in a Simple Stochastic Macro Model," Quarterly Journal of Economics, vol. 84 (May 1970), pp. 197-216.

16. Perry D. Quick, "Federal Reserve Discount Window Reforms: Policies Without Administrative Pressure," Board paper, July 1980.

17. John Scadding and John Judd. "The Disequilibrium Demand for Money," forthcoming.

18. Thomas Simpson and Richard Porter. "Some Issues Involving the Definition and Interpretation of the Monetary Aggregates," in Controlling the Monetary Aggregates III, Federal Reserve Bank of Boston, forthcoming.

19. Charles Sivesind and Kevin Hurley. "Choosing an Operating Target for Monetary Policy," Quarterly Journal of Economics, vol. 94 (February 1980), pp. 199-203.

20. Peter Tinsley and Peter von zur Muehlen. "A Maximum Probability Approach to Short-Run Policy," Journal of Econometrics, vol. 15 (January 1981), pp. 31-48.

21. Peter Tinsley, Peter von zur Muehlen, Gehard Fries, and Warren Trepeta. "Money Market Impacts of Alternative Operating Procedures," January 1981.

22. Thomas D. Thomson, James L. Pierce, and Robert T. Parry. "A Monthly Money Market Model," Journal of Money, Credit and Banking, vol. 7 (November 1975), pp. 411-31.

TREND AND NOISE IN THE
MONETARY AGGREGATES

David A. Pierce
Special Studies Section
Division of Research and Statistics

December 1980

Any views expressed or errors contained herein are solely the responsibility of the author, who is grateful to William P. Cleveland, Darrel W. Parke and several other staff members for helpful comments, to Gerhard Fries for computational assistance, and to Valerie Watkins for typing.

SUMMARY

This paper reports results of an investigation attempting to measure the length of run over which short-run fluctuations in aggregates may, with reasonable probability, be said to reflect change in trend. The results are enumerated after the next paragraph and are illustrated by Figure 1, which shows the relationships between the sizes of the fluctuations in M-1A (annualized growth rates) and the number of months necessary before that degree of fluctuation reflects, with 70% probability and (in parentheses on vertical axis) 95% probability, a change in trend. (Values for M-2 may be obtained by replacing numbers on the vertical axis by entries about 75% as large.) As an example of interpreting this figure, if trend growth rate in M-1A (or M-1B) had been 5% (seasonally adjusted annual rate) and a current month's figure is 8%, we could not say with even 70% probability that a change in trend had occurred since that would require a 4.5% deviation from the current trend, contrasted to our observed 3% deviation. Examining Figure 1 shows that it would require two months of growth averaging 8% to say with 70% probability, and four months of (average) 8% growth to say with 95% probability, that the trend was now different from 5%.

The paper does not develop a specific procedure for the estimation or specification of trend. Instead, the measures of noise developed are used to assess the plausibility of departures from a desired or hypothesized value of the trend. For example, the presumed 5% trend in the previous paragraph's illustration of Figure 1 could be the desired or targeted M-1A growth path over the current period. The incoming M-1A figures would then be examined relative to the noise they are likely to contain (as in Figure 1) to see if a statistically significant departure from 5% growth had occurred.

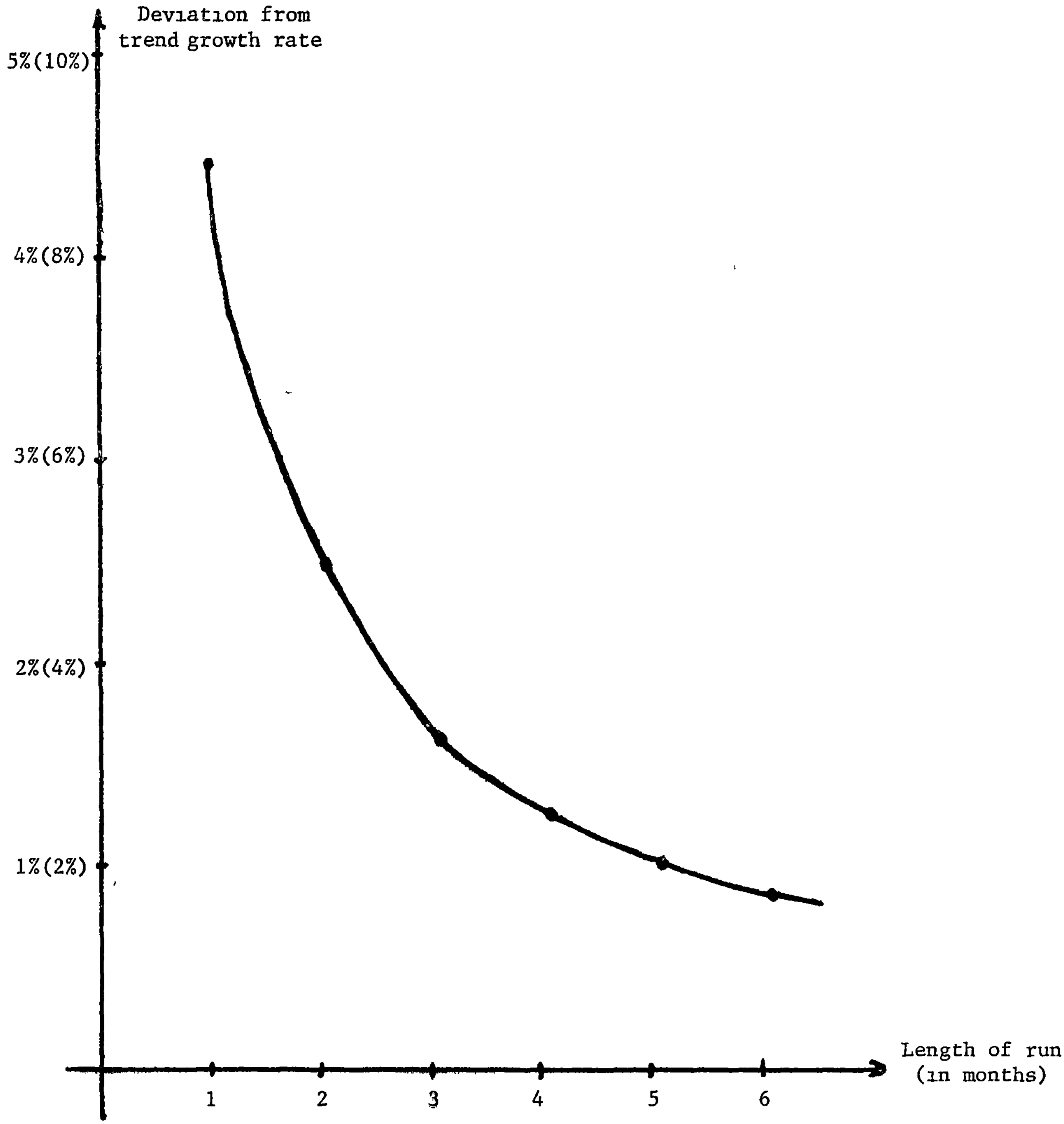


Figure 1. Required deviation of observed growth rate from trend to say with 70% (95%) probability that a change in trend has occurred, M-1A and M-1B

The principal findings of this study are as follows.

1. Annualized growth rates determined from the first published monthly monetary aggregates have estimated standard deviations of 4-1/2% for M-1A and M-1B [or $1.5 billion, assuming a level of $400 billion for these aggregates] and 3-1/2% for M-2, attributable to noise (error, uncertainty, randomness) in these series. Transitory variation and seasonal factor uncertainty are the principal contributors to this noise.

2. Growth rates over longer periods than one month have markedly decreasing noise levels. The estimated standard deviation of noise in an annualized three-month growth rate is about 1.7% for M-1A and M-1B and 1.3% for M-2. For six-month growth rates the analogous measures are 0.8% for M-1A and M-1B and 0.6% for M-2.

3. Noise in levels of monthly data has an estimated standard deviation (not annualized) of 0.29% for M-1A and M-1B and 0.23% for M-2 or about ± $1 billion and + $4 billion for current levels of these series. These figures steadily decrease to 0.13% and 0.10% (± $.5 billion and ± $1.6 billion) for six-month averages of the aggregates.

4. For changes in weekly data (M-1A and M-1B) the estimated noise standard error is ± $3.3 billion. Transitory variation and seasonal factor uncertainty are again the main contributors.

5. There is substantial negative correlation between transitory variations and revisions in seasonal factors, providing further evidence that factor revisions tend to smooth the series. Moreover, considerable information on the seasonal revision is available at the time of initial publication (from a concurrent adjustment), so that it is evidently possible to construct improved first-published monetary aggregate data with decreased noise.

The method of this study was to construct and use models for the monetary aggregates (particularly M-1A, M-1B and M-2) to separate the first-published versions of these series into trend and noise components. The noise is assumed to be composed of errors in seasonal adjustment; irregular/transitory variations; and, to a lesser extent, sampling errors. These components are analyzed separately and jointly to derive an overall measure, the standard deviation, of the total of these sources of uncertainty on weekly and monthly bases and over several months.

Then, regarding trend as the series net of these sources of error/uncertainty, there are three quantities such that one can in principle be determined from the other two:

(a) Length of time period of the fluctuations.

(b) Size(s) of the fluctuations.

(c) Probability that a change in trend has occurred.

In particular the probability that a change in trend has occurred is the probability that the fluctuations in the aggregate cannot be accounted for by noise alone, when the noise is measured relative to its standard deviation.

1. INTRODUCTION

That the monetary aggregates are subject to considerable uncertainty, irregularity, noise, error, etc. is known to virtually all observers of these series. Such movements obscure changes in the underlying more permanent aspects of these series, such as changes in trend. The problem addressed in this paper is the extent to which this obfuscation necessarily takes place, versus the extent to which a given sequence of movements in the observed aggregates can impart information concerning trend, that is, the assessment of experience about length of run over which short-run fluctuations may, with reasonable probability, be said to reflect changes in trend.

There are three main dimensions to this problem: (1) the size(s) of the fluctuations, (2) the length of run (number of weeks or months) over which the fluctuations or movements occur, and (3) the probability that a change in trend has occurred. In principle, given suitable definitions of the trend and non-trend components of the aggregates, any of these three elements is determined from the other two; for example, if the trend growth rate in M-1A has been 5% and in the last three months the observed growth rate averages 10%, what is the probability that the trend is now in excess of 5%? Or, more in line with the phrasing of the above quotation, how many months of an observed 10% growth rate are required to ensure, with 70% probability (or 95% probability), that a change in trend (from 5% growth) has occurred?

To answer such questions we require the following:

(a) A notion of what we mean by trend.

(b) An enumeration and measurement of the major ways in which an observed money supply figure can depart from this trend.

Concerning (a), we regard trend simply as the "underlying" or "true" series (or series growth) that would be observed except for the presence of error or noise. The trend is thus unobservable; however, we can still make inferences about possible values or ranges for the trend, as indicated in the third paragraph of the summary. This approach has several features, vis à vis the alternative of constructing an explicit model for trend based on prior knowledge and assumptions relating the aggregates and other variables. There is substantial uncertainty and disagreement regarding the appropriate specification of such relationships, for example, whether monetarist or Keynesian or whether and how shifts in money demand have occurred. Indeed a major cause of this uncertainty is errors in variables of the type that produce the random fluctuations in the aggregates under investigation here. Any estimate of trend is sensitive to these assumptions and is itself subject to error. Furthermore, many sources of error or randomness in the monetary aggregates are already accorded a non-structural treatment. For example, a major source of uncertainty is due to the seasonal adjustment process; and, whether appropriately or not, published seasonal factors for (say) demand deposits are determined from other demand deposit values and not from relationships to time deposits, interest rates, etc. Finally, the problem as posed is in a sense statistical, to address whether a change in trend has occurred rather than why. This problem is most directly addressed by regarding trend as the series net of various sources of noise (error, uncertainty, randomness), which are now described, and to measure the extent and impact of this noise.

Concerning (b) above, there are several reasons why an observed monetary aggregate series, even after seasonal adjustment, will depart from its underlying trend; we will distinguish the following:

1. Transitory variation. Irregular, evanescent fluctuation in a data series, due to causes extraneous to those related to our concept of the series. This phenomenon was examined in some detail by the Committee on Monetary Statistics [1] and by Porter et al. ([6]).

2. Sampling and reporting error. The true series is a population total (for example bank deposits) and only a sample from this population is available, from which an estimate of the population figure is constructed. An important example for monetary statistics has been the presence of nonmember banks that report their deposits only one week each quarter. Furthermore, member and nonmember banks alike may commit reporting errors, which may or may not be discovered at a later date.

3. Seasonal adjustment error. This is partly conceptual insofar as we do not know very well what we want to remove from a series, the seasonal adjustment technique may be faulty, and even the best method generally provides only an estimate of any "true" seasonal factor that we are able to specify. And the first published data on the aggregates have a further source of error because of subsequent revisions of the preliminary seasonal factors.

A second classification of noise in the monetary aggregates is according to whether (a) it exists only in preliminary or first-published data and is eliminated in a subsequent version of the series, or (b) it is imbedded in the final data, as well as in any preliminary versions of the series. Revisions are errors that are discovered and removed from preliminary data series when further information subsequently becomes available, an example being revisions due to improved estimates of the seasonal factors. Remaining (unobservable) sources of noise include transitory variation and parts of seasonal adjustment and sampling errors.

The problem of detecting a change in trend is an ongoing one and is in general based on an analysis of current and recent data. It is thus necessary to measure the extent of uncertainty or randomness in the preliminary monetary aggregate data, including both revisions and final-data error.

The basic framework of this study is as follows. Let m_t^o denote the first published, seasonally adjusted monetary aggregate (usually in logged form). Write this as the sum

$$m_t^o = \overline{m}_t + n_t , \tag{1.1}$$

of the trend $\overline{m}_t$ and all sources of noise, randomness, uncertainty, error, irregularity, etc., n_t. A major task is then to estimate the probability distribution -- or the standard deviation, assuming normality -- of the noise n_t and of successive averages of this term. Given this, we could then state how large the noise term would need to be in order to have (say) a 70 (or 95)% probability of a change in trend: this would occur if the observed value of this term were larger than its standard error (or twice its standard error). Results of this type (see Figure 1) show the tradeoff between the size of a fluctuation and the length of time over which that size of departure would need to persist, in order to signal, at a given probability level, a trend change. Even a single week's number could strongly indicate such a change if deviant enough (for example, the $9 billion increase on August 6, 1980), whereas a more modest change in trend or level would show itself only after several weeks or months.

The estimation of the standard deviation of the noise is accomplished in Section 3, after investigating the component noise sources (seasonal, transitory, sampling) in Section 2. Also in Section 3 are the basic results (summarized in Figure 1 and Table 2) relating the size of fluctuations, length of run, and probability of a change in trend. Section 4 presents some results for weekly data.

2. MEASUREMENT OF NOISE COMPONENTS

We enumerated several ways in which an observed monetary aggregate series, especially as first published, can depart from its trend, namely, transitory variations, seasonal factor errors, and sampling and reporting errors. The composite of these is the overall noise term in the representation of the first published aggregate as the sum

$$m_t^o = \bar{m}_t + n_t \tag{2.1}$$

of trend and noise.

To estimate the standard deviation of n_t, it is necessary to evaluate the variances and covariances of the sources of error and randomness comprising it. We therefore write n_t as the sum 1/

$$n_t = -r_t + \delta_t + \rho_t + \varepsilon_t \tag{2.2}$$

of the following components:

(a) revisions r_t, due mainly to seasonal factor revisions but also to such things as more complete reporting, correction of reporting errors, and heretofore, benchmarking; 1/

(b) historical seasonal factor errors δ_t;

(c) transitory variations ρ_t; and

(d) sampling errors ε_t (as with benchmark revisions, much less important after implementation of the Monetary Control Act).

1/ The minus sign in front of r_t in equation 2.2 reflects the fact that the revision r_t itself is added to the preliminary data to obtain the revised data, so that the revision error present in the preliminary data is the negative of r_t.

The determination of the variation and covariation of these noise components is based on autoregressive-integrated moving average (ARIMA) models fitted to the monetary aggregates. The series analyzed were M-1A, M-1B, and M-2, using monthly data from 1973 through 1979 inclusive. The models were fit on the changes in logarithms (approximately the rates of growth) of these series. The main feature of these models is that they are all similar to a model given by Cleveland [2], which accurately characterizes the X-11 seasonal adjustment procedure. This means that inferences for such quantities as the seasonal adjustment error and the transitory variance can be based on the known characteristics of the Cleveland model, as X-11 is the primary means of seasonal adjustment for these series.

Seasonal Adjustment Error

Let x_t denote a not seasonally adjusted monetary aggregate series, assumed to be written in logged form as

$$x_t = \overline{m}_t + s_t + e_t \tag{2.3}$$

where $\overline{m}_t$ is the trend, s_t the unknown true seasonal component, and the "irregular" component $e_t = \xi_t + \varepsilon_t$ represents noise from other-than-seasonal sources. The first published seasonally adjusted series, as in equation 2.1, is then

$$m_t^o = x_t - s_t^o = \overline{m}_t + (s_t - s_t^o) + e_t \tag{2.4}$$

and the final seasonally adjusted series (after seasonal factor revisions) is

$$m_t^f = x_t - s_t^f \tag{2.5}$$

where s_t^o and s_t^f are preliminary and final seasonal factors. Writing equation 2.4 as

$$\begin{aligned} m_t^o &= x_t - s_t^o = \overline{m}_t + (s_t - s_t^f) + (s_t^f - s_t^o) + e_t \\ &= \overline{m}_t + \delta_t - r_t + \xi_t + \varepsilon_t \end{aligned} \tag{2.6}$$

shows explicitly the contribution of seasonal revisions and final seasonal adjustment error to the overall noise n_t in equation 2.2. Thus the uncertainty in monetary aggregates stemming from seasonal adjustment may be broken down into seasonal factor revisions (r_t) and error in the final seasonal factors (δ_t). Applying results in Pierce [3] to the new aggregates it was found that

$$\sigma_r = .31\sigma_* ,$$

where σ_* is the standard deviation of the year-over-year difference in the monthly change $\nabla x_t = x_t - x_{t-1}$ of x_t, that is, the standard deviation of $\nabla x_t - \nabla x_{t-52}$, a quantity that appears in the ARIMA model for the aggregate series. These standard deviations were found to be 1/

$$\sigma_* = (.0052, .0052, .0043) \quad \text{for} \quad (\text{M-1A, M-1B, M-2});$$

thus

$$\sigma_r = (.17\%, .17\%, .13\%) \quad \text{for} \quad (\text{M-1A, M-1B, M-2}) . \qquad (2.7)$$

The interpretation of this result is that if, for example, the first published M-1A figure were \$400 billion then a 95% confidence interval for the final revised figure (due only to seasonal revisions and ignoring benchmarking and other effects) would be \$400 billion $[1 \pm 2\sigma_r]$ or \$400 billion ± \$1.4 billion.

Similarly, for the error δ_t in the final seasonally adjusted data (which is also present in the preliminary data as in equation 2.2) it was found that

$$\sigma_\delta = .19\sigma_*$$

$$= (.10\%, .10\%, .08\%) \quad \text{for} \quad (\text{M-1A, M-1B, M-2}) .$$

Note that these error figures and resulting confidence limits are expressed as <u>percentages</u> of the <u>levels</u> of the series, as they are computed from the series' logarithms. However, the quantities of greatest interest are usually the <u>growth rates</u> of the aggregates, which are essentially the changes in the logs of these series. For these rates of change, it is thus the standard deviation of

$$\nabla r_t = r_t - r_{t-1}$$

1/ The size of the seasonal factor revisions can also be measured empirically if enough first-published and revised data are available. This is not possible for the new aggregates, however. Thus it is noteworthy that in Pierce [3] the model-based and empirical revision standard errors for old M-1 were found to be in close agreement with each other.

that is of interest, and similarly of

$$\nabla\delta_t = \delta_t - \delta_{t-1} \cdot$$

The basic result relating standard deviations for a series u_t and its series of changes ∇u_t is that

$$\sigma_{\nabla u} = \sigma_u\sqrt{2(1 - \rho_u(1))} \tag{2.8}$$

where $\rho_u(k)$ is the lag-k autocorrelation of u, or the correlation coefficient between u_t and u_{t-k} (here k=1). For the seasonal adjustment errors, autocorrelations of r_t are given by Pierce [3] and those for δ_t were kindly supplied by W.P. Cleveland. In particular $\rho_r(1) = 0.52$ and $\rho_\delta(1) = -0.27$, whence

$$\sigma_{\nabla r} = (.17, .17, .13) \text{ for } (\text{M-1A, M-1B, M-2})$$

and

$$\sigma_{\nabla\delta} = (.16, .16, .13) \text{ for } (\text{M-1A, M-1B, M-2}) ,$$

all in percentage terms. Note that the positive serial correlation coefficient for r_t tends to hold down the value for $\sigma_{\nabla r}$ (and in fact to make it essentially the same as σ_r), whereas the negative value of $\rho_\delta(1)$ tends to increase $\sigma_{\nabla\delta}$, both relative to the values obtaining if these seasonal adjustment errors were not autocorrelated. Also note that all growth-rate results are not annualized.

An interpretation analogous to that following equation 2.7 is that if a first published seasonally adjusted monthly growth rate for M-1A were 0.5% (6% annualized), a 95% confidence interval for the final rate (again ignoring benchmarking and other revisions and errors) would be 0.5% ± .34% or (1.9% to 10.1%) annualized.

Sampling and Reporting Error

Sampling error arises because data are available for most of the 8,700 nonmember banks only on the call reports once each quarter, except for a sample of 600 nonmember banks that report their deposit balances each week. The sampling error for monthly data has been estimated at $320 million, or less than 0.10% of M-1A or M-1B. In addition, there are benchmark revisions as new data from the quarterly call reports are used to update the nonmember bank deposit estimates.

We shall not deal further with sampling error in this study. It is relatively small, and since successive sampling/benchmark errors are very highly autocorrelated (some statistics on this were kindly supplied by Darrel Parke), the effect of these errors on growth rates would be even smaller. (On the other hand, we caution that occasional reporting errors, which can occur in member or nonmember bank data, would behave much as transitory variations discussed earlier.) Moreover, the Monetary Control Act greatly decreases the importance of sampling and of call report data.

Transitory Variation

Over time the monetary aggregates are subject to very short run variations that bear little or no relation to the economy in general. These kinds of variations are called transitory because they are fleeting in nature and provide no information about underlying economic processes. Such variations were studied by the Committee on Monetary Statistics [1] and in greater detail by Porter et al. [6]. Widely ranging estimates of transitory standard deviation were found, depending on the frequency of data employed in the model and on the model employed for the systematic part of the series.

A single precise definition of transitory variation does not exist. In the present study we are interested in separating all short-run irregular variation from the longer-run, more slowly varying part of the series (the trend-cycle) and from the seasonal part of the series. It thus seems reasonable to label whatever part of the series that is purely random, or serially uncorrelated, as transitory. Such a component is unrelated to past or future values of the aggregate. This concept of transitory variation has the further feature that the Cleveland model for X-11 incorporates an irregular component that has this property, that it is the random or serially uncorrelated component of the aggregate with maximum variance (Tiao and Hillmer [8]). In this sense the transitory component is similar to the irregular component estimated by the X-11 procedure. The qualification needed in adopting this approach is that a serially uncorrelated component may still be related to other series, such as interest rates, so that the identification of such a relationship could alter what is labeled as irregular or as trend, as discussed in Section 1.

As before we denote the transitory component by ξ_t. From calculations with the Cleveland model,

$$\sigma_\xi = .40\sigma_*$$

and thus the transitory standard deviation for the three monetary aggregate series under study is

$$\sigma_\xi = (.21\%, .21\%, .17\%) \text{ for } (M\text{-}1A, M\text{-}1B, M\text{-}2) .$$

As the transitory component is by definition serially uncorrelated, it follows that $\rho_\xi(k) = 0$, and therefore from equation 2.8 the transitory standard deviation for the growth rate of each series is $\sqrt{2}$ times σ_ξ, or

$$\sigma_{\nabla\xi} = (.30\%, .30\%, .24\%) \text{ for } (M\text{-}1A, M\text{-}1B, M\text{-}2) .$$

This is the largest single source of uncertainty in the monetary aggregates, compared with seasonal adjustment and sampling error. For example, a reported M-1A growth rate of 8% could, within $\pm$ 1 standard-error limit, be as low as 4.4% or as high as 11.6% due to irregular or transitory variation.

3. OVER-ALL MEASURES OF NOISE

Measures of randomness or noise in the first published seasonally adjusted aggregates can now be obtained, based in part on the standard deviations derived in Section 2. The additional information needed is the contemporaneous covariances and correlations between the various sources of uncertainty, for assessing noise in aggregates at a single month, and autocorrelations and lagged cross-correlations of these components, for aggregates measures over several months. Noting as in the previous section that the inclusion of sampling/reporting error would have relatively little effect on the result and that much of the role of sampling and call report procedures is being eliminated, we concentrate on transitory variations ξ_t and the two seasonal adjustment errors r_t and δ_t.

Noise in Single-Month Monetary Aggregate Data

It is shown in Pierce [3, 4] that seasonal revisions are uncorrelated with error in the final seasonal factors, and that r_t and δ_t are negatively correlated with the transitory component ξ_t. In particular, for $|k| < 12$ it is shown in Pierce [4] that

$$\mathrm{Cov}(\delta_{t-k}, \xi_t) = \mathrm{Cov}(r_{t-k}, \xi_t) = -\sigma_\xi^2 \nu_{-k}$$

where ν_k is the k^{th} term in the moving average of the X-11 seasonal adjustment procedure, that is, the coefficient of x_{t-k} when the X-11 seasonal factor is written as

$$s_t = \Sigma \nu_k x_{t-k} .$$

In particular, $\nu_0 = 0.181$ for $k = 0$ and we have

$$\mathrm{Cov}(\delta_t, \xi_t) = \mathrm{Cov}(r_t, \xi_t) =$$

$$(-.80, -.80, -.52) \times 10^{-6} \quad \text{for} \quad (\text{M-1A, M-1B, M-2}) .$$

Now the variance of n_t is the sum of the variances of δ_t, r_t, and ξ_t plus twice the nonzero covariances, and since r_t enters with a negative sign in equation 2.2, these covariances cancel each other. Thus the variance of n_t is the sum of the three component variances, and taking square roots,

$$\sigma_n = (.29\%, .29\%, .23\%) \quad \text{for} \quad (\text{M-1A, M-1B, M-2}) .$$

For growth rates the calculations are analogous except that the first order serial covariances also need to be taken into account. We have, as in equation 2.8,

$$\sigma\nabla_n = \sigma_n\sqrt{2(1 - \rho_n(1))}$$

$$= (.377\%, .377\%, .297\%) \quad \text{for} \quad (\text{M-1A, M-1B, M-2}) , \qquad (3.2)$$

as $\rho_n(1) = 0.15$ for M-1A, B and 0.14 for M-2.

Annualized, these growth rate standard deviations are 4.52% for M-1A and M-1B and 3.58% for M-2, which we round to 4-1/2 and 3-1/2% respectively. As an example, if a first-published seasonally adjusted monthly M-1A growth rate is 8%, a 70% confidence interval for the "true" M-1A, or the trend, would be

$$8\% \pm \sigma \quad \text{or} \quad (3.5\% \text{ to } 12.5\%) ,$$

and a 95% confidence intervals for the trend rate of growth would be

$$8\% \pm 2\sigma \quad \text{or} \ (-1\% \text{ to } 17\%) .$$

Alternatively, if the previous trend were anywhere from 3-1/2 to 12-1/2%, we could not say even with 70% probablity that a change in trend had occurred, on the basis of a one-month observation of 8% growth.

Table 1 summarizes the results of Section 2 and this discussion.

TABLE 1. Standard deviations of noise in monthly monetary aggregates

	M-1A and M-1B				M-2			
	Levels		Growth rates		Levels		Growth rates	
se rce	Percent	Billions of dollars 1/	Percent	Annual rate (percent)	Percent	Billions of dollars 2/	Percent	Annual rat (percent)
nsitory iations	.21	.8	.30	3.6	.17	2.9	.24	2.9
sonal isions	.17	.7	.17	2.0	.13	2.2	.13	1.6
or in final sonal tors	.10	.4	.16	1.9	.08	1.4	.13	1.6
al	.29	1.2	.38	4.5	.23	3.9	.30	3.6

Based on a level of $400 billion.

Based on a level of $1.7 trillion.

Noise in Data Spanning Several Months

The example concluding the previous subsection shows clearly that uncertainty, noise, error, irregularity, etc. in the monetary aggregates are so great that very little can be said about trend or underlying movements in these series on the basis of one month's movement in the current data. We are now able to address the question motivating this paper, of how long it does take before these fluctuations in the observed data begin to signal possible changes in trend.

We shall determine the standard deviation of k-month averages and k-month growth rates in M-1A, M-1B, and M-2, as a function of k. To do this we note that the transitory component ξ_t is serially independent and that, while the seasonal adjustment errors δ_t and r_t were autocorrelated at lag k=1 (Section 2), their autocorrelations were small at lags $k > 1$, at least up to the annual lag of 12; thus this is also true for n_t.

If n_t is the total noise term for a one-month average of the aggregate at month t, then $(1/2)(n_t + n_{t+1})$ is the noise for a two-month average of the aggregate, and in general the total deviation from trend for a k-month average is

$$n_t^{(k)} = \frac{1}{k}\sum_{j=1}^{k} n_{t+j-1} \quad . \tag{3.3}$$

It is straightforward to determine the standard deviation of $n_t^{(k)}$ given the standard deviation and the lag-1 autocorrelation of n_t (below equation 3.2) and the fact that other autocorrelations of n_t can be neglected. Table 2 shows the resulting standard deviations, along with those of the k-month growth rates.

Table 2. Standard deviations of noise in k-month averages and growth rates of monetary aggregates 1/

In percent

k	k-month average		k-month growth rate	
	M-1A and M-1B	M-2	M-1A and M-1B	M-2
1	.29	.23	.38 (4.5)	.30 (3.6)
2	.22	.17	.21 (2.5)	.16 (1.9)
3	.18	.14	.14 (1.7)	.11 (1.3)
4	.16	.12	.10 (1.2)	.08 (1.0)
5	.14	.11	.08 (1.0)	.06 (0.7)
6	.13	.10	.07 (0.8)	.05 (0.6)

1/ Annualized growth rates are shown in parentheses.

The analogous calculation for growth rates is simpler since the noise in an average k-month rate is just

$$(n_{t+k} - n_t)/k \ , \tag{3.4}$$

multiplied by 12 to annualize. The standard deviation of equation 3.4 is thus $\sigma_n\sqrt{2}/k$, or 0.41/k for M-1A and M-1B and 0.32/k for M-2, except for k=1 where for k=1 where the nonzero lag-1 serial correlation of $\{n_t\}$ also plays a role. This is a more rapid decrease, as k increases, than for the average levels, an effect that is apparent in Table 2, where for k=1 the growth-rate standard deviations are higher but where for larger k they drop well below those for k-month averages.

Figure 1 is a plot, against k, of the third column of Table 2.

4. NOISE IN WEEKLY DATA

It was seen how the noise in the monetary aggregate data decreased as we went from a single-month figure to averages over two and more months. Since monthly data themselves can be regarded as (suitably prorated) averages of weekly data, clearly the opposite effect holds (that is, a sharp increase in all forms of randomness or noise) as one goes from a monthly to a weekly frequency of observation. However, in terms of their serial correlation patterns and in other ways, weekly data are more difficult to analyze. In particular there is no known model (such as the Cleveland X-11 model for monthly data) to characterize the Board's weekly seasonally adjustment procedure or the extent of irregular/transitory variation. Thus we will necessarily be less precise and more ad hoc in our assessment of noise in weekly data, though we can still make some reasonable approximations.

Since a month is an average of slightly over four weeks, it would follow that any noise component in weekly data that is serially uncorrelated from week to week would have a standard deviation approximately double that in monthly data. Consider first the transitory error. Assuming that the arguments for serial independence of transitory variations in monthly data are also valid for weekly data, we would have a transitory standard deviation, from Table 1, of

$$\sigma_{\xi} = 2(.21\%) = .42\%$$

for weekly M-1A or M-1B. This figure is in line with results reported in Porter et al. [6] based on a signal extraction method.

Concerning weekly seasonal adjustment errors, we would expect some negative within-month serial correlation in both preliminary-factor revisions and final-factor errors, since weekly seasonal factors need to be consistent with those for monthly data. On the other hand, a given revision in a monthly factor would be on average applied to factors for each week in that month, inducing positive autocorrelation. If these effects approximately offset each other, our "doubling" rule would again apply, giving

$$\sigma_r = 2(.17\%) = .34\%, \quad \sigma_\delta = 2(.10\%) = .20\%$$

respectively for seasonal revision and final-factor errors.

To combine these standard error estimates into an overall measure of noise in weekly M-1A and M-1B it is necessary to take account of the correlation between the preliminary seasonal, final seasonal, and transitory disturbances. For monthly data, in was found in Section 3 that transitory variations were negatively correlated with both revisions and final-factor errors, the latter two being independent of each other. Since revisions are adjustments to preliminary data and are therefore the negative of the revision errors in that data, those errors are positively correlated with transitory variations. In particular in Section 3 it was seen that the correlation between these two disturbances exactly offsets that between final-factor errors and transitory variations, as both are related in the same way to the "central" moving average weights in X-11. Assuming that such an offset also occurs with weekly data, the standard deviation of the total noise in weekly M-1A and M-1B is

$$\sigma_n = \sqrt{(.42^2 + .34^2 + .20^2)} = .58\% .$$

For changes in weekly data, assuming serial independence (see below), the standard deviation of the noise is

$$\sigma_{\nabla n} = \sigma_n \sqrt{2} = .82\%,$$

and similarly the standard deviations of preliminary seasonal, final seasonal and transitory noises for weekly changes are respectively 0.48%, 0.28%, and 0.59% These results are displayed in Table 3, together with their dollar effects assuming a level of M-1A or M-1B of $400 billion.

It is also possible to separate the measurement of preliminary seasonal factor error, which will be corrected when the series is revised, and the measurement of noise, which remains in the final factors. To do this it is necessary to account for the correlation between the revisions and transitory variations. From equation 3.1 it can be shown that for monthly data the correlation between these was -0.24 (+0.24 for the revision errors present in initial data). Assuming this result also holds for weekly M-1A, M-1B, then it can be shown that the standard deviation for noise in final (revised) data is 0.38% ($1.5 billion) for levels and 0.54% ($2.2 billion) for changes. These are substantially less than the standard deviations that would have obtained (0.47% and 0.66%) without the negative serial correlation, a result that confirms the widely held view that not only does revision of seasonal factors remove the preliminary-data seasonal adjustment errors, but such revision also partially smooths the transitory variations.

As noted earlier in this section, there is more uncertainty surrounding these estimates of noise than in the case of monthly data, largely because of the possible effects of serial and contemporaneous correlation among the noise components. As a simple example of the effects of serial correlation, and hence of the sensitivity of this paper's results, suppose the noise in weekly data, instead of being serially independent as assumed, had correlation coefficient $\rho = 0.3$ between adjacent weeks within a month. [Possible arguments for positive serial correlation between weeks were given above for

TABLE 3. Estimated standard deviations of noise in weekly aggregates (M-1A and M-1B)

Source of noise	Levels		Changes	
	Percent	Billions of dollars 1/	Percent	Billions of dollars 1/
1. Transitory variations	.42	1.7	.59	2.4
2. Seasonal revisions	.34	1.4	.48	1.9
3. Error in final seasonal factors	.20	.8	.28	1.1
4. Total	.58	2.3	.82	3.3
5. Noise in final data 2/	.38	1.5	.54	2.2

1/ Assuming aggregate level of $400 billion.

2/ Line 1 combined with line 3.

were given above for seasonal adjustment errors and can also be given for transitory variations.] Then (1) instead of doubling, the noise standard deviation would increase by a factor of 1.8 in going from levels of monthly to levels of weekly data, and (2) the growth rate standard deviation would increase by a factor of $\sqrt{2(1 - \rho)} = 1.2$ rather than $\sqrt{2} = 1.4$. The combined effect of these is that the noise standard deviation for changes in weekly data would be

$$\frac{1.8}{2} \times \frac{1.2}{1.4} \times \$3.3 \text{ billion} = \$2.5 \text{ billion}$$

rather than $3.3 billion as previously calculated.

Conversely, the presence of negative serial correlation in noise between weeks within a month (for example as a result of consistency constraints between weekly and monthly data) would increase the weekly noise standard deviation relative to the monthly noise standard deviation.

In general, these results are further evidence that very little can be inferred from any but the most atypical movements in weekly data. However, the converse should also be noted -- a significant move in the "true" data, that is, a pronounced change in underlying trend or level, will likely go undetected in one or a few weeks' time.

REFERENCES

1. Bach, G.L., Phillip D. Cagan, Milton Friedman, Clifford G. Hildreth, Franco Modigliani, and Arthur Okun. Improving the Monetary Aggregates: Report of the Advisory Committee on Monetary Statistics, Washington, D.C.: Board of Governors of the Federal Reserve System, 1976.

2. Cleveland, William P. Analysis and Forecasting of Seasonal Time Series. Ph.D. dissertation, University of Wisconsin, Department of Statistics, 1972.

3. Pierce, David A. "Data Revisions in Moving Average Seasonal Adjustment Procedures," Journal of Econometrics, vol. 14 (Special Federal Reserve Issue, 1980), pp. 95-114.

4. __________. "Sources of Error in Economic Time Series." Washington, D.C.: Board of Governors of the Federal Reserve, Special Studies Section, 1980.

5. __________, Darrel W. Parke, William P. Cleveland, and Agustin Maravall. "Uncertainty in the Monetary Aggregates: Sources, Measurement and Policy Effects," Journal of Finance, forthcoming (Papers and Proceedings of Denver Meeting, September 1980).

6. Porter, Richard D., Agustin Maravall, Darrel W. Parke, and David A. Pierce. "Transitory Variations in the Monetary Aggregates," in Improving the Monetary Aggregates: Staff Papers. Washington, D.C.: Board of Governors of the Federal Reserve System, 1978.

7. Shiskin, Julius, Allan H. Young, and John C. Musgrave. "The X-11 Variant of the Census Method-II Seasonal Adjustment Program." Technical Paper 15. U.S. Bureau of the Census, February 1967.

8. Tiao, George C., and Steven C. Hillmer. "Some Consideration of Decomposition of a Time Series," Biometrika, vol. 65 (December 1978), pp. 497-502.

The New Operating Procedures and Economic Activity since October 1979.

Paper Written for a
Federal Reserve
Staff Review of Monetary
Control Procedures

by

Lawrence Slifman and Edward McKelvey

CONTENTS

THE NEW OPERATING PROCEDURES AND ECONOMIC ACTIVITY SINCE OCTOBER, 1979*

I. SUMMARY OF PRINCIPAL FINDINGS

On October 6, 1979, the Federal Reserve announced a fundamental change in operating procedures designed to assure greater control over growth in the monetary aggregates as part of a more comprehensive package of policy changes.[1] In the months immediately preceding this action economic activity had been surprisingly robust, and inflation and inflationary expectations had intensified. The shift in procedures was intended to provide more effective restraint on excessive aggregate demand pressures and ultimately to reduce inflation and the inflationary psychology that had been developing. This paper reviews the course of economic activity since October 1979 and assesses the probable impacts of the new procedures.

In analyzing the influence of the new procedures on economic activity it is important to remember that the objectives of monetary policy were not affected; the only alteration was to the shorter-run procedures used to help achieve the longer-run objectives. Thus, while interest rates were allowed to fluctuate more widely over the short run in response to market forces, the target ranges for the growth rates of the monetary aggregates were unchanged. Hence, in assessing the events since October 1979, the focus primarily is on the implications for real sector activity arising from the increased frequency and amplitude of interest rate movements that have occurred over the past 16 months. The analysis is made more difficult because of the large number of

1/ The other actions were a 1 percentage point increase in the discount rate from 11 to 12 percent and the establishment of an 8 percent marginal reserve requirement on managed liabilities.

* This study was coordinated by Lawrence Slifman and Edward McKelvey, major contributions were made by Susan Burch, Carol Corrado, James Freund, James Glassman, David Green, Owen Irvine, Charles Steindel, and Che Tsao. The manuscript drafts were typed by Karen Pashkevich, Sharon Sherbert, and Debbie Vorce. Research assistance was provided by Ron Sege and Martha Waldheger.

atypical events that have buffeted the economy since October 1979, including an oil price shock, credit controls, intensified inflation expectations and an attendant commodity speculation, and heightened budget uncertainties.

One central purpose of the new operating procedures is to provide greater assurance that the target growth rates for the monetary aggregates will be met. Over time, success in achieving this objective should lower expectations about prices, and, in turn, facilitate the planning of long-term saving and investment commitments by businesses and households. Thus, while wider cyclical movements in interest rates may affect the short-run (for example, quarterly) pattern of changes in GNP, over the longer run the new operating procedures should have a favorable influence on the growth path of the economy.

The principal findings of this paper are:

(1) Economic activity, as measured by real GNP, almost certainly would have contracted in any event during 1980, as a result of fundamental forces already at work before October 1979. The near doubling of oil prices during 1979, which generated a sizable transfer of income to foreign oil producers, combined with a decline in labor productivity, had led to slow growth in real disposable income and a deterioration in household balance sheet positions. At the same time, an acceleration in the overall inflation rate--in part a result of the oil price shock--and a concomitant rise in inflation expectations had generated additional imbalances and overextensions by both consumers and businesses, which left the economy vulnerable to a slowdown in activity.

(2) It is difficult to assess the effects of the new operating procedures per se, as compared to the constraining effects of the monetary targets themselves and other forces operating on the economy, on the timing and composition of output changes during 1980. To the extent interest rates

reacted more promptly to fluctuations in money and credit demands, the contraction of activity in 1980 may have been hastened, however, the subsequent rebound also developed more quickly. The decline in output during the second quarter was intensified by the imposition of credit controls in connection with the administration's anti-inflation program announced March 14, 1980. In particular, the reduced availability of credit and the unwillingness of consumers to borrow appears to have been an important factor in the sharp drop in household spending between March and June. As the program was phased out and credit conditions eased early in the summer, spending for housing and consumer goods rebounded sharply.

(3) In the housing sector, it is especially difficult to separate the impact of the new procedures from the effects of other factors. The depth and speed of the decline in housing activity between October 1979 and May 1980 probably was magnified by the unprecedented movement of mortgage rates to historically high levels; and the subsequent sharp rebound in residential construction reflected the swift decline in mortgage rates that occurred during the spring and summer. Some of the rate variability in mortgage markets likely reflected the switch in procedures; however, developments in real estate markets also were heavily influenced by other factors. In particular, credit controls apparently had an adverse, though largely unintended, effect on the availability of real estate financing at some institutions. In addition, various institutional and regulatory changes affecting the thrift industry and the mortgage market probably contributed significantly to the pattern of housing activity throughout the year.

(4) Surveys of consumer attitudes taken immediately after October 6, 1979, indicated a significant deterioration in attitudes towards the purchase of debt-financed items such as cars and large household durables. The heightened

pessimism primarily reflected fears that the new monetary package would be associated with reduced credit availability, and the drop in consumer spending, which began early in 1980, probably was influenced somewhat by these uncertainties. But, the more dominant factors were sluggish growth of real income, a relatively low saving rate, high debt burdens and financing costs, and households' concern about the acceleration of inflation. These fundamental forces were exacerbated by the psychological reaction of consumers to the credit control program. With the dismantling of the controls program in early July, however, consumer markets began to recover.

(5) Because of the lags in the capital spending process, the behavior of business investment in 1980 was, to a sizable degree, dependent on commitments made before October 1979. Nevertheless, the slump in real outlays that did occur probably was influenced by the unexpectedly sharp decline in aggregate demand during the first half of 1980--a decline that was exacerbated by the unusually sharp cyclical rise in interest rates and by credit controls. The subsequent easing of financial conditions during the summer and the rebound in aggregate demand helped to arrest the contraction of real capital spending in the last half of the year.

(6) The new procedures apparently affected the pattern of inventory movements in 1980, but the impact is hard to disentangle from other influences. The excess accumulation and subsequent liquidation of stocks that occurred in 1980 reflected sharp swings in final sales that were associated with the cyclical movements in income, unusually wide fluctuations in interest rates, and the credit control program. The steep rise in credit costs during the first part of the year, coupled with the rapid stock buildup, also caused serious financing problems for many firms--most notably auto dealers--and probably provided additional stimulus for liquidation.

(7) On balance, the shift in procedures has not, as yet, had a clear effect on inflation expectations, although there was some improvement for about half a year following the imposition of credit controls. The evidence does suggest, however, that expectations have not worsened since October 1979, despite the persistence of rapid price increases.

II. PRELIMINARY CONSIDERATIONS

The new procedures. Economic activity in the third quarter of 1979 was surprisingly robust in the face of deteriorating fundamental forces Coupled with rapidly rising prices, this unexpected resilience in aggregate demand produced strong demands for money and credit. In this turbulent environment, the FOMC announced on October 6, 1979, a fundamental change in its operating procedures. Since then less emphasis has been placed on containing day-to-day fluctuations in the federal funds rate, and more attention has been focused on controlling reserves.

At the time the new procedures were instituted it was recognized that they would entail greater freedom for the funds rate to change over the short run in response to market forces. Thus, it was expected that interest rates would exhibit greater short-run variability (on a day-to-day or week-to-week basis) as well as more rapid and possibly larger adjustments to cyclical variations in aggregate demand. As discussed in the paper by Dana Johnson, "Interest Rate Variability under the New Operating Procedures and the Initial Response in Financial Markets," in this compendium, there is evidence that interest rates indeed have become more variable since October 6 on both a short-run and cyclical basis.

Of course, it is impossible to know how events would have unfolded during 1980 in the absence of the change in procedures and therefore difficult to draw firm conclusions about the nature and extent of their effects on the economy. The task is made harder by the fact that the past year was in many other ways quite different from most other years in the postwar period. The economy was still absorbing the effects of the 1979-80 oil price shock, rapid inflation was distorting traditional patterns of behavior, and inflation expectations were quite high Indeed, by the spring of 1980 the situation seemed to require special measures, and on March 14 a governmentwide anti-inflation program was announced, which included selective credit controls. This action complicates further any attempt to separate the effects of the new procedures from the influence of other events and circumstances.

In spite of these difficulties, this paper attempts to draw inferences about the effects of the new procedures from a review of what did happen. In the sections that follow, developments in several key credit-related sectors are discussed. In the course of this study, three fundamental issues are raised:

(1) Did the increased cyclical amplitude and frequency of interest rate movements lead to a shorter and sharper recession in the first part of 1980 and hasten the subsequent recovery?

(2) Did the increased short-run variability of interest rates, by increasing uncertainty, permanently reduce the level of aggregate demand and hence output?

(3) How have the new procedures affected expectations?

In order to address these issues, it is first necessary to outline the analytical framework that describes the relationship between monetary control procedures and economic activity.

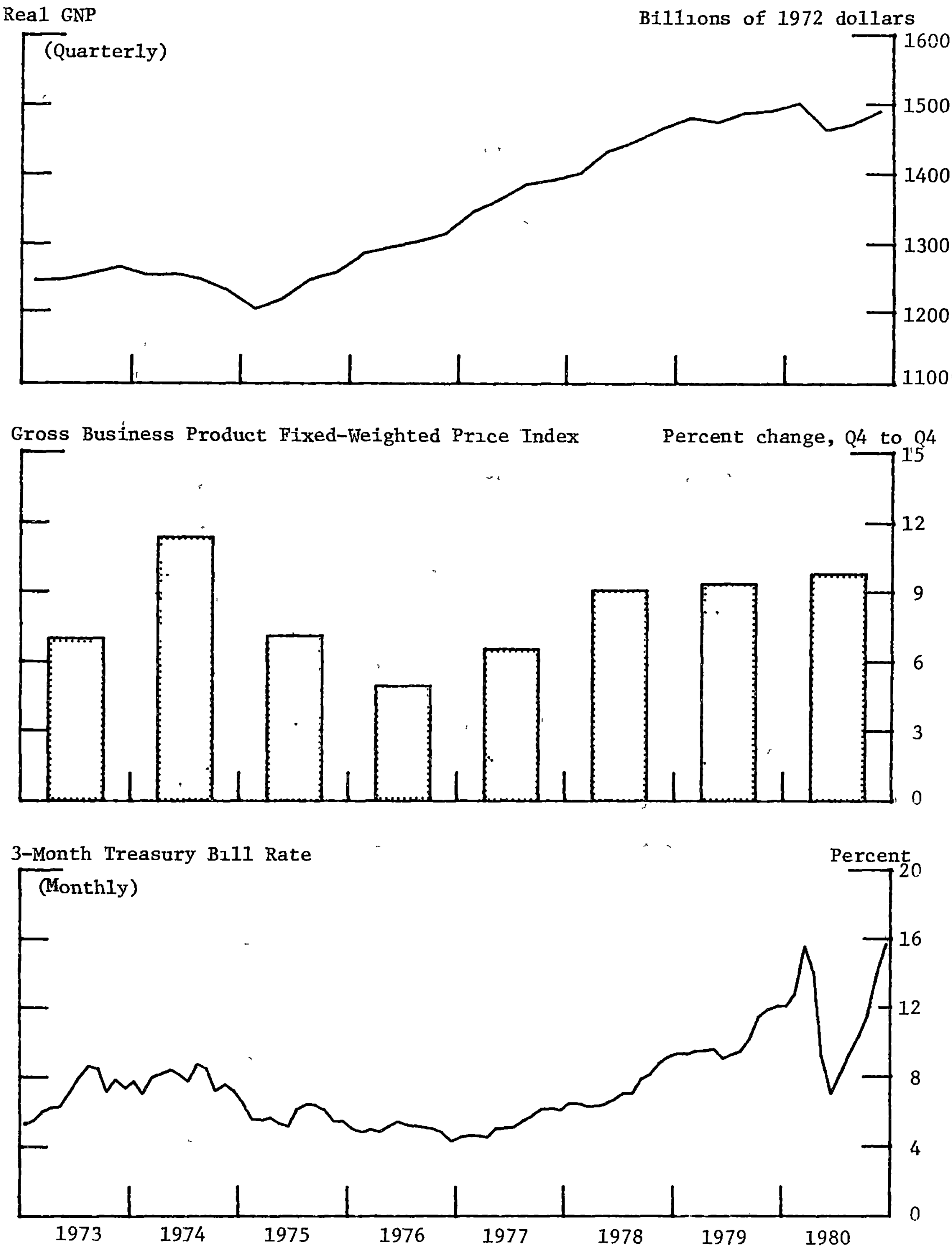
The monetary control problem. In discussing the effects of adopting the new procedures, it is important to distinguish between the long-run objectives of monetary policy and the short-run method by which the FOMC attempts to meet those objectives. Over the past decade, the Committee has followed a dual strategy in planning and executing monetary policy. In the first stage, the Committee has established longer-run (one-year) target ranges for the monetary aggregates that are thought to be consistent with

The evidence reviewed below indicates that the cyclical contractions in housing and in consumer expenditures for durable goods experienced during the spring of 1980 were unusually sharp. Perhaps surprisingly, the resumption of activity in these sectors following the rapid declines in interest rates that occurred during the late spring and early summer also appears to have been more prompt than might have been expected under such unprecedented circumstances. But, as is suggested below, these altered cyclical patterns more likely reflected, at least to a significant degree, the effects of the credit control program that was operating between March and July.

The second credit-related mechanism relies on a presumption that average yields on longer-term securities would increase as a result of the higher short-run volatility in interest rates that appears to have been associated with the October 6 action. The evidence supporting this presumption is not clear cut, however. On the one hand, the results reported by Johnson in "Interest Rate Variability under the New ... Procedures" in this compendium suggest that the liquidity premium on Treasury coupon issues was little changed after October 6. On the other hand, the Board's quarterly econometric model has shown a statistically significant link between the variability of short-term rates and the average level of yields on long-term corporate bonds.[1] Economic theory suggests at least two reasons why an increase in rate volatility may boost the level of long-term yields. One possibility is that the removal of policy constraints on interest rate movements has had asymmetric effects that are biased upward, this would have raised average rates across the maturity spectrum during 1980. Alternatively, it is conceivable that efforts by borrowers and lenders to minimize risks by lengthening liabilities and

1/ The relevant equation in the current version of the Board's model was estimated over a period that does not include the experience since October 1979.

ECONOMIC INDICATORS



shortening assets could have increased liquidity premiums and thus made the yield curve steeper. Under either circumstance, a permanently lower level of output would result as activity in the interest-sensitive sectors was discouraged, however, it must be emphasized that the evidence on this mechanism is far from conclusive.

Longer-run effects. One principal purpose of the change in procedures was to reduce inflation expectations by providing greater assurance that the System would meet its basic money growth objectives. The reduction in the level and in the variability of inflation that might be achieved through a smoother growth path for the aggregates could ultimately exert a moderating influence on expectations. Moreover, once the new procedures show signs of success, consumers and business firms might change their basic outlook about prices. Lower and more stable expectations about prices would facilitate the planning of long-term spending commitments and thereby spur capital formation.

The evidence on price expectations so far is inconclusive, as discussed further in section VII and appendix II; however, it may yet be too early to rule out a significant effect. At best, one can say that expectations did not deteriorate further immediately following the October 6 announcement, even though prices continued to accelerate. There was an upward movement in expectations around the beginning of the year, but in the spring they abated somewhat--possibly in response to the credit controls as well as the sharp drop in output-and they generally held at this lower level until near the end of the year.

The economic environment. The unexpected resilience of aggregate demand and the rapid rate of inflation that prompted the October 6 actions continued throughout the fourth quarter of 1979. Real final sales rose at about a 3 percent annual rate, boosted by a substantial advance in consumption. At the same time, consumer prices were rising at a 13 percent annual rate.

Despite the strength of aggregate demand, the economy at the end of 1979 appeared on the brink of a contraction in activity. In addition to the Federal Reserve's efforts to restrain the growth of the monetary aggregates, the nearly 80 percent increase in the price of imported crude oil that occurred during 1979 transferred some $30 billion of income to foreign oil producers and added perhaps as much as 2-1/4 percentage points to the overall inflation rate.[1] As a result of the sharp change in the relative cost of this price-inelastic good, consumers increased their total nominal spending in order to maintain lifestyles. The higher consumer outlays were financed out of reduced saving and increased borrowing, driving the personal saving rate to a relatively low level and keeping the debt-income ratio near its record high of the third quarter. Inflation-induced credit demands by businesses and a rising federal deficit also pushed interest rates up further.

Reflecting these pressures, economic activity began to turn down early in 1980. Initially the contraction was concentrated in household sector demand, with residential construction, autos and other durable goods most severely affected. Despite the emerging weakness, inflation and inflation expectations continued to intensify--fanning the flames of speculation in many commodity markets and pushing interest rates even higher. Nonetheless, growth in money and credit surged in February. Thus, on March 14 the President invoked the Credit Control Act of 1969, and under the provisions of this legislation the Federal Reserve announced a program of credit controls.

These measures hastened the reductions in credit availability that were already in train at many lenders. In addition, some lenders reportedly imposed tighter nonprice credit terms, including stricter approval standards, lower maximum borrowing limits, and higher minimum monthly payment requirements.

1/ Estimates of the effects of recent oil market developments on output and prices differ substantially. These matters are analyzed in appendix I.

The announcement of the program apparently induced consumers to curtail their use of credit as well. Retail stores in particular reported a steep decline in credit use, and a sudden drop in applications for new accounts. Banks also noticed sharp reductions in credit card use.

These adjustments in the supply and demand for credit reinforced fundamental factors--such as the rise in oil prices, sluggish growth of real income, illiquid balance sheets, and an accelerating price level--to produce the sharpest single-quarter contraction in output recorded for the postwar period. Real GNP fell nearly 10 percent at an annual rate in the second quarter. Over the first half of the year, the index of industrial production dropped a cumulative 7.3 percent (not at an annual rate), and employment declined by 1-1/4 million. The output reductions were largest in the motor vehicle and construction-related sectors, although credit controls were not intended to restrict lending in these areas. Nevertheless, outside the auto and housing sectors industrial production dropped a total of 7 percent between January and July. At the same time, firms responded to the high interest rates prevailing during the first part of 1980 by cutting their stocks and reducing their orders.

Credit conditions eased abruptly in the spring in response to the developing slack in the economy. Consequently, the rise in most interest rates came to a halt in late March and early April, and yields began to drop at a record pace. Most private short-term rates fell 7 to 9 percentage points in less than four months, to their lowest levels since the spring of 1978. As loan demand fell in most sectors, the credit restraint guidelines were phased out beginning in the late spring, and the program was completely dismantled in early July.

With the easing of credit market conditions, economic activity began to revive in the mid-summer. Those sectors hardest hit during the first half of the year--autos and housing--led the rebound. Consumer outlays for household durable goods such as furniture and appliances, which often are credit financed, also improved during the summer. In addition, the rapid drop in rates relieved the inventory financing pressures that had constrained many businesses earlier in the year.

Interest rates began climbing again later in the summer, and by the end of 1980 most rates were at or above their previous peaks. However, the immediate response to this run-up in rates was less dramatic than had occurred earlier in the year. Housing starts and retail sales continued to rise through the autumn, and economic activity as a whole maintained considerable momentum through the end of the year.

III. RESIDENTIAL STRUCTURES

A dramatic contraction in the housing industry took place in 1980. For the year as a whole, real residential investment expenditures were nearly 20 percent below their 1979 level. Private housing starts averaged 1.3 million units in 1980--a rate of production lower than every year in the past decade except 1975. Housing activity declined with unprecedented speed early in the year, and the recovery that developed during summer and early fall was unusually strong. These rapid movements in construction mirrored developments in mortgage markets, where costs of credit climbed to record levels and then fell quickly to their pre-1980 levels. By the end of 1980, housing activity had rebounded substantially, even though credit conditions once again were unusually tight.

A review of the experience since October 1979. Real residential construction began to slow dramatically in the autumn of 1979 at about the time the new operating procedures were announced. Activity had been unexpectedly strong in preceding months, with total housing starts hovering in the 1.7 to 1.9 million unit range throughout the spring and summer. The decline in new residential construction that ensued was both deep and rapid; by February starts had dropped to a 1.3 million unit rate.

Adjustments to the higher financing costs that followed in the wake of the October 6th action were particularly visible in the single-family sector. Mortgage rates rose quickly to an unprecedented 13 percent level and remained there through the end of 1979; between September and December total home sales dropped 15 percent, and the rate of increase in home prices slowed markedly for both new and existing units. Indeed, the average sales price of new homes actually fell during the fourth quarter of the year, reflecting both a slowing in price increases for units of a given quality and downgrading of units purchased. In the same period, prices of existing units rose by only half the rate of the preceding year. Despite the softening in real estate markets, builders managed to trim stocks of unsold houses, thus limiting increases in the inventory/sales ratio.

In the spring of 1980 financial conditions became more disorderly--with mortgage rates climbing rapidly to above the 16 percent level--and production adjustments in the housing sector became even more acute. Between March and May builders sliced another 400,000 units from the pace of new activity, bringing housing starts near their postwar low. Cutbacks in work forces also were sharp during the spring. By April new home sales had hit a nadir of 345,000, and while reduced production kept the stock of unsold units declining, the inventory/sales ratio reached a record high of 12.6 months' supply. Taken together, the retrenchment in housing activity in late 1979 and early 1980 was unusually rapid, with starts declining by 900,000 units at an annual rate from 1.84 million in September to 940,000 in May. In contrast, it took nearly a year and a half for starts to fall by a similar amount during the downturn in 1973 and 1974.

The role of credit controls in the 1979-80 housing contraction is somewhat problematical. The program applied mainly to commercial banks and placed no specific limits on mortgage credit. Indeed, banks were encouraged to treat such lending normally in light of general market conditions, and they were specifically urged to maintain the availability of funds to small businesses, farmers, and homebuyers. Nevertheless, mortgage rates rose sharply in the first few weeks after the program was announced, and the flow of funds in this market slowed to a trickle.

Initially, those banks specializing in real estate lending may have curtailed these activities in order to satisfy the Board's overall guideline of 6 to 9 percent growth in total loans. In a subsequent statement, the Board clarified its original intent to avert even such an indirect limitation on extensions of mortgage credit. Of course, it is impossible to estimate the degree to which institutions--both banks and thrifts--may have cut back such lending in spite of the provisions of the program, but the sharp decline that did occur suggests that the effect probably was significant.

Mortgage rates declined rapidly in the late spring, in conjunction with a widespread easing in credit conditions. The substantial reductions in financing costs prompted a resurgence in housing starts in the summer and fall that was far more swift and robust than had been experienced in previous postwar housing cycles. Underlying demand for owner-occupied housing had reportedly remained quite strong throughout the preceding contraction, and thus fueled the surge in activity when financial constraints eased. Moreover, thrift institutions--through the use of new deposit instruments--had avoided the liquidity squeeze characteristic of previous cycles, and were thus in a better position to resume lending when the demand resurfaced. Between April and July new-home sales rebounded almost 90 percent, and the average price of these units reaccelerated. Builders apparently were quite aggressive in restarting production and reassembling work crews, possibly anticipating that the upturn in activity would be prolonged.

The renewed strength in housing production continued well into autumn, despite the resumption of increases in mortgage interest rates that began in early August. Part of this strength may have reflected transactions postponed from the second quarter; some buyers also may have purchased homes in anticipation of further rate increases. In addition, builders seemed reluctant to disband recently reassembled work forces. At the end of 1980 construction activity continued to be surprisingly strong in spite of worsening financial conditions, with total housing starts remaining stable at about 1-1/2 million units.

Analytical considerations. Residential construction is one of the sectors of the economy most sensitive to changes in financial conditions; thus, it is in this area that the change in operating procedures would have been expected to have its largest impact. Purchases of single-family homes usually entail substantial mortgage financing and therefore depend heavily on both the cost and the availability of credit. Multifamily structures--whether owned as condominium units or built for rental use--also are highly leveraged in most cases. In addition, for all types of residential construction the profits realized by developers hinge on financing costs.

By no means can all of the ups and downs in residential construction over the past five quarters be attributed to the new procedures. Activity in this sector appeared to be on the verge of a downturn when the new procedures were announced in October 1979, and it seems highly likely that a substantial contraction would have taken place in 1980 in any event. Moreover, as already indicated, the credit restraint program appears to have had a significant, though largely unintended effect. Finally, after the previous housing cycle in 1974-75, there had been other important changes in the financial landscape--most notably in the ability of thrift institutions to attract funds in periods of high interest rates.

The enhanced competitive position of thrift institutions and other regulatory changes in the mortgage market created a new regime in which price rationing rather than the availability of credit determined the level of housing activity as interest rates rose to cyclical highs. The most important element of this new regime was the ability of thrift institutions to issue deposit liabilities with yields tied to open-market rates of interest. The new instruments--money market certificates and later the small saver certificates--insulated these institutions somewhat from the sharp drop-offs in deposit flows that had been characteristic of previous cycles. In addition, advances from the Federal Home Loan Bank System were more readily available than in earlier periods of credit stringency, thus augmenting further the resources available to the thrift institutions. Under these circumstances, thrifts were able to maintain a steadier flow of funds to the mortgage market as interest rates rose. Moreover, even when rates eventually peaked and deposit flows dropped off, the liquid asset positions of these institutions remained relatively comfortable, and they were therefore better prepared to reenter the mortgage market when rates began to plummet. Finally, state usury ceilings also were rendered ineffective during most of the 1979-80 housing cycle by a federal statute that took effect in January 1980, and borrowers also enjoyed unprecedented access to funds through secondary markets, which functioned well throughout the period.

It is especially difficult to disentangle the impact of the new procedures from the effects of improvements in the ability of thrifts to compete for funds, since the latter may well have contributed to the amplitude of interest rate movements over the last year or two. In previous cycles, cutbacks in credit flows to the housing sector, induced by increases in market rates above deposit rate ceilings, had been a key element by which monetary restraint had limited real activity. The ability of thrifts after May 1978 to offer deposit instruments paying market yields relaxed the constraints on the availability of funds and thus may have created a situation in which higher interest rates were required to achieve a given degree of restraint. In this regard it is noteworthy that mortgage flows continued to be relatively strong throughout 1978 and most of 1979, even though yields on substitutes for deposits were rising during most of that period to levels that were then considered high. Indeed, even when market rates peaked in the spring of 1980, there were reports indicating that, at least in some areas, credit was available "at a price."

Nevertheless, adoption of the new monetary control procedures--perhaps by contributing to a speedier response of interest rates to underlying changes in supply and demand--probably had some effects on real estate transactions. Because the financial arrangements associated with these transactions generally require several months to consummate, the more rapid changes in interest rates that occurred in 1980 increased the risk exposure for those attempting to purchase new or existing homes. During the spring of 1980, for example, potential homebuyers found that mortgage rates were increasing 50 to 100 basis points over periods as short as three or four weeks, and that these higher financing costs either would disqualify them from meeting lenders' standards for mortgages or simply impinge too heavily on their own budgets. Under these circumstances they were understandably reluctant to incur the risk of contracting for financing at rates to be determined at the time of settlement; yet for the same reasons lenders were hesitant to make fixed-rate commitments for loans to be made several months later.

In principle, the emergence of renegotiable and variable-rate mortgages should have helped alleviate the situation, at least from the lenders' perspective. However, these instruments still were very new, and borrowers were understandably skeptical of their advantages. Moreover, the variable-rate mortgage was not designed with sufficient interest rate flexibility to neutralize the lenders' risks of rapid, short-run rate fluctuations. Consequently, the standard fixed-rate mortgage remained the dominant instrument in this market in 1980.

The risks associated with more rapid movements in interest rates also affected builders, both directly and indirectly. To the extent that borrowers and lenders could not make contracts, builders were faced with high carrying costs for unexpected inventories of unsold houses. Also, the frequency and magnitude of interest rate movements probably increased the number of contracts that ultimately were broken. These risks were largest in the case of custom-built homes, for which the lags between commitment and settlement dates typically are longest. Even though builders typically would receive cancellation penalties in instances where contracts were broken, they still were faced with the problem of financing and reselling these units during a period when prospects for finding buyers were dim.

Builders also were subject to greater risks arising out of their own construction financing. Speculative building apparently was curtailed, as builders sought to avoid the costs of carrying unsold inventory. Moreover, those working on units with sales contracts found that their profits were more uncertain, since the sales price would already be fixed while the construction loan often would stipulate a floating rate tied to the prevailing prime rate. Although this risk theoretically could have been symmetric, the tendency for purchasers to sign contracts during periods of low interest rates skewed the builders' risk to the upside.

In summary, several factors combined in 1980 to produce the sharpest housing cycle of the postwar period. Adverse developments in the fundamental determinants of housing--such as sluggish real income growth and the effects of rising mortgage rates on monthly financing costs--laid the groundwork for some retrenchment in construction activity even before changes in operating procedures were implemented. To the extent that the new procedures made interest rates more responsive to changes in underlying credit conditions, they may have contributed to the speed of both the downturn in real estate activity in the first half of the year and the subsequent rebound in the third quarter. However, other changes of a more institutional nature, most notably the greater flexibility of thrift institutions to attract funds, also were important in this regard. Finally, although the credit controls program was not intended to restrict mortgage flows, the pattern of developments in the second and third quarters strongly suggest that the controls did influence events in a significant way.

IV. THE CONSUMER SECTOR

The October 1979 monetary policy package, including the new procedures, had an immediate impact on consumer attitudes toward purchasing durable goods and on opinions about the economic outlook. The University of Michigan Survey Research Center (SRC) made a special tabulation of responses to their usual monthly survey questions on the basis of whether the questions were answered before or after October 6. In this tabulation the SRC found that initially households did not think the new package would increase interest rates or--at least over the next 12 months--lower the inflation rate.[1] For over a year prior to the policy change, the Center had reported that consumers thought that interest rates were at record levels; in October respondents indicated no further increase in expected interest rates despite an increase in the number of those who said that "credit was in short supply." In contrast, as shown in table 1, the rate of inflation expected for the succeeding 12 months, which had dipped during the summer of 1979, resumed its upward movement in late 1979--after the October 6 announcement. A literal interpretation of the SRC data--that is, higher reported expected inflation rates, but unchanged expected interest rates--implies that respondents thought the real rate of interest would decline. Since economic theory suggests that lower real interest rates provide an incentive to boost spending on long-lived goods, the implied decrease in the real rate of interest should have been associated with a desire for higher outlays on consumer durables and houses. Yet the SRC found a significant deterioration in attitudes towards the purchase of

1/ It is somewhat puzzling that households did not correctly predict a further rise in interest rates. This may have been because consumer credit rates already were so high by historical terms--11.9 percent for a new auto loan at a commercial bank and 20.4 percent for a personal loan at a finance company--that most survey respondents thought further increases impossible.

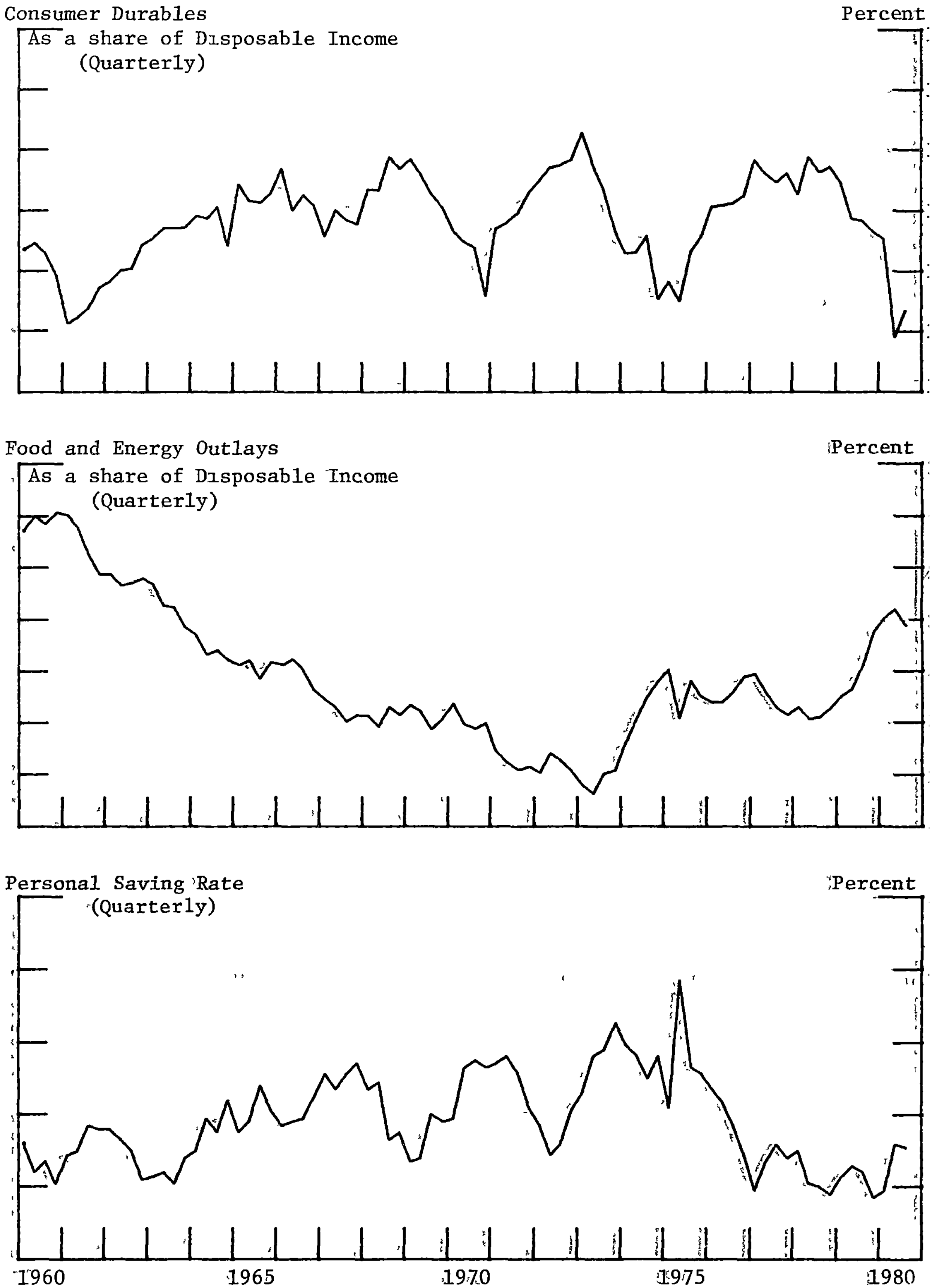
Table 1

SELECTED INDICATORS OF CONSUMER ATTITUDES
(Percentage of households reporting)

Question	1979					1980								
	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1. Credit is tight	5	6	9	20	14	7	9	22	24	16	9	5	5	8
2. Bad time to buy--credit is tight, interest rates are high:														
Large household goods	5	11	9	13	17	12	11	19	28	31	24	19	16	13
Autos	7	7	8	18	18	13	14	17	24	29	22	11	11	10
Houses	31	n.a.	n.a.	68	n.a.	n.a	56	n.a.	76	75	66	53	41	50
3. Households expecting interest rates to rise during next 12 months	61	70	70	62	40	45	47	71	56	26	21	21	39	53
4. Expected change in prices next 12 months (mean percent)	10.4	9.7	1/	11.2	10 8	13.1	10.7	12.0	11.1	8 2	8.1	9.0	8 0	8.5
5. Perceived change in prices over last 12 months (mean percent)	n.a.	n.a.	n.a.	16.0	16.4	16.6	16.1	16.6	17 4	15.9	14.4	14.5	14 4	14.5

1/ Responses to the October survey were tabulated separately, depending on whether the questions were answered before October 6 or October 6 and later the earlier figure was 8.6 percent, the later responses were 9.5 percent. The average for the month was 8.9 percent.

ALLOCATION OF DISPOSABLE PERSONAL INCOME



cars and large household durables after the announcement, and opinions about whether it was a good time to buy a house became more pessimistic.

The consumer reaction evident in the SRC data apparently reflected a perception by households that there would be less credit available over the coming months than they had anticipated and hence that they had little choice but to scale back plans for durable goods outlays and rebuild liquid asset positions. Moreover, the rise in inflation expectations, coupled with the SRC indication of a greater desire to cut back on discretionary durable goods purchases, suggests that households--for precautionary reasons--wished to accumulate financial rather than tangible assets. Consistent with these survey results, households began to shift their portfolios towards shorter-term assets in the autumn of 1979 in order to reduce the capital risk associated with increased interest rate variability.

The experience since October 1979. At the time of the change in operating procedures, the best-known measures of consumer confidence already were in a well-established downtrend. This reflected households' concern about sluggish real income growth over the past year, the acceleration of inflation, and high and rising debt burdens. Thus, faced with unfavorable credit market and income developments, consumers had seriously begun to cut back on discretionary outlays prior to October 6.[1] In particular, despite vigorous promotional efforts unit auto sales had declined to a sales rate of only 10.8 million units in the third quarter of 1979 from a 12.1 million unit peak in the second quarter of 1978.

1/ Contemporaneous economic analysis during 1979 and early 1980, however, was somewhat obscured by the severe 1978-79 winter and gasoline shortages of the spring, which artificially shifted substantial consumer demand to the second half of 1979.

At the same time that consumers were reducing their discretionary outlays in 1979, the share of family budgets devoted to items often considered essential was rising dramatically. This reallocation of household income toward essentials reflected the sharp jump in the relative prices of food and energy--goods that have relatively low short-run price elasticities. Thus, with real income growth sluggish and relative prices shifting in an adverse direction, households in the second half of 1979 chose to reduce their saving and take on additional debt in order to maintain their lifestyles.

This behavior, however, could not be sustained for long, and in February 1980 consumer outlays began to slide as households attempted to build savings and reduce borrowing in the face of rapidly rising interest rates. The bulk of the subsequent drop in consumption was for discretionary items such as autos, furniture, and appliances, which are the most credit-sensitive consumer purchases.

The factors that acted to retard consumption early in 1980 were reinforced by the credit control program. The major element of the program as it affected consumers was to limit the growth of open-end credit, such as credit-card debt, and those forms of closed-end credit that were either unsecured or secured by collateral not being purchased with the proceeds of the credit. Extensions of automobile and mortgage credit were exempted from specific limitations because consumer demand in these sectors already was weak.

In the first few weeks after controls were announced, many commercial banks and some retailers took steps to restrict the availability of consumer credit, usually by adopting more stringent credit-approval standards. Many banks instituted user fees on credit cards, lowered borrowing limits, or stopped issuing cards, perhaps taking advantage of the program to do what they had wanted to do anyway but feared might anger established customers. Retailers most commonly tightened credit terms through higher lending standards and by raising minimum monthly payment requirements. However, there were many reports by retailers that consumers had cut back voluntarily on credit card use after the controls program was invoked, and that applications for new accounts were off dramatically. All forms of consumer installment credit dropped at an 8 percent annual rate in April, the first full month under credit controls, compared with increases of 5 percent in March and 7 percent for the first quarter as a whole.

Following the imposition of credit controls, spending at retail stores continued declining through the spring, and by May real outlays were down more than 9 percent from their January peak. Despite the exemption of closed-end auto loans from the credit control program, unit auto sales declined in each successive month until May, when they reached a 5-year low of 7.3 million units. The peak-to-trough decline in retail sales was the most precipitous drop in consumer spending in the postwar period--about 25 percent deeper than in the 1974-75 cycle.

Inflation expectations eased significantly in the spring--apparently the combined result of the sharp cycle in interest rates during the winter and spring, the anti-inflation program announced March 14, 1980, and the dramatic cutbacks in consumer spending. As indicated in line 4 of table 1, the expected inflation rate declined from the double digit level of late 1979 and early 1980 to an 8 to 9 percent range beginning in May. Although there was concurrently some reduction in the actual inflation rate as measured by the consumer price index, SRC data on the perceived rate of inflation did not change as much as the expectational data.

With the dismantling of credit controls in early July, consumer markets began to recover. Unit auto sales picked up sharply in July and remained in an 8-1/2 to 9 million unit rate range through the autumn. Spending for general merchandise, apparel, and furniture and appliances was up a strong 4 percent in the third quarter, and consumer outlays generally were well maintained through the end of the year.

Summary. Theoretically, consumers adjust expenditures to expectations of longer-term earnings and to developments that affect returns from accumulated savings or wealth. The second factor suggests a principal role for interest rates as a determinant of consumption. As a practical matter, however, it appears that apart from investment in housing, most households in the past typically were concerned more with the availability than the cost of credit.[1] Increases in interest rates on credit-financed purchases--such as automobiles or major durable goods--used to play a secondary role, since the movement in rates was relatively small and therefore added little to the contracted monthly payment stream. While the SRC data suggest that credit availability continued to be the primary concern of households in 1980, reports from retailers indicated that higher financing costs gained new importance. Thus, in terms of their effects on households, the new operating procedures first reinforced fears that credit might not be available to support additional expenditures or to meet emergency needs, and later induced a more pronounced response to changes in interest rates.

1/ Higher interest rates can depress the value of household holdings of corporate equities and credit-market debt; but these negative wealth effects on consumption are thought to be small--especially in the short run.

V. BUSINESS FIXED INVESTMENT

The determinants of business capital spending can be divided into those that determine the level of the capital stock, and those that regulate the speed at which the actual amount of capital is adjusted to the desired level. Somewhat more problematically, the adjustment process may be divided into two lags, the first being the lag between the recognition of deficiencies in the capital stock and the decision to invest, and the second being the lag between the decision to invest and the actual installation of new capital. Because of the lags in the capital spending process, it is unlikely that wider or more frequent cyclical swings in interest rates--such as those in 1980--would have a very significant effect on capital spending. However, to the extent the average level of (long-term) interest rates was higher in 1980 than it might have been under alternative operating procedures or policy objectives, the long-run capital stock ultimately will be lower.

Theoretical considerations. The neoclassical theory of investment, developed by Dale Jorgenson and his associates,[1] starts by deriving the stock demand for capital. In this theory the optimal level of capital is an increasing function of the expected, long-run level of real output ("accelerator" effects) and a decreasing function of the real "service cost of capital." The service cost of capital is the value of the after-tax cash flow produced by a unit of new capital over a period, and in equilibrium it will be equal to the cost of raising the funds to hold the new capital for the period. Although tax and portfolio considerations complicate the issue,

1. See, for example, Hall and Jorgenson (1967).

in general the service cost of capital is an increasing function of market interest rates and a decreasing function of inflation rates.[1]

Within the framework of the neoclassical theory of investment, unusually sharp cyclical fluctuations in interest rates could be expected to affect capital spending directly through changes in the cost of capital and indirectly through induced swings in output. Neoclassical models of business investment typically employ long distributed lags on the output and cost of capital variables. This reflects the belief that business spending decisions are not based on the interest rate or sales demand prevailing at a particular moment, since these data may contain a good deal of "noise." Rather, it is believed that firms use a longer planning horizon and base spending decisions on expected "permanent" output and capital costs, which are represented empirically as distributed lags. Thus, given the lags in the capital-stock adjustment process and firms' concerns about permanent rather than actual output and capital costs, the effects of cyclical interest rate movements on business fixed investment are likely to be small.

While the overall effect of sharp interest rate cycles on capital spending should theoretically be small, there could be some effect on the short-run timing and composition of investment. During periods when interest rates are cyclically high, especially if cash flow is deficient, firms might postpone orders of items with short lead times, defer purchases of goods bought "off the shelf," or attempt to stretch out delivery dates for previously

1/ An important issue is whether the cost of capital depends on short- or long-term interest rates. Most empirical work has been done with long-term rates. Strictly speaking the use of long rates is an implication of the "putty-clay" hypothesis; that is, that the ratio of capital to labor inherent in the existing capital stock cannot be modified to reflect the optimal proportions called for by current interest and wage rates. This hypothesis is controversial. For a discussion of the pros and cons of the putty-clay hypothesis, see Hall (1977) and the comment by Modigliani (1977).

ordered items. Although there is some flexibility for firms to engage in these types of short-run timing adjustments, there is little evidence to suggest an unusual amount of this behavior in 1980.

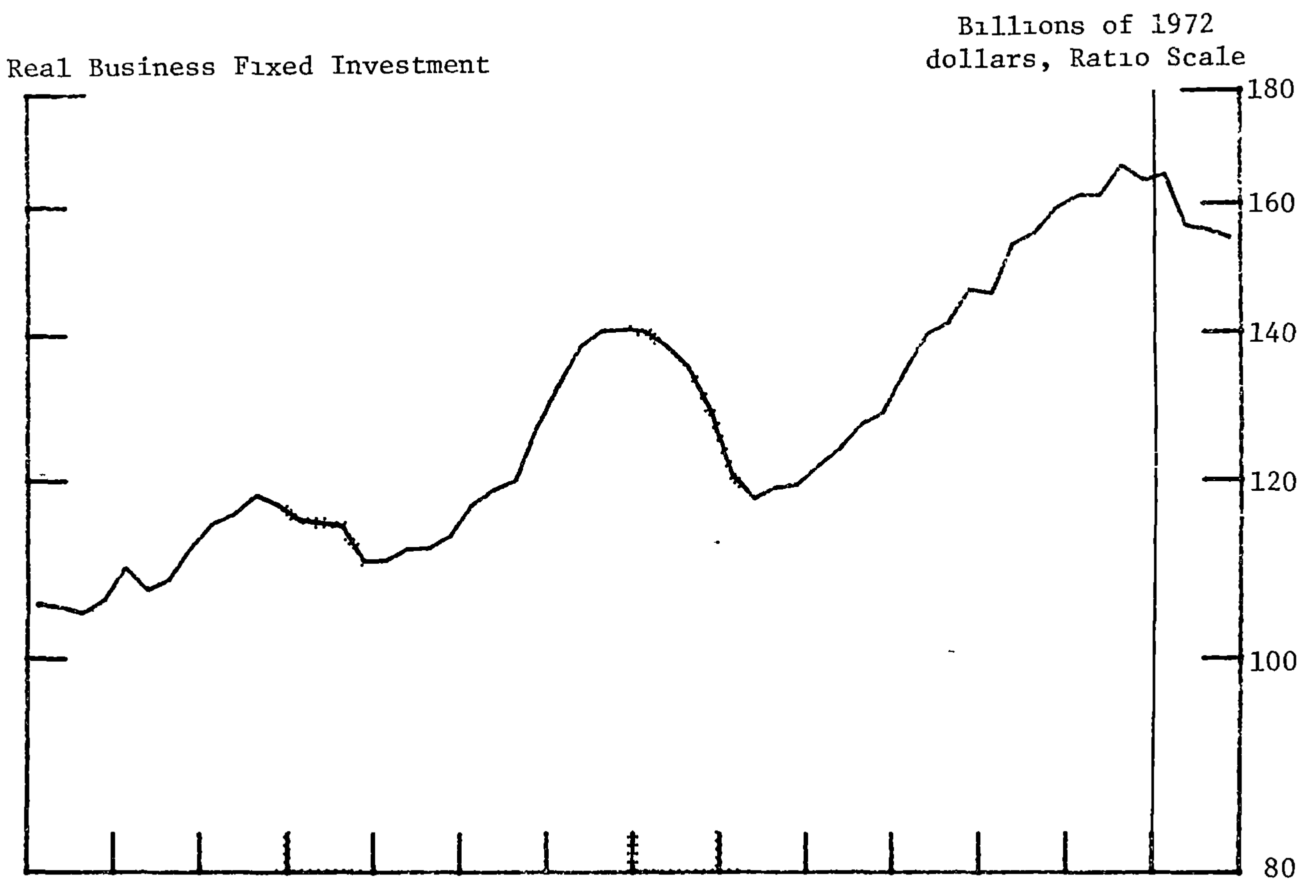
As was noted above, the demand for capital is believed to be a decreasing function of long-term interest rates. It has been argued by some observers of financial markets that the average level of long-term rates in 1980 was higher than would have been the case under alternative operating procedures or if the economy had not been subjected to such atypical events as the imposition and removal of credit controls, an inflation-induced commodity speculation, and unusually robust credit demands by households and businesses. To the extent the average level of long-term rates was unusually high last year, the desired stock of capital may have been lowered, and investment might well be reduced until such time as the actual stock adjusts to the new desired level. To a certain extent firms could counteract the higher cost of capital resulting from increased long-term rates by reducing the proportion of investment financed by debt. Issuing new shares of stocks probably would not be a less costly means of raising capital, given the tendency of stock and bond yields to move together, but increasing the share of investment financed internally might prove advantageous.

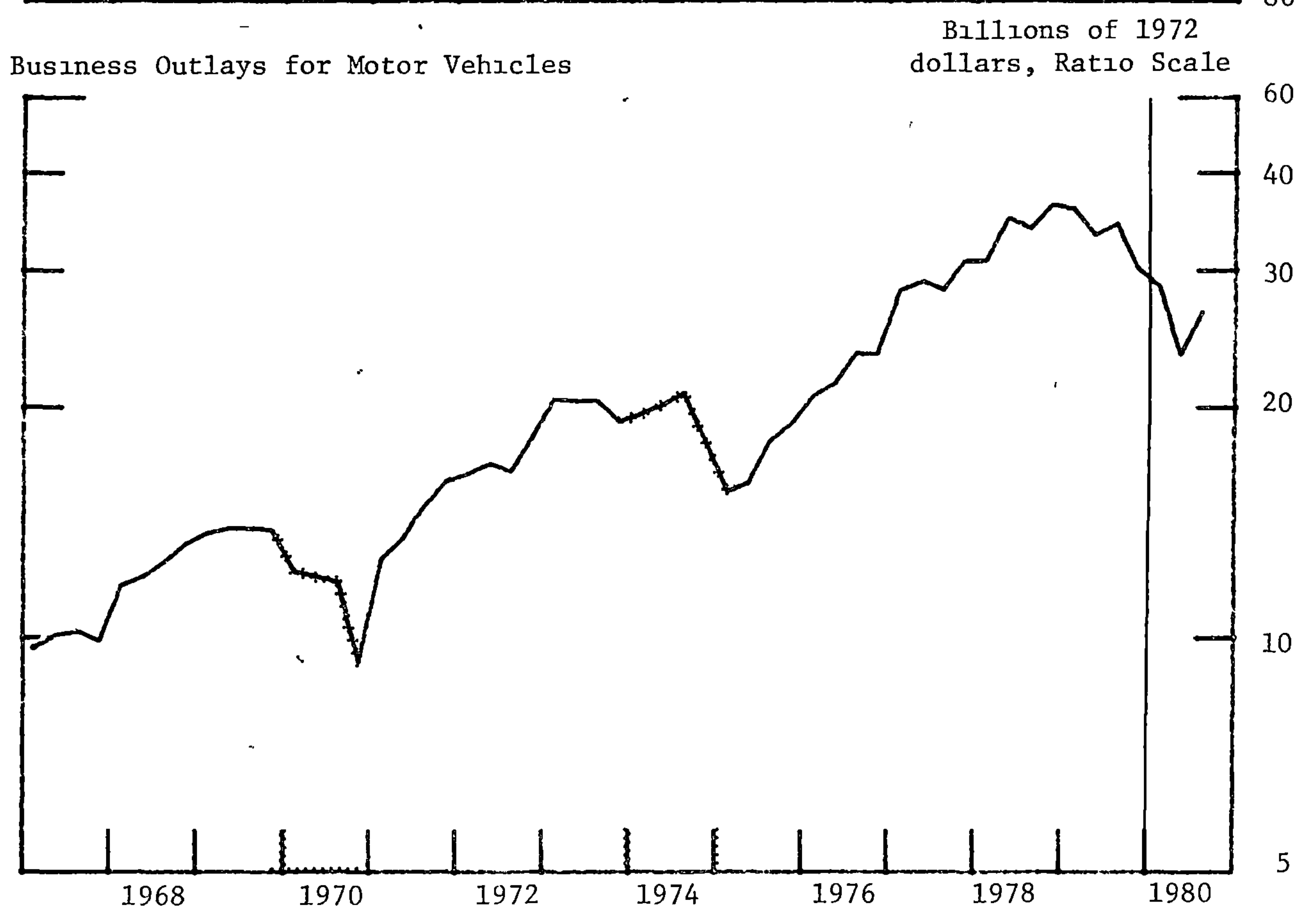
In the long run, the new operating procedures could promote greater cyclical stability in capital spending. By allowing interest rates to respond more promptly to shifts in credit demands and supplies, the new procedures might eventually contribute to a shortening and damping of business cycles. If so, future cyclical changes in output would be less likely to be viewed as "permanent," and firms would be more confident of a quicker return to normal demand following a decline in sales. Thus, to the extent that demand for capital depends upon permanent rather than actual output, the new operating procedures ultimately could reduce the procyclical variation in capital spending.

The experience since October 1979. The fundamental determinants of capital spending generally were not supportive prior to October 1979. Growth in real GNP, although somewhat erratic on a quarterly basis, slowed from nearly a 5-1/2 percent annual rate during 1978 to about a 2 percent rate over the first three quarters of 1979. Reflecting the sharp deceleration in final demands, constant-dollar orders and contracts for new fixed investment were relatively flat during the first nine months of 1979. On the whole, these movements suggest that a slide in real investment spending probably would have occurred during 1980 even if the operating procedures had not been changed.

The investment environment became even less hospitable after October 1979. Although a downturn in overall activity had long been anticipated, final demands began to contract in early 1980 at a rate that surprised most observers, and probably was not expected by most businesses. Moreover, the credit control program restricted business access to most sources of short-term financing at a time when cash flow was dropping rapidly. Under these conditions, real business fixed investment (BFI) declined at a 20 percent annual rate in the second quarter of 1980.

It is interesting to note that despite the rapid rise in nominal interest rates that occurred in late 1979 and early 1980, the real long-term interest rate apparently moved up little, on average, if at all. During the autumn and winter, the corporate bond rate rose about 4 percentage points before peaking in April. Based on evidence from the McGraw-Hill plant-and-


Real Business Fixed Investment
Billions of 1972 dollars, Ratio Scale
180
160
140
120
100
80


Business Outlays for Motor Vehicles
Billions of 1972 dollars, Ratio Scale
60
40
30
20
10
5
1968
1970
1972
1974
1976
1978
1980

equipment spending survey, the expected inflation rate for business product prices also rose 4 percentage points over the period, suggesting little change in the real cost of capital.[1] Similarly, the real cost of capital variables in the Board's econometric model, which are based on equity prices, only rose about 1/2 to 1-1/2 percentage points during the run-up in interest rates that occurred around the turn of the year. Similarly, an ex post calculation of real corporate bond rates showed an increase of only about 1-1/4 percentage points between September 1979 and March 1980.[2] The evidence of little movement in real rates suggests that the cyclical swing in nominal interest rates probably had only limited effect on real BFI during 1980-Q2.

The bulk of the second-quarter decline in business capital outlays was concentrated in reduced spending for trucks and autos, items whose acquisition is easily postponed when demand or financial conditions deteriorate. Indeed, a sharp decline in motor-vehicle outlays often occurs in the early stages of a cyclical contraction. Excluding these two items, real business fixed investment fell at a 13-1/4 percent annual rate in the second quarter. Business purchases of motor vehicles rebounded sharply in the third quarter, but this was more than offset by widespread investment cutbacks elsewhere--especially for structures--and total BFI in constant dollars slipped another 1-1/2 percent (annual rate). However, in the fourth quarter of 1980 real capital spending edged up, with the increase concentrated in nonresidential structures.

1/ In the McGraw-Hill survey taken during late September and early October of 1979, firms expected to raise their product prices 8 percent over the next year; in the March-April 1980 survey, they expected a 12 percent rise in their product prices. The putty-clay hypothesis of investment indicates that product prices rather than capital goods prices should be used to measure real interest rates.

2/ The ex post calculations are based on the AAA corporate bond rate and a measure of expected product price increases. The price expectations variable is calculated as an exponentially declining weighted 3-year moving average of the producer price index (PPI) for finished goods excluding food.

Summary. Business fixed investment generally is considered to be coincident with overall economic activity at cyclical peaks. (One exception is the 1973-75 recession, when the significant reductions in real BFI did not begin until 1974-Q3.) Thus, the timing of the decline in real BFI during 1980-Q2 was not out of line with the usual experience in previous business cycles. The intensity of the decline, however, was a bit different from other cycles (table 2). Often, as a capital spending downturn begins the biggest loss (in percentage terms) occurs during the second quarter of the contraction. In contrast, during 1980 the biggest loss was in the first quarter of the BFI cycle (1980-Q2), and it was considerably larger than most first-quarter cyclical losses. Averaging over the first two quarters of previous BFI cyclical contractions, however, the magnitude of the 1980 decline was well within the range of previous cyclical experience. The composition of the reductions in real BFI during 1980 also resembled earlier investment cycles. In particular, the 58 percent (annual rate) drop in real outlays for business trucks and cars in 1980-Q2 was similar to the reductions evident in earlier cycles.

The behavior of real BFI during 1980--particularly in the construction area--was to a sizable degree dependent on commitments made before October 1979. Thus, the pattern of capital spending during 1980 was determined primarily by movements in final demand that already had been observed or were expected prior to the announcement of the new operating procedures. To the extent that the new procedures influenced business investment during 1980, the effects mainly occurred indirectly through changes in overall activity (accelerator effects) that might have been induced by the new procedures. The data do suggest, however, that the unexpectedly sharp decline

Table 2

CYCLICAL CHANGES IN REAL BUSINESS FIXED INVESTMENT[1]
(Percent change, compound annual rate)

Beginning quarter of BFI contraction	Change during...		Average for first two quarters
	First quarter of contraction	Second quarter of contraction	
1949-Q1	-18.2	-18.9	-18.7
1953-Q4	-2.6	-9.3	-5.9
1957-Q4	-9.2	-22.9	-16.5
1960-Q3	-8.8	0.4	-4.4
1969-Q4	-3.8	-6.7	-5.2
1974-Q3[2]	-8.3	-17.1	-12.7
1980-Q2	-19.9	-1.5	-11.2

1/ Cycles are based on the contraction in business fixed investment; these cycles may vary in timing from the NBER-designated contractions in overall activity.

2/ There was a fractional decline in real BFI during 1974-Q2, but the significant contraction did not begin until 1974-Q3.

in output during the winter and spring of 1980--which was exacerbated by the unusually rapid cyclical rise in interest rates and by credit controls--may have intensified the 1980-Q2 drop in real BFI. But, the easing of financial market conditions during the summer and the rebound in economic activity probably ameliorated the contraction of real BFI in 1980-Q3.

VI. INVENTORY INVESTMENT

The determinants of inventory investment. Observed changes in inventory levels, that is, inventory investment, can be decomposed conceptually into planned and unplanned changes. Unplanned changes result from unanticipated events such as production disruptions or differences between actual and forecasted sales. Planned changes, on the other hand, result from firms adjusting their inventories toward desired or target inventory levels. Since rapid adjustments in stocks to their desired levels are costly, these changes generally are spread over several months or quarters.

Reflecting the fact that inventories serve as a buffer, the target level of inventories depends on the expected level of future sales and production. In addition, target inventory levels depend inversely on per unit inventory carrying costs, which consist of good-specific carrying costs (such as maintenance costs and depreciation) and financial carrying costs. These financial inventory-carrying costs consist of two components. First there is the opportunity cost (or direct cost if external financing is used) of the funds invested in a unit of inventory. The second component is the reduction in carrying costs that comes about from increases in the price of the good while it is held in inventory. Hence, financial inventory-carrying costs are properly measured by a real interest rate, that is, the nominal interest rate used to measure the opportunity cost of the funds invested minus the expected rate of price inflation (for specific goods) over the inventory holding period. Multiplying this real interest rate (assuming it is expressed at an annual rate) by the good's price gives the number of dollars per year it costs to hold a unit of the good in inventory.

Unfortunately, over any given period of time, changes in actual inventory levels do not necessarily track very well changes in target inventory levels. This is because: (1) in the presence of adjustment costs, it is optimal for firms to plan to spread the adjustment over several periods, and (2) actual inventory levels can be heavily influenced by unplanned inventory investment. Indeed, when unplanned inventory investment is large, actual inventory levels and target inventory levels can even move in opposite directions. Estimates of the speed at which inventory levels are adjusted to their target values range from three months to several years and are the subject of much dispute in the economic literature. The slowest speeds of adjustment have been estimated for manufacturing inventories, the fastest for retail trade.

Interest rate variability and inventory investment. Traditionally, retail firms have depended heavily on short-term bank loans to finance part of their inventory. For items like appliances and automobiles, specific arrangements to finance "floor plans" are common. Some automobile dealers also obtain financing from their manufacturers' credit corporation. Less is known about the extent to which manufacturers finance their inventories through external borrowing arrangements.

Greater variability in short-term interest rates increases the firm's risk of encountering the cash-flow problems associated with refinancing at high levels of interest rates. To minimize these risks, firms are likely to seek alternative sources of financing for their inventories. One possibility is to tap longer-term sources, an option that generally will be more expensive if pursued for any length of time. In addition, firms may also depend more on internal financing, which can make inventory investment more sensitive to cash-flow fluctuations.

In either case, assuming firms attempt to minimize costs, any shifts in sources of financing induced by greater variability in short-term rates presumably raises financial carrying costs and in turn leads to lower target inventory levels. In the trade sector, this probably will cause more frequent shortages, less selection in the stores, and more special ordering of goods. Also, since inventory financing costs are an operating cost, upward pressure will be placed on prices. In the manufacturing sector, smaller target inventory levels will likely lead to more frequent shortages, more back orders, and perhaps larger fluctuations in output and employment as firms attempt to gear production more closely to sales.

In summary, over the short run the effects of greater interest rate variability are likely to be higher inventory carrying costs and smaller target inventory levels. The fewer inventories that are available to serve as a buffer stock, the more other variables (such as output and employment) will have to fluctuate in response to shocks hitting the economy. On the other hand, to the extent the new operating procedures improve the ability of the Federal Reserve to pursue a policy that ultimately reduces both the level and volatility of the aggregate inflation rate, variations in spending and production could diminish over the longer run. In this event, the economy will need smaller buffer stocks and the short-run effects on production and output might be mitigated or offset altogether.

The experience since October 1979. Changes in inventory levels during 1980 were heavily influenced by the unplanned inventory investment that accompanied the business-cycle turning point in January 1980. While there were reports that businesses were cautious about building large stocks toward the end of 1979, it is likely that few anticipated the steepness of the decline in final sales that actually occurred in the first half of 1980.

Hence, much of the inventory buildup in early 1980 probably was due to errors in forecasting sales.

In table 3 the inventory levels held by each major sector are listed; changes over the past year are given in columns (4) and (5). While there was substantial liquidation by retail-sector firms, stocks accumulated in the manufacturing sector. This pattern is typical at the early stage of a cyclical contraction in activity: in response to declining sales, retail firms cut orders and begin to liquidate excess inventories rather quickly. In turn, manufacturers accumulate unplanned inventories until the rate of production can be reduced to a level below their unexpectedly low sales rate. Often these excess manufacturing inventories are not liquidated until retail firms have nearly completed selling their excess inventories and have resumed ordering at a pace consistent with the level of final sales.

The observed changes in inventory levels reflected, in part, planned responses toward altered inventory target levels. The change in the major determinant of each sector's target level--its sales or shipments--over the first year of the new procedures is reported in columns (8) and (9) of table 3. In the retail sector, by far the largest liquidation occurred in the automotive group, which experienced the largest sales decline. The inventories of other retail durable goods also were drawn down, presumably reflecting the sharp drop-off in sales. The absence of liquidation in nondurable retail inventories is consistent with the fact that sales for firms in this sector declined only slightly. On the other hand, manufacturing sales fell 3.8 percent, and yet there was a small buildup of stocks over the year. This accumulation at manufacturing firms reflected unplanned inventory accumulation over the year, as well as the divergence of trends affecting various specific industries--in

Table 3
INVENTORIES, SALES AND INFLATION EXPECTATIONS

Sector	Avg inventory 1960-79 as a percent of NIA level	Inventory end of Sept 1979 (1972 dollars)	Inventory end of Sept 1980 (1972 dollars)	Inventory investment over the year		Sector sales level		Change in sales over the year		Inflation expectation measures				
										Actual inflation observed over previous year as of			Actual inflation rate over next six months as of	
				1972 dollars	Percent of initial level	Sept 1979	Sept 1980	(1972 dollars)	Percent of initial level	Sept 1979	Apr 1980	Sept 1980	Sept 1979	Apr 1980
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Retail sector	19 03	65 3	62 6	-2 7	-4 13	47 7	44 7	-3 0	-6 29	12 02	13 66	11 49	13 81	8 65
Auto group	4 13	16 3	14 0	-2 3	-14 11	9 7	8 3	-1 4	-14 43	6 73	7 09	12 15	8 25	5 14
Nondurable goods	10 61	35 5	36 1	6	1 69	30 0	29 3	- 7	-2 33	13 36	16 16	12 70	15 75	7 39
Other durable goods	4 29	13 5	12 5	-1 0	-7 41	8 0	7 1	- 9	-11 25	10 43	10 23	9 87	11 70	10 56
Merchant wholesalers	12 50	49 9	50 1	2	40	38 1	39 6	1 5	3 94	9 70	11 75	10 82	16 10	6 03
Manufacturing sector	43 00	142 5	143 4	9	63	76 2	73 3	-2 9	-3 81	11 15	14 04	14 61	15.76	9 21
Subtotal Manufacturing and trade	74 53	257 7	256 1	-1 6	- 62	161 7	157 6	-4 1	-2 54					
Farm sector	15 20	43 0	43 4	4	93									
Other sector	10 28	43 0	42 8	- 2	- 47									
Total NIA inventory	100 00	343 7	342 3	-1 4	- 41									

particular the large accumulation of stocks at nonauto transportation manufacturers (such as aircraft plants and shipbuilding yards). Without this buildup, manufacturing inventories would have declined.

Presumably, in late 1979 and in 1980, target inventory levels also were influenced by the large swings in nominal interest rates and inflation rates, as well as by unexpected changes in sales. Between September 1979 and April 1980 the prime rate rose from around 13 percent to 20 percent, and the commercial paper rate rose from about 12 percent to 16 percent. This large increase in nominal rates does not appear to have been accompanied by a concomitant change in short-run inflation expectations of the same magnitude. Lacking data on movements in the expected rate of change of each subsector's prices, the right-hand columns of table 3 report two proxy inflation forecasts: (1) a naive forecast that assumes the inflation rate over the relevant inventory holding period (taken here to be six months) would have been equal to that observed over the preceding 12-month interval, and (2) the perfect foresight forecast that prices would increase at the rate that actually materialized over the following six months.[1] It seems reasonable to assume that the actual inflation expectations held by most firms lay somewhere between these two proxy forecasts. The values of these proxy forecasts are reported in table 3 for September 1979 and for April 1980 (the month that nominal interest rates peaked). The value of the naive forecast also is reported for September 1980.

1/ It is important to observe two differences between the inflation expectations measures shown in table 3 and those reported on page 31: (1) the measures in table 3 attempt to reflect the inflation rate expected over the near term (since they are to be compared with short-term interest rates), while the evidence on page 31 pertains to longer-run expectations; and (2) these measures are industry specific while those on page 31 are for for all product prices. Thus, it is possible for real short-term rates to rise in a specific industry, while real long-term rates for all businesses on average are little changed.

The expected inflation proxies for the retail auto subsector suggest that the expected rate of inflation for automotive products probably declined somewhat between September 1979 and April 1980. Hence, the increase of 4 to 6 percentage points in short-term nominal interest rates was associated with a rise in the real interest rate faced by automobile dealers of somewhere between 4 and 9 percentage points. These sharply higher carrying costs partly explain why automobile inventories declined substantially more than did automotive sales; econometric estimates suggest that around $1 billion of the $2.3 billion liquidation in automotive stocks can be attributed to the rise in the real interest rate. After April, both the decline in nominal rates and the pickup in the rate of auto price inflation worked to reduce these financial carrying costs.

The proxies reported in table 3 suggest that the expected inflation rate for other retail durable goods did not increase between September 1979 and April 1980. Hence, the rise in nominal interest rates was translated into higher real inventory-carrying costs for these goods and thus was a factor behind the substantial liquidation observed in this sector. During this period the naive forecast of nondurable-goods price inflation rose by nearly 3 percentage points, whereas perfect foresight would have yielded a considerable drop in the expected nondurable-goods inflation rate. Hence, it is not clear which way actual inflation expectations changed. In any case, between September and April the increase in nominal rates probably helps account for the small liquidation observed here in late 1979 and early 1980. The rise in real interest costs between September and April probably also helped stimulate the small liquidation of merchant wholesaler stocks that occurred in late 1979 and early 1980.

The rapid cyclical run-up in interest rates during the first part of 1980 probably also affected inventory investment indirectly by depressing sales of automobiles, houses, furniture and appliances, and other interest-sensitive items. The height of the cyclical peak in nominal rates and the impact of credit controls undoubtedly surprised most firms, causing actual sales to fall short of their sales forecasts, and thus led initially to at least some unplanned inventory investment. Also the effects of the higher rates and credit controls on sales during the spring may have led to lower target inventory levels. Hence the indirect effects on sales of an unusually sharp cyclical rise in interest rates, coupled with credit controls, probably accentuated recent inventory movements; by causing a larger accumulation initially and possibly a reduction in desired stocks, more liquidation was needed to bring inventory levels back down to their target values.

In those sectors characterized by relatively fast speeds of adjustment (such as retail trade establishments), the unusually high cyclical peak in real rates during the spring may have caused a higher observed rate of liquidation. However, the prompt and precipitous decline in rates after the peak probably moderated the amount of this extra liquidation. For the more slowly adjusting manufacturing sector the additional liquidation induced by the extremely sharp cyclical run-up in rates was smaller; by the time most manufacturers were in a position to liquidate their inventories (the third quarter of 1980) short-term interest rates were well below their April 1980 cyclical peaks.

Hence it is reasonable to conclude that most of the extra liquidation was confined mainly to the rapidly adjusting trade inventories. Moreover, to the extent that the new operating procedures provided a steadier availability of bank loans over the high interest rate period, this too moderated the observed liquidation somewhat by decreasing the number of forced sales of excess inventory. Because most of the extra liquidation probably took place in the trade sector, the overall inventory investment cycle that accompanied the 1980 recession will appear to have occurred somewhat earlier in the business cycle.

In summary, the inventory cycle that accompanied the 1980 recession was relatively mild in comparison with previous business cycles. This primarily reflected the cautious inventory behavior practices followed by firms after the 1973-75 recession. However, the rapid rise in financing costs and the unexpectedly sharp drop in sales in the first part of 1980 caused serious difficulties for many firms--most notably auto dealers. The ensuing liquidation of stocks was exacerbated by the effect of high interest rates on final sales and the unexpectedly strong impact of credit controls on consumer demand. Despite the easing of credit markets during the summer and the pick up in final sales in the last half of 1980, firms continued to maintain tight control over inventories through the end of the year.

VII. INFLATION EXPECTATIONS

One objective of the shift to a reserve operating guide for open market operations was to help reduce inflation expectations by providing greater assurance that targeted growth rates for the monetary aggregates would be realized. In this section data from several surveys and inferential information from the behavior of long-term interest rates since October 1979 are examined in an effort to assess the effects of the change in procedures on expectations. Appendix II provides a more detailed analysis of the data, as well as a discussion of related theoretical and empirical problems. On balance, the evidence does not suggest that the October 6 action led to an immediate improvement in inflation expectations; however, it may be too early to rule out such an effect, since many survey respondents and market participants presumably would have awaited some signs of success for the new procedures before revising their expectations.

Measures of inflation expectations from three surveys are summarized in table 4. These data show no reduction in the expected rate of inflation in the months immediately following the October 6 action; indeed, all three series indicated some deterioration by the end of the year. Data from the University of Michigan Survey Research Center (SRC) show that consumers' expectations of inflation over the ensuing 12-month period rose quite sharply in November 1979 following a steady decline since the spring of that year.[1] Thereafter, the average expected rate of inflation peaked at 13 percent in

1/ The SRC asks several questions every month that are designed to measure consumers' expectations about inflation. The data on anticipations are constructed from the following questions: "During the next 12 months do you think that prices in general will go up, or go down, or stay where they are now?" and "By about what percent do you expect prices to go up, on average, during the next 12 months?" The questions refer to the CPI.

Table 4
MEASURES OF INFLATION EXPECTATIONS[1]
(Percent)

Period	University of Michigan (SRC) survey[2]	Livingston survey[3]	Blue Chip Economic Indicators[4]
1977-Q4	6.5	6.3	n.a.
1978-Q1	7.4		n.a.
Q2	7.8	6.7	n.a.
Q3	8.3		n.a.
Q4	8.1	7.1	n.a.
1979-Q1	9.1		n.a.
Q2	11.1	8.5	n.a.
Q3	10.3		8.3
1979-September	9.7		8.5
October	8.9		8.5
November	11.2		8.8
December	10.8	9.6	8.9
1980-January	13.1		8.2
February	10.7		8.6
March	12.0		8.9
April	11.1		9.1
May	8.2		9.0
June	8.1	10.1	8.9
July	9.0		8.9
August	8.0		8.7
September	8.5		8.9
October	9.2		9.1
November	8.7		8.9
December	10.1	10.3	9.5
1981-January	7.8		n.a.

1/ All expectations are for the CPI, except that the GNP deflator is shown for the Blue Chip Economic Indicators.

2/ Mean increase of responses to the question: "By about what percent do you expect prices to go up, on the average, during the next 12 months?" The question refers to the CPI.

3/ Expected increase constructed by the Federal Reserve Bank of Philadelphia from disaggregated Livingston data; data are for the last month of the quarter indicated.

4/ Consensus forecast; series begins in May 1979.

January 1980 and remained high through April. From May to November expectations were more moderate, possibly as a result of the credit controls, with the average expected rate of inflation generally fluctuating in the 8 to 9 percent range--the same as in late 1978 and early 1979.

The other two surveys generally confirm the pattern of expectations shown in the SRC data. The Livingston biannual survey of "informed" business economists indicated a clear increase in the inflation expectations of these respondents between June and December of 1979, and again in the subsequent half-year period.[1] The Blue Chip Economic Indicators survey data failed to show any immediate impact of the revised open market procedures on the anticipations of private economic forecasters.

In an analytical sense, the relevance of the survey data could be discounted because there is no evidence that transactions actually are based on these expectations. The behavior of long-term interest rates, on the other hand, conveys information about changes in inflation expectations that is directly the outcome of financial transactions. In the economic literature, the expectations hypothesis of the term structure of interest rates--a widely accepted view of interest rate relationships--holds that long-term rates are weighted averages of current and anticipated short-term rates, adjusted appropriately for liquidity and risk premiums. Because expected future rates presumably incorporate expected rates of inflation, movements and shifts in the yield curve should embody some information about changes in the expectations of market participants.

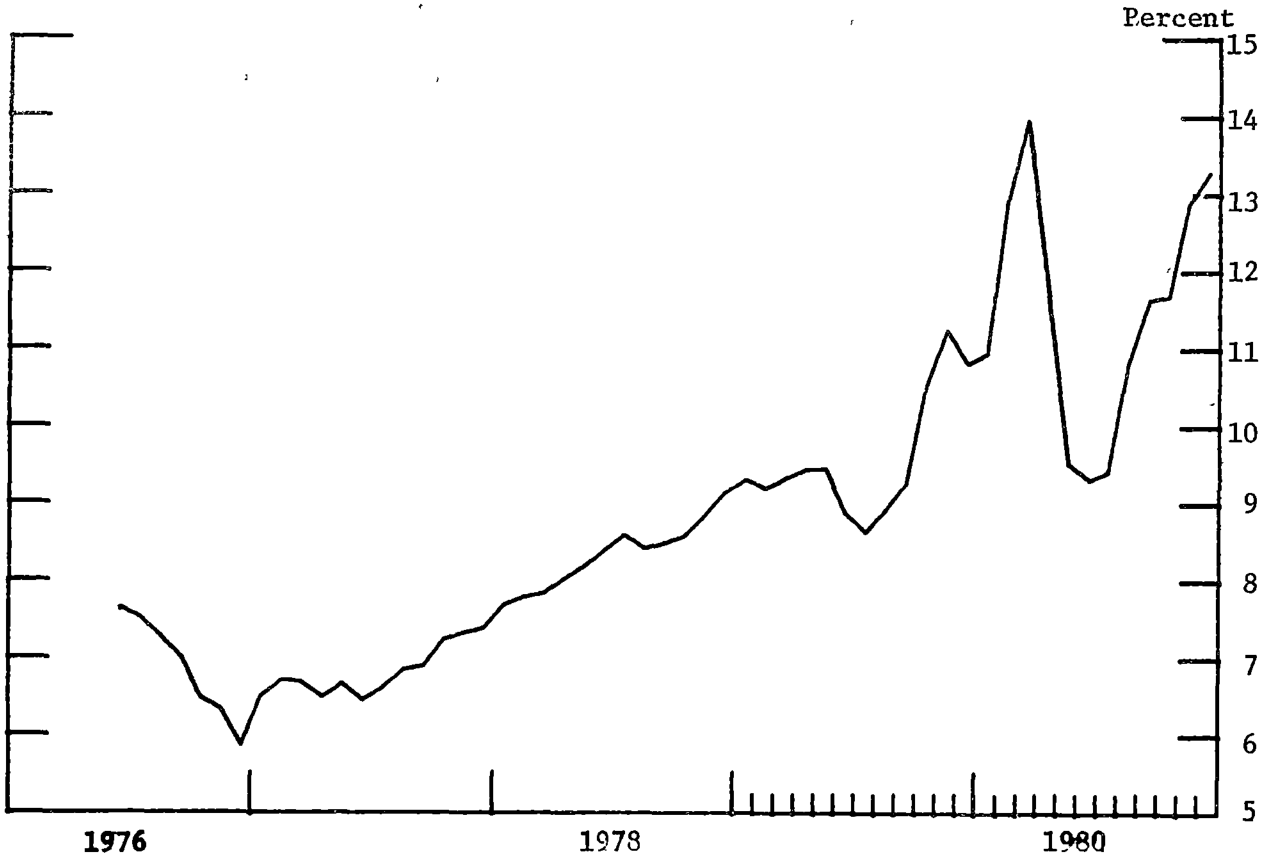
1/ Since 1947 Joseph A. Livingston has collected biannually the anticipations of economic variables from businessmen, economists, and professional forecasters. Livingston mails questionnaires in early December and May, and asks for 6-, 12-, and (in May) 18-month ahead forecasts of the CPI and the PPI for finished goods. Results of these surveys are published regularly in Livingston's column in either the Philadelphia Inquirer or the (Philadelphia) Bulletin.

Unfortunately, the post-October 1979 data are difficult to interpret; at best one can say that they too provide no evidence of a significant improvement in expectations following the change in procedures. Analysis is complicated by the possibility that several other factors can also cause long-term rates to change. These include changes in liquidity and risk premiums, as already suggested, as well as movements in the real rate of interest and differences that may arise from the segmentation of securities markets from one another.

These difficulties can be minimized by confining the investigation to yields on Treasury securities. These yields, whose average level and volatility increased dramatically after October 1979, have been studied extensively in the paper by Johnson, "Interest Rate Variability Under the New ... Procedures," in this compendium. That study produced little, if any, evidence to support the hypothesis that liquidity premiums have risen following the change in procedures, a result which increases the possibility that changes in inflation expectations were responsible for the behavior of longer-term Treasury yields. If so, the data would indicate that inflation expectations rose sharply in the fall of 1979 and have remained both high and highly volatile since then. However, such a conclusion must be highly tentative, given the difficulties in measuring liquidity premiums and uncertainties about the movement of the real rate of interest over this period.

On balance, the available information on expectations does not indicate any clear improvement in expectations following the October 6 action. They generally suggest a worsening in expectations over the subsequent six months or so, followed by an improvement later in the spring of 1980. It should be emphasized, however, that little is known about how households and

ONE-YEAR FORWARD RATES IMPLIED
IN THE YIELD CURVE FOR TREASURY SECURITIES[1/]



1/ According to the expectations hypothesis, the series plotted represents the yield on one-year Treasury obligations expected by market participants to materialize one year ahead of the dates indicated (the "one-year forward rate"). This rate is calculated using the one- and two-year constant maturity Treasury yields, and is arrived at by the following formula:

$$r_{f,t} = 100\left[\left(1+\frac{r_{2,t}}{100}\right)^2 \Big/ \left(1+\frac{r_{1,t}}{100}\right) - 1\right],$$

where $r_{f,t}$ is the one-year forward rate, in percent,

$r_{1,t}$ is the one-year constant maturity yield, in percent,

and $r_{2,t}$ is the two-year constant maturity yield, in percent.

businesses form expectations, and particularly about how quickly they react to changing events; moreover, measurements of inflation are subject to potentially large error. Consequently, it may be too early to conclude that the change in procedures had no effect in reducing expected rates of inflation.

Appendix I

THE EFFECTS OF THE 1979 OIL PRICE SHOCK

In October 1979, when the Federal Reserve System was implementing its new operating procedure, two important events were affecting the domestic and international energy markets. First, the political situation in Iran during early 1979 and strong worldwide demand were leading to sharp increases in international oil prices. Second, the initial phase of the domestic oil decontrol program had just begun and already was proceding at a rapid pace. These events continued to put upward pressure on domestic energy prices and, by worsening the general inflationary outlook, played a key role in shaping the economic environment over the past two years. This appendix addresses the question of the impact of the 1979 energy price shock on both real activity and the general level of prices.

Analytical considerations. The transmission of energy price shocks to overall economic activity can be viewed using a number of increasingly broader and more realistic analytical frameworks. Consider first the impact of the price shock within the production sector of the economy. As energy prices go up, the initial effect is an increase in production costs, which drives up output prices and leads to a first-round decline in final demand and some unintended inventory accumulation. This first-round market response will then trigger secondary reductions in interindustry flows, higher wages and higher prices of intermediate goods, and ultimately further declines in intermediate and final demands. The initial impact plus the subsequent interindustry adjustments will lower the levels of real income and employment and raise prices.

The above scenario captures the essential response of producers in the very short run. Over a longer period of time, other considerations become important and tend to imply further depressing effects on real activity and increasing pressure on prices. They are briefly discussed below.

1. Changes in the aggregate input structure: As energy prices rise and energy resources become more costly relative to other inputs, a producer's optimal input structure will change. Inevitably some input substitution will take place. Between energy and labor inputs the empirical evidence seems to suggest that higher energy costs induce producers to substitute labor for energy. What happens between energy and capital is less clear.[1] In the short run, especially if there is some flexibility in capacity utilization, the weight of evidence seems to suggest complementarity between energy and capital services. In this case, higher energy costs will lead to increased use of labor and reduced capacity utilization in most industries. In the aggregate, this type of input adjustment tends to slow down capital formation and labor productivity growth. This line of reasoning is consistent with the post-1973/74 experience of a high employment, low investment recovery path in the U.S. economy. In this context, energy price hikes further depress real output.

2. Monetary and financial repercussions: Energy price increases will also have important effects outside the production sector, as interest rates respond and induce still further changes in the economy. Regarding the energy price effect transmitted through interest rates, the actual course of the economy obviously depends on the response of the monetary authority.

1/ For an interesting discussion see Berndt and Wood (1979).

Assuming a neutral, nonaccommodative policy stance, we can focus our attention on repercussions that are endogenous to the system. At the initial stage, real liquidity demand will tend to fall after an oil price shock because of the reduced level of real activity. Whether nominal transaction demands will rise or fall depends on how rapidly the general price level rises at this time. It is generally impossible to tell beforehand whether the falling real output or the rising price level will have the predominant effect on money demand. It is quite possible that the output effect and the price effect largely will offset each other. If so, a nonaccommodative policy would, at least at the initial stage, leave short-term interest rates little changed. On the long end of the market, however, results will depend on market participants' inflationary expectations and risk assessments. It is almost inevitable that rapidly rising energy costs would lead to renewed inflationary expectations, and would have the tendency to drive up long-term bond yields and lower bond prices. Such a development would tend to depress domestic demand for consumer durables and capital goods and retard capital formation. This is yet another possible source of depressing forces on real output.

3. Balance of payments and trade effects. Increases in oil prices act like an excise tax on the economy--reducing demand, raising unemployment, and generating more inflation. If the price increase originates from abroad, as is the case with OPEC price hikes, the adverse effect on domestic real output will be made more serious by the outflow of dollars, causing deterioration in the nation's trade balance and payment positions. Further, the adverse impact of increased oil payments overseas is not limited to current accounts alone. Excess oil payments to foreign producers cause concern abroad about

the effects of U S. energy policy on the dollar's future and tend to weaken the dollar. In such an environment, private capital outflows are likely to rise, leaving deficits in U.S. capital accounts as well.

There are other complications in the international market that tend to make foreign oil price increases have a more severe impact than comparable domestic price increases. For instance, OPEC price shocks affect all oil-consuming nations at the same time, and bring higher price levels and slower growth to most U.S. trading partners. The interdependence of major oil-consuming nations on the world market makes the final impact of OPEC price shocks worse for the United States than would be the case if the United States were the only country affected.

Review of energy studies. In order to sort out these effects, we have reviewed a number of energy studies that use simulation techniques to examine the impact of the 1978-79 oil price shocks. Results from four studies are briefly summarized to provide a sense of the magnitude of the impact. The four are selected because each one deals with at least one of the aspects discussed above. The results are summarized in table AI-1.

Thurman and Berner (1979) used the MPS econometric model of the U.S. economy in their simulations. Their basic price senario started from the June 1979 OPEC price schedule, and involved raising the average price of imported oil in the United States by 62 percent by the end of 1979, with an additional increase of 9.5 percent in 1980. Using this price assumption, they found that the level of real output would have been reduced 0.4 percent by the end of 1979 and 0.9 percent at the end of 1980. The inflation rate for domestic consumption prices would have been only fractionally higher in 1979, and 0.7 percentage points higher in 1980.

Table AI-1

SUMMARY OF RESULTS AND PRICE ASSUMPTIONS

Author(s)	Price increase scenario for imported crude oil[1]	Impact on the level of real GNP (percent deviation from control)		Impact on rate of inflation (percentage points)[2]	
		End of		During	
		1979	1980	1979	1980
Thurman-Berner	Scenario I: 62 percent in 1979, 9.5 percent in 1980	-.4	-.9	.1	.7
	Scenario II: 68 percent in 1979, 28 percent in 1980	-.5	-1.5	.1	1.3
Rasche-Tatom	Actual through 1979 (roughly 28 percent rise in the relative price of energy from 1978-Q4 to 1979-Q4	-3.1	--	--	--
Tatom	Actual through 1980-Q3 relative price of energy assumed constant in 1980-Q4	-1.7	-6.0	.7	2.4
Mork-Hall	72 percent increase in 1979 and additional 25 percent in 1980	-1.1	-3.9	1.8	1.3

1/ In Thurman and Berner's study, the "control" scenario assumes crude import prices increase 26.5 percent in 1979 and 2.7 percent in 1980. In the other studies, the price scenario described was compared to a hypothetical case in which real oil prices remained roughly constant.

2/ For Thurman-Berner and for Tatom this is the rate of change of the GNP deflator, for Mork and Hall this is the rate of change in the domestic price level.

In November 1979, when their paper was written, Thurman and Berner could not foresee the price changes that actually did occur. In an alternative scenario, however, they assumed that the price of imported oil increases an additional 26 percent. Under this more inflationary assumption their results suggest that real output would have been reduced by 0.5 percent at the end of 1979 and would have been 1.5 percent lower at the end of 1980, the inflation rate would have been boosted 1.3 percentage points in 1980. We should note that even these more drastic price assumptions underestimated the nominal price changes that have actually occurred. Both the basic scenario and the higher-priced one suggest that increases in oil prices of the magnitudes assumed by Thurman and Berner lowered the level of nominal GNP from what it would have been in the absence of an energy price shock. This is because higher petroleum prices induce increases in the overall price level that are more than fully offset by decreases in real output. In part this seems to be caused by an emphasis on rising import prices as the "driving" variable, and the underestimate of the 1979 increases in domestic crude prices. This overestimates the income transfer abroad (see Thurman and Berner, page 21) and underestimates the increase in domestic refiner costs and subsequent petroleum-product price increases. Thus, the model tends to underestimate the impact of the increases in crude oil prices on the domestic price level.

Mork and Hall (1979) used a macroeconomic model in which energy, labor, and capital demands are derived from an implied aggregate production function. Their model allows for energy substitution when relative input prices change. Their price scenario involved a crude-oil price increase from $12.50 per barrel in 1978 to $21 50 per barrel in the second quarter of 1979. At the beginning of 1980, oil prices were assumed to rise another

14 percent, making the 1980 average about 25 percent higher than that of 1979. (Again this underestimates the actual price changes. By June, the average price of imported oil had risen 53 percent over the average of 1979.[1]) The model suggests that the oil price shock caused the level of real GNP to be 1.1 percent lower by the end of 1979 and 3.9 percent lower by the end of 1980 than it would have been otherwise. In addition, the domestic inflation rate was 1.8 percentage points higher in 1979 and 1.3 percentage points greater in 1980. Since the underlying oil price assumptions were too low, the conclusions of their model also should be taken as underestimates.

Rasche and Tatom (1981) used the argument that a rise in the relative price of energy reduces the economic capacity of producers, causes more inflation, and reduces the full-employment level of output. Given time, the energy price hikes also will reduce business investment in plant and equipment, and lower the desired capital-labor ratio. Their empirical results were obtained from production function estimates. Increases in the relative energy price were calculated to be 28 percent from 1978-Q4 to 1979-Q4, based on the actual crude-oil price changes from $12.93 per barrel in December 1978 to $23.63 in December 1979. This relative price increase was estimated to have slowed output growth by 3.1 percent over the four-quarter period.[2] They did not provide explicit estimates of the impact of increased energy prices upon the general rate of price inflation.

1/ Department of Energy, Monthly Energy Review, September 1980, p. 74.

2/ These results are, of course, sensitive to the specific price assumptions. In an alternative exercise, the authors examine the impact of a relative energy price change equivalent to the difference between the average price for 1979 and that for 1978. In this exercise the output growth is estimated to have been slowed by 1.6 percent.

In a follow-up study, Tatom (1980) used a price equation and a variant of the Anderson-Jordan equation from the Federal Reserve Bank of St. Louis Model to assess the impact of energy price increases on GNP and inflation.[1] Both equations were estimated using quarterly data for the period 1955-Q1 to 1978-Q3. The energy price scenario in Tatom's simulations was based on actual price developments up to 1980-Q3; the relative price of energy was then assumed to remain unchanged after that. The impact of energy price changes was measured by implicitly assuming an alternative price scenario in which relative energy prices remained constant.

Tatom's equation estimates indicate that the 1979-80 oil price increases caused nominal GNP growth to be 1.1 percentage points lower than it otherwise would have been in 1979, and 2.0 percentage points lower in 1980. In 1981, his model predicts that nominal GNP will increase as a result of rising prices. The 1979-80 energy price changes are also estimated to have added 0.7 percentage points to the measured inflation rate in 1979 and 2.4 percentage points in 1980. Combining these two sets of results, Tatom found the impact on real GNP to be a 1.7 percent lower level of output at the end of 1979 and 6.0 percent lower at the end of 1980.

Summary. The diverse model structures and feedback mechanisms in these simulations make it difficult to compare the results directly. However, if their oil-price scenarios were uniformly adjusted to approximate what actually took place from mid-1979 on, their simulations suggest that the level of real GNP at the end of 1980 could have been as much as 6 percent lower than what would have occurred in the absence of the oil price run-up.

1/ Tatom's price equation basically relates the rate of increase in the implicit GNP deflator to a distributed lag of rates of growth in money stock.

In terms of the impact on the general level of prices, the studies reviewed suggest that the oil price hikes boosted the inflation rate between 0.1 and 1.8 percentage points during 1979, and between 0.7 and 2.4 percentage points in 1980. Given the wide variation in these results and the concern that these studies might underestimate inflation impacts, we have performed a simulation exercise of our own.

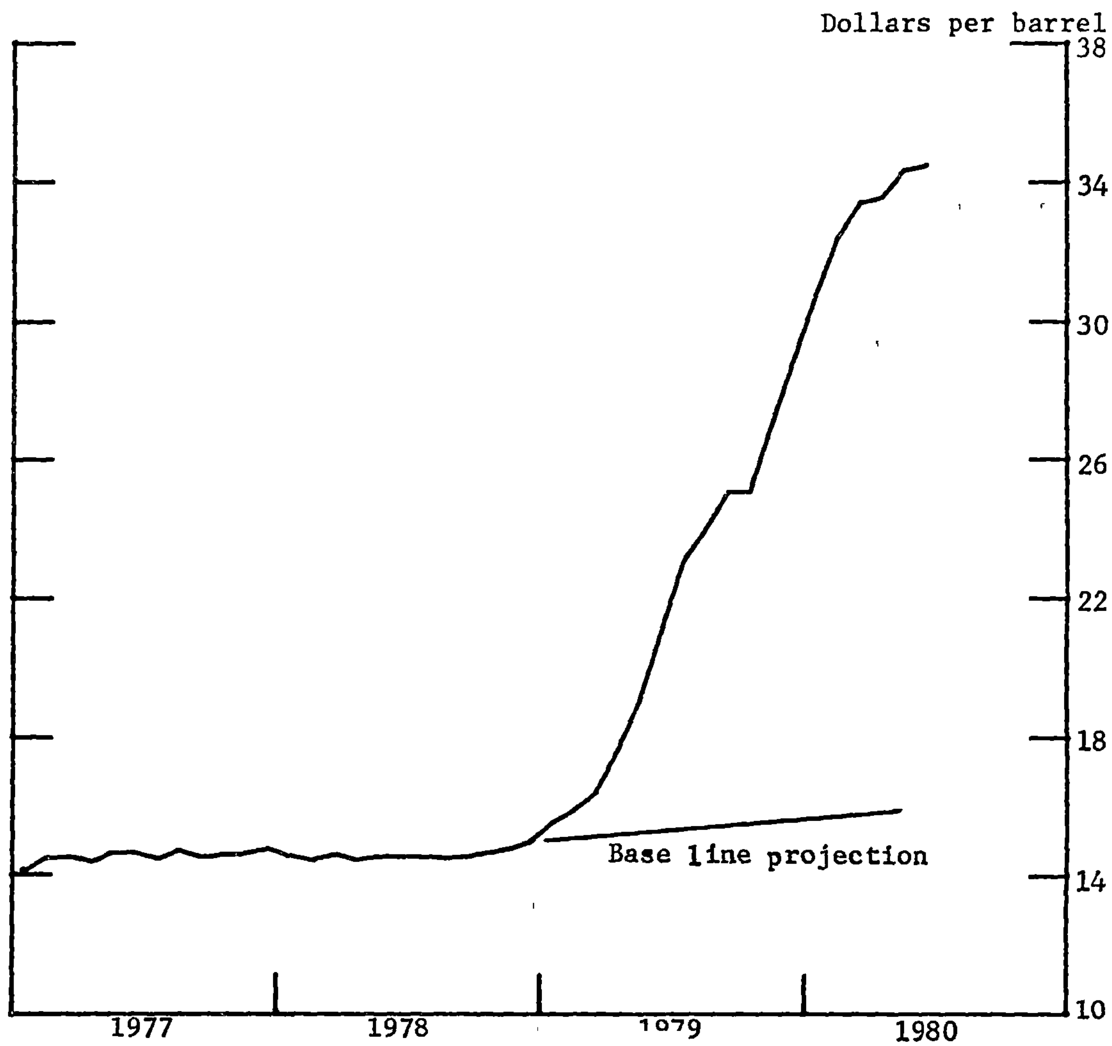
Simulation results. The impact of the actual increase in crude-oil prices since the beginning of 1979 can be estimated by calculating the increase in the national "oil bill" due to higher import prices.[1] First, total payments made for crude oil--both domestic and imported--during 1979 and 1980 are calculated. This is contrasted with an estimate of the size of these payments under the assumption that oil prices had continued to increase at the rate established in 1978 (the base-line in figure AI-1.)

We have assumed as a matter of simplicity that the levels of imports and of domestic production are constant and equal for both price scenarios. By this we do not mean to ignore such changes as the decreased level of oil imports seen over the last year. Rather these assumptions were made in order to concentrate on the short-term effects of oil-price changes. The changes that have occurred in both production and consumption are largely the result of long-run adaptations and we ignore them in our calculations.[2]

1/ The actual calculations utilized data and programming supplied by John Rosine, of the Board's Wages, Prices, and Productivity Section. He is, of course, not responsible for any errors in interpretation or assumption that have been made.

2/ Referring to Professor L.D. Taylor's excellent review of the small amount of literature on the demand for petroleum products, we note that, for example, the estimates of the short-run price elasticity of demand for gasoline vary from -0.07 to -0.80. (See Taylor (1977), page 32, table 1.7.) The estimates of short-run income elasticity for gasoline range from 0.30 to 0.74. These are widely varying results and reflect both different data sets and models; they make it difficult to suggest any one picture concerning the level of imports and consumption under the alternative price scenario In short, there seems no simple alternative to the assumptions we have chosen. These assumptions, however, probably bias upward our estimate of the inflationary impact of the recent international oil-price increases

Figure AI-1: REFINER ACQUISITION COSTS FOR IMPORTED CRUDE OIL



While the quantities of oil are assumed equal in both our scenarios, prices, of course, are not. In particular, the prices of domestic crude are assumed to follow a "decontrol path" designed to bring their prices to the level, in each case, of imported oil by the end of 1981.[1]

These assumptions allow us to form an estimate of the national crude-oil bill under our two different price paths. We assume that the increased oil bill following the early 1979 price explosion was fully passed on, partly in terms of higher petroleum production prices, and partly in terms of higher prices for other goods and services. The ratio of the change in the total oil bill to the total value of final goods and services provides an estimate of the change in the CPI due to higher oil prices.

Table AI-2 presents the results of the simulation. Column 1 shows the impact on domestic prices of the actual change in import prices. Column 2 shows the hypothesized direct impact of a continuous increase in import oil prices of 3 percent per year. The final column shows the difference in these two price scenarios. Thus, adding up the quarterly impacts, the rise in imported oil prices over the past two years added about 2.2 percentage points to the inflation rate in 1979 and 2.3 percentage points in 1980. To the extent the price increases have not been passed on immediately, these changes have tended to come in 1980 (and probably in 1981) rather than in 1979 and 1980.[2]

1/ See the program discussed in Carson and Harnish (1979). This exercise was performed before domestic crude oil was ordered decontrolled on January 28, 1981; however, any adjustments to reflect this action would, of course, be confined to 1981 and later.

2/ Increases in oil prices have noticeable effects on the prices of such substitute energy forms as coal and natural gas. Therefore, we should not look at the impact of an increased oil bill, but at the impact of an increased energy bill. Very rough calculations suggest that these additional price increases might aggravate the inflationary impact shown in table 3 by as much as 20 percent. Concentration only on the effects of increased petroleum expenditures offsets the upward bias contained in some of the assumptions underlying these calculations.

Table AI-2

IMPACT OF OIL PRICE INCREASES ON THE INFLATION RATE
(Percentage points)

Period	Estimated Contribution to Increase in CPI: Actual crude oil price changes	Hypothetical price changes	Difference[1]
1978-Q4	.13	.04	.09
1979-Q1	.45	.09	.36
Q2	.85	.09	.76
Q3	.52	.20	.32
Q4	.89	.12	.77
1980-Q1	.68	.01	.67
Q2	.70	.03	.66
Q3	.43	.02	.41
Q4	.56	.01	.54

1/ Differences may not agree with entries in the first two columns because of rounding errors.

Appendix II

INFLATION EXPECTATIONS

Inflation expectations play a critical role in many important behavioral macroeconomic relationships, yet very little is known about them. One problem is measurement, since expectations are inherently unobservable. However, inferences about them can be drawn from several surveys as well as from observed economic behavior. Two sources of information are commonly used and are discussed in the body of this paper. First, information about the inflation expectations of various types of economic agents is collected directly in several private surveys. Second, indirect evidence on inflation expectations can be gleaned from the financial securities markets. While such data may indicate roughly how price expectations have changed over time, they suffer from significant uncertainties and difficulties in measurement and, by themselves, can convey no insight into how expectations might shift in a changing environment.

In principle, models of inflation expectations, derived from economic theory, can provide such insights in a framework that is consistent with the axioms of rational economic behavior. These models, however, frequently are not conducive to empirical estimation of crucial parameters. Moreover, their basic structure may change when a new regime in monetary policy is introduced, thus making assessments of the change in operating procedures quite difficult if not impossible. In this appendix both the conceptual and the empirical difficulties in examining changes in inflation expectations are explored further. The discussion is divided into a review of problems inherent in survey data, the evidence from financial markets, and theoretical models.

Survey data. Private surveys offer the most direct measures of inflation expectations, but the samples often are statistically deficient. Three surveys are discussed in the main text. The University of Michigan Survey Research Center (SRC) asks several questions every month that are designed to measure directly consumer inflation expectations.[1] The Livingston biannual survey of "informed" business economists provides a less timely measure of expectations.[2] Finally, the Blue Chip Economic Indicators newsletter provides monthly results from a survey of several private economic forecasters.

As noted in the text of the paper, all three surveys indicated roughly the same pattern of changes in expectations following the policy action of October 6, 1979. In the months that followed, the average expected rate of inflation increased noticeably, in some instances dramatically, and it remained high in the first few months of 1980. After the introduction of

1/ The SRC anticipations data are constructed from the following questions: "During the next 12 months, do you think that prices in general will go up, or go down, or stay where they are now?" and "By about what percent do you expect prices to go up, on the average, during the next 12 months?" The questions refer to the CPI.

2/ Since 1947, Joseph A. Livingston has collected biannually the anticipations of economic variables from economists, businessmen, and professional forecasters. Livingston mails questionnaires to respondents in early December and May and asks for a 6-, 12-, and (in May) an 18-month ahead forecast of the level of the CPI and the PPI for finished goods. Results of these surveys are published regularly in Livingston's column in either the Philadelphia Inquirer or the (Philadelphia) Bulletin.

Early research used the reported average survey response (Turnovsky, 1970; Turnovsky and Wachter, 1972; Pesando, 1975), but these figures are often arbitrarily adjusted by Livingston. More recently, analysts have obtained individual forecaster responses to calculate a better measure of the expected inflation rate (Carlson, 1977; Wachtel, 1977; Figlewski and Wachtel, 1978; Hafer and Resler, 1980). Moreover, it is not clear whether the responses represent predictions of the price level using May and December as the base period or April and October (months for which index numbers are supplied to the respondents by Livingston). Recent research (Hafer and Resler, 1980) has suggested that rationality tests of the Livingston survey are quite sensitive to the interpretation of the length of the forecast horizon.

Table AII-1

PERCEIVED AND ANTICIPATED INFLATION

Period	Perceived[1]	Anticipated[2]
1979-October	n a.	8.9
November	16.0	11.2
December	16.4	10.8
1980-January	16.6	13.1
February	16.1	10.7
March	16.6	12.0
April	17.4	11.1
May	15.9	8.2
June	14.4	8.1
July	14.5	9.0
August	14.4	8.0
September	14.5	8.5
October	15.0	9.2
November	14.7	8.7
December	15.2	10.1

1/ Mean increase obtained from "By what percent do you think prices have gone up, on the average, during the last 12 months?"
2/ Mean increase obtained from "By about what percent do you expect prices to go up, on the average, during the next 12 months?"

credit controls in March 1980 and a record decline in the money supply in April, expectations eased significantly. They generally remained at these lower levels until the end of 1980.

Analysis of survey data suggests a note of caution in the use of these indicators of inflation expectations. The Michigan survey, for example, exhibits several deficiencies. Changes in this measure tend to be fairly sensitive to movements in the prices of food and gasoline--items that are observed by consumers more frequently than most other categories. Another characteristic of this survey is the persistent contrast between expectations and perceptions of inflation--perceived inflation is usually much higher than expected inflation.[1] The magnitude of the difference between perceived and anticipated inflation rates is quite startling, as is the failure of subsequent expectations to respond to changes in perceptions.

Livingston's surveys of price expectations have been the subject of considerable analysis. Most studies have been interested in the rationality of surveyed expectations. The test of rationality has usually taken the form of:

$$p_t = a_0 + a_1 E_{t-1} \{ p_t \} + U_t, \qquad \text{(AII-1)}$$

where p_t is the inflation rate for period t and $E_{t-1} \{ p_t \}$ is the previous period's expected rate of inflation. Rationality requires that the expectations be unbiased--in equation AII-1 this is equivalent to the joint hypothesis that $a_0=0$ and $a_1=1$, where the errors, U_t, are assumed to be serially independent.

1/ This information is obtained from the question: "During the last 12 months, have prices of the things you buy remained unchanged, or have they gone up, or have they gone down?" and "By about what percent do you think prices have gone up, on the average, during the last 12 months?"

With these parameter restrictions, the actual inflation rate deviates from the expected rate only in an unanticipated way.

Early tests for efficiency (Pesando, 1975; and Carlson, 1977) employed the following structure:

$$p_t = \Sigma a_i p_{t-i} + U_{1t} \qquad \text{(AII-2)}$$

$$E_{t-1} \{ p_t \} = \Sigma b_i p_{t-i} + U_{2t}. \qquad \text{(AII-3)}$$

If expectations are efficient and prices can be characterized by the time-series process in equation AII-2, then $a_i = b_i$ for all lags i. This test is inappropriate, however, if the errors are not homogeneous and independent. An alternative test regresses forecasting errors on past inflation rates:

$$(p_t - E_{t-1} \{ p_t \}) = b_o + \Sigma b_i p_{t-i} + U_{3t}. \qquad \text{(AII-4)}$$

If the forecasts are efficient, they should be uncorrelated with any past information.[1] This form of the efficiency hypothesis requires all coefficients to be zero.

Early studies of the Livingston data (Turnovsky and Wachter, 1972; Pyle, 1972; Gibson, 1972; deMenil and Bhalla, 1975) employed the average reported mean of inflation expectations. A general consensus emerged from the studies that expectations could be described by an adaptive or extrapolative scheme. However, these studies were marred by the quality of reported expectations, which often were arbitrarily adjusted by Livingston.

More recent tests of rationality expressed in the form of equation AII-1 have presented mixed results. Pesando found the data to be consistent with the rational expectations hypothesis; however, Figlewski and Wachtel

1/ Note that this statement of rationality is a weak form of the hypothesis since "past information" includes only the past history of prices.

(1978) were able to reject the hypothesis using a pooled time-series, cross-section sample that included more recent data. More recently, Hafer and Resler (1980) found characteristics of bias in the Livingston forecasts, regardless of the forecast horizon and the sample period used.

Some tests for efficiency (Carlson, 1977; and Pesando, 1975), which are based on equation AII-2, are flawed by the presence of nonhomogeneous residuals--under those conditions the F-statistic does not take on the properties usually assumed. An alternative test using equation AII-4 was proposed by Mullineaux and also was used by Hafer and Resler (1980). Mullineaux's test rejected efficiency for the sample period 1959-1969. However, Hafer and Resler have shown that the efficiency tests are not robust and depend on the sample selected and the forecast horizon of the survey respondents.[1] Nevertheless, their evidence suggests that forecasters are more efficient in predicting longer-term inflation than short-term price developments.

In summary, most evidence suggests that the Livingston surveys have serious limitations. Because they fail to conform with rationality criteria, either (1) the survey does not accurately measure inflation expectations, or (2) expectations are slow to absorb new information. From a theoretical point of view the second implication is difficult to accept.

Evidence from financial markets. In an analytical sense, surveys of inflation expectations may not be regarded as a useful source of information since there is no evidence that economic actions are directly based on these expectations. However, there are several sources of data, directly linked to

1/ Confusion in the interpretation of the appropriate time horizon in the Livingston data has led to the use of several different forecasting horizon lengths: (1) Mullineaux assumes the horizon to be from April to October, (2) Jones-Jacobs employed a May-December horizon, and (3) others assume it to be from April to December.

economic activities of one sort or another, from which inferences about expectations potentially can be extracted. These include the financial futures markets, the implied forward rates in long-term securities, the commodity futures markets, and the wage bargaining process--particularly for the unionized sector, where coverage by formal escalator clauses is concentrated. Because an extensive literature is available on the movement of interest rates, we examine most closely the information available in financial market transactions.

The expectations hypothesis of the term structure of interest rates is a widely accepted explanation of interest rate relationships. This hypothesis holds that long-term rates are a weighted average of expected short-term current and forward rates; because forward rates should reflect the expected rate of inflation, observations on levels of and shifts in the yield curve should embody some information about market expectations of inflation. However, alternative hypotheses suggest other sources of change in the forward rates, including: (1) a nonconstant real rate,[1] (2) risk premiums, (3) liquidity premiums, or (4) differences arising from the possibility that securities may be traded in segmented markets. It may be possible

1/ Earlier studies have shown that long-term rates reflect market expectations of inflation and are efficient forecasts of future prices (Granger and Rees, 1968; Bierwag and Grove, 1971; Laffer and Zecher, 1975, Phillips and Pippenger, 1976; Sargent, 1976, 1979; Mishkin, 1978; Pesando, 1978; Fama, 1975; Barro, 1978; Lucas, 1973, Sargent and Wallace, 1975; Phelps and Taylor, 1977; Fischer, 1977). For example, Fama (1975) finds that market rates use all relevant information about price developments and that the real rate is constant. However, Shiller (1979) suggests that the relatively constant real rate in Fama's sample may be attributable to Federal Reserve behavior, not the inability of the Federal Reserve to induce unanticipated surprises on the market. He identifies and analyzes tests of three nested hypotheses about expectations that are common in the literature and concludes that "none of the hypotheses is likely to be so strictly true as to rule out completely a predictable effect of systematic monetary policy on expected real interest rates" (p. 65).

to abstract from considerations regarding risk and differences due to trading in segmented markets by concentrating on Treasury securities, which have relatively uniform risk characteristics.

Since late 1979 yields in intermediate- and longer-term Treasury markets have risen noticeably and displayed greater volatility. Analysis by the staff, presented by Johnson in "Interest Rate Variability Under the New ... Procedures" in this compendium, found little evidence that liquidity premiums rose during periods of interest rate volatility. At best, this factor may account for only a very small fraction of the rise in interest rates. However, at the same time rates on securities with maturities of about one year were much more volatile than would have been implied by an ex post rational long-term rate--that is, a hypothetical series which would have resulted from a perfect forecast of short-term rates. This result raises the question whether the volatility in intermediate-term rates discredits the expectations hypothesis or whether there is information in the forward rates about market expectations of inflation.

Shiller (1979), among many other analysts, has addressed this issue and argues that conventional tests of rationality may be weak if long-term interest rates are too volatile. The high relative volatility of long rates compared with that of short rates violates some of the assumptions which lead to the traditional characterization of long rates as a weighted average of expected short rates. His tests generally reject the expectations model in favor of a model that allows for long rates to be influenced by transient effects unrelated to expectations. However, he makes some allowance for influence by expectations.

On balance, the literature on this subject suggests that discretion should be used in making inferences about inflation expectations based on the implied forward rates in the term structure of interest rates. If inflation expectations were the predominant influence on the expected forward rates embedded in the term structure over the past two years (chart AII-1), two observations are suggested: (1) inflation expectations became more pessimistic last fall and remained high even at the trough of long-term rates in June 1980 and (2) the relationship among forward rates for various time horizons was so erratic in 1980 that it is difficult to explain how relevant incoming information could have been systematically utilized.

Theoretical models. Models of inflation expectations are useful because they provide a characterization that is consistent with the principles of rational economic behavior. A wide variety of models for inflation expectations have been used in past research. Most efforts to model inflation expectations are special cases of the more general autoregressive expectations mechanism:

$$E_t \{ p_{t+1} \} = \sum_{i=0}^{n} a_i p_{t-i}.$$

They range from naive expectations models, where

$$E_t \{ p_{t+1} \} = p_t,$$

to extrapolative models, where

$$E_t \{ p_{t+1} \} = p_t + \lambda (p_t - p_{t-1}), \qquad \lambda \leq 1,$$

to adaptive expectations, where

$$E_t \{ p_{t+1} \} = E_{t-1} \{ p_t \} + \beta (p_{t-1} - E_{t-1} \{ p_t \})$$
$$= \sum_j (1 - \beta)^j p_{t-j} \qquad \beta \leq 1.$$

These models are thought to be consistent with a limited concept of rationality. However, Feige and Pearce (1976) suggested a framework in which autoregressive models might be economically rational given the costs of obtaining additional information. In fact, they demonstrated that an autoregressive expectations mechanism will provide an efficient forecast of inflation; the residual of an appropriate ARIMA model for inflation was uncorrelated with lagged innovations in monetary or fiscal policy. This question is an empirical issue and could be tested in a more general class of models that allows for other explanatory variables, in addition to information available in the past history of prices.

The modeling approach to inflation expectations suggests that an appropriate model of the inflation process be selected and then used to forecast inflation. This procedure is subject to several criticisms. First, the structure of the model should change with every transition to a new regime of monetary policy. In addition, to the extent that the Federal Reserve does not immediately affect the actual inflation rate, an extrapolative model of inflation will ignore essentially all information about the new operating procedures. However, these models may be useful in analyzing the behavior of real interest rates.

Concluding remarks. This appendix has explored several sources and methods that frequently have been used in the past to make inferences about inflation expectations. On balance, modeling techniques are of limited usefulness because they require more data than are available. Inferences about inflation expectations that are based on financial market transactions are highly tenuous because of the implications of high interest rate volatility for the expectations hypothesis of the term structure. Finally, although survey data provide a direct estimate of inflation expectations, they exhibit a number of peculiar characteristics.

REFERENCES

Barro, Robert. "Unanticipated Money, Output and the Price Level in the United States," Journal of Political Economy, August 1978, 86(4), pp. 549-80.

Berndt, Ernst R., and David O. Wood. "Engineering and Econometric Interpretations of Energy-Capital Complementarity," American Economic Review, June 1979, 69(3), pp. 342-3.

Bierwag, G. O., and M. A. Grove. "A Model of the Structure of Prices of Marketable U.S. Treasury Securities," Journal of Money, Credit and Banking, August 1971, 3, pp. 605-29.

Carlson, John. "A Study of Price Forecasts," Annals of Economic and Social Measurement, Winter 1977, 6, pp. 27-56.

Carson, William, and Douglas Harnish. "Final Regulatory Analysis of Rulemaking on Phased Decontrol of Upper Tier Crude Oil," U.S. Department of Energy, Economic Regulatory Administration, November 1979.

deMenil, George, and Surjit Bhalla. "Direct Measurement of Popular Price Price Expectations," American Economic Review, March 1975, 65(1), pp. 169-80.

Fama, Eugene F. "Efficient Capital Markets: A Review of Theory and Empirical Work," Journal of Finance, May 1970, 25, pp. 383-417.

______________. "Short-Term Interest Rates as Predictors of Inflation," American Economic Review, June 1975, 65(3), pp. 269-82.

______________. "Forward Rates as Predictors of Future Spot Rates," Journal of Financial Economics, October 1976, 3, pp. 361-77.

Feige, Edgar L., and Douglas K. Pearce. "Economically Rational Expectations: Are Innovations in the Rate of Inflation Independent of Innovations in Measures of Monetary and Fiscal Policy?" Journal of Political Economy, June 1976, 84(3), pp. 499-522.

Figlewski, Stephen, and Paul Wachtel. "The Formation of Inflationary Expectations," New York University, Graduate School of Business Administration, November 1978.

Fischer, Stanley. "Long-Term Contracts, Rational Expectations and the Optimal Money Supply Rule," Journal of Political Economy, February 1977, 85(1), pp. 191-205.

Gibson, William E. "Interest Rates and Inflationary Expectations: New Evidence," American Economic Review, December 1972, 62(5), pp. 854-65.

Phillips, Llad, and John Pippenger. "Preferred Habitat vs Efficient Market - A Test of Alternative Hypotheses," Federal Reserve Bank of St. Louis Review, May 1976, 58(5), pp 11-19.

Pyle, David H. "Observed Price Expectations and Interest Rates," Review of Economics and Statistics, August 1972, 54, pp. 275-80.

Rasche, Robert, and Tatom, John Energy Price Shocks, Aggregate Supply and Monetary Policy: The Theory and International Evidence. Carnegie-Rochester Conference Series on Public Policy. Vol. 14 1981.

Sargent, Thomas J. "Rational Expectations and the Term Structure of Interest Rates," Journal of Money, Credit and Banking, February 1972, 4, pp 74-97.

______________. "A Classical Macroeconometric Model of the United States," Journal of Political Economy, April 1976, 84(2), pp. 204-37.

______________. "A Note on Maximum Likelihood Estimation of the Rational Expectations Model of the Term Structure," Journal of Monetary Economics, January 1979, 5, pp. 133-43.

______________, and Neil Wallace. " 'Rational' Expectations, the Optimal Monetary Instrument, and the Optimal Money Supply Rule," Journal of Political Economy, April 1975, 83(2), pp. 241-54.

Shiller, Robert J. "Can the Fed Control Real Interest Rates?" Research Paper 39. University of Chicago, April 1979.

______________. "The Volatility of Long-Term Interest Rates and Expectations Models of the Term Structure," Journal of Political Economy, December 1979, 87(6), pp. 1190-1219.

______________. "Alternative Tests of Rational Expectations Models: The Case of the Term Structure." Working Paper 563. National Bureau of Economic Research, October 1980.

Tatom, John A. "Energy Prices and Economic Performance." Federal Reserve Bank of St. Louis, November 1980 (mimeo).

Taylor, Lester D. "The Demand for Energy: A Survey of Price and Income Elasticities," in William D. Nordhaus, ed., International Studies of the Demand for Energy. Amsterdam: North-Holland, 1977, pp. 3-43.

Thurman, Stephan, and Richard Berner. Analysis of Oil Price Shocks in the MPS Model, CEPR Conference on Energy Prices, Inflation, and Economic Activity, Cambridge, Massachusetts, November 1979.

Turnovsky, Stephen J. "Some Empirical Evidence on the Formation of Price Expectations," Journal of the American Statistical Association, December 1970, 65, pp. 1441-54.

______________, and Michael L. Wachter. "A Test of the Expectations Hypothesis Using Directly Observed Wage and Price Expectations," Review of Economics and Statistics, February 1972, 54, pp. 47-54.

U. S. Department of Energy, Monthly Energy Review, September 1980.

Wachtel, Paul. "Survey Measures of Expected Inflation and Their Potential Usefulness," in Joel Popkin, ed., Analysis of Inflation: 1965-1974, Ballinger for the National Bureau of Economic Research, 1977.

Money Market Impacts of Alternative Operating Procedures

January 1981

Paper Written for a Federal Reserve
Staff Review of Monetary Control Procedures

by

Peter A. Tinsley, Peter von zur Muehlen,
Warren Trepeta, and Gerhard Fries

MONEY MARKET IMPACTS OF ALTERNATIVE OPERATING PROCEDURES */

In October 1979, reserves-oriented operating procedures were adopted for the execution of short-run monetary policy. The historical record of money market volatility since that date has not been encouraging. As shown in figure 1, the standard deviations of both the monthly growth rate of M-1A and the monthly change in the federal funds rate increased markedly during the 12 months subsequent to the alteration of procedures in contrast to the standard deviations for the preceding 12 months.

This paper explores the short-run volatility consequences of money stock targeting under current and alternative operating procedures. The focus is narrowly drawn on the feasibility of money stock targeting, an issue that may be considered independently of the desirability of intermediate targeting on monetary aggregates. Two principal issues are considered:

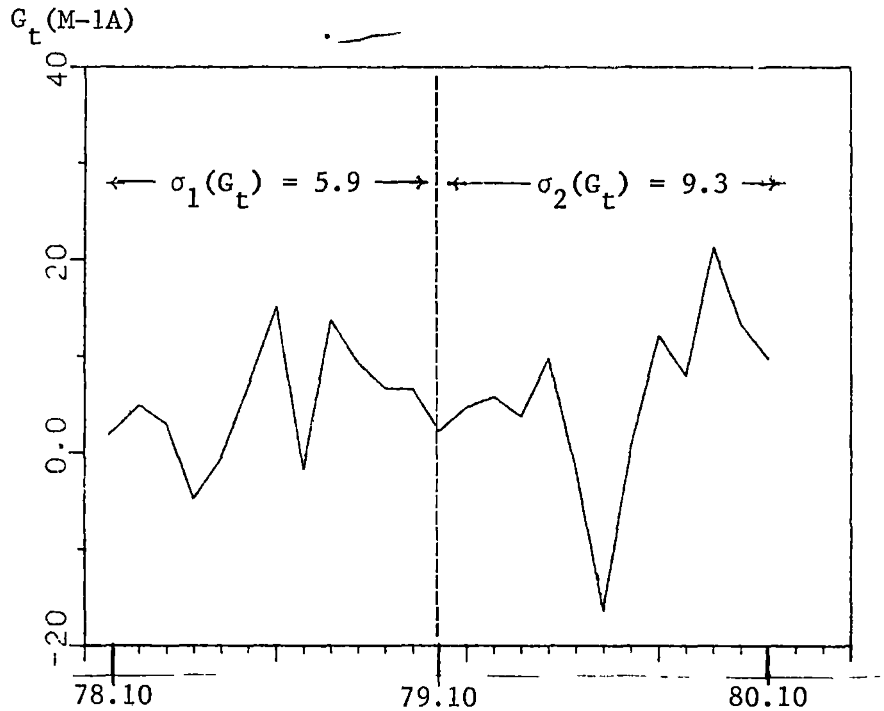
- Was the money market buffeted by atypical events in 1980, or is there an inherent flaw in current operating procedures that tends to induce volatility in money markets?
- Does there exist a well-behaved trade-off between the volatility of deviations of M-1A from long-run targets and the volatility of short-term interest rates under current and alternative operating procedures that may be exploited by short-run monetary policy?

*/ Sections of this paper were prepared by P.A. Tinsley, P. von zur Muehlen, and G. Fries (sections 1-4 and appendix A) and W. Trepeta (section 5 and appendixes B and C) with special assistance from H. Farr, B. Garrett, J. Lovin, V. Watkins, and C. Wilson.

Figure 1: Historical Variability in the Monthly Growth Rates of Monetary and Reserve Aggregates and the Monthly Change in the Federal Funds Rate

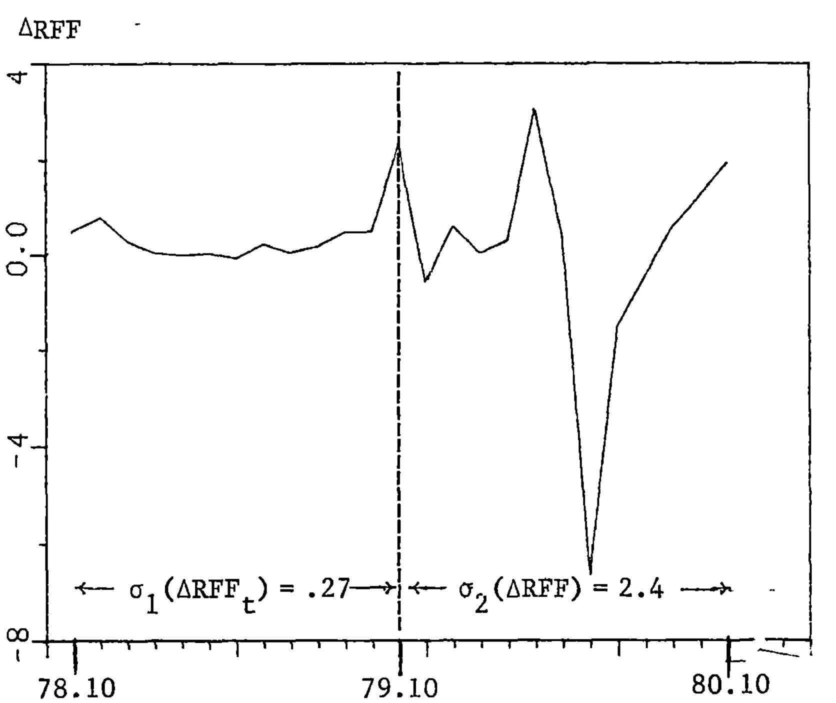
1.a M-1A

1978.10 - 1980.10



G_t(M-1A) - annualized growth rate of M-1A in month t
$\sigma_1(G_t)$ - standard deviation of growth rates 78.10 - 79.09
$\sigma_2(G_t)$ - standard deviation of growth rates 79.11 - 80.10

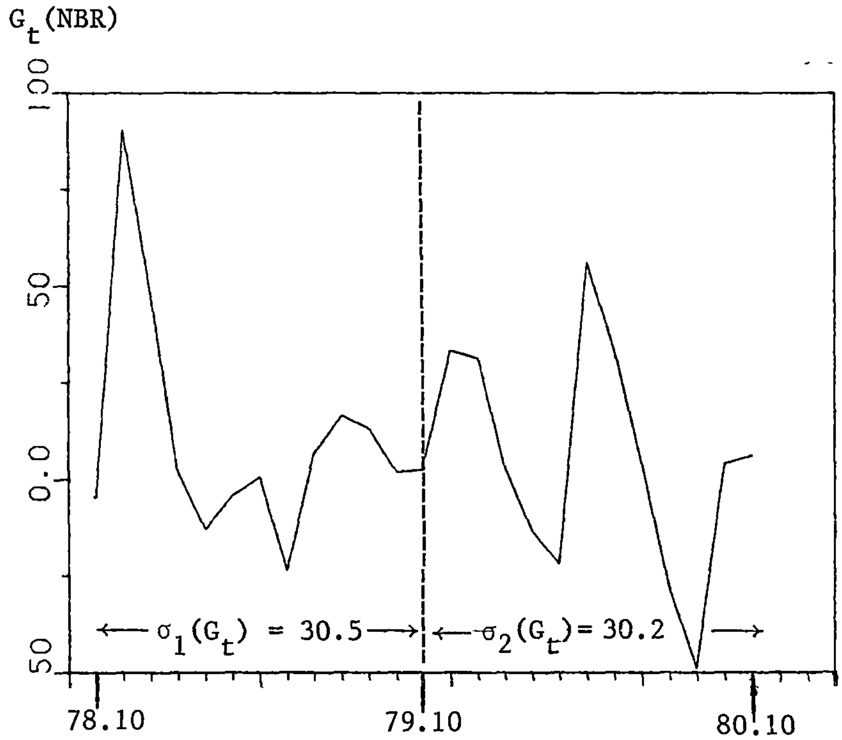
1.b RFF



ΔRFF - change of federal funds rate in month t
$\sigma_1(\Delta RFF_t)$ - standard deviation of monthly change 78.10 - 79.09
$\sigma_2(\Delta RFF_t)$ - standard deviation of monthly change 79.11 - 80.10

Figure 1, continued

1.c NBR

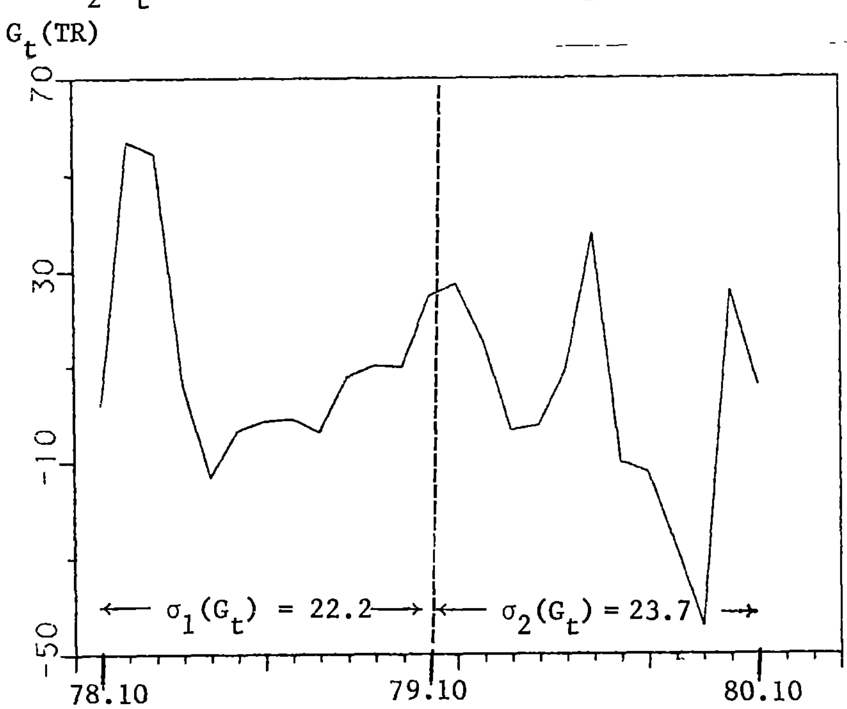


G_t(NBR) - annualized growth rate of nonborrowed reserves (seasonally adjusted) in month t

$\sigma_1(G_t)$ - standard deviation of growth rates 78.10 - 79.09

$\sigma_2(G_t)$ - standard deviation of growth rates 79.11 - 80.10

1.d TR



G_t(TR) - annualized growth rates of total reserves (seasonally adjusted) in month t

$\sigma_1(G_t)$ - standard deviation of growth rates 78.10 - 79.09

$\sigma_2(G_t)$ - standard deviation of growth rates 79.11 - 80.10

The results of this study, obtained by both deterministic and stochastic simulations of a monthly money market model used by the staff, are the following:

- o The odds are at least two to one that a portion of the increased money market volatility observed in 1980 should not be solely ascribed to current operating procedures.
- o There exists a well-behaved trade-off between the volatility of money stock targeting performance and the volatility of short-term interest rates in the sense that an improvement in the performance of one objective can be exchanged for a bounded deterioration in the performance of the other.

Other results of this study include the following:

- o Both interest rate and reserves policies are more successful in attaining year-over-year money stock targets than in maintaining close adherence to a money stock target path within the year.
- o Examination of short-run M-1A objectives in 1980 suggests that the FOMC attempted to make up about 30% of the perceived gap between the projected money stock and the annual target path in the following month.
- o Tight restrictions on the target range of admissible monthly variations in the federal funds rate will dominate variations in the desired speed of reentry to the annual money stock target path.

- If the target range on the federal funds rate is sufficiently relaxed, the estimated speed of reentry to the annual money stock target path estimated for historical procedures is approximately efficient in the sense that faster speeds of reentry would yield much larger fluctuations in the federal funds rate with only small improvements in the volatility performance of the money stock.
- There is some evidence that approximately the same money stock targeting performance can be achieved by a federal funds rate policy as by a nonborrowed reserves policy at a lower cost in interest rate volatility if the planned settings of the federal funds rate are sufficiently aggressive.
- No evidence is provided in this study of unstable interest rate cycles induced by money stock targeting. Thus, at least in the context of this study, it is unlikely that interest rate instability is a significant constraint on the design of short-run monetary policy.

Discussion in the paper is organized along the following lines: First, the concept of short-run stochastic volatility is introduced briefly in section 1. One consequence of the design of short-run operating procedures is the allocation of random disturbances within money markets. The selection of a reserves-oriented or an interest-rate-oriented policy affects the allocation of transient disturbances between the money stock and short-term interest rates.

Second, in order to examine the volatility allocations of alternative operating procedures, it is necessary to have some method of generating the expected consequences of alternative policies. Section 2 describes a procedure for stochastic simulations of the econometric model of monthly activity in money markets used by the staff. The design and execution of monthly monetary policy is characterized by simulations of policy planning and execution stages.

In the policy planning stage, the policy authority selects a short-run money stock objective (for M-1A) and a policy instrument setting (either nonborrowed reserves, total reserves, or a federal funds rate setting) that will achieve the short-run money stock objective in the next month, at least in the absence of forecast errors. Generally, if the money stock has been displaced from the annual money stock target path in recent history, the short-run money stock objective does not represent a plan for an immediate return to the annual target path within the next month because month-to-month departures from the annual target path are viewed as partially the result of transient disturbances that will tend to "wash out" over time.

In the policy execution stage, the ex ante money stock targeting plans of the policy authority may be partially frustrated by the impacts of unforeseen random disturbances. These impacts are represented by stochastic simulations of the monthly money market model, given the ex ante policy instrument setting selected by the policy authority. Two types of stochastic simulations are used in this study: (1) in pseudo-history simulations, the forecast errors of the monthly model in 1980 are added to estimate the performance of monetary policies under conditions that existed in 1980; (2) in average-history simulations, random disturbances similar in size and pattern to the forecast errors of the monthly model from the nine-year sample

1971-79 are added to gauge the robustness of money stock targeting performance when policies are exposed to a full spectrum of plausible money market shocks.

Section 3 contrasts the performance of current operating procedures under pseudo-history and average-history stochastic simulations in 1980. The purpose of this comparison is to determine if the random disturbances observed in 1980 were unusually severe in contrast to shocks in the 1970s, or if reserves-oriented operating procedures are largely responsible for the increased volatility of money markets in 1980.

Simulation experiments described in section 4 contrast the allocation of money market volatility associated with alternative operating procedures. The results suggest that money stock targeting performance is sensitive to the range of variation permitted for the federal funds rate. Another important determinant of money stock targeting performance is the planned monthly speed of reentry to the annual money stock target path represented by the selection of the short-run money stock objective. The results suggest that the current rate of reentry to the annual money stock target path implied by historical short-run money stock objectives in 1980 is approximately efficient in the sense that attempts to close the gap between the money stock and the annual target path more rapidly would produce large increases in the expected volatility of the federal funds rate in exchange for small improvements in money stock targeting performance.

Section 5 explores the possibility that close control of the money stock may induce undamped cycles in short-term interest rates. Results of an experiment with the staff monthly model suggest that interest rate instability is not an effective constraint on the design of money stock targeting procedures.

Finally, three appendixes provide more explicit descriptions of (1) the essential economic structure of the staff monthly money market model, the simulation characterization of monthly policy used in this paper, and the methodology underlying stochastic simulations; (2) an approximation of the FOMC selection of short-run objectives for the narrow money stock (M-1A) in 1980; and (3) an examination of the potential for the staff monthly money market model to exhibit interest rate instability.

1. The Concept of Short-Run Stochastic Volatility

High-frequency oscillations in the indicators of monetary policy may be viewed with dismay by money market participants, in part, because they obscure the underlying intentions of the policy authority. However, not all kinds of measured increases in the variability of money market instruments imply less information about policy intentions. In the case of money stock targeting, the gross variability of the monthly growth rate of the money stock may be an inappropriate measure of policy performance. If the money stock is forced off a target path by an unanticipated disturbance, the growth rate of the money stock must be aggressively altered in subsequent months to recover the targeted path. In this case, a more suitable measure of undesirable volatility may be the standard deviation of monthly departures from the money stock target path. Similarly, the dispersion of unexpected changes in short-term interest rates may be a more relevant measure of undesirable interest rate volatility than the fluctuations of total changes in interest rates. Thus, in this paper, undesirable volatility is differentiated from gross variability when volatility is a short-run stochastic concept referring to the dispersion of outcomes around planned objectives or expectations.

Stochastic volatility is unavoidable in an economic environment that is subjected to unpredictable and sizable disturbances. Where that volatility is allocated within money markets depends importantly on the design of monetary policy. Attempts to eradicate transitory variations in target variables, for example, may increase the short-run volatility of other money market variables in exchange for little improvement in the long-run performance of the target variables. The extent of this unavoidable short-run stochastic volatility and the nature of the trade-off allocations available to money stock targeting procedures are examined in the next three sections of this paper.

2. An Econometric Portrayal of U.S. Money Markets and Alternative Operating Procedures

An econometric model of monthly financial behavior

Estimates of short-run stochastic volatility in money stock targeting procedures have been obtained from stochastic simulations of an econometric model used by the staff to generate monthly econometric forecasts of money market behavior. The stochastic simulation approach was adopted to circumvent the lack of an extensive historical track record with the new operating procedures. Stochastic simulations permit 1980 to be "rerun" under alternative random disturbances or under competing policy procedures.

In the current version of the model, 20 estimated equations plus several accounting identities project reserve aggregates, the components of M-3, and selected short-term interest rates, given judgmental projections of the monthly paths of personal income and the consumer price index (CPI), and an assumed path for the policy instrument -- nonborrowed reserves (NBR), total reserves (TR), or the federal funds rate (RFF).[1/] Real economic activity is

1/ See appendix A of this paper for a discussion of the economic structure of the monthly model. For a complete description of the current monthly econometric model, see H.T. Farr, "The Monthly Money Market Model," working paper (Board of Governors of the Federal Reserve System, July 1980, revised November 1980).

exogenous in this model and not affected by short-term alterations in the conduct of monetary policy. Essentially, the model provides a characterization of the interactions of money demand and supply based on projections of nonbank demand for bank liabilities and the consequent short-term portfolio adjustments by banks.

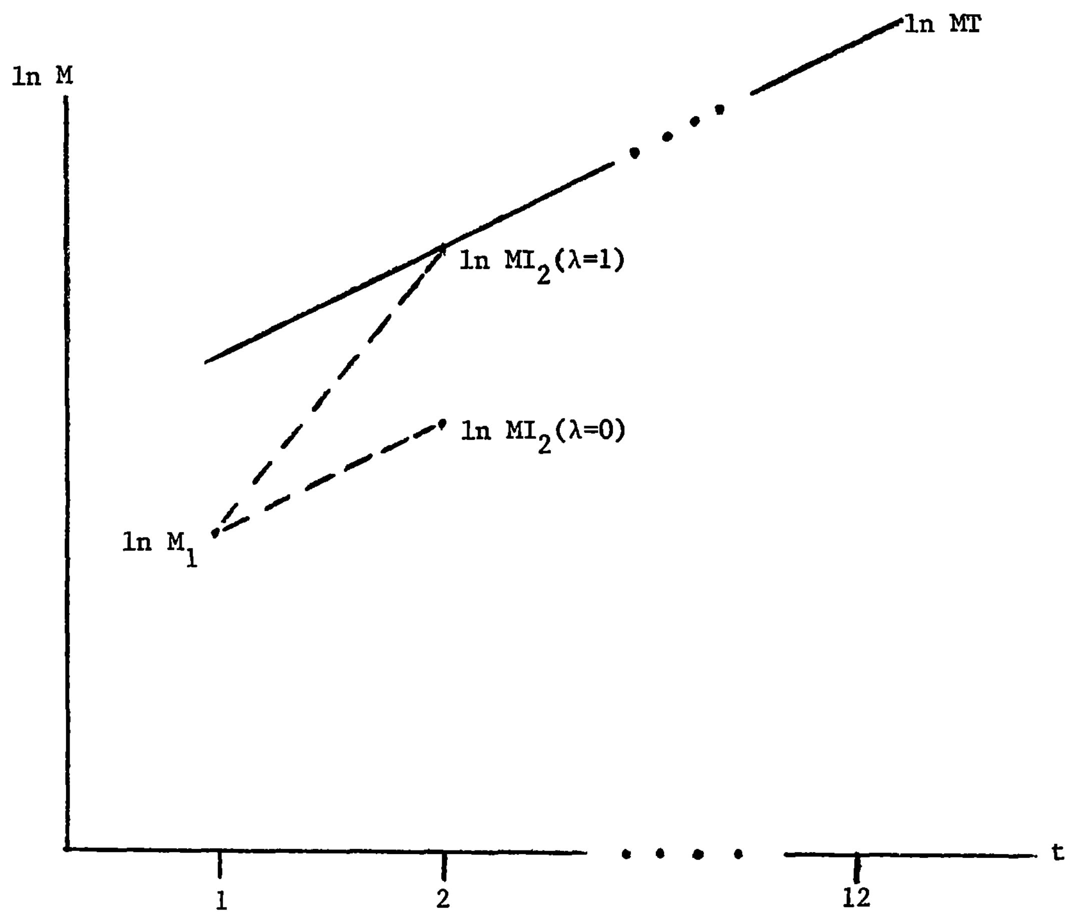
Three equations were added to the existing monthly model: Judgmental projections of both personal income and the CPI were replaced by econometric time series projections since a complete history of judgmental forecast errors was not available. Also, an estimate of a historical reaction rule for the Federal Reserve discount rate was added to provide a description of the probable adjustment of the discount rate in hypothetical simulation experiments. In counterfactual simulations, such as those described in section 4, the federal funds rate may move far off its historical path, and it is unlikely that the policy authority would permit a large spread between the discount rate and the federal funds rate to persist for an indefinite period. As described in appendix A, the estimated historical reaction rule adjusts the discount rate toward the federal funds rate with a mean lag of about three and one-half months.

Given the econometric model description of monthly financial activity, a characterization of the design and impacts of monthly monetary policy is represented by the following three steps.

1. Setting the interim money stock target.

At each FOMC meeting, the policy authority selects an interim M-1A target for the month ahead. This procedure is illustrated in figure 2. In monthly terms, the 1980 target path for M-1A (denoted as MT) is represented by a 4.75% growth path from 1979.11 to 1980.11, approximating the midpoint

Figure 2: Illustration of Selection of Interim M-1A Target



MT - M-1A target path (4.75% annual growth)

M_1 - Projected M-1A in month 1

MI_2 - Interim M-1A target for month 2

(a) λ=0; no closure of relative target gap (base drift),

(b) λ=1; full closure of relative target gap in one month

λ - Monthly rate of reentry to annual target path (MT)

ln - natural logarithm

of the fourth-quarter-to-fourth-quarter target range selected for M-1A by the FOMC. At the time of the FOMC meeting, which typically occurs near the end of the month (month 1 in figure 2), the policy authority is faced with an unplanned deviation of the projected money stock of the current month, M_1, from the target path, MT. The FOMC then selects an interim money stock target for the next month (month 2). The fraction of the gap between the money stock and the annual target path that the committee plans to eliminate in the next month is termed in this paper the "monthly rate of reentry" to the annual target path, denoted by λ. If $\lambda = 1$, the policy authority plans to return to the annual target path, MT, in one month. On the other hand, if $\lambda = 0$, the authority plans to achieve an annualized monthly growth in M-1A equal to the annualized growth rate of the target (4.75%) but starting from the current money stock, M_1, rather than the target value for month 1. Thus, in the case of $\lambda = 0$, the policy authority does not intend to reduce the relative money stock target gap in month 2, a choice that leads to planned base drift.

In this characterization of interim target selection, the selection of the reentry rate, λ, determines the persistence of past random disturbances in the current money stock target gap, MT_t/M_t. If $\lambda = 1$, the effect of a random disturbance in period 1 that causes the money stock, M_1, to deviate from targeted money, MT_1, is eliminated in one month. Since the reentry rate is fixed for all months in the planning horizon, a zero reentry rate ($\lambda = 0$) implies that the effective duration of the impact of a random disturbance is infinite since there will be no planned offset. A reentry rate, λ, can be converted to an implied monthly age, A, of random disturbances in the money stock target gap, as shown in table 1. The typical monthly reentry rate of

Table 1. Translation of Monthly Reentry Rate (λ) to

Average Age (A) of Money Stock Target Misses

	Reentry rate (λ)					
	1	.333	.292 2/	.167	.111	0
Average monthly age (A) 1/	1	3	3.4	6	9	∞

1/ Average age (in months) of random disturbances in the money stock target gap ($\ln MT_t - \ln M_t$). More explicitly,

$$A = \lambda \sum_{i=1}^{\infty} i(1 - \lambda)^{i-1} ,$$

$$= 1/\lambda.$$

2/ Estimated reentry rate of historical interim targeting procedures 80.02 - 80.11; see appendix B.

current targeting procedures in 1980, estimated by W. Trepeta, is 0.292.[2/] This implies an average age of random disturbances in the annual money stock target gap of about three and one-half months.

2. Setting the policy instrument.

A planned setting for the intermeeting interval (represented by the following month in this discussion) is then selected for one of three possible policy instruments -- nonborrowed reserves, NBR, total reserves, TR, or the federal funds rate, RFF.

The selection of the policy instrument setting is approximated in model simulation exercises by the following procedure: It is assumed that the projection of the money stock in the current month of the meeting is sufficently accurate so that any remaining forecast error may be neglected. A forecast of money market behavior in the following month is then simulated by the staff monthly model as if the interim money stock target, MI, for that month is the effective policy instrument. This forecast provides settings for nonborrowed reserves, NBR, total reserves, TR, and the federal funds rate, RFF, that are consistent with achieving the interim money stock target, MI, at least in the absence of forecast errors.

In some of the cases analyzed, the FOMC is assumed also to place a target range on the federal funds rate so it cannot move by more than 300 basis points from the current month to the following month. [3/] In these

2/ Estimation of the historical reentry intentions of current procedures is discussed in appendix B.

3/ One motivation for a target range on an auxiliary variable, such as the federal funds rate in a nonborrowed reserves policy, is to provide a rough check for operational breakdowns of the planning model. If actual events move the auxiliary variable outside the auxiliary target range, actual events may not be statistically compatible with the ex ante forecast. When this occurs, the planning model may be missing some ingredient in the structure of the actual economy, and the policy authority may wish to reconsider planned policy. Using this interpretation, the target range for the auxiliary variable should bear some resemblance to a confidence interval of the ex ante projection of the auxiliary variable.

cases, the funds rate constraint must be satisfied in both the ex ante policy planning stage and in the ex post policy execution stage (when random disturbances are encountered, as explained shortly). 4/

3. Simulation of subsequent "history."

After selecting a policy instrument setting (either nonborrowed reserves, total reserves, or the federal funds rate) that will achieve the interim money stock target, MI_t, in the absence of random disturbances, the model is then resimulated in the second month with nonzero random disturbances. All variables except the policy instrument are affected by the random disturbances.

There are two types of stochastic simulations: (1) In pseudo-history stochastic simulations of a month in 1980 (1980.01-1980.10), the historical forecast errors for the model are included in the simulation. Thus, if the policy instrument is set at its historical path, actual monthly history would be simulated for all variables in the pseudo-history simulations. (2) In average-history stochastic simulations, random disturbances similar in pattern and size to those encountered during the nine-year sample period, 1971.01 through 1979.12, are incorporated. 5/ The purpose of average-history simula-

4/ In all policy simulations, the federal funds rate was subject to a floor of two percentage points and a ceiling of forty percentage points to prevent simulation of events that are far removed from the sample experience. In simulations in which a reserve aggregate is the policy instrument, if the federal funds rate hit a target range boundary on the monthly change or a floor-ceiling boundary on the level, the federal funds rate became the effective policy instrument for the planning stage and/or the execution stage of that month.

5/ The random disturbances of the stochastic simulations reproduce the cross correlations of the historical monthly forecast errors of the model, both over time and across equations in a given month. The standard deviation of the monthly forecast error of demand deposits was increased by about 8% to account for ex post information on recent shifts in the money demand function that is incorporated in the current version of the model. This information is introduced into the model by shift parameters, which include rough approximations for the impact of repurchase agreements, the appearance of ATS accounts, and so on.

tions is to examine the robustness of the response of alternative operating procedures to a full spectrum of plausible random disturbance patterns.

Thus, the planning stage of a monthly policy operating procedure is characterized by two components: (1) selection of the interim target for the money stock, MI_t, as determined by the rate of monthly reentry, λ, to the annual target path, MT_t; and (2) selection of the policy instrument -- nonborrowed reserves (NBR), total reserves (TR), or the federal funds rate (RFF) that will be held invariant to incoming random disturbances throughout the subsequent month. The execution stage of monthly policy is represented by a stochastic simulation in which the effect of the planned policy is eval uated by a monthly model simulation having nonzero random disturbances.

The policy cycle consisting of the following:

1. selection of the monthly interim money stock target,
2. selection of the monthly policy instrument setting, and
3. execution of monthly policy under random disturbances

is repeated in each month of the effective policy horizon, 1980.01 to 1980.10.

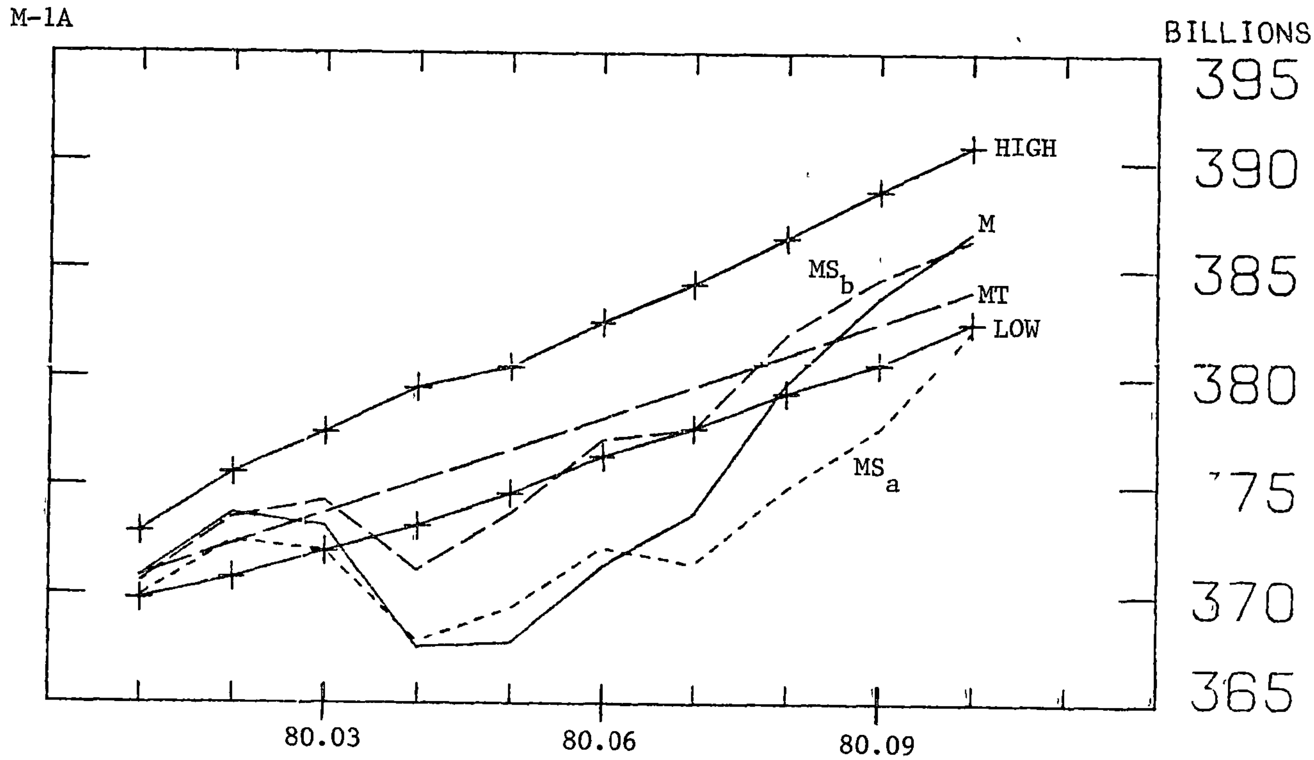
3. A Comparison of Pseudo-History with Average-History Performance of Current Operating Procedures

The annual performance of an operating policy procedure depends to a great extent on the type of random disturbances encountered. As noted in appendix A, some policies are more vulnerable to shocks to the demand for money while others are more affected by supply side shocks. It is of interest to determine whether the intrayear deviations of the actual money stock, M, from the annual target path, MT, were due to some inherent flaw in the current operating procedure or whether the random disturbances encountered in the first 10 months of 1980 were atypical (incorporating the impacts of unusual events such as the imposition of special credit restraints in mid-March).

Three policy "histories" for M-1A are presented in figure 3. The first is actual M-1A, denoted by M. This can be obtained by simulating the monthly model over the first 10 months of 1980 with historical disturbances and with monthly nonborrowed reserves, NBR, maintained on its historical path. The two remaining "pseudo-historical" paths, MS_a and MS_b, are also obtained by simulations with historical disturbances but the nonborrowed reserves paths, NBR_a and NBR_b, of these simulations are obtained by average approximations of current operating procedures. In both cases, the constant monthly rate of reentry, λ, to the target money stock path was set at the typical value estimated for historical planned policy in 1980, $\lambda = 0.292$. Also, both policies were subject to the restriction that the monthly change in the federal funds rate could not exceed 300 basis points. Since both the monthly rate of reentry, λ, and the federal funds rate target range are only approximate characterizations of historical policy procedures, the simulated results will recover only approximations of the consequences of actual policy.

In the first approximation of historical procedures, labeled "NBR policy (restrict ΔRFF)," the simulated policy authority selects that level of nonborrowed reserves, NBR, that will attain the interim money target, MI, in the absence of random disturbances but subject to a monthly target range of six percentage points on the federal funds rate, RFF. Under historical 1980 disturbances, this approximation of policy, denoted NBRa, produces the money stock MS_a. As shown in figure 3, this policy closely mimics movements in the historical money stock, M, in the first six months of 1980, although

Figure 3. Historical and Expected Performance
of Current Procedures



MONTH	LOW	M	MSA	MSB	MT	HIGH
8001	369.793	370.810	369.912	370.569	370.837	372.845
8002	370.759	373.684	372.425	373.481	372.274	375.573
8003	371.955	373.118	371.992	374.283	373.716	377.457
8004	373.113	367.585*	367.844*	371.094*	375.164	379.495
8005	374.615	367.782*	369.364*	373.689*	376.618	380.474
8006	376.332	371.292*	372.137*	377.093	378.077	382.530
8007	377.625	373.670*	371.382*	377.587*	379.542	384.291
8008	379.268	379.713	374.865*	381.944	381.013	386.418
8009	380.604	383.668	377.604*	384.530	382.489	388.645
8010	382.500	386.658	382.138*	386.341	383.971	390.738

LOW (+—+) - lower boundary of 70% confidence interval for NBR policy (restrict ΔRFF)
M (——) - historical M-1A
MS_a (----) - simulated "history" - NBR policy (restrict ΔRFF) with historical disturbances
MS_b (—-—) - simulated "history" - NBR policy ($\hat{BOR} = BOR_{-1}$) with historical disturbances
MT (—-—) - target M-1A (4.75% annual growth 79 11-80 11)
HIGH(+—+) - upper boundary of 70% confidence interval for NBR policy (restrict ΔRFF)
* - outside 70% confidence interval

it returns more slowly to the annual target path, MT, in the remaining four months. 6/

The second approximation to current operating procedures is similar to NBRa, but the simulated policy authority first selects a total reserves estimate, TR_t, consistent with the interim money stock target. In this policy, the nonborrowed reserves path, NBR_b, is obtained by subtracting the current "pseudo-history" of borrowed reserves, BOR_{-1}. 7/ In other words, the assumption of a continuation of current borrowings by the policy authority leads to the selection of the nonborrowed instrument setting, $NBR_b = TR - BOR_{-1}$. This policy approximation, NBR_b, is identified as "NBR policy ($BOR = BOR_{-1}$)" and is also subject to the restriction that the monthly target range for RFF cannot exceed six percentage points. The money stock attained by this policy under 1980 disturbances is labeled MS_b. As noted in figure 3, the 10-month growth of the money stock of this policy approximation is quite close to actual history except during April 1980 when the decrease is not so pronounced. 8/

The results in figure 3 suggest that the two nonborrowed reserves policies are reasonable approximations of current operating procedures since

---

6/ The return to target path is inhibited by the restriction that the monthly RFF change must not exceed three percentage points, whereas in actual history the federal funds rate dropped by 6.63 percentage points in May 1980.

7/ "The amount of nonborrowed reserves -- that is total reserves less member bank borrowing -- is obtained by initially assuming a level of borrowing near that prevailing in the most recent period." p. 82, "The New Federal Reserve Technical Procedures for Controlling Money," attachment to Chairman Volcker's testimony before the Joint Economic Committee on The 1980 Economic Report of the President, February 1, 1980. See also related discussion in M. Hadjimichalakis, "Precision of Monetary Control and Volatility of Rates: A Comparative Analysis of the Reserves and the Federal Funds Operating Targets," working paper (Board of Governors of the Federal Reserve System, December 1980).

8/ This policy tends to produce more modest changes in the federal funds rate since the simulated policy authority does not implicitly recognize the projected offset in borrowed reserves when selecting the planned change in the supply of nonborrowed reserves.

the resultant money stocks, MS_a and MS_b, bracket the result of historical operating procedures, M.

To estimate the range of money stock outcomes that might have occurred under current operating procedures had 1980 been an "average" year, a 70% confidence interval was generated for the first approximation of current NBR policy (restrict ΔRFF). 9/ The 70% confidence interval is obtained from 100 stochastic simulations of the first 10 months of 1980. Random disturbances for each simulation differ but are selected to replicate the historical pattern of the forecast errors encountered by the monthly model over the nine-year sample, 1971.01 - 1979.12. After 100 money stock paths are generated by the average approximation of current operating procedures, the upper 15 and lower 15 of the simulated money stock paths are removed to define the boundaries of the 70% confidence interval shown in figure 3. As indicated, both the actual money stock, M, and the "pseudo-historical" money stocks, MS_a and MS_b, obtained using 1980 historical disturbances fall below the 70% confidence interval in at least 3 of the first 10 months of 1980.

Under the assumption that the relative accuracy of the model description of money market behavior is not substantially affected by the shift in operating procedures, this result suggests that the odds are at

9/ Relative to the annual target path, MT, there is a discernible "upside risk" implied by the effective midline of the 70% confidence interval. This is due, in part, to the logarithmic formulation of money demand in the monthly model. To illustrate, if the logarithmic forecast error is normally distributed

$$\ln\hat{M} - \ln M = \varepsilon \ , \ \varepsilon \sim N(0, \sigma^2) \ ,$$

the mean of the simulated forecasts, E(M), will exceed the certainty-equivalent (zero residual) forecast, $\hat{M}$.

$$E(M) = \hat{M}\, e^{\sigma^2/2} \ .$$

least two to one that a portion of the gyrations of the money stock observed during 1980 can be ascribed to unusually severe disturbances encountered in 1980 and not to instability generated by current operating procedures.

4. Expected Trade-offs in the Volatility of Monthly Money Stock Target Gaps and of Changes in the Federal Funds Rate Under Alternative Operating Procedures

This section examines the volatility implications of varying the monthly rate of reentry, λ, to the money stock target path, MT. One measure of the volatility of the federal funds rate is the standard deviation of the monthly change, σ (ΔRFF). Under general conditions, this statistic can be interpreted as one-half the width of the 70% confidence interval for month-to-month variations in RFF.

One measure of the volatility of money stock performance is the standard deviation of monthly deviations of the annualized cumulative growth rate of the money stock from the annualized cumulative growth rate of the money stock target, where the latter is 4.75% for every month in the policy horizon. The precise measure used is the square root of squared deviations from 4.75% or the root mean squared error, RMSE. The RMSE also penalizes persistent "biases" in performance when the money stock consistently grows below or above the target path as in the case of base drift. In all cases reported below, the mean bias is negligible (since the average random disturbance is zero) so the RMSE corresponds closely to the standard deviation and is approximately equal to one-half the range of the 70% confidence interval for monthly departures from 4.75% growth.

It can be demonstrated that this volatility measure of monthly cumulative growth rates around 4.75% is equivalent to the RMSE of the logarithm of the annualized monthly target gap, RMSE(GAP), when the annualized target gap for month t is

$$GAP_t = \ln \left[\left(\frac{MT_t}{M_t} \right)^{\frac{12}{t}} \right] \times 100.$$

Thus, in the results discussed below, if the root mean squared error of the money stock target gap is two, RMSE(GAP) = 2.0, this indicates that the annualized cumulative growth rate of the money stock in a given month will fall between 6.75% (4.75 + 2.0) and 2.75% (4.75 - 2.0) with approximately 70% probability. 10/

The results that follow tabulate the expected trade-off between target-gap volatility of the money stock and the volatility of the federal funds rate. Points on the volatility trade-off "frontier" are generated by altering the monthly rate of reentry, λ, to the money stock target path. As the monthly rate of reentry moves from zero (base drift) to unity (full gap closure), it is of interest to determine if the frontier is "unstable" (positively sloped) or well-behaved (negatively sloped). In the case of the former, the volatility of both the money stock target gap and the federal funds rate would increase with the speed of monthly reentry, suggesting that a viable trade-off does not exist. In the latter case, an increase in the volatility of the federal funds rate can be exchanged for a reduction in the volatility of the monthly target gap.

The volatility frontier is estimated for a particular policy by average-history simulations of the monthly econometric model. As discussed

10/ The simulation results do not include an estimate of "noise" introduced by preliminary seasonal adjustment. An examination of recent work by D. Pierce suggests that estimates of the target-gap volatility presented later underestimate total money stock volatility by about 1 percentage point; see D. Pierce, "Data Revisions with Moving Average Seasonal Adjustment Procedures," Journal of Econometrics, vol. 14 (September 1980), pp. 95-114.

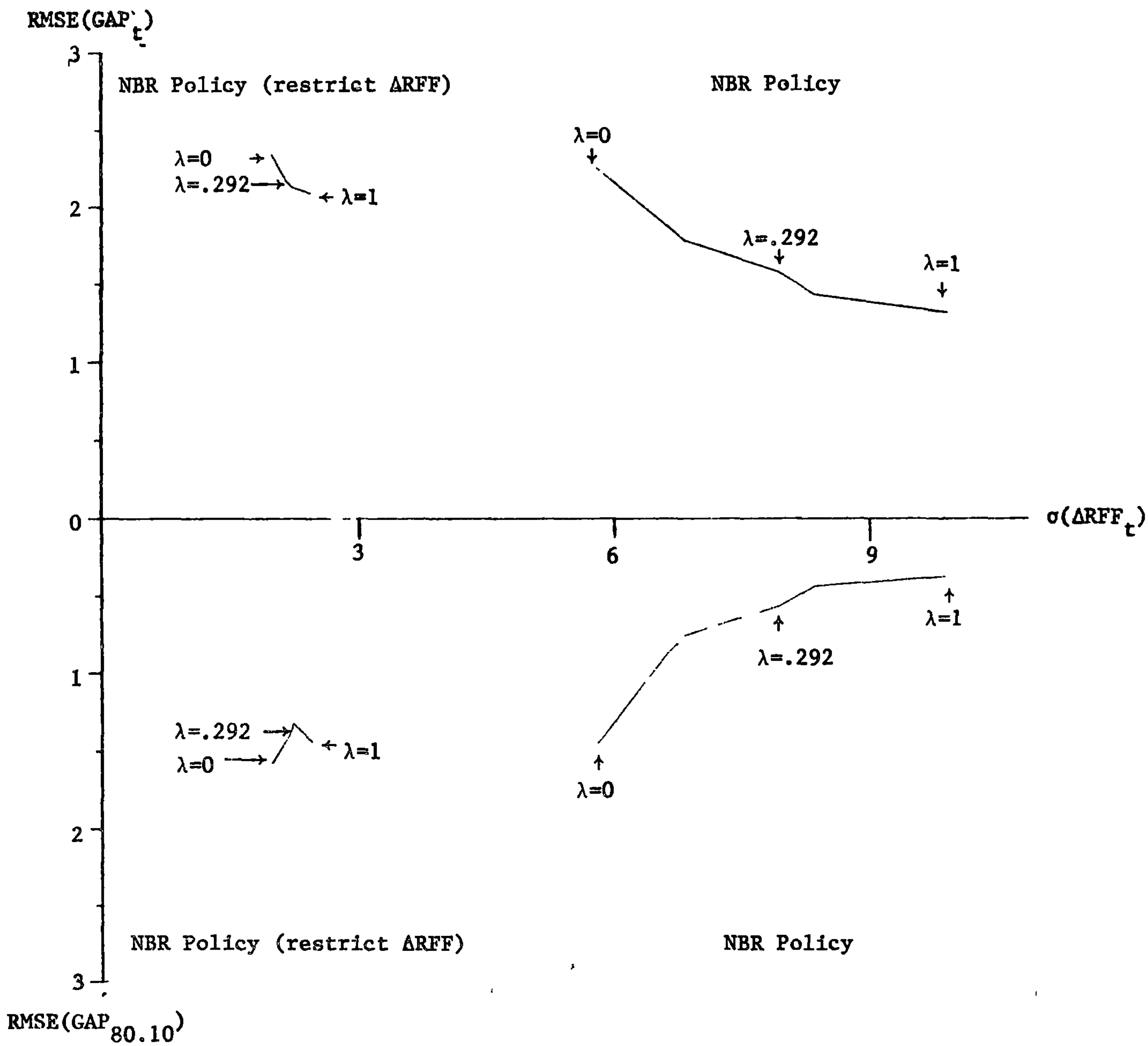
earlier, the pattern of random disturbances of average-history stochastic simulations resembles the pattern of historical forecast errors generated by the monthly model over the sample span, 1971.01 - 1979.12.

The following four operating procedures are examined:

1. NBR. Nonborrowed reserves are selected as the policy instrument that is held invariant to random disturbances during the policy execution stage of each month.
2. NBR (restrict RFF). The nonborrowed reserves policy is subject to a federal funds target range of six percentage points. That is, the monthly change in the federal funds rate cannot exceed 300 basis points in either the policy planning stage, the policy execution stage, or both.
3. RFF. The federal funds rate is selected as the policy instrument that is held invariant to random disturbances in the policy execution stage of each month. Thus, all monthly changes in the federal funds rate under this policy are planned changes selected in the planning stage to return the money stock to its interim target level.
4. TR. Total reserves is selected as the policy instrument that is held invariant to the impact of random disturbances in the policy execution stage of each month.

Trade-offs in the volatility of the federal funds rate and the volatility of the money stock target gaps under the four alternative operating procedures are displayed in figures 4-6. The horizontal axis indicates interest rate volatility as represented by the standard deviation of monthly changes in the funds rate, $\sigma(\Delta RFF)$, measured in percentage points. The

Figure 4. Reentry Trade-off Schedules under Nonborrowed Reserves Policies



$\sigma(\Delta RFF_t)$ - Standard deviation of monthly change in RFF

RMSE - Root mean square error

GAP_t - Log of annualized relative gap between target money and actual money in month t

$GAP_{80.10}$ - Log of annualized gap in last month of horizon (80.10)

λ - Monthly rate of reentry to the money stock annual target path vertical axis provides two measures of money stock target gap volatility. The upper panel (going up from the horizontal axis) indicates the monthly volatility in money stock target gaps for all months in a sample of 10-month policy horizons. Thus, the upper panel measures month-to-month variability of the money stock target gap within a 10-month "year." The lower panel (going down from the horizontal axis) measures the volatility of the terminal gap at the end of a sample of 10-month "years." It is assumed that the policy authority wishes to reduce all measures of volatility -- money stock target gap volatility within a policy year, RMSE (GAP_t); terminal target gap volatility, $RMSE(GAP_{80.10})$; and funds rate volatility, $\sigma(\Delta RFF_t)$. However, the results indicate that this is not possible.

The unrestricted nonborrowed reserves policy, NBR policy, is displayed on the right side of figure 4.[11/] For the case of base drift ($\lambda = 0$), the upper panel indicates that a target gap volatility of about 2.26% is obtained by the NBR policy at the cost of a monthly funds rate volatility of about 5.9 percentage points. As the monthly reentry rate, λ, moves toward unity, the volatility of the monthly money stock target gap is <u>reduced</u> at the cost of an <u>increase</u> in monthly funds rate volatility. Thus, the trade-off moves in a southeasterly direction as the reentry rate, λ, increases. At $\lambda = 1$, the unrestricted NBR policy obtains a 60% reduction in monthly money stock target gap volatility at the cost of a 75% increase in the monthly volatility of the federal funds rate, RFF. [12/]

11/ As noted earlier, this policy is not subject to a target range restriction on monthly changes in the federal funds rate.

12/ This may be a relatively optimistic trade-off since the short-run and long-run interest rate elasticities of the demand for money in the staff monthly model were the highest among models examined by the authors. A procedure for selecting the monthly rate of reentry that minimizes undesirable consequences of money market volatility is explored in P. von zur Muehlen and P. Tinsley, "A Measure of the Cost of Money Market Volatility Associated with Money Stock Targeting," working paper (Board of Governors of the Federal Reserve System, December 1980).

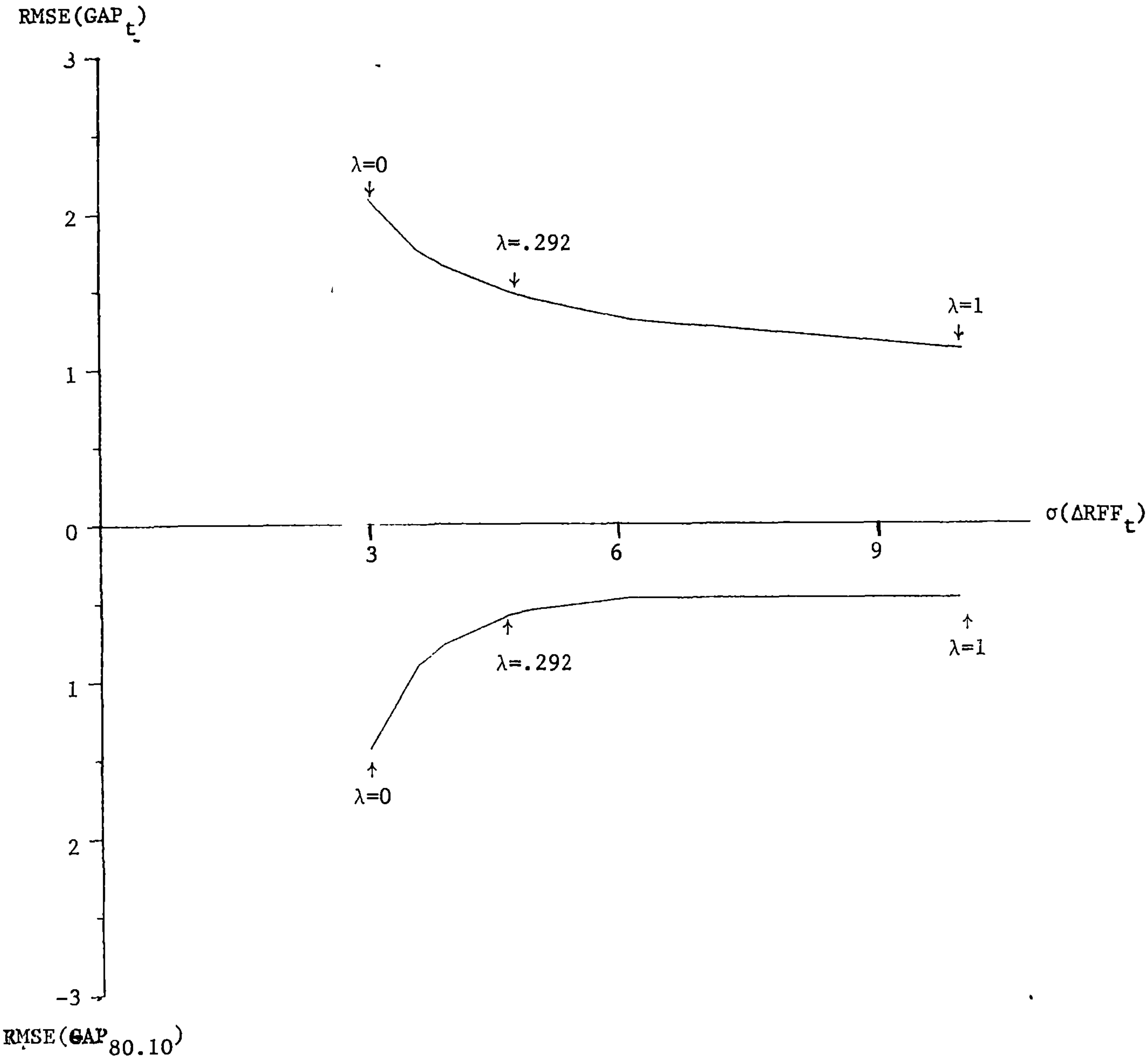
As the reentry rate, λ, goes to unity, the monthly money stock target gap volatility does not go to zero. This is because the reentry rate is established in the planning stage without benefit of perfect foresight of the random disturbances that will be encountered during the subsequent month. Thus, 1.3% is the lowest monthly gap in volatility that can be achieved by the unrestricted NBR policy, at the cost of a monthly funds rate volatility of 10.2 percentage points. Note also that not much is gained in terms of a reduction in monthly money stock volatility by moving from $\lambda = 0.292$ (the estimated historical rate of reentry) to $\lambda = 1$ (planned complete closure of the money stock target gap in one month).

The bottom panel is roughly a mirror image of the top panel except that the terminal gap volatility measures for corresponding rates of reentry, λ, are uniformly lower. This property was found for all policies examined and indicates that all policies will be more successful in attaining year-over-year targets than in maintaining close adherence to the target path within the year.

The left side of the panels in figure 4 indicate the expected volatility trade-off for a nonborrowed reserves policy that is subject to a range restriction of 6 percentage points on monthly changes in the federal funds rate, RFF. This policy is a closer approximation to current operating procedures than the unrestricted NBR policy. The results in figure 4 suggest that variation in the reentry rate under current procedures is largely futile since performance is dominated by the imposition of the target range restriction on monthly variation of the federal funds rate.

Figure 5 indicates the expected trade-offs for an unrestricted interest rate policy when the federal funds rate, RFF, is held constant during the month rather than nonborrowed reserves, NBR. Of course, the

Figure 5. **Reentry** Trade-off Schedules under a Federal Funds Rate Policy



$\sigma(\Delta RFF_t)$ - Standard deviation of monthly change in RFF

RMSE - Root mean square error

GAP_t - Log of annualized relative gap between target money and actual money in month t

$GAP_{80.10}$ - Log of annualized gap in last month of horizon (80.10)

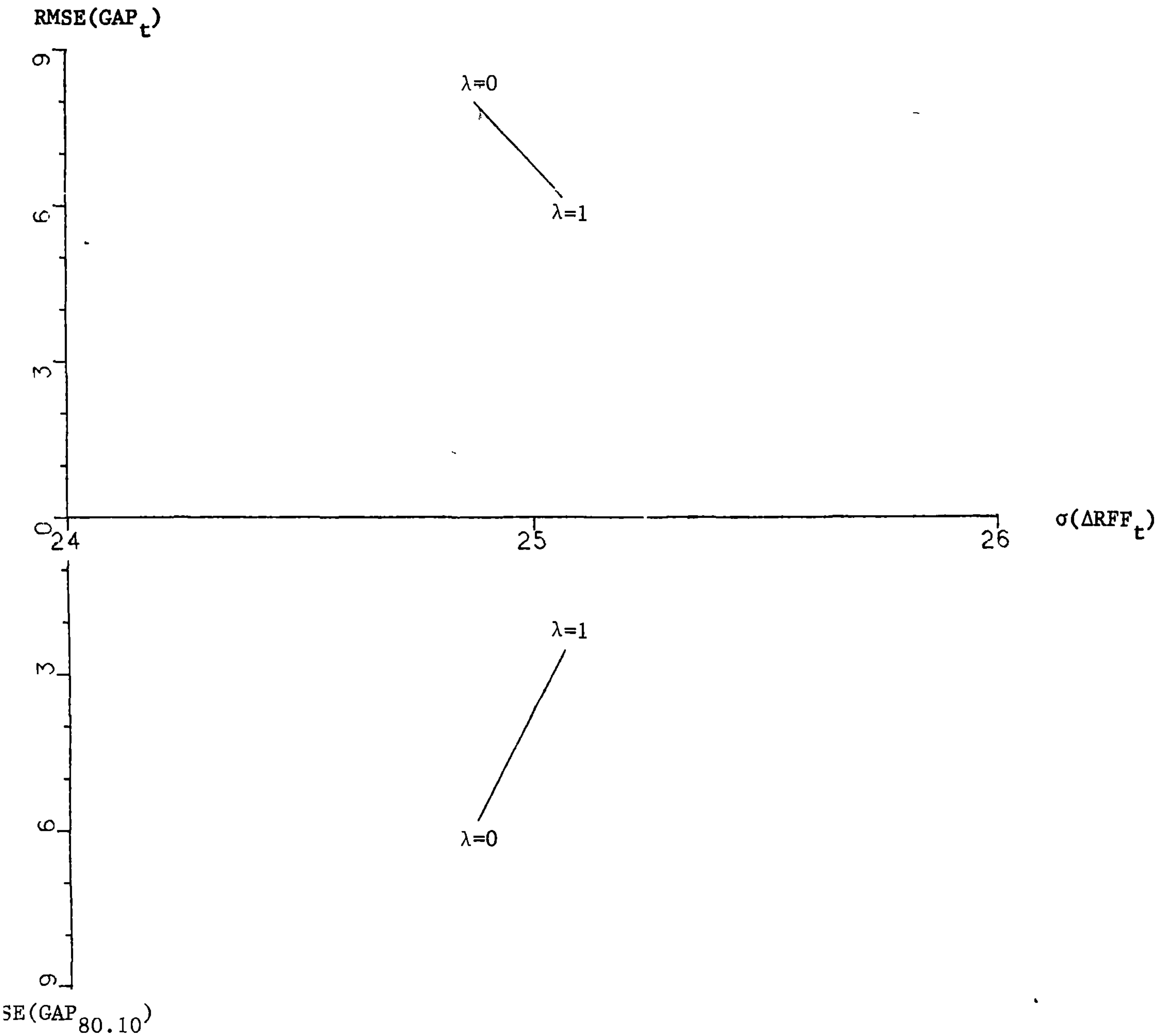
λ - Monthly rate of reentry to the money stock annual target path federal funds rate is reset at the beginning of each month to obtain the interim money stock objective.

One characteristic of the unrestricted interest rate policy, RFF, is that comparable reductions in both monthly and terminal gap volatility are obtained at lower levels of interest rate volatility. That is, at the historical rate of planned reentry, $\lambda = 0.292$, the monthly money stock gap volatility under an unrestricted nonborrowed reserves policy, NBR, is 1.6, a result that is close to the 1.5 obtained for the unrestricted interest rate policy, RFF. Similarly, the terminal gap volatility at $\lambda = 0.292$ is 0.56 for the unrestricted NBR policy and 0.58 for the RFF policy. However, the corresponding monthly RFF volatility measure at $\lambda = 0.292$ is 8.0 percentage points for the NBR policy and only 4.8 percentage points for the RFF policy. 13/

Simulation experiments with total reserves, TR, as a policy instrument were not encouraging. As indicated in figure 6, both monthly and terminal money stock target gap volatility remain large and the trade-off that exists is associated with extremely large measures of monthly volatility in the federal funds rate, RFF. As indicated in appendix A, this may occur if the projections of required and excess reserves are inaccurate. Two conclusions may be drawn from this result regarding the use of total reserves as a policy instrument. If one believes that projections of the total reserves money stock multiplier provided by the monthly econometric model are inferior to those that can be obtained by other models (judgmental or econometric), one may reject the results in figure 6. Alternatively, if the monthly model projections of the total reserves money stock multiplier are representative of projections under

13/ Since, as noted in appendix A, planned settings of the funds rate are identical under all policies, the results in figure 5 could be obtained approximately by a nonborrowed reserves policy with a relatively wide target range on planned changes in the funds rate and tight restrictions on unplanned changes in the funds rate.

Figure 6. Reentry Trade-off Schedules under a Total Reserves Policy



σ(ΔRFF$_t$) - Standard deviation of monthly change in RFF.
RMSE - Root mean square error.
GAP$_t$ - Log of annualized relative gap between target money and actual money in month t.
GAP$_{80.10}$ - Log of annualized gap in last month of horizon (80.10).
λ - Monthly rate of reentry to the money stock annual target path.

current institutional arrangements, additional modifications in policy procedures (such as the design of more predictable reserve requirements on current deposits) might be considered before evaluating procedures involving the use of total reserves as a policy instrument.

5. The Issue of Interest Rate Instability

In contrast to the case of short-run volatility examined in preceding sections by which money markets may be subjected to frequent and sizable transient disturbances, the possibility exists that an attempt to exert close control over the money stock may induce undamped cycles in short-term interest rates. This condition, termed interest rate instability, is not related to the pattern of unforeseen disturbances but, rather, to the nature of lagged interest rate effects on the demand for money.

Suppose, for example, that lagged impacts of the federal funds rate on the demand for money are more powerful than the contemporaneous impact. In this case, ever-larger changes in the funds rate might be required to offset the current impacts of previous settings of the federal funds rate.

Examination of the staff monthly money market model suggests that even very tight month-to-month control of the money stock, M-1A, would not produce interest rate instability. (Details of this exploration of the dynamic structure of the monthly econometric model are discussed in appendix C.) However, this conclusion must be tempered with several qualifications. First, alternative specifications of the distributed-lag impacts of interest rates on money demand may yield different stability conclusions. 14/ Second, appendix C examines only the direct impacts of interest rates on money demand

14/ Indeed, J. Ciccolo found evidence of instability in several models estimated prior to the mid-1970s shift in money demand. See J. Ciccolo, "Is Short-Run Monetary Control Feasible?" Monetary Aggregates and Monetary Policy (Federal Reserve Bank of New York, 1974), pp. 82-91.

and does not explore the impact of indirect transmission channels such as the interest rate elasticity of capital investment. 15/ Third, the dynamic response structure of money demand may alter as the public reacts to perceived changes in the operating procedures of monetary policy.

Since no evidence of interest rate instability was uncovered in this study, it would appear that interest rate instability is not a major barrier to money stock targeting procedures. A number of studies in the early 1970s explored the general problem of policy instrument instability. 16/ One result of this literature suggests that if instability seems to exist, the difficulty may lie in the design of the policy strategy. That is, for any model with an arbitrary lag structure, it is possible to concoct a policy rule that may yield (unstable) cycles in the target variable, the policy instrument, or both. This does not imply that instrument instability will exist for a policy that recognizes the dynamic response structure of the model in question. In many instances, the difficulty may lie in the selection of an inappropriate indicator of policy performance or the adoption of an inflexible policy rule that disregards available measurements.

Two additional factors may also reduce the likelihood of interest rate instability. First, there is mounting evidence that the structure of the economy may be more adequately represented by stochastic coefficient

---

15/ For discussion of model simulation experiments incorporating both direct and indirect impacts of interest rates on money demand, see J. Enzler and L. Johnson, "Cycles Resulting from Money Stock Targeting," working paper (Board of Governors of the Federal Reserve System, December 1980).

16/ A partial list includes: R.S. Holbrook, "Optimal Economic Policy and the Problem of Instrument Instability," American Economic Review, vol. 62 (March 1972), pp. 57-65; G.C. Chow, "Problems of Economic Policy from the Viewpoint of Optimal Control," American Economic Review, vol. 63 (December 1973), pp. 825-37; M. Aoki, Optimal Control and System Theory in Dynamic Economic Analysis (Amsterdam: North-Holland, 1976); and especially S.J. Turnovsky, "The Stability Properties of Optimal Economic Policies," American Economic Review, vol. 64 (March 1974), pp. 136-48.

models than by fixed coefficient models, 17/ a result that may rationalize cautious market interventions by both public and private agents. 18/ Second, it is likely that normal arbitrage in money markets would tend to dampen or eliminate predictable cycles in interest rates.

6. A Note of Caution

All policy analysis is model specific and the results of this paper are not exempt from that dictum. Two limitations of the existing monthly econometric model may be noted.

1. As indicated in appendix A, the economic structure and scope of the current monthly econometric model are limited. It would be desirable to incorporate a full spectrum of portfolio adjustments by bank and nonbank sectors as well as interactions between real and financial economic activity.19/ Efforts in these directions are impeded by the limited scope of available monthly data.

2. Stochastic simulations provide a more robust method of analysis than deterministic simulations since they account

17/ See recent empirical evidence on annual and quarterly models with stochastic structures in P.A.V.B. Swamy and P.A. Tinsley, "Linear Prediction and Estimation Methods for Regression Models with Stationary Stochastic Coefficients," Journal of Econometrics, vol. 12 (February 1980), pp. 103-42; and P. Tinsley, J. Berry, G. Fries, B. Garrett, A. Norman, P.A.V.B. Swamy, and P. von zur Muehlen, "The Impact of Uncertainty on the Feasibility of Humphrey-Hawkins Objectives," Journal of Finance (1980 proceedings of the American Financial Association, forthcoming).

18/ That is, aggressive intervention in a stochastic coefficients model may increase the unpredictability of the response to the intervention.

19/ The richness of analysis that can be obtained by examination of a complete capital account model is demonstrated in the theoretical analysis of M.G. Hadjimichalakis, "Precision of Monetary Control and Volatility of Rates: A Comparative Analysis of the Reserves and the Federal Funds Operating Targets," working paper (Board of Governors of the Federal Reserve System, December 1980).

for the historical forecast error record of the model employed. Although the boundary limits of uncertainty are delineated by this technique, all uncertainty is allocated to additive external "surprises." Evidence is accumulating that the essential structure of the economy is better described by allocations of forecast uncertainty over all model coefficients, in contrast to the conventional assumption that the model structure is fixed over time. [20] Although progress in this area of inquiry is slow and tedious, it is strongly suspected that the existence of stochastic policy multipliers requires prudent policy interventions if the aim of policy is to reduce, rather than increase, volatility indices of performance.

20/ See references cited in note 17.

APPENDIX A: Planned and Unplanned Changes in the Money Stock (M) and the Federal Funds Rate (RFF) Under Alternative Operating Procedures */

Table A.1 presents the essential structure of the staff monthly econometric model used in stochastic simulations described in this paper. 1/ The structure is sufficiently simple that most deviations in the patterns of planned and unplanned changes in the money stock and short-term interest rates due to alterations in operating procedures can be interpreted by direct inspection of the model as shown below.

The model structure

This model is a characterization of short-run behavior. Changes in variables (denoted by Δ) refer to changes induced by altered settings of the policy instrument and the impacts of random disturbances. The predictions of all excluded variables (such as GNP and price inflation) are presumed invariant to short-run changes in the policy instruments. Prediction errors of excluded variables are contained in the relevant random disturbances. For example, if GNP is overpredicted, the money demand disturbance (a_0) will include a negative component.

As shown in table A.1, the skeletal model consists of seven equations. The first equation indicates that the demand for money is inversely related to the federal funds rate. The next five equations comprise the effective supply of money. The second equation defines required reserves. This equation contains a random disturbance (b_0) representing errors in projecting the change in required reserves that is associated with a given change in the money stock. This error term includes errors in predicting

*/ Prepared by P. Tinsley.

1/ The complete structure of the FRB staff monthly econometric model is presented in H.T. Farr, "The Monthly Money Market Model," working paper (Board of Governors of the Federal Reserve System, revised November 1980).

Table A.1 A Skeletal Money Market Model

Equation	Description
1. $\Delta M = a_o - a_1 \Delta RFF$.	money demand (stochastic)
2. $\Delta RR = b_o + b_1 \Delta M$.	required reserves (stochastic)
3. $\Delta EXR = c_o$.	excess reserves (stochastic)
4. $\Delta TR = \Delta RR + \Delta EXR$.	total reserves (identity)
5. $\Delta BOR = d_o + d_1 (\Delta RFF - \Delta RDIS)$.	borrowed reserves (stochastic)
6. $\Delta NBR = \Delta TR - \Delta BOR$.	nonborrowed reserves (identity)
7. $\Delta RDIS = e_1 \Delta RFF$.	discount rate (policy rule)

Variable Definitions

1. M - money stock
2. RFF - Federal funds rate
3. RR - required reserves
4. EXR - excess reserves
5. TR - total reserves
6. BOR - borrowed reserves
7. NBR - nonborrowed reserves
8. RDIS - FR discount rate

Coefficient Properties

(i) slope coefficients

a_1, b_1, and d_1 are all positive

(ii) discount rate reaction rule

e_1 lies between 0 and 1

(iii) random disturbances (intercept coefficients)

a_o, b_o, c_o, and d_o have zero means and constant variances the distribution of the money stock over different types of deposits and among banks of different sizes. Since the own rate on excess reserves is zero, the third equation suggests that net changes in excess reserve holdings are unplanned. The fourth equation defines total reserves, and the fifth indicates that borrowings are positively related to the spread between the federal funds rate and the cost of borrowing. Finally, the sixth equation defines nonborrowed reserves.

The last equation is a characterization of discount rate policy. The discount rate is pegged at a given level if e_1 is zero; alternatively, the spread between the discount rate and the federal funds rate is maintained if e_1 is unity. Historical policy lies between these two extremes. The historical reaction rule for the discount rate (RDIS) incorporated in the monthly model suggests that e_1 is about 0.25. 2/

Planning and execution stages

The policy authority may choose one of three variables as its policy instrument -- total reserves, TR; nonborrowed reserves, NBR; or the federal funds rate, RFF. In table A.2, planned settings of variables are denoted by Δ^p. To illustrate, under a funds rate procedure, the planned change in RFF is determined by the planned target objective for the money stock

$$\Delta^p RFF = - \frac{\Delta^p M}{a_1},$$

where $-a_1$ is the interest rate coefficient in the demand for money (equation 1 in table A.1).

2/ This is the coefficient for the first-month reaction. As fitted by von zur Muehlen, the historical reaction function suggests a mean lag in adjustment of about three and one-half months and full adjustment to an RFF change in about nine months.

Table A.2: Planned and Unplanned Consequences of Alternative Operating Procedures 1/

Policy	Change in federal funds rate	Change in money stock
	planned	planned
all policies	$\Delta^p RFF = -\frac{\Delta^p M}{a_1}$	$\Delta^p M$
	unplanned	unplanned
RFF policy	$\Delta^u RFF_{rff} = 0.$	$\Delta^u M_{rff} = a_o.$
TR policy	$\Delta^u RFF_{tr} = \frac{b_1 a_o + b_o + c_o}{a_1 b_1}.$	$\Delta^u M_{tr} = -\frac{(b_o + c_o)}{b_1}.$
NBR policy	$\Delta^u RFF_{nbr} = \theta \Delta^u RFF_{tr} - \frac{d_o \theta}{a_1 b_1}.$	$\Delta^u M_{nbr} = \theta \Delta^u M_{tr} + (1-\theta)\Delta^u M_{rff} + \frac{d_o \theta}{b_1}.$
		where $\theta = \frac{a_1 b_1}{a_1 b_1 + d_1(1 - e_1)}.$

1/ Subscripts (rff, tr, nbr) denote policy selection. For example, $\Delta^u M_{rff}$ is the unplanned change in the money stock under an RFF operating procedure. The following superscripts denote planned and unplanned changes:

$\Delta^p M$ - planned change in M (before random disturbances)

$\Delta^u M$ - unplanned change (forecast error)

ΔM - total observed change ($\Delta M = \Delta^p M + \Delta^u M$).

Note that, in the planning stage, the planned change in the money stock ($\Delta^p M$) sought by the policy authority can be viewed as the effective policy instrument. In this stage, the model is cast into a forecast mode by setting all random disturbances equal to zero ($a_0 = b_0 = c_0 = d_0 = 0$) since zero is the "best" forecast of each prediction error. Given planned money change ($\Delta^p M$), the seven equations of the model are then solved to give the planned settings of the remaining seven variables. Since there must be only one solution of the linear model for a given money stock target, the planned changes of all variables must be identical under any operating procedure. (This property is explicitly indicated only for planned RFF settings in table A.2.)

Given the ex ante planned settings, the execution stage of policy is defined by adding nonzero values of the random disturbances (a_0, b_0, c_0, d_0). Distinctions among operating procedures are determined by the selection of one variable (designated the policy instrument) that is held constant or invariant to the random disturbances encountered during the policy execution stage (however short in duration). Holding one variable constant forces the impact of the random disturbances onto the remaining seven variables (that now include the unplanned change in the money stock $\Delta^u M$). Thus, the expected pattern of unplanned changes (denoted by Δ^u in table A.2) is entirely determined by (1) the selection of the policy instrument, and (2) the distributions or typical historical patterns of the random disturbances. 3/

The methodology of the stochastic simulations and that of underlying classical econometrics and control theory in general is that the probabilities of the random disturbances of the model structural relations are invariant to variations in the selected policy instruments. In other

3/ The purpose of stochastic simulations is to isolate and quantify the role of the selection of the policy instrument by using random disturbance patterns similar to those observed in recent history.

words, in the case of n variables subject to m structural "laws," the distributions of the random disturbances are invariant to the motion of the n-m "instruments." This does not imply necessarily that the instruments are statistically independent of the realizations of the disturbances as would not be the case for feedback policies.

For models with additive random disturbances, it may be argued that the stochastic volatility is merely allocated by policy since the impact of a random disturbance may be partially or fully absorbed by an instrument without diminishing or magnifying the additive disturbance impact. 4/ This would not be true for models with stochastic coefficient structures where stochastic disturbances interact multiplicatively with the instrument settings.

Alternative selections of policy instruments that are held invariant between policy intervention dates influence the ultimate destinations of random disturbances. This alteration in the allocation of volatility is a principal reason that apparent correlations between target variables and potential instruments (caused by the impacts of common disturbances) seem to break down when the potential instruments are, in fact, employed as policy instruments. This phenomenon, well-known in control theory, may be interpreted as the raison d'etre of Goodhart's law: "Any statistical regularity will tend to collapse once pressure is placed upon it for control purposes." 5/

Some unplanned consequences of alternative policy procedures

It is useful to sketch some of the major differences in unplanned consequences for the money stock and the federal funds rate under alternative policies.

4/ The allocation of uncertainty by alternative feedback strategies and the dramatic alterations in projected confidence regions that may result are discussed and illustrated in P. Tinsley and P. von zur Muehlen, "A Maximum Probability Approach to Short-Run Policy," Journal of Econometrics, vol. 15 (January 1981), pp. 31-48.

5/ As cited in Albert M. Wojnilower, "The Central Role of Credit Crunches in Recent Financial History," Brookings Papers on Economic Activity, 1980:2, p. 324.

1. RFF as policy instrument.

There is no unplanned change in RFF ($\Delta RFF = \Delta^{p} RFF$) and unplanned changes in the money stock ($\Delta^{u} M$) are determined only by the random disturbance of the money demand schedule (a_0).

2. TR as policy instrument.

In counterpoint to the RFF policy, the unplanned change in the money stock under a total reserves policy (TR) is wholly determined by two "supply side" shocks -- b_0, the forecast error of required reserves; and c_0, the forecast error of excess reserves. The results of stochastic simulations presented in the paper suggest that the performance of a total reserves policy is apparently sensitive to the accuracy of the required reserves forecast. As indicated in table 2, the unplanned change in RFF is a function of both demand (a_0) and supply (b_0, c_0) shocks and inversely related to the interest rate coefficient of money demand (a_1) and reserve requirements (b_1). Unplanned changes in neither money nor RFF are affected by forecast errors of borrowings (BOR) or the discount rate policy (e_1).

3. NBR as policy instrument.

In several respects, a nonborrowed reserves policy, NBR, may be interpreted as a hybrid policy, mixing elements of both RFF and TR policies. The unplanned change in the money stock, for example, is a weighted average of the unplanned changes that would be observed under the competing policies. That is, the weights on unplanned money stock changes under an RFF policy, $\Delta^{u} M_{rff}$, and unplanned money stock changes under a TR policy, $\Delta^{u} M_{tr}$, sum to unity and are fractional for fractional e_1, the discount rate reaction coefficient. Thus, under a nonborrowed reserves policy, discount rate policy is an important determinant of the relative impacts of demand and supply side shocks. If larger demand shocks are expected judgmentally in the near term,

e_1 might be raised closer to unity; conversely, if difficulties are expected in forecasting required reserves, the response of the discount rate might be muted (moving e_1 toward zero).

NBR is the only policy under which unplanned changes in both the money stock and the funds rate, RFF, may be induced by forecast errors in borrowings (d_0). Indeed, the presence of the borrowing projection error (d_0) and a discount reaction (e_1) of less than unity are the only elements that provide a distinction between NBR and TR policies. That is, if $d_0 = 0$ and $e_1 = 1$, NBR policy is identical to TR policy since ΔBOR, in this case, would always be zero (see equations 5 and 6 of table A.1).

The results in table A.2 also indicate that unplanned changes in the funds rate will tend to be smaller under NBR policy than under TR policy due to the positive slope of the effective total reserve supply schedule under the NBR policy (e_1 less than unity). Thus, under current assumptions, dispersion of total changes in the federal funds rate will tend to be smallest under a funds rate policy, RFF, and largest under a total reserves policy, TR.

APPENDIX B: Construction of the Desired Speed of Reentry (λ) to the Long-Run M-1A Target Path in 1980 */

1. Characterization of FOMC Intentions

At each meeting, the FOMC selects short-run targets for several monetary aggregates, expressed as seasonally adjusted average growth rates over a horizon of two or more months. Staff then translate the FOMC's desired short-run growth rates for the aggregates into monthly target levels of the aggregates. At times, this translation requires variable month-to-month growth rates in order to accommodate anticipated transitory variations in money demand. This discussion focuses on the FOMC's short-run objectives for M-1A alone, and bases its estimates of the typical intended M-1A reentry speed on monthly translations of the FOMC's short-run objectives.

Specifically, the FOMC short-run objective for M-1A is represented as a plan to reduce the gap between the long-run annual target path for M-1A and the level of M-1A in the month following the FOMC meeting to a given fraction of the current gap in the month of the FOMC meeting, as projected by the staff at the time of the meeting. 1/ An algebraic formulation of this linkage between short-run and long-run M-1A objectives of the FOMC is

$$\ln MT_{t+1} - \ln MI_{t+1} = (1 - \lambda)(\ln MT_t - \ln M^P_t), \qquad (B.1)$$

*/ Prepared by W. Trepeta with research assistance from H. Hayssen, M. McLaughlin, and A. Reilly.

1/ This characterization does not incorporate FOMC intentions to influence, subsequent to its meeting, the level of M-1A that is projected for the current month of a meeting. This abstraction seems permissible, given that the FOMC met on average around mid-month and often later in the month, when little could be done to alter the average level of M-1A projected for that month.

where the subscript t denotes the month of the FOMC meeting; t+1 the month following the meeting; ln indicates a natural logarithm; MT is the long-run annual target path for M-1A; MI is the FOMC's short-run objective for M-1A as judgmentally translated by staff; M_t^p denotes the staff's judgmental projection of the level of M-1A in the month of the FOMC meeting; and λ denotes the desired speed of reentry to the long-run target path implied by equation B.1.

The left-hand side of equation B.1 (multiplied by 100) is the desired percentage gap in the month following the FOMC meeting between the long-run target path for M-1A (MT_{t+1}) and the level of M-1A (M_{t+1}). Similarly, the second term on the right-hand side (multiplied by 100) is the percentage gap projected for the month of the meeting. The desired ratio of the target gap in month, t+1, relative to the current projected gap in the current month, t, is $1 - \lambda$. That is, λ , the desired speed of reentry to the annual target path, is that fraction of the current projected gap that the FOMC desires to close over the coming month. If $\lambda = 0$, no closure of the target gap is planned; this is equivalent to planned base drift, when it is desired that M-1A grow in the next month at an annualized rate equal to the annual target rate of growth. Alternatively, if $\lambda = 1$, the intention is to eliminate fully over the next month the projected gap between M-1A and its long-run target path. Note that the desired speed of reentry, λ, is only an ex ante intention that may be frustrated subsequently by forecast errors.

2. Empirical Estimates

Estimates of the desired speed of reentry, λ, were based on FOMC decisions at nine meetings from February 1980 through November 1980. 2/ From February through May, it is assumed that the long-run target path for M-1A

2/ The FOMC did not meet in June.

corresponded to the midpoint of the announced FOMC target range of 3-1/2 to 6 percent growth for M-1A from 1979 Q4 through 1980 Q4. This long-run path of 4-3/4 percent growth is anchored to a base, centered on November 1979, of $369.7 billion, which was the estimate until June 1980 of the average level of M-1A in the fourth quarter of 1979. From July onward, the long-run path was anchored to a base of $368.1 billion, which, following June benchmarking, was the revised estimate of average M-1A in the fourth quarter of 1979.

The estimates assume also that, from July onward, the long-run target path for M-1A was lowered to 4-1/4 percent growth. This one-half percent decrease in the long-run target reflects the fact that, in July, staff increased by 1/2 percent its estimate of the depressing effect of ATS deposit growth on M-1A expansion. This revised estimate of ATS growth implies that a 1/2 percent downward revision of the long-run target range for growth of M-1A would be consistent with the original FOMC intentions embodied in the target range announced in February. Indeed, from July onward, the FOMC's short-run target paths for M-1A consistently pointed toward year-end levels below the midpoint of the target range selected in February.

Given these assumptions, the ordinary least-squares estimate of the desired speed of reentry to the effective long-run target path of M-1A is $\lambda = 0.292$. 3/ This estimate implies that, in 1980, the FOMC did not

3/ Specifically, an ordinary least-squares regression of the dependent variable ($\ln MT_{t+1} - \ln MI_{t+1}$) on the independent variable ($\ln MT_t - \ln M_t^p$) yields the following results: a coefficient on the independent variable of 0.708, having a standard error of 0.072 and a t-statistic of 9.821; $\bar{R}^2 = 0.9234$; and the standard error of regression = 0.0022.

Alternatively, if it is believed that ordinary least squares place disproportionate emphasis on large target gaps, an arithmetic mean estimate of the desired speed of reentry is 0.392, slightly higher than the ordinary least-squares estimate of 0.292. The arithmetic mean estimate suggests an average "age" of random disturbances in the desired M-1A target gap of about two and one-half months.

wish the average age of random disturbances to M-1A to exceed three and one-half months. 4/

3. Concluding Remark

The average desired speed of reentry, λ, is a simple characterization of the short-run objectives of the FOMC. This representation treats M-1A as the sole intermediate target of policy and specifies that the desired reentry speed is independent of observed and forecast values of GNP, the inflation rate, and other variables of potential concern to the FOMC. Nevertheless, this approximation of FOMC intentions is superior to a number of more complicated specifications 5/ and may serve as a useful benchmark for policy discussion.

4/ In months, the average "age" of random disturbances in the long-run target gap implied by equation B.1 is $1/\lambda$. Due to the nature of exponential decay, complete elimination of the influence of a given disturbance to M-1A implied by equation B.1 can be a lengthy process. For $\lambda = 0.292$, seven months are required to eliminate 90% of a given disturbance. (One month is required for $\lambda = 1$ and twenty months for $\lambda = 0.111$.)

5/ Several tests were conducted to explore the possibility that the planned reentry speed, λ, was systematically related to selected explanatory variables, such as (1) time remaining in the policy horizon (80.01 - 80.12), (2) the absolute value of the money stock target gap projected for the current month, or (3) the signed value of the target gap projected for the current month (to allow for asymmetric responses to positive and negative deviations from the target path). Ordinary least-squares regressions of λ on a constant and these potential explanatory variations, both singly and in various combinations, indicate that λ was not related to these variables at a 90 percent level of confidence.

APPENDIX C: An Examination of the Interest Rate Instability of the Staff Monthly Money Market Model */

The issue of interest rate instability was examined by analyzing the implicit stability of the distributed lag impacts of the federal funds rate on the currency and demand deposit equations of the staff monthly money market model.

Elasticities of the demand for M-1A with respect to current and lagged federal funds rates were approximated by volume-weighted averages of the component elasticities of M-1A with weights of 0.3 and 0.7 applied to the currency and demand deposit components respectively. Combining the influence of all other variables affecting money demand together with random disturbances in an error term, V_t, yielded the following function describing monthly growth in the demand for M-1A: 1/

$$\ln M_t = \text{constant} + \sum_{i=0}^{7} a_i \Delta \ln RFF_{t-i} + V_t \ , \qquad (C.1)$$

where

$a_0 = -.0254467$, $a_4 = -.0172627$,
$a_1 = -.0253940$, $a_5 = -.0125832$,
$a_2 = -.0240131$, $a_6 = -.0068288$,
$a_3 = -.0213024$, $a_7 = -9.8427 \times 10^{-9}$,

and

$$V_t = \rho V_{t-1} + \varepsilon_t \ , \qquad (C.2)$$

with estimated to equal 0.69.

*/ Prepared by W. Trepeta.

1/ The left-hand variable, $\Delta \ln M_t$, times 1200 percent equals the annualized monthly growth rate of demand for M-1A.

In equation C.1, M and RFF denote the levels of M-1A and the federal funds rate respectively; the subscript t indicates month t; Δ indicates a monthly change; and ln the natural logarithm. Equation C.2 indicates that a disturbance to the growth of money demand in month t, V_t, tends to equal 69 percent of the disturbance in the previous month plus a random component, ε_t, with a mean of zero.

The policy authority is assumed to manipulate the funds rate in order to minimize the expected value of the current month's squared deviations of the monthly growth rate of M-1A from a fixed monthly growth rate target given knowledge of ρ, the coefficient of serial correlation between values of V in successive months. 2/ This strategy involves setting

$$\begin{aligned}\Delta \ln RFF_t = \frac{1}{a_0} [\Delta^* \ln M - (1 - \rho) \text{ constant} \\ - \sum_{i=1}^{7} (a_i - \rho a_{i-1}) \Delta \ln RFF_{t-i} + \rho a_7 \Delta \ln RFF_{t-8} \\ - \rho \Delta \ln M_{t-1}],\end{aligned} \qquad (C.3)$$

where $\Delta^* \ln M$ denotes the fixed target for monthly growth of M-1A.

Intuitively, this equation represents a federal funds rate reaction function involving a monthly setting designed to offset fully all predictable deviations of the monthly growth rate of money from target. With the federal funds rate setting thus specified, algebraic analysis parallel to Ciccolo's

2/ Alternatively, the analysis could assume that the policy authority varies the monthly growth rate target in order to return M-1A to a given long-run target path whenever random disturbances have driven M-1A off this path. In this case, the monthly growth rate target, $\Delta^* \ln M$, would contain a random component, and the variance of the federal funds rate would be somewhat different from that discussed above. However, pursuit of a fixed long-run target, by itself, would not induce interest rate instability, if instability does not arise in the case of a fixed monthly growth rate target.

reveals that, after a disturbance to money demand, the federal funds rate converges to a stable value rather than exhibiting ever-larger cycles. 3/ However, for the very tight monetary control procedure assumed, the margin between stability and instability is extremely small, especially in light of the standard errors of the coefficient estimates. This margin is greater, though, for less rigid control procedures involving an expected return of the monthly growth rate of money to target in more than one month.

3/ Ciccolo, "Is Short-Run Monetary Control Feasible?" This algebraic analysis involves examining the Schur determinants of the difference equation

$$a_0 \Delta \ln RFF_t + \sum_{i=1}^{7} (a_i - \rho a_{i-1}) \ln \Delta RFF_{t-i} - \rho a_7 \Delta \ln RFF_t = \text{constant},$$

to see if all exceed zero, a necessary and sufficient condition for stability. Use of the Schur theorem in stability analysis is discussed in A. C. Chiang, Fundamental Methods of Mathematical Economics, 2d ed. (McGraw-Hill, New York, 1974), pp. 599-600.

The New Federal Reserve Operating Procedure:

An External Perspective

February 1981

Paper Written for a Federal Reserve
Staff Review of Monetary Control
Procedures

by

Edwin M. Truman and others

February 1981

The New Federal Reserve Operating Procedure: An External Perspective

CONTENTS | Page

February 1981

The New Federal Reserve Operating Procedure: An External Perspective*/

Section I -- Introduction and Summary

When the Federal Reserve adopted its new operating procedure with its greater emphasis on the supply of bank reserves, its decision was motivated in part by the pronounced weakness of the dollar in September 1979. The adoption of the new procedure followed by 6½ years the structural shift that occurred in exchange rate arrangements among major currencies in March 1973; the change in procedure has many elements of similarity with that earlier shift to managed floating exchange rates, and our analysis concentrates on a comparison of experience since October 1979 with experience between March 1973 and that date.

Section II presents a brief overview of developments since October 1979 and lays out the framework for our analysis. That analytical framework is based upon the fact that, holding other factors constant,1/ the link between the new procedure and the variability of spot and forward exchange rates (which is analyzed in Section III) depends on whether the new procedure has been associated with greater variability in nominal dollar interest rates (a topic that is investigated

---

*/ This paper was prepared by the staffs of the Federal Reserve Bank of New York and the Division of International Finance of the Board of Governors of the Federal Reserve System and was coordinated by Edwin M. Truman. The paper benefited from comments on an earlier draft by the staff of the Federal Reserve Bank of San Francisco.

1/ For the period under consideration this is a particularly strong assumption that is, nevertheless, useful.

in another paper in this study),[1/] on the extent to which interest rates on assets denominated in other currencies move in line with dollar interest rates (as a consequence, for example, of the policies of other countries), and on whether the new procedure influences the variability of expectations of U.S. inflation.

It is desirable to distinguish, to the extent possible, between the effects of the new operating procedure per se and the possible consequences for the effective stance of monetary policy of the adoption of the new procedure, e.g., the possibility of a tighter policy on average. This distinction is especially relevant to the assessment of reactions of foreign countries in Section IV. Changes in the pattern of capital flows may be induced by the new procedure; experience in this area is examined in Section V in the context of the balance of payments identity. Finally, to the extent that exchange rates have become more variable since October 1979, it is useful to consider the consequences of such increased variability, the use of the exchange rate as an information variable under the new procedure, and the possible scope under the new procedure for using the exchange rate as a policy instrument. These issues are discussed in Section VI.

Our principal findings are as follows.

1. The foreign exchange value of the dollar appreciated immediately following the Federal Reserve's adoption of its new operating procedure. It rose sharply in the spring of 1980, fell back in the

---

1/ That paper, "Interest Rate Variability under the New Operating Procedures and the Initial Response in Financial Markets," concludes that there has been an increase in the variability of U.S. interest rates since October 1979.

summer, and rose again more recently. By the end of November 1980, the dollar was 5½ percent above its level at the end of September 1979 (Section II). A portion of this appreciation may be attributable to U.S. monetary policy that may have been tighter on average over the period than it otherwise would have been as an indirect consequence of the new procedure. However, in the absence of an accepted set of counter-factual assumptions about the performance of the U.S. and world economy and about U.S. economic policies during the past year, the size of this portion cannot be quantified.

2. Since October 1979, the variability of international interest rate differentials over daily, weekly, and monthly intervals has increased significantly because of the increase in the variability of dollar interest rates, which, in turn, is attributable at least in part to the new operating procedure (Section II.A).

3. The increase in the variability of interest rate differentials since October 1979 has contributed to a significant increase, compared with earlier periods, in the day-to-day variability of spot dollar exchange rates (Section III.A).

4. The evidence of an increase in the month-to-month variability of spot dollar exchange rates although clear is somewhat less conclusive The month-to-month variability of interest rate differentials, however, has increased significantly, and the responsiveness of exchange rates to changes in such differentials appears not to have changed after October 1979. These results suggest a decline in the variability of determinants of exchange rates other than interest rate differentials. Exchange rate variability

of course is a function not only of developments in the U.S. economy but also of economic developments abroad. This joint determination is illustrated most dramatically in the case of the rise in the variability of the yen-dollar exchange rate since October 6, 1979 (Sections III.A and III.B).

5. One-year forward dollar exchange rates for individual currencies, especially over monthly intervals, have exhibited some cases of reduced variability since October 1979. This phenomenon has not been observed for five-year forward rates. This evidence provides limited support for the hypothesis that the new procedure could lead to a reduction of the variability of forward exchange rates (Section III.A).

6. We found little evidence of a fundamental change in exchange market intervention behavior since October 1979. Our analysis did identify a possible shift back toward the pattern of less active intervention prevailing prior to November 1, 1978 (Section III.C). This finding suggests that patterns of exchange rate movements have not been contaminated by changes in intervention behavior; it also suggests that we cannot read into intervention behavior any evidence of foreign countries' being sufficiently unhappy with the new Federal Reserve operating procedure to alter such behavior.

7. We found little evidence of a significant increase in the month-to-month variability of foreign interest rates related to the increase in the variability of dollar interest rates or to the new operating procedure. Canada is an important exception (Section IV.B).

8. The available anecdotal evidence supports the view that, at least until recently and aside from Canada, the Federal Reserve's new

operating procedure has not resulted in significant deviations from what policies in the major industrial countries otherwise would have been. Recently, German policies have been constrained by high dollar interest rates, which some observers have attributed to the new operating procedure (Section IV.C). The uncertainty surrounding the wide swings in dollar interest rates have caused technical policy problems, especially for some developing countries (Section IV.D). However, some of these apparent problems may reflect unfamiliarity with the implications of the new procedure during its initial use over the past year.

9. Although gross U.S. international capital flows have been quite variable during the past year, we have not been able to identify any significant developments that can be associated with the new operating procedure per se. Such flows were influenced importantly by other developments during the past year, e.g., the credit restraint and managed liabilities programs (Section V).

10. Our review of the available literature revealed little empirical evidence that an increase in exchange rate variability, such as has occurred since October 1979, has adverse economic and financial effects. In particular, we found no direct or indirect evidence of a link between the variability of dollar exchange rates and the level of domestic prices. In other words, the so-called ratchet effect, which hypothesizes that fluctuations in exchange rates raise the average inflation rate, does not appear to be a feature of the U.S. economy (Section IV.A).

11. The adoption of the new operating procedure neither reduced nor enhanced the role of the exchange rate as one of several financial

variables useful as information variables in carrying out monetary policy. However, it may well be neither feasible nor desirable to adopt the spot exchange rate as a policy instrument under the new operating procedure. While attempts to stabilize spot exchange rates through sterilized intervention may be successful, the variability of forward exchange rates could well be increased -- with uncertain economic consequences (Section VI.B).

Section II -- Background and Framework[1/]

An extended slide of the dollar was arrested toward the end of 1978 following the November 1 package, and the dollar moved higher over the first half of 1979. Weakness reemerged in early summer and again in September 1979. In both episodes, the decline in the value of the dollar generated heavy net exchange market purchases of dollars by both U.S. and foreign authorities, averaging almost $1 billion equivalent per week. In early October 1979, rumors of a new policy package, followed by the announcements from the Federal Reserve on October 6, provided substantial support to what had been, in late September, a very weak dollar. The dollar rebounded sharply during October, and the rebound was accompanied by substantial net official sales of dollars at about the same rate as the previous purchases, that is, about $1 billion per week.

The strength in the dollar was not long lived. Following the taking of the U.S. hostages and the subsequent freezing of Iranian official assets, as well as the round of substantial increases in the price of oil in late 1979, the weighted-average exchange value of the dollar declined in November and December and ended the year below its September trough.

An upward movement of the dollar in early 1980 was fueled by increases in U.S. interest rates that apparently outweighed the effects of a deterioration in the outlook for U.S. inflation. A stronger dollar was also encouraged through the first part of 1980 by increasingly optimistic assessments of the likely U.S. current-account position compared with the expected positions of other major industrial countries, especially

---

1/ The principal contributors to this section were Peter Isard and Karen H. Johnson.

Japan and Germany. This upward momentum accelerated dramatically in March, in the wake of the introduction of the credit restraint program and the further sharp increases in U.S. interest rates relative to those abroad. From late January through early April, the dollar's weighted-average exchange value rose by more than 10 percent.

When U.S. interest rates began their steep decline in April, falling even more rapidly and substantially than they had earlier risen at a time when foreign interest rates were declining only moderately, the spot exchange value of the dollar plunged -- falling by about 9 percent from early April to the end of May. While official dollar sales had been very heavy during the runup of the dollar, the net purchases were relatively light as the dollar declined in April and May.

The dollar's foreign exchange value continued to decline gradually from the end of May through mid-July and, subsequently, fluctuated in a narrow range through mid-October. Meanwhile, interest rates abroad declined somewhat in response to evidence of slower real economic growth, dollar interest rates began to rise again, and the United States moved into current-account surplus. Dollar interest rates rose significantly after mid-October, and the dollar's weighted-average foreign exchange value also increased significantly to a level at the end of November 1980 about 7 percent above its July 1980 low and 5½ percent above its level at the end of September 1979.[1/] Net intervention sales of dollars, especially by U.S. authorities, also increased dramatically.

1/ The dollar rose somewhat further through mid-December as dollar interest rates continued to rise relative to rates on foreign-currency-denominated assets. Note that the analyses and material cited in this paper use the end of November 1980 as a common cutoff date.

Chart 1 provides a perspective on the foreign exchange value of the dollar not only during the past two years but also since the beginning of January 1973. The relatively sharp fluctuations on a weekly average basis during the past 18 months are quite evident in the chart, but they are not unprecedented since the widespread adoption of floating exchange rates in March 1973. Chart 2 presents the same data in the form of three-month moving averages. Casual inspection of these two charts suggests that while the dollar's average value has exhibited quite marked short-term fluctuations since October 1979, the fluctuations over somewhat longer periods have been less pronounced. Finally, by way of introduction, Chart 3 presents weekly average observations on spot, one-year forward, and five-year forward bilateral DM-dollar exchange rates during the past three years. The chart suggests somewhat less variability in the one-year forward rate than in the spot rate during 1980, although the five-year forward rate appears to have been no less variable. We will return to the data presented in Charts 1-3 in Section III.

Changes in the degree of exchange rate variability since October 1979, of course, may reflect more than the shift in the Federal Reserve's operating procedure. Interpretation of the charts and the statistical data, therefore, will be facilitated by a brief examination of how exchange rates may be influenced by the Federal Reserve's new operating procedure.

Holding other factors constant, the link bewteen the new procedure and the variability of exchange rates depends on several considerations: (1) whether the new operating procedure produces greater variability in

Chart 1

Weighted Average Foreign Exchange Value of the U.S. Dollar Against Ten Major Foreign Currencies: Weekly Average

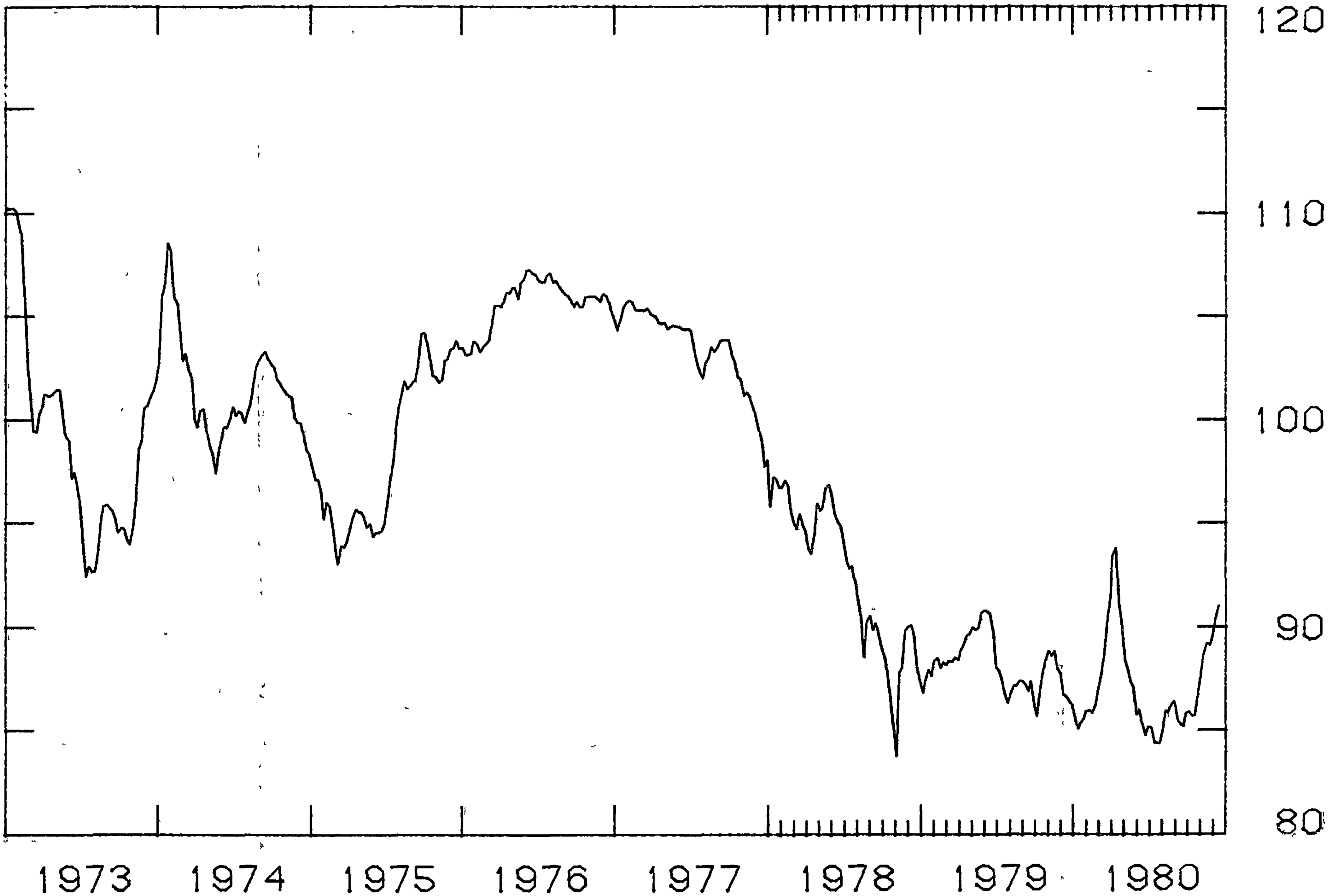


Chart 2

Weighted Average Foreign Exchange Value of the U.S. Dollar Against Ten Major Foreign Currencies: Three-Month Moving Average

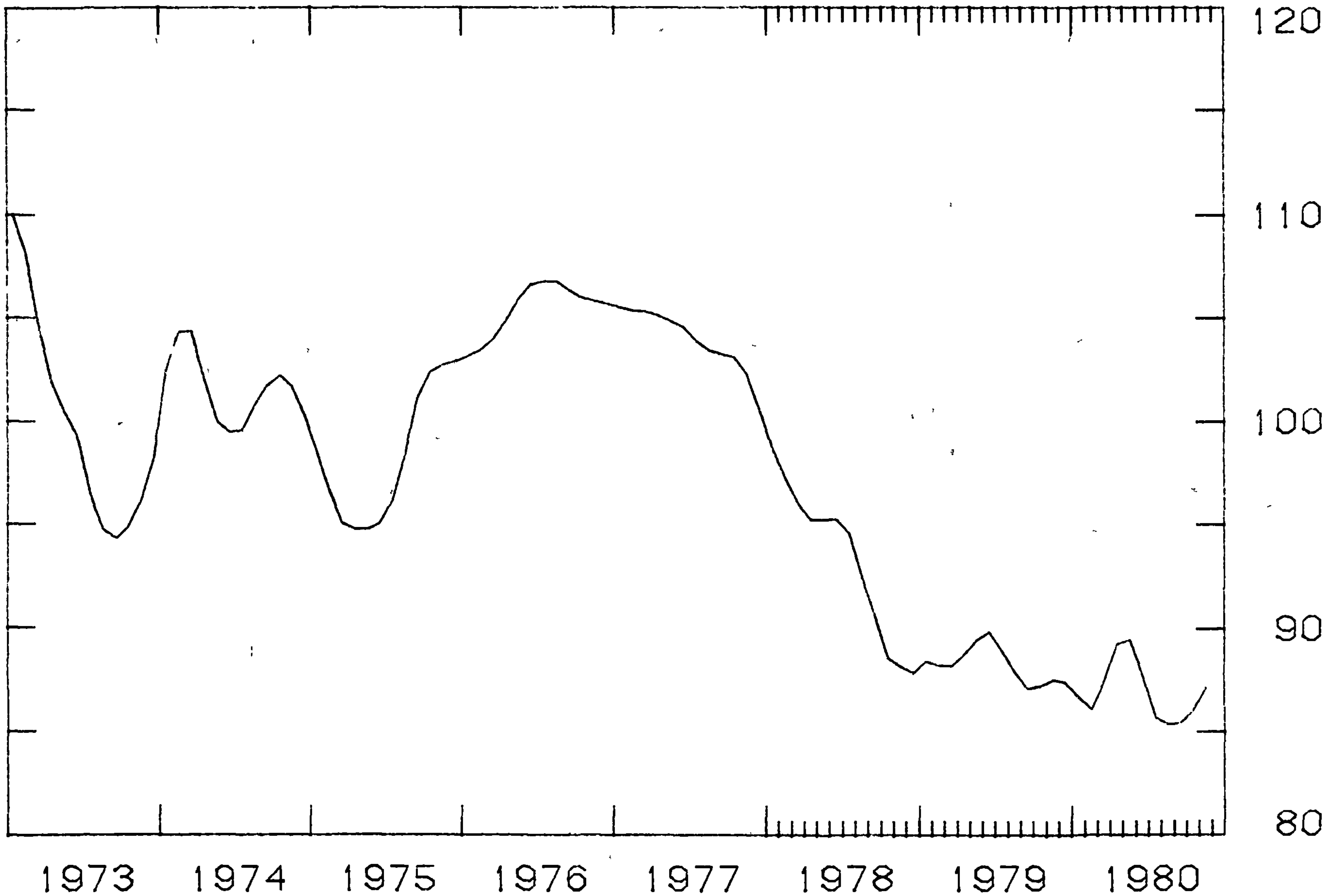
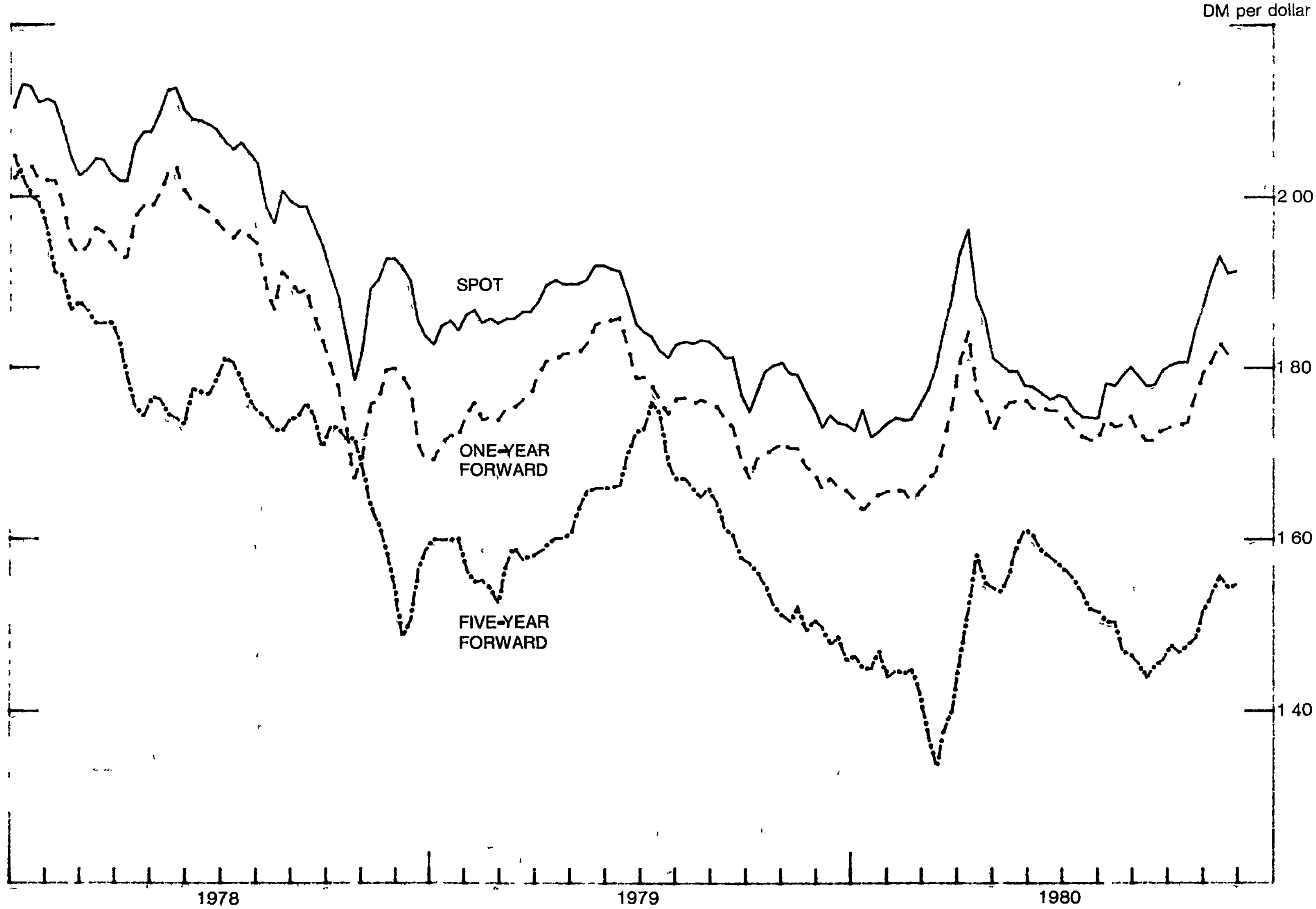


Chart 3

DM—Dollar Exchange Rates
(Weekly Average)



nominal dollar interest rates (which was expected to occur in the short run especially for short-term rates but need not continue in the long run especially for longer-term rates); (2) the extent to which interest rates on assets denominated in foreign currencies move in line with dollar interest rates; and (3) whether the conduct of monetary policy influences the variability of U.S. inflation expectations. To the extent that the new operating procedure produces greater variability in dollar interest rates, especially longer-term rates, that is not offset by similar movements in foreign interest rates (as a result, for example, of a policy response by foreign authorities), it will tend to increase the variability of spot dollar exchange rates. But if the new operating procedure has caused, or eventually causes, market participants to expect less relative variability of U.S. price inflation than under the earlier procedure, the new procedure will have contributed to greater stability of long-term forward dollar exchange rates, other things remaining equal, and, thereby, might actually reduce the variability in spot dollar exchange rates as well.

The analytical structure outlined in the paragraph above rests on two premises. The first is the presumption that the influence of monetary policy on exchange rates is transmitted primarily through interest rates and inflation rates, both actual and expected. The second is the approximation that the difference between the spot and forward exchange rates -- the forward discount -- can be equated with the nominal interest rate differential.1/ Neither premise denies the fact that exchange rates (spot

1/ This is the covered interest rate parity condition, which holds exactly, in the absence of current or prospective capital controls, for interest rates on securities that are comparable (in terms of maturity, tax treatment, liquidity, and default risk), reflecting the fact that competitive exchange markets bid away any profit that might be earned by covering spot foreign exchange transactions with equal and opposite forward transactions. These conditions are closely met in the Eurocurrency markets.

and forward) are also influenced (directly or indirectly) by factors that have little to do with the Federal Reserve's operations: for example, by shifts in countries' relative current-account positions as the result of real phenomena such as oil discoveries, changes in productivity, or other changes in competitiveness, by the imposition and removal of credit controls, or by exogenous variations in expectations of high inflation rates.

Under the first premise, monetary policy influences exchange rate movements over the long run primarily by influencing expected inflation rates. Accordingly, since the level of the forward exchange rate reflects, inter alia, expectations about the future level of the spot rate, revisions in expectations about inflation rate differentials are the primary monetary factor contributing to changes in the forward rate. When U.S. inflation expectations change without an accompanying change in nominal dollar interest rates, spot and forward exchange rates will move by the same amount, other things equal. In such cases a change in the expected inflation differential results in an equal change in the real interest rate differential, where the real interest rate is the difference between the nominal interest rate and the expected inflation rate. At the other extreme, when a revision in U.S. inflation expectations is accompanied by an equal change in nominal dollar interest rates, such that no change occurs in the differential between U.S. and foreign real interest rates, the forward rate will still respond to the change in inflation expectations but the spot rate will remain unchanged.[1/]

1/ Strictly speaking, interest rates and inflation expectations have time horizons or term structures, and the changes in spot and forward exchange rates that accompany a given change in short-term interest rates or inflation expectations depend on how these term structures have shifted. Even a very large increase in the variability of the overnight federal funds rate, in particular, would have a small impact on exchange rate variability if it were not accompanied by substantial increases in the variability of interest rates on monthly or annual maturities, other things equal. Thus, an assessment of the maturity-dimension of interest rate variability is important in considering the degree to which the new operating procedure has influenced the variability of exchange rates.

Thus, stability of the spot exchange rate requires stability of differentials between real interest rates, other things remaining equal. Consequently, a monetary policy operating procedure that tends to reduce the variability in U.S. inflation expectations (and thus the variability of the forward rate, assuming expectations of inflation abroad are not negatively correlated with expectations of U.S. inflation) should contribute to stability of the spot rate -- because the expected inflation differential is a component of the real interest rate differential. In addition, policy adjustments involving sharp movements in real interest rates may be less likely when inflation expectations are more settled. Whether or not the new Federal Reserve operating procedure has to date reduced the relative variability of expectations of U.S. inflation is addressed in other contributions to this study. Without persuasive evidence that expectations have become significantly less variable as a consequence of the new operating procedure, any change in the variability of interest rate differentials relative to that of exchange rates during the past year reflects changes in the variability of the non-monetary factors that contribute to exchange rate determination.[1/] Empirical findings concerning the relative variability of interest rates and exchange rates since October 1979 are discussed in Sections III.A and III.B.

The volatility of interest rates and exchange rates has sometimes been associated with capital flows. (See Section V.) The potential for actual capital flows should be considered in the context of the balance of

---

1/ It should be recognized, however, that real interest rates can also vary because of fluctuations in money and credit demand that are not accommodated by the monetary authority.

payments accounting identity, which constrains net private capital flows to equal, with the sign reversed and including the statistical discrepancy, the sum of net current-account flows and net official intervention flows. With no exchange-market intervention and a given current-account position, a strengthening of net private demand for assets denominated in one currency matched by a weakening of demand for assets denominated in another currency cannot generate any net change in private capital flows, but instead results in a change in the exchange rate. In particular, exchange rates will adjust to offset the influence of interest rate movements on net private demands for currencies.

On the other hand, official intervention can resist changes in exchange rates by purchasing currencies for which net private demand has weakened and selling currencies for which net private demand has strengthened, thus permitting net private capital flows to occur. In this context it is important to distinguish between intervention that is "sterilized" through open market operations or other procedures that prevent the intervention from leading to changes in bank reserves in either country whose currency is being bought or sold and intervention that is "unsterilized." Unsterilized intervention is generally more effective than sterilized intervention in resisting changes in exchange rates following a shift in net private demands for assets denominated in different currencies, since the changes in bank reserves and, hence, in money supplies will operate through interest rate adjustments to moderate or offset the effects of the initial shift in currency demands. Sterilized intervention -- particularly when it is visible to market participants -- may provide a sense of policy commitment that also influences interest rates or expectations about inflation and may thereby succeed in moderating exchange rate variability without an associated adjustment of monetary growth rates.[1/]

Whether or not the moderation of exchange rate variability should be a policy objective depends both on whether exchange rate variability has undesirable consequences for the U.S. inflation rate and real activity (as ultimate target variables) and on the extent to which exchange rate variability makes it more difficult for foreign countries to stabilize their economies. In this context, the evidence suggests that greater short-run exchange rate variability does not generally have significant undesirable consequences for U.S. or foreign inflation rates or real activity levels. It has been hypothesized, in particular, that increases in import prices ratchet up domestic price levels while declines in import prices do not have a symmetric downward effect, which would imply a net inflationary impact of greater exchange rate variability. Little empirical evidence of such ratchet effects has been found, especially for the U.S. economy. (See Section VI.A.)

Nevertheless, to the extent that tighter U.S. monetary policy as a consequence of the new operating procedure has led to stronger dollar exchange rates or to policy adjustments abroad, the shift in operating procedures may indeed have had important impacts on foreign prices and

---

1/ Sterilized intervention may also influence exchange rates through a second channel. In an uncertain world, assets denominated in different currencies that offer the same expected yields will not necessarily be regarded as perfect substitutes by risk-averse investors. Accordingly, forward exchange rates may differ from expected future spot rates by the "risk premium" that private investors require to match the currency composition of their aggregate portfolio with the relative stocks of public debts that authorities have thrust upon them. Whether changing the currency composition of private portfolios through sterilized intervention has a quantitatively significant impact on risk premiums and thereby on exchange rates, however, remains an open empirical question.

activity levels, with additional feedback effects on U.S. price and activity variables. The principal types of impacts on U.S. and foreign prices and activity can be described by considering two basic cases.

When policies in foreign countries do not respond and the dollar appreciates (in both nominal and real terms), foreign currencies will face higher local-currency prices for their imports and consequent upward pressure on their domestic price indexes. The United States will face lower dollar prices for imports and less domestic inflationary pressure. Furthermore, the appreciation of real dollar exchange rates, although not permanent, will have lagged effects on trade flows for several years. Foreign countries will be led to substitute away from U.S. exports toward competing products, while U.S. consumers will also shift away from U.S. products and increase their imports. Thus, in this case, the tighter U.S. policy will have a depressing influence on U.S. activity that is reinforced by international substitution effects away from U.S. output, whereas foreign activity will be promoted by the substitution effects but held down by lower U.S. import volumes associated with lower U.S. activity.

If, as an alternative case, foreign countries respond to tighter U.S. monetary policies by letting their interest rates rise in order to stabilize exchange rates, the tighter U.S. and foreign-country policies will put downward pressures on both U.S. and foreign real activity variables (with feedback or international multiplier effects operating through lower import volumes). While in this case both U.S. and foreign import prices will remain relatively stable in the absence of any exchange rate change, the downward pressures on activity are transmitted to downward pressures on prices in all economies.

Because of its impacts on prices and activity, the tighter U.S. monetary policy if sustained -- whether it leads to tighter policies abroad or to stronger dollar exchange rates -- may also induce significant changes in trade and current-account balances. Trade volumes will change to reflect both the income effects of changes in activity levels in the United States and abroad and the substitution effects of changes in real exchange rates. Trade balances, measured in value terms, will be further influenced by changes in the prices of tradable goods and may adjust over time to exhibit the familiar J-curve pattern.

In addition to its effects on the variability of exchange rates and the actual tightness of U.S. monetary policy, the new operating procedure may have been associated with greater uncertainty among foreign policy authorities with regard to their perceptions about U.S. monetary policy. Such uncertainty was particularly notable when U.S. interest rates rose in March and, again, in November of 1980 to levels that foreign countries may not have desired to follow. (See Section IV.) At such times foreign authorities might not have great concerns if they were confident of their expectations that the extreme movements in U.S. interest rates and exchange rates would be short lived -- that is, confident of their underlying perceptions about the general stance of U.S. monetary policy and the general performance of the U.S. economy. It can be argued that the increased uncertainty about U.S. policy over the past year or so may reflect an unfamiliarity with the implications of the new operating procedure and may not be inherent in the use of the procedure in the future.

Section III -- Exchange Market Developments

In this section we present the results of our investigations of exchange market developments since October 6, 1979. First, we analyze the statistical behavior of international interest rate differentials as a necessary introduction to our analysis of the behavior of dollar exchange rates (spot and forward); next, we look for possible changes in the responses of exchange rates to changes in determinants of exchange rates, particularly interest rates; finally, we look for possible systematic changes in the intervention behavior of monetary authorities.

A. Variability of Exchange Rates[1]

As is reported in another paper in this study, since October 6, 1979, the variability of the federal funds rate and of interest rates on Treasury securities across the maturity spectrum has increased.[2] Other things being equal, such an increase in variability might be expected to have been associated with an increase in the variability of international interest rate differentials and, in turn, with an increase in the variability of exchange rates -- at least spot exchange rates. In this subsection, we report on our empirical examination of these two related questions using a common methodological framework.

We first had to define what we meant by the term "variability." It may refer to the changes (absolute or algebraic) from one observation to the next or to the dispersion of such changes between successive observations. It may also refer to the extent of error in prediction. The

1/ The principal contributor to this Section was Ralph W. Smith.
2/ See Dana Johnson and others, "Interest Rate Variability under the New Operating Procedures and the Initial Response in Financial Markets."

time interval over which variability is measured -- daily, weekly, monthly, etc. -- must also be specified. In the case of exchange rates, one might look at forward exchange rates for various time periods as well as at spot exchange rates. In the case of interest rates, one might look at rates on assets of various maturities.

In the case of the differential between the interest rate on dollar-denominated assets and the interest rate on foreign-currency-denominated assets, we examined three-month interest rates (the Euro-dollar rate minus a representative three-month rate in the relevant domestic market). We calculated algebraic changes in these series over intervals of 1 day, 1 week (5 days) and 1 month (21 days)[1/] and calculated the standard deviations of the changes as the basic measure of variability. Each series was divided into three periods: (1) the period from March 1973 (or somewhat later, as determined by data availability) when floating exchange rates began to October 5, 1979; (2) the period of the new operating procedure from October 8, 1979, to the end of November 1980; and (3) the period from November 1, 1978, to October 5, 1979. The third period was selected to begin with the date of the "dollar defense" package, which some observers viewed as signifying a change in U.S. exchange rate policy toward providing more intervention and policy support for the dollar to assure less variability

1/ The 5-day interval corresponded to 7 calendar days (1 week), and the 21-day interval corresponded to the average number of market days in a calendar month. We constructed the weekly and monthly series as changes from a single day to a single day to avoid the downward bias to the measure of variability that would have been imparted by averaging daily observations. Using this procedure we generated 5 "weekly" series and 21 "monthly" series from the 5th and 21st differences in the basic series.

in the dollar's exchange value. Comparisons were made between variability in the post-October 6 period and variability in each of the other two periods.

Table 1 presents the results of the analysis of the variability of three-month interest rate differentials. The results show a statistically significant increase in the variability of all the calculated differentials after October 6, 1979, regardless of the country, the time interval (daily, weekly, monthly), or the time period used in the comparison.[1/] As is discussed in more detail in Section IV.B below, in a few countries the variability of three-month interest rates appears to have increased somewhat after October 1979, but the increases are much smaller than those for the three-month Eurodollar interest rate. Thus, the results presented in Table 1 reflect primarily the large increase in the variability of three-month dollar interest rates that is reported in another paper in this study. Given the general results showing an increase in the variability of interest rates on Treasury securities across the maturity spectrum, it is not surprising that we found similar results for Eurocurrency interest rate differentials for longer maturities -- one-year rates and five-year rates.[2/]

1/ The formal statistical test is of the hypothesis that the variances of the series in two periods are equal -- that their ratio equals 1.00. If the test showed that the probability of obtaining the calculated value of the ratio (when the "true" value was 1.00) was less than 5 percent, then the equal-variance hypothesis was rejected. The fact that for some of the tests reported below the estimated variances increased or decreased is not useless information, even in the case when the change was not statistically significant. We can at least say that it is more probable that the variance increased (decreased) than that it decreased (increased).

2/ For the series examined, the only exception to the pattern was the series for the one-year Eurodollar-Eurosterling interest rate differential since October 1979 compared with the entire 6½-year preceding period. Here either there was little change or the increase was not significant in a large number of cases.

Table 1

Variability of Three-Month Interest Rate Differentials:
Eurodollar Minus Foreign Rate

(Standard deviations of changes)

	3/73 - 9/79	10/79 - 11/80	11/78 - 9/79
DAILY			
Germany	.252	.407	.271
Switzerland	.236	.394	.250
Japan	.220	.412	.231
Canada	.284	.410	.256
United Kingdom	.376	.483	.314
WEEKLY			
Germany	.446	.876	.360
Switzerland	.373	.781	.388
Japan	.408	.938	.338
Canada	.473	.754	.337
United Kingdom	.678	.966	.517
MONTHLY			
Germany	.965	2.601	.661
Switzerland	.751	2.371	.761
Japan	.904	2.766	.672
Canada	.761	1.902	.643
United Kingdom	1.212	2.608	1.092

Note. Standard deviations of weekly and monthly changes are means of standard deviations of 5 series of 5-day changes and 21 series of 21-day changes respectively. All series showed a statistically significant increase in variability in the post-October 6 period compared with the two earlier periods.

In the case of exchange rate variability we used as our basic measure of variability the standard deviation of algebraic changes in percent.[1/] Changes, rather than levels, were chosen in order to eliminate the influence of strong time trends in some of the series. Percentage changes were used because they seemed more appropriate, that is, consistent with the formulation of most models of exchange rate determination. The rest of the procedures was similar to those summarized above for the interest rate differentials.

Table 2 presents this measure of the daily variability in spot and one-year forward exchange rates for the weighted average dollar and for five bilateral dollar exchange rates and two five-year forward bilateral exchange rates.

The spot 10-currency weighted average dollar, shown in the top line of the top panel of Table 2, increased in variability after October 6, 1979, compared with either the preceding 11-month period or the entire $6\frac{1}{2}$-year period.[2/] The results for the bilateral exchange rates are similar except that the increase in the variability of the rate with the Swiss franc is not significant when the period since October 6, 1979, is compared with the longer preceding period.

The results for the one-year forward weighted-average dollar, shown in the top line of the middle panel, show a significant increase

---

1/ We also computed, but do not report here, mean absolute changes, which yielded the same general pattern of results.

2/ As shown by the asterisks in the first and third columns the hypothesis that the variances are equal can be rejected at the 5 percent level of significance.

Table 2
Daily Exchange Rate Variability

(Standard deviations of percentage changes)

	3/1/73 - 10/5/79	10/9/79 - 11/28/80	11/1/78 - 10/5/79
SPOT			
Weighted-average dollar	.373*	.428	.337*
German mark	.573*	.707	.427*
Swiss franc	.738	.770	.596*
Japanese yen	.488*	1.337	.590*
Canadian dollar	.195*	.244	.211*
Sterling	.462*	.770	.512*
1-YEAR FORWARD			
Weighted-average dollar	.408*	.489	.627*
German Mark	.627*	.578	.541
Swiss franc	.799	.788	.719
Japanese yen	.528*	.783	.681*
Canadian dollar	.255*	.318	.284*
Sterling	.609	.548	.610*
5-YEAR FORWARD			
German mark	.759*	1.070	.769*
Swiss franc	.910*	1.136	.897*

*Significantly different from 10/9/79 - 11/28/80 period at .05 level of significance.

in variability after October 6, 1979, compared with the entire 6½-year period, but a significant decrease in variability compared with the 11-month period from November 1978 to October 1979. However, the results for the weighted-average dollar are somewhat contaminated by the averaging process, and it is appropriate to look again at the bilateral exchange rates. Here a somewhat more mixed pattern emerges than was the case with the spot exchange rates. When the comparison of the recent experience is made with the shorter preceding period (columns 2 and 3), two of the bilateral one-year forward rates show significant increases in variability (the yen and Canadian dollar), two show increases in variability that are not significant (the mark and Swiss franc), and one shows a significant decrease in variability (sterling). When the comparison is made with the longer preceding period (columns 1 and 2), the same two exchange rates show significant increases in variability, but the other three rates show reductions in variability -- a significant reduction in the case of the mark. As shown in the last panel, the five-year forward rates for the mark and the Swiss franc show significant increases in variability since October 1979 compared with either earlier period.

One other aspect of the results reported in Table 2 is interesting. In the post-October 6 period, three of the five one-year forward bilateral exchange rates (mark, yen, and sterling) exhibit less variability than do the spot rates for the same currencies. (Compare the middle and top panels in the second column.) In contrast, in the two earlier periods (first and third columns), the variability of the one-year forward exchange rates is greater than the variability of the spot rates for all five currencies in the table This finding is consistent with the hypothesis, developed in Section II, that the increased variability of real dollar interest rate differentials should affect the variability of spot more than forward exchange rates. However, the two five-year forward rates shown in the last panel of Table 2 do not exhibit less variability compared with the spot rates since October 1979. This result suggests the hypothesis that the variability of the five-year interest rate differentials in the recent period reflected, to a greater degree than has been the case for some of the one-year interest rate differentials, variations in nominal rather than real interest rates.

Tables 3 and 4 present measures of exchange rate variability over weekly and monthly intervals. As for the calculations using the interest rate differentials presented in Table 1, five non-overlapping series of weekly intervals and twenty-one non-overlapping series of monthly intervals were constructed. The results in Tables 3 and 4 are the means of standard deviations from the respective series.[1/]

As the length of the interval over which the series of exchange rate changes increased from daily to weekly to monthly, the proportion of the series showing an increase in variability declined and the proportion showing reduced variability increased. The monthly results in Table 4 in comparison with the daily results in Table 2 illustrate this pattern. All of the spot exchange rate comparisons shown in the top panel, except that for sterling compared with the post-November 1978 period, show a rise in the mean standard deviation. However, for the weighted-average dollar only about half of the 21 series show a statistically significant

1/ Significance tests were performed for each non-overlapping series, and the results are summarized in Appendix Tables 1 and 2.

Table 3
Weekly Exchange Rate Variability

(Means of standard deviations of five series of five-day percentage changes1/)

	3/73 - 9/79	10/79 - 11/80	11/78 - 9/79
SPOT			
Weighted-average dollar	.870	1.021	.789
German mark	1.290	1.459	.977
Swiss franc	1.630	1.705	1.471
Japanese yen	1.128	2.260	1.316
Canadian dollar	.469	.565	.511
Sterling	1.069	1.393	1.263
1-YEAR FORWARD			
Weighted-average dollar	.888	1.011	1.319
German mark	1.381	1.241	1.200
Swiss franc	1.736	1.555	1.707
Japanese yen	1.210	1.712	1.491
Canadian dollar	.546	.638	.616
Sterling	1.345	1.120	1.476
5-YEAR FORWARD			
German mark	1.633	1.983	1.891
Swiss franc	1.893	2.165	2.259

1/ Significance tests of the individual weekly series are summarized in Appendix Table 1.

Table 4

Monthly Exchange Rate Variability

(Means of standard deviations of 21 series of 21-day percentage changes[1/])

	3/73 - 9/79	10/79 - 11/80	11/78 - 9/79
SPOT			
Weighted-average dollar	2.041	2.777	1.748
German mark	3.046	3.537	2.197
Swiss franc	3.430	3.946	2.886
Japanese yen	2.609	4.529	2.150
Canadian dollar	1.158	1.325	1.309
Sterling	2.450	2.617	2.830
1-YEAR FORWARD			
Weighted-average dollar	1.915	2.334	2.369
German mark	3.120	2.819	2.797
Swiss franc	3.727	3.181	3.622
Japanese yen	2.852	3.834	2.676
Canadian dollar	1.289	1.289	1.509
Sterling	2.975	1.958	3.113
5-YEAR FORWARD			
German mark	3.472	4.527	4.436
Swiss franc	4.032	4.224	4.396

1/ Significance tests of the individual monthly series are summarized in Appendix Table 2.

increase in variability after October 6 compared with either preceding period. For the bilateral spot exchange rates, the yen (in the comparison with preceding 11-month period) shows a significant increase in variability after October 6 in more than half of the 21 series, and the mark (in the same comparison) shows a significant increase in about half of the 21 series. Both currencies show less evidence of a significant increase in variability after October 6 when the comparison is made with the longer preceding period.

For the 1-year forward exchange rates (middle panel), the comparison with the November 1978 to September 1979 period shows a slight reduction in the mean standard deviation in the monthly variability of the weighted-average dollar (none of the 21 series showed a significant change) as well as reductions in the monthly variability for the Swiss franc, the Canadian dollar, and sterling. (Only for the last currency did any of the 21 series show a significant decline in variability.) A small increase was recorded in the mean standard deviation in the monthly variability of the 1-year forward mark (none of the 21 series showed a significant change) and a larger increase for the yen (only 1 of the 21 series showed a significant increase). The results of the comparison with the longer preceding period are similar -- a bit more evidence of an increase in the monthly variability of the weighted-average dollar, the yen, and the Canadian dollar and a bit more evidence of a reduction in the monthly variability of sterling, the Swiss franc, and the mark. For the 5-year forward exchange rates (bottom panel), only the results for the mark yielded substantial evidence of any change in monthly variability, for the mark, there was some increase in monthly variability in the post-October 6 period compared with the longer preceding period.

Again comparing the variability of the spot and forward rates, one can see in Table 4 that in the post-October 6 period the mean standard deviations of the monthly series for each of the five one-year-forward bilateral exchange rates was lower than for the corresponding spot exchange rate in contrast with the pattern in the two preceding periods. However, the mean standard deviation of the monthly series for the two five-year-forward rates again shows an increase relative to the spot rates in all the periods.

Cross-country analysis of the results presented in Tables 2-4 on daily, weekly, and monthly exchange rate variability (and, indeed, the results for interest rate differentials in Table 1 as well) does not reveal many striking patterns. Such analysis does focus attention on the fact, as was noted in Section II, that the variability of bilateral exchange rates depends not only on developments in the U.S. economy but also on developments in individual economies abroad and common developments, e.g., international oil price increases, that may have different effects on different economies. One example from Tables 2-4 may help to illustrate this point. The variability of the yen-dollar exchange rate (spot and one-year forward) in the period after October 6 increased more in comparison with the two preceding periods for all three time intervals (daily, weekly, and monthly) than did the variability for any of the other four bilateral rates shown in Tables 2-4.[1/] Indeed, in some cases

1/ The measure used was the ratio of the standard deviation (or the mean standard deviation for the weekly and monthly series) in the post-October 6 period to the standard deviation in each of the two preceding periods.

for the other currencies, the variability declined. This result probably reflects not so much effects of the Federal Reserve's operating procedure but rather the strong cyclical movement in the yen over this period -- induced by Japan's inflation and current-account performance -- as well as the somewhat more relaxed attitude of the Japanese authorities toward fluctuations in the yen's exchange rate noted in Section IV.C below.

The results of all of these calculations point to a definite increase of variability of spot exchange rates measured over daily, weekly, and monthly intervals. The evidence for forward rates is not conclusive, though there are certainly cases of decreased variability especially for the longer intervals. This latter evidence offers limited support to the hypothesis that the new operating procedure could lead to a reduction of the variability of forward exchange rates.

Another approach to measuring variability would be to measure the variability of prediction errors from a "structural" economic model of exchange rate determination. An examination of residual variances in the model reported on in the following section indicated no significant change in prediction error of monthly average exchange rates after October 6.

B. Responses of Exchange Rates[1/]

Having established that the variability of spot exchange rates increased after October 1979, we next examined the causal factors under-

---

1/ The principal contributors to this section were Peter Hooper and John Morton.

lying the increased variability with a focus on the response of exchange rates to the increased variability of interest rates -- more precisely to the increased variability of interest rate differentials. We sought, first, to determine if the responsiveness of exchange rates to changes in U.S. interest rates increased or decreased following the October 1979 measures. No statistically significant evidence of a shift in this causal relationship attributable to the new operating procedures was found. We then estimated the change in the variability of interest rates since October 1979, assuming that no shift in the causal relationship between interest rates and exchange rates had taken place. This analysis suggested that, by one measure at least, the month-to-month variability of exchange rates attributable to interest rate changes increased three-fold after October 1979, compared with the average experience during the previous six years. However, the total variability of exchange rates increased much less between these two periods, as fluctuations in other factors that affect exchange rate declined.

1. Tests for Structural Shift

To test for a structual shift in exchange rate relationships, we estimated a model of exchange rate determination that express dollar's weighted-average foreign exchange value as a function of the differential between U.S. and foreign short-term interest rates, relative U.S. and foreign prices, and a variable indicating the degree of imbalance in the U.S. trade position.[1] The last two factors are included to explain, respectively, changes in the underlying nominal and real exchange rate

---

1/ To be consistent with the other series used in the model, monthly averages of the exchange rate and interest rate series were used rather than the pure series constructed for the analysis in Section III.A.

levels that are not directly associated with changes in interest rate differentials.[1/] This equation, estimated over the period August 1973 to October 1980, is shown in column 1 of Table 5.

In order to test for structural shifts, the period December 1973 to October 1980 was partitioned into subperiods, divided before and after October 1979. Chow tests were employed to test for structural stability of the whole equation. To test for structural stability of the interest rate coefficient in particular, dummy variables and t-tests were used. (These results are shown in line 4 of Table 5; the estimated coefficients indicate the additional responsiveness of exchange rates to interest rates during the period when the possible shift occurred.)

The results suggest that the structure of exchange rate determination was not the same after October 1979 (based on a Chow test for the results shown in columns 5 and 6 of Table 5). Also, the responsiveness of the exchange rate to interest rate changes appears to have increased, as indicated by the significance of the last coefficient in column 2. While these results appear to support the hypothesis that the change in operating procedure in October 1979 was associated with a shift in the responsiveness of exchange rates to interest rates, the evidence is not conclusive.

Any of a number of events during the floating exchange rate period could have precipitated a shift in the exchange rate determination

---

1/ The variables are described in more detail in Table 5. It should be noted that interest rates are assumed to be exogenous. In some circumstances, this assumption may be questionable. For a discussion of the theoretical justification for modeling the process of exchange rate determination in this way, see Hooper and Morton (1980).

Table 5

Monthly Exchange Rate Equations for the Weighted-Average Dollar1/2/

(t-ratios in parentheses)

	Full sample period 8/73 - 10/80				Sample split at October 1979		Sample split at November 1978		
	8/73 - 10/80				8/73-9/79	10/79-10/80	8/73-10/78	11/78-10/80	
Determinant	1	2	3	4	5	6	7	8	9
(1) Relative prices3/	.49 (.86)	.62 (1.32)	.77 (1.37)	.78 (1.57)	.86 (2.44)	2.78 (.36)	1.28 (3.44)	.02 (.01)	.47 (.16)
(2) Cumulative trade balance	.18 (5.69)	.17 (6.46)	.17 (5.44)	.16 (5.98)	.22 (6.37)	-.06 (-.39)	.31 (5.82)	-.00 (-.14)	.00 (.13)
(3) Nominal short-term interest differential4/	.55 (2.88)	.09 (.34)	-.16 (-.51)	-.33 (-.95)	.99 (.28)	.73 (3.09)	.69 (.18)	.70 (3.71)	.40 (1.00)
(4) Nominal short-term interest differential5/ Oct. 79 - Oct. 80		.67 (2.16)		.36 (1.02)					.34 (.90)
(5) Nominal short-term interest differential6/ Nov. 78 - Oct. 80			.86 (2.73)	.72 (2.08)					
$\bar{R}^2$	.9545	.9563	.9578	.9578	.9433	.5461	.9067	.5817	.5772
Sum of Squared residuals	.0211	.0201	.0194	.0192	.0167	.0018	.0137	.0031	.0030

1/ Index of weighted-average exchange value of U.S. dollar against currencies of other G-10 countries plus Switzerland. Weights are 1972-76 total trade of each of the 10 countries.

2/ Equations corrected for autocorrelation with Cochrane-Orcutt technique.

3/ Weighted-average (10-country) foreign CPI, divided by U.S. CPI with both series expressed as 6-month weighted moving averages.

4/ U.S. 3-month CD rate minus 10-country weighted average of foreign 3-month rates.

5/ Interest differential times 0-1 dummy which takes value 1.0 beginning in October 1979.

6/ Interest differential times 0-1 dummy which takes value 1.0 beginning in November 1978.

process. To test for uniqueness of the apparent October 1979 shift, the same tests were run splitting the sample at November 1978, coinciding with the adoption of the dollar defense program, the shift in U.S. exchange market intervention behavior, and U.S. monetary policy actions aimed at strengthening the dollar. The results indicate an even stronger rejection of the hypothesis that the exchange rate determination process did not change (columns 7 and 8 of Table 5) and a more significant shift in the exchange rate-interest rate relationship (column 3) after November 1978 than after October 1979. Column 4 in Table 5 reports the results of an equation in which both shifts were tested simultaneously with dummy variables, and column 9 reports those for an equation estimated from November 1978 to October 1980, in which the October 1979 shift alone was tested. These results indicate that, after allowing for the shift in November 1978, the additional shift in October 1979 was not significant.

The tests reported in Table 5 employed monthly data and the ten-currency weighted-average dollar index. Similar tests were run using monthly equations for bilateral (dollar) exchange rates against the German mark, Japanese yen, Canadian dollar, and British pound, as well as quarterly equations for the dollar's weighted-average value. In addition, these tests and those reported above were repeated with the real interest differential substituted for the nominal interest differential and, in the case of the quarterly equations, using a more complex model of exchange rate determination.[1/] The results of these tests, while

---

1/ The quarterly model is described in Hooper and Morton (1980).

differing in detail, in general supported the conclusion that the October 1979 change in operating procedure by itself was not associated with a significant shift in the structure of exchange rate determination, after allowing for the possibility of a shift following the November 1978 measures.

Finally, we also compared the 1980 interest rate and exchange rate cycles with those of 1974-75, a time period roughly similar in many respects including the apparent importance of interest rate developments for exchange rates.

Table 6 shows the net movement of exchange rates and three-month interest rate differentials from peak to trough and from trough to peak. Troughs and peaks were dated by months in the case of the weighted-average exchange rate and by weeks in the case of the DM-dollar exchange rate. The weighted-average and bilateral comparisons show similar results: the swings in interest rate differentials in 1980 were larger than in 1974-75 (although at a higher level of rates and at a more rapid pace), whereas the swings in spot exchange rates were smaller at least through November. While the ratios reported in the last column in Table 6 suggest that the movement of exchange rates relative to interest rates was lower in 1980 than in the 1974-75, it should be recognized that the ratios do not take into account factors other than interest rates that affected exchange rates during these periods. In any event, the data at least provide additional, though weak, evidence that the responsiveness of exchange rates to interest rates following the October 1979 measures did not increase significantly relative to comparable historical experience.

Table 6

Interest Rate and Exchange Rate Cycles1/
1974-75 and 1980

Weighted-average rates	Percentage change in: Exchange rate	Percentage change in: Interest rate differential2/	Ratio3/
Period:			
1974-75			
Peak (Sept.) to trough (Mar.)	- 8.7	- 2.7	3.2
Trough (Mar.) to peak (Sept.)	+ 9.7	+ 2.9	3.3
1980			
Trough (Jan.) to peak (Apr.)	+ 6.5	+ 3.1	2.1
Peak (Apr.) to trough (July)	- 7.0	- 8.6	0.8
Trough (July) to November	+ 5.5	+ 8.3	0.7
DM-dollar rates			
Period:			
1974-75			
Peak (Sept. 11) trough (Mar. 5)	-14.4	- 4.3	3.3
Trough (Mar. 5) to peak (Sept. 24)	+16.1	+ 4.1	3.9
1980			
Trough (Jan. 9) to peak (Apr. 9)	+13.8	+ 5.1	2.7
Peak (Apr. 9) to trough (July 23)	-10.6	-10.4	1.0
Trough (July 23) to Nov. 26	+10.1	+ 9.2	1.1

1/ Peaks and troughs are dated by exchange rates. Peaks and troughs in interest rate differentials, reported here, generally preceded exchange rate peaks and troughs by one or two periods.

2/ U.S. three-month CD rate minus foreign three-month interest rate in percentage points.

3/ Exchange rate change divided by the change in the interest rate differential.

2. Variability of Exchange Rates due to Interest Rates

Based on the conclusion that the responsiveness of exchange rates to interest rates was not significantly altered by the change in operating procedure, Table 7 provides an indication of the impact on exchange rate variability of the increased variability of interest rates since October 1979. Line 2 of the table indicates that since October 1979 the average absolute monthly variation in the differential between nominal U.S. and foreign short-term interest rates has more than tripled to 1.56 percentage points, compared with previous experience beginning in either March 1973 or November 1978.[1/] A stable relationship between exchange rates and interest rate changes would suggest a similar tripling of the monthly variation of exchange rates associated with interest rate changes. Based on the significant interest rate coefficient reported in column 8 of Table 5 (.70), the average absolute percentage change in the monthly average weighted-average value of the dollar due to changes in the interest rate differential rose from .32 percent during November 1978 to September 1979 to 1.09 percent during October 1979 to October 1980.[2/]

1/ Note from lines 1 and 2 that on this measure the increased variability of the interest rate differential is more than accounted for by the increased variability of the U.S. interest rate.

2/ The interest rate coefficient for the period August 1973 to November 1978 was about the same magnitude (compare columns 7 and 8 of Table 5), though not statistically significant. Based on this coefficient, the variability of exchange rates attributable to interest rate changes also about tripled after October 1979 when compared with the average experience during the previous six years, as shown by the figure in parentheses in Table 7.

Table 7

Variability of Interest Rates and Exchange Rates

(Average absolute month-to-month changes)

	March 73-Sept. 79	Oct. 79-Oct. 80	Nov. 78-Sept. 79
U.S. 3-month CD rate (percentage points)	.42	1.56	.38
U.S.-foreign 3-month interest differential (percentage points)	.45	1.56	.46
Exchange rate changes due to changes in interest differential (percentage changes)1/	(.31)	1.09	.32
Exchange rate change (percent)	1.37	1.68	1.10

1/Based on estimated interest rate coefficient of .7 for the period November 1978-October 1980 (reported in column 8 of Table 5).

A comparison of the bottom two lines of Table 7 shows that while interest rate variability alone would have caused monthly exchange rate variability to increase after October 1979, the total variability of exchange rates due to all causes increased by much less on this measure.[1] This suggests that a decline in the variability of exchange rate determinants other than interest rates -- such as actual and expected relative price movements or trade balance changes -- partially offset the impact of increased interest rate variation.

C. Exchange Market Intervention[2]

As Section III.A of this paper reported, fluctuations in short-term interest rate differentials have increased since October 1979 and day-to-day exchange rate changes also have increased. Somewhat greater variability in spot exchange rates over weekly and monthly intervals has also been experienced. Has this increased variability led to more forceful intervention action by monetary authorities to resist spot exchange rate changes, or has it perhaps occurred because the authorities have been less willing to commit intervention resources now than they might have been in past years? This question is relevant to two aspects of

1/ The post-October 6 increase in the measure of month-to-month variability of the spot weighted-average dollar shown in the last line of Table 7 (about 50 percent compared with the period from November 1978 to September 1979 and about 25 percent compared with the period from March 1973 to September 1979) is roughly equivalent to the increase shown by the measure in the top line in the top panel of Table 4 (about 60 percent compared with the shorter period and 35 percent compared with the longer period).

2/ The principal contributor to this section was John F. Wilson.

the overall analysis. First, if intervention behavior has changed, the observed pattern of exchange rate movements, in turn, may have been influenced.[1] Second, if intervention behavior has changed, such a change might be interpreted as evidence that the Federal Reserve's new operating procedure has caused difficulties for other countries -- a topic that is discussed in more detail in Section IV.

Table 8 provides summary information on annual changes in the weighted-average value of the dollar and on U.S. and foreign net intervention from March 1973 through November 1980.[2] The annual amount of net intervention rose sharply in 1977 in comparison with earlier years and has remained high since then. However, one cannot judge on the basis of the amount of intervention alone whether monetary authorities have changed their intervention behavior.

The question of a possible change in intervention behavior can be explored by statistical methods that search for changes in amounts of intervention per unit of exchange rate change. However, October 1979 was not the only recent landmark which might be associated with a basic change in intervention behavior. An important earlier, possible benchmark was the November 1978 announcement of a massive cooperative program of support for the dollar. In the interval from March 1973 to November 1980, therefore, structural changes in intervention behavior may have occurred at least twice.

1/ This statement assumes that exchange market intervention affects exchange rates at least in the short run.

2/ Net intervention is presented because the table presents the net change in the dollar's exchange value for the relevant period.

Table 8

Exchange Value of the Dollar and Intervention by Major Countries: 1973-80

Period	Change in weighted-average value of the dollar[1] (percent)	Net intervention (billions of dollars) U.S.	Foreign[2]	Total
1973 (Mar.-Dec.)	1.2	-.1	-14.8	-14.9
1974	-4.8	.1	-11.4	-11.3
1975	6.2	-.2	5.0	4.7
1976	1.0	-.4	-3.7	4.1
1977	-7.8	-.4	36.1	35.6
1978	-10.3	5.7	27.8	33.4
1979	-.8	-.8	-17.2	-18.0
1980 (Jan.-Nov.)	5.1	-7.1	-14.7	-21.8

1/ End of year (or month) from the end of the preceding year (or month).

2/ G-10 countries plus Switzerland, Denmark, Ireland, and Norway.

Our investigation of these possible shifts involved linear regression analysis. The absolute value of U.S., foreign, and total (U.S. plus foreign) monthly net intervention, deflated by the U.S. CPI, was related to the absolute percentage change in the dollar's value in that month. The possibility of asymmetries in intervention behavior when the dollar is appreciating and when it is depreciating was examined by partitioning the independent variable accordingly. The tests for structural shifts were performed by including, for the two subperiods of interest, dummy variables in the equation along with the basic explanatory variables.[1/] It should be noted that there are a number of potential statistical problems with this procedure, including the possibility that the exchange rate change is endogenous. From this perspective as well as for several other reasons the results should be regarded as illustrative.

Table 9 presents the results for the basic equation. The results for U.S. intervention, shown in column 1, indicate that there was a significant shift in U.S. intervention behavior in the direction

---

1/ The basic equation was the following:

$$I = a_0R_1 + a_1D_1R_1 + a_2D_2R_1 + b_0R_2 + b_1D_1R_2 + b_2D_2R_2$$

where

I = absolute value of monthly net intervention, deflated by the U.S. CPI;
R_1 (R_2) = absolute value of monthly percentage change (end of month) in the spot dollar's weighted-average value (10-currency index) when the dollar is appreciating (depreciating); other values 0;
D_1 = dummy variable, 0 prior to November 1978 and 1 thereafter; and
D_2 = dummy variable, 0 prior to October 1979 and 1 thereafter.

A better "deflator" of intervention activity might be some measure of exchange market volume, but this is not available for the long sample or on a monthly basis. Since the CPI rose far less over the sample than benchmark indications of exchange market volume, the price index can be regarded as a conservative deflator.

Table 9

Estimates of Central Banks' Intervention Response, Percentage Change in Weighted-Average Dollar[1/]

(March 1973 - November 1980)

	United States[2/] 1	Foreign[3/] 2	U.S. + Foreign 3
Dollar appreciating			
Whole sample	44.2 (1.5)	490.5 (4.5)	497.4 (4.0)
Post 10/78 shift	164.5 (3.5)	-195.5 (-1.2)	-30.3 (-.2)
Post 9/79 shift	37.3 (.7)	271.9 (1.5)	337.6 (1.6)
Dollar depreciating			
Whole sample	62.8 (2.4)	579.5 (6.2)	605.6 (5.7)
Post 10/78 shift	377.4 (5.7)	128.6 (.5)	513.4 (1.9)
Post 9/79 shift	-340.9 (-4.4)	-467.1 (-1.7)	-883.5 (-2.8)
$\bar{R}^2$	.59	.49	.53

Note. See footnote 1, p.43, for details of equation specification.

1/ t - ratios in parentheses.

2/ Includes Desk operations for both System and Treasury accounts.

3/ Japan, Canada, United Kingdom, Germany, France, Switzerland, and Italy.

of offering greater resistance to exchange rate changes (appreciation as well as depreciation) following the November 1, 1978, announcement. In the period since October 6, 1979, there apparently has been a significant reduction in U.S. resistance to the dollar's depreciation which has approximately offset the increase after November 1, 1978. Thus, on balance, the only significant net change in U.S. intervention behavior since November 1, 1978, has involved heavier purchases of foreign currencies when the dollar was appreciating. This apparent shift in behavior, in turn, may merely reflect the fact that a significant amount of U.S. swap debt was outstanding on November 1, 1978, which the U.S. monetary authorities sought to cover as promptly as possible.

The results for the combined group of foreign countries shown in column 2 suggest no significant shifts in intervention behavior either after November 1, 1978, or after October 6, 1979.

Combining the U.S. and foreign net intervention yields the results shown in the last column of the table. Here there is weak evidence of a somewhat greater response to the dollar's depreciation after November 1, 1978, and considerably stronger evidence of reduced response (from this higher rate) after October 6, 1979.

Some exploration was also conducted of the influence of time trends (as proxies for omitted influences) and of measures of intramonth exchange rate variability as additional explanatory factors in intervention behavior. One or the other factor, taken alone, often improves the equation fit, but when entered together the trend effect tends to dominate, leaving the variability coefficient insignificant. This is suggestive of some "underdeflation" of the data, but may also result from other influences. In any case, entering such terms did not affect the basic pattern of results.

Overall, the empirical findings lead toward the conclusion that it was U.S., rather than foreign, intervention behavior that has changed the most following the 1978 dollar-defense measures and the 1979 change in operating procedure. The U.S. results suggest somewhat greater tolerance of depreciation of the dollar since October 1979, and this apparent tolerance, when combined with weaker evidence for the foreign countries as a group, carries through in the overall equation shown in the last column in the table. However, this effect in part is an offset to the shift in the opposite direction following the November 1 package and may only reflect the fact that the dollar has not experienced a period of sustained decline since October 1979.

It should be emphasized that these results are quite sensitive to the specificiation of the equations. We have not presented here a full model of intervention behavior, but we feel comfortable in concluding that we have not, to date, observed a dramatic change in intervention behavior by monetary authorities as a group since October 1979. Rather we appear to have found a possible shift back toward the basic pattern that prevailed prior to November 1, 1978, and weak evidence of somewhat greater tolerance of depreciation of the dollar.

Subject to these qualifications, the results, in turn, suggest two conclusions. First, it is unlikely that the observed patterns of exchange rate movements have been contaminated by changes in intervention behavior. Any bias is likely to be small and would be in the direction of observing increased exchange rate variation in the period since October 1979 compared with the previous year but not the previous 6½ years. Second, the results do not provide any evidence in support of the hypothesis that the new operating procedure has caused difficulties for other countries. However, we examine other evidence relating to this hypothesis in the next section.

Section IV -- The Foreign Experience under the New Federal Reserve Operating Procedure

A. Introduction

As discussed in Section II above, the new Federal Reserve operating procedure, through its effect on the level or variability of U.S. interest rates or of the exchange value of the dollar, may influence foreign output, prices, and current-account balances, and thereby also have feedback effects on the United States. However, the impact of greater short-run (i.e., day-to-day, week-to-week, or even month-to-month) exchange rate variability *per se* is likely to be small. The impacts are likely to be confined to increased uncertainty as it affects private and public decision-making. Empirical studies, while not denying the theoretical possibility of such effects, have generally not been able to isolate them. (See Section VI.A.)

Thus, the major impact on foreign countries of the new Federal Reserve operating procedure has been through its possible effect on the average level of dollar interest rates and exchange rates. However, in the absence of discretionary policy reactions abroad, the net effect of tighter U.S. monetary policy on foreign economic variables is ambiguous. Lower demand in the United States will tend to reduce foreign output and prices and reduce foreign current-account balances. On the other hand, the tendency for the foreign currencies to depreciate against the dollar will tend to raise foreign price levels somewhat and, with a longer lag to divert demand from U.S. to foreign goods, thereby raising foreign output and increasing current-account balances.1/

1/ These qualitative statements are consistent with the results of simulations with the Multi-Country Model (MCM) developed in the Division of International Finance at the Board of Governors of the Federal Reserve System.

However, if foreign officials act, through exchange market intervention and other monetary policy actions, to peg their exchange rates, the impact of tighter U.S. policy becomes unambiguous with respect to output and prices (but not current-account balances). Indeed, the negative impact on foreign output and prices of weaker U.S. demand would be reinforced by the restrictive policy abroad and, by assumption, no competitive gain from a currency depreciation would offset this impact. It is this aspect of an "interest rate war" -- raising the specter of a synchronized and mutually reinforcing global recession -- that was discussed in the press and in international fora early in 1980.

Changes in dollar interest rates and exchange rates have induced policy reactions abroad, especially in Canada, in continental Europe, and in some developing countries with currencies pegged to the dollar. The level and, especially, the timing of movements of foreign interest rates were altered. However, until recently, the available evidence supports the view that the new Federal Reserve operating procedure did not result in significant deviations from what policies in the major industrial countries would otherwise have been. Fundamentally, domestic economic conditions abroad (notably the high level of inflation and increased oil bills) were sufficiently similar to those in the United States that essentially similar policy stances would have been called for and would have been adopted in any case.

In contrast to the situation prevailing for most of the period since October 1979, a case can be made that domestic conditions abroad, especially in the key German economy, in recent months have called for policy actions that are different from those appropriate to developments in the United States. Such a conflict between domestic and external needs is by no means the result of the new operating procedure per se but may be exacerbated by it. Given that macroeconomic developments in the United States and abroad are not synchronized (and policies are not harmonized), it is inevitable that conflicts between domestic and external needs may arise from time to time. The new Federal Reserve operating procedure may accentuate such conflicts to the extent that the new technique is designed to ensure a prompter and more automatic response of interest rates to changes in money demand.

Even if monetary policies in the foreign industrial countries have not deviated significantly over the past year from what they otherwise would have been, the large swings in U.S. interest rates have caused problems for foreign officials. Several governors of foreign central banks have said that fluctuations in U.S. interest rates, which were produced by excessive concentration on week-to-week fluctuations in the money supply, were too large and imparted large fluctuations to exchange rates with serious consequences for other countries.

To some extent foreign concerns may simply be a matter of a general dislike of variability. Two specific aspects can also be identified. One is the increased uncertainty about what the level of U.S. interest rates will be, which makes it difficult for monetary authorities to be responsive to domestic conditions and at the same time to achieve short-run exchange rate objectives and also makes it difficult to predict or control budgeted borrowing costs. Another aspect is the increased interest rate variability, which has caused problems especially in some developing countries where domestic interest rate structures are relatively rigid.

B. U.S. and Foreign Interest Rates[1]

In order to examine the relationship, if any, between the variability of interest rates on dollar-denominated and foreign-currency denominated assets, several exercises were performed.

Standard deviations of changes in interest rates over daily, weekly, and monthly intervals were calculated for three-month interest rates in five foreign countries and for the three-month Eurodollar rate.[2] The results are shown in Table 10.[3] All the series show an increase in variability of interest rates in the post-October 6 period compared with the preceding 11-month period for all three intervals; in a number of cases, however, the increase was not significant. When compared with the entire 6½-year preceding period, German and British interest rates show a reduction in variability; the reduction was sometimes

1/ The principal contributor to this section was Ralph W. Smith.

2/ See Section III.A for a fuller description of the methodology employed. A full daily series for the U.S. three-month CD rate was not available. The results for the three-month Eurodollar rate appear to show an increase in variability of about the same order of magnitude as that shown for three-month U.S. Treasury bills in Table 5 of "Interest Rate Variability under the New Operating Procedures and the Initial Response in Financial Markets."

3/ Generally similar results, not reported here, were found for three-month domestic interest rates in France, the Netherlands, and Belgium, for selected one-year Eurocurrency rates and for five-year Eurocurrency rates.

Table 10

Variability of Foreign and Eurodollar Three-Month Interest Rates

(Standard deviations of changes)

	3/73 - 9/79	10/79 - 11/80	11/78 - 9/79
DAILY			
Germany	.156*	.130	.119
Switzerland	.178	.190	.110*
Japan	.099*	.153	.076*
Canada	.213*	.304	.141*
United Kingdom	.321	.313	.206*
Eurodollar	.194*	.389	.223*
WEEKLY1/			
Germany	.297	.242	.207
Switzerland	.348	.424	.261
Japan	.224	.433	.176
Canada	.357	.593	.158
United Kingdom	.603	.508	.419
Eurodollar	.355	.886	.301
MONTHLY1/			
Germany	.647	.499	.391
Switzerland	.674	.862	.519
Japan	.499	1.291	.408
Canada	.618	1.392	.250
United Kingdom	1.073	1.005	.849
Eurodollar	.781	2.647	.612

* Significantly different from 10/79 - 11/80 period at .05 level of significance. Significance tests of the individual weekly and monthly series are summarized in Appendix Table 3.

1/ Standard deviations of weekly and monthly changes are means of standard deviations of 5 series of 5-day and 21 series of 21-day changes respectively.

significant in the German case.[1/] The variability of foreign interest rates, whether over daily, weekly, or monthly intervals, was substantially less, however, than the variability of Eurodollar rates.

Four conclusions can be drawn from the results in Table 10. First, the increased variability of dollar interest rates during the past year, which presumably at least in part is attributable to the new Federal Reserve operating procedure, has led to an increase in the variability of Canadian interest rates, as the Canadian authorities responded to the increased variability of dollar interest rates. Second, the observed increase in the variability in Japanese rates probably reflects a secular trend toward greater flexibility in Japanese rates that has little to do with the new procedure or the variability of dollar interest rates. Third, it is of particular interest that the evidence concerning the variability German 3-month interest rates is inconclusive. The variability of German 3-month interest rates increased somewhat compared with the preceding 11-month period and declined somewhat compared with the entire 6½-year preceding period.[2/] Fourth, the results for the United Kingdom and Switzerland are mixed but, on balance, lend little support to the hypothesis that the rise in the variability of dollar interest rates induced a rise in the variability of foreign rates.

1/ Statistically significant changes are marked by an asterisk in Table 10 for daily rates; for the individual weekly and monthly series, tests of signficance are presented in Appendix Table 3.

2/ One-year and five-year Euro-DM rates showed a pattern of increases compared with both preceding periods, which may have reflected the greater variability of underlying economic and financial conditions. It is also of some interest that the series on three-month interest rates in France, the Netherlands, and Belgium in all but one period showed the German pattern -- more variability compared with the shorter preceding period and less compared with the longer period.

The relative stability of foreign interest rates might be thought to result from actions by foreign authorities that would stabilize those interest rates but at the same time increase the variability of the respective money supplies. An examination of monthly rates of growth in monetary aggregates for the major foreign countries shows that for most countries the standard deviation of the monthly growth rate of M-1 relative to the mean growth rate was somewhat higher since October 1979 than during the whole period since January 1973.1/ However, these results most likely reflect the variability of the underlying economic situation rather than the indirect influence of the Federal Reserve's new procedure.

We further examined the relationship between U.S. and foreign interest rates by regression techniques. Specifically, we regressed changes in (monthly average) foreign 3-month interest rates on contemporaneous changes in the (monthly average) U.S. CD rate for the same three time periods.2/ Table 11 shows the coefficient on the U.S. interest rate (b) and the coefficient of determination ($\bar{R}^2$) for each equation. The overall explanatory power of the equations is very low except in the case of the Canadian interest rate, and the coefficient on the U.S. interest rate is significant in only two cases aside from the three Canadian equations. The evidence presented in Table 11 is consistent with that in Table 10 in that variations in U.S. interest rates apparently have strongly influenced rates abroad, since October 6, 1979, only in the case of Canada.

1/ Using just the standard deviation to measure variability yields fewer cases of increased variability, and no general pattern of increased variability was found for the broader aggregates.

2/ An exploration of lagged responses did not alter the results.

Table 11

Relationship Between U.S. and Foreign Interest Rates[1/]

	b	$\bar{R}^2$
WEIGHTED-AVERAGE FOREIGN		
March 1973-September 1979	.339*	.214
October 1979-November 1980	.092	.138
November 1978-September 1979	.220	.094
GERMANY		
March 1973-September 1979	.181	.038
October 1979-November 1980	.045	.040
November 1978-September 1979	.225	.071
SWITZERLAND		
January 1975-September 1979	.288	.044
October 1979-November 1980	.159	.214
November 1978-September 1979	.144	.048
JAPAN		
March 1973-September 1979	.053	.005
October 1979-November 1980	.042	.008
November 1978-September 1979	.275	.156
CANADA		
March 1973-September 1979	.550*	.431
October 1979-November 1980	.403*	.559
October 1978-September 1979	.349*	.448
UNITED KINGDOM		
March 1973-September 1979	.381*	.055
October 1979-November 1980	.097	.096
November 1978-September 1979	.521	.134

* Significant at .05 level.

1/ Equation: change in foreign interest rate = b (change in U.S. CD rate)

Note. Monthly averages of three-month interest rates were used.

C. Reactions in Major Industrial Countries[1/]

The announcement of the new Federal Reserve operating procedure in October 1979 was welcomed by officials in other countries. Given the relatively high U.S. inflation rate observed in the first three quarters of 1979 and the weakness of the dollar in September, a policy initiative that promised a more stable U.S. policy (and, therefore, helped to stabilize the dollar) and that was perceived to promise a somewhat tighter U.S. policy was deemed appropriate. At a press conference on October 25, 1979, shortly after the new U.S. operating procedure was announced, President Leutwiler of the Swiss National Bank stated that Swiss authorities welcomed the new U.S. package and that the Bank would not do anything to endanger its success. More recently, the governor of a foreign central bank remarked that, despite some problems for his country caused by dollar interest rate volatility, U.S. authorities are doing what others had urged them to do with respect to monetary policy.

Similarly, the increase in dollar interest rates and the rise in the exchange value of the dollar that followed the announcement were not viewed abroad as a problem. Inflation rates abroad also had been rising and real growth was unexpectedly strong, so that some upward presure on interest rates worldwide was consistent with most countries' domestic economic objectives. To be sure, some concern was expressed that interest rates had risen too far. In late 1979, representatives of some

1/ The principal authors of this and the following section were Karen H. Johnson and Larry J. Promisel with the assistance of their colleagues at the Board of Governors and the Federal Reserve Bank of New York.

C. Reactions in Major Industrial Countries[1/]

The announcement of the new Federal Reserve operating procedure in October 1979 was welcomed by officials in other countries. Given the relatively high U.S. inflation rate observed in the first three quarters of 1979 and the weakness of the dollar in September, a policy initiative that promised a more stable U.S. policy (and, therefore, helped to stabilize the dollar) and that was perceived to promise a somewhat tighter U.S. policy was deemed appropriate. At a press conference on October 25, 1979, shortly after the new U.S. operating procedure was announced, President Leutwiler of the Swiss National Bank stated that Swiss authorities welcomed the new U.S. package and that the Bank would not do anything to endanger its success. More recently, the governor of a foreign central bank remarked that, despite some problems for his country caused by dollar interest rate volatility, U.S. authorities are doing what others had urged them to do with respect to monetary policy.

Similarly, the increase in dollar interest rates and the rise in the exchange value of the dollar that followed the announcement were not viewed abroad as a problem. Inflation rates abroad also had been rising and real growth was unexpectedly strong, so that some upward presure on interest rates worldwide was consistent with most countries' domestic economic objectives. To be sure, some concern was expressed that interest rates had risen too far. In late 1979, representatives of some

1/ The principal authors of this and the following section were Karen H. Johnson and Larry J. Promisel with the assistance of their colleagues at the Board of Governors and the Federal Reserve Bank of New York.

of the smaller European countries expressed the view that the worldwide interest rate structure was becoming too high. However, the focus of their attention was not the United States, but Germany, where short-term interest rates had risen from around 4 percent in early 1979 to 9½ percent in November-December. See Table 12.[1/]

The period February-May 1980, when interest rates on dollar assets first rose and then declined very sharply, posed more significant problems for other countries, especially those of continental Europe.[2/]

The upward pressure on dollar exchange rates that resulted from the rise in dollar interest rates in February-March was resisted partly by a rise in foreign interest rates and partly by heavy intervention in the foreign exchange markets. The weighted average foreign interest rate rose about 150 basis points from January to March-April while dollar rates rose almost 450 basis points from January to March. Total net foreign intervention sales of dollars were substantial in March.

When dollar interest rates subsequently fell 750 basis points by May, foreign interest rates on average declined only slightly (on the order of 50 basis points). Foreign monetary authorities sold dollars, net, in April, but in May there were net intervention purchases.

1/ All interest rates cited in this section are monthly averages of daily quotations on three-month rates.

2/ The behavior of U.S. interest rates during this period, especially after March, reflected to an important extent the influence of the March credit restraint program and not the new operating procedure. We ignore this aspect in what follows.

Table 12
Three-Month Interest Rates

(Interbank loan or nearest equivalent, average of daily rates)

Period	Belgium	Canada	France	Germany	Italy	Japan	Nether-lands	Sweden	Switzer-land	United Kingdom	Weighted average foreign	U.S. CD's	Euro-dollars
	1	2	3	4	5	6	7	8	9	10	11	12	13
1979-Jan.	8.93	10.87	6.55	3.85	11.12	4.52	8.69	5.84	0.05	12.61	5.98	10.51	11.16
Feb.	8.22	10.94	6.83	4.13	11.38	4.50	7.42	5.84	0.13	13.28	6.03	10.19	10.79
March	7.63	11.08	7.05	4.42	11.45	4.55	7.35	5.84	0.93	11.98	6.08	10.13	10.64
April	7.63	11.18	6.96	5.50	11.52	5.13	7.23	5.84	0.93	11.64	6.86	10.06	10.60
May	8.16	11.26	7.63	5.89	11.37	5.25	7.82	5.83	1.54	11.76	7.29	10.16	10.75
June	9.09	11.17	8.63	6.40	11.27	5.46	8.55	5.83	1.51	13.02	7.76	9.95	10.52
July	11.18	11.29	9.90	6.77	11.46	6.26	9.53	6.14	1.19	13.87	8.37	10.11	10.87
Aug.	11.42	11.78	10.85	7.03	11.50	7.00	9.51	6.60	1.66	14.06	8.86	10.71	11.53
Sept.	11.88	11.89	11.67	7.82	11.51	7.00	9.82	6.60	1.94	14.11	9.26	11.89	12.64
Oct.	12.99	13.34	12.14	8.84	12.71	7.01	10.09	7.06	2.57	14.12	9.94	13.66	14.59
Nov.	14.17	14.19	12.72	9.57	13.13	8.13	11.86	9.03	3.97	16.09	11.12	13.90	15.00
Dec.	14.49	14.02	12.55	9.54	16.01	8.42	14.56	9.74	5.67	16.74	11.70	13.43	14.51
1980-Jan.	14.38	13.93	12.31	8.79	17.00	8.44	11.85	10.79	5.45	17.30	11.44	13.39	14.33
Feb.	14.45	13.96	12.63	8.94	17.88	9.10	11.99	10.79	5.19	17.72	11.77	14.30	15.33
March	16.23	14.72	13.94	9.51	18.12	12.37	11.48	10.79	6.57	18.07	12.86	17.57	18.72
April	17.10	16.31	12.84	10.12	16.92	13.51	10.76	10.78	6.87	17.70	13.05	16.14	17.81
May	16.31	13.23	12.62	10.18	17.20	13.63	11.18	12.89	5.85	16.97	12.72	9.79	11.20
June	14.69	11.73	12.37	10.00	17.25	13.51	10.72	12.89	5.64	16.68	12.40	8.49	9.41
July	13.30	10.91	11.87	9.56	17.49	12.89	10.06	12.89	5.29	15.82	11.81	8.65	9.33
Aug.	12.52	10.47	11.20	8.93	17.30	12.04	9.97	12.89	5.52	16.45	11.42	9.91	10.82
Sept.	12.35	10.73	11.81	8.90	17.50	11.46	10.31	12.84	5.57	15.89	11.43	11.29	12.07
Oct.	12.24	11.71	11.69	8.99	18.16	10.98	9.63	12.84	5.40	15.87	11.41	12.92	13.55
Nov.	12.40	12.96	11.26	9.37	17.51	9.74	9.59	12.90	5.53	15.84	11.35	15.68	16.46

In June and July, dollar interest rates declined an additional 200 basis points, and foreign interest rates on average declined 100 basis points. Although dollar interest rates began to rise again in August, foreign interest rates on average declined somewhat further. From August through November foreign interest rates remained essentially unchanged on average -- although DM rates edged up after late October, and yen and sterling rates eased -- while dollar interest rates again rose sharply. In the four months ending in November, the dollar appreciated by almost as much as it did earlier in the year, but net foreign intervention sales of dollars were smaller.

Given Germany's dominant role in Europe, the German policy reaction is a central element in the general reaction in continental European countries to U.S. economic developments in general and the new Federal Reserve operating procedure in particular. As noted above, interest rates in Germany had risen significantly during 1979, and in the first quarter of 1980 the Bundesbank saw no reason to relax its relatively restrictive stance. Economic activity remained (surprisingly) strong, with no evident signs of the generally forecast slowdown. Inflation rates were high and the rate of increase of producer prices, a leading indicator of consumer prices, was not letting up. Central bank money growth was near the upper limit of the target range announced in December 1979. The German current account was recognized as on its way to a record deficit. Thus, when dollar interest rates rose, German interest rates seemed to rise in response, but the rise in German interest rates seemed to be based on domestic considerations, as was noted by the Bundesbank at the time. This latter view is reinforced by the fact that German interest rates did not decline significantly from April to June despite the plunge in dollar rates.

In late 1980, in the absence of rising dollar interest rates and the consequent exchange rate implications, German authorities appeared to have wanted to permit interest rates to decline further.[1/] This would have been clearly in line with domestic economic conditions; economic activity had been unexpectedly weak -- industrial output fell substantially during the second and third quarters -- inflation rates declined, and central bank money growth was below the lower end of the 5-8 percent target range for 1980.

The pattern of German interest rates seems to have influenced other continental European countries more than did U.S. rates. That is a natural result of the dominant position of Germany within Europe. To the extent that the European Monetary System commits its members to greater exchange rate stability, the EMS constrains independent monetary policy further and thus enhances Germany's dominance.

1/ In a speech at Pforzheim on October 20, Dr. Schlesinger, Vice President of the Bundesbank, said "The fact that the Central Bank Council at its last meeting in Berlin did not decide to lower the Bank's interest rates further was due first and foremost to the narrow limits imposed by the present external economic constellation on the scope of our interest rate policy."

The Bank of Italy introduced its new bank credit enforcement procedures in March. Interest rates rose at that time and remained high during the spring; in June the Bank of Italy announced additional credit tightening. The March action had been under consideration for some time, as a means to fight inflation and discourage stockpiling, especially of imports; there was widespread recognition that the credit ceilings in force were being exceeded. The timing of the Italian package with the U.S. credit restraint program apparently was coincidental. The June action came in response to pressure on the lira within the EMS.

Similarly, it appears that the behavior of Dutch and Belgian interest rates in 1980 -- to the extent that they deviated from what would have been desired purely on domestic grounds -- were determined primarily by German rates. Only to the extent that German rates, in turn, reflected dollar rates can one attribute changes in Dutch and Belgian rates to the new Federal Reserve operating procedure.

The same can be said of French interest rates. However, in France more than in most other countries, the volatility of interest rates (as distinct from the level) has been an important issue, as well. Since the French banking system and financial structure are based on large amounts of refinancing at the central bank, and since French industry is heavily reliant on fairly short-term bank financing, the economy is seen to be very sensitive to changes in interest rates. The inertia that many economies have due to the fixed nature of a large share of capital costs is not present in France unless interest rates are stable. Thus, despite pronounced changes in world interest rates, French interest rates were held fairly steady. Indeed, over the whole year 1980 the range for the Bank of France's money market intervention rate (the key rate in the French system) was less than 2½ percent. The continued strength of the French franc within the EMS made it possible for the Bank of France to pursue the above policy despite whatever impact it may have had on the franc-dollar rate. However, the downward adjustment in early November in the Bank of France's intervention rate was precipitated by the weakness of the German mark within the EMS arrangement, which, in turn, was attributed to a rise in dollar interest rates.

In sum, authorities in continental European countries were affected by the new operating procedures; they were affected by both the higher level and, to a much lesser extent, the volatility of U.S. interest rates. However, the problems caused were not great, given that internal and external objectives were broadly consistent. Any problems stemmed primarily from German policy actions and conflicts and were thus at most only indirectly related to the Federal Reserve's new operating procedure.

Three other countries also merit discussion. Canada because it was the country most clearly influenced by U.S. policies, the United Kingdom because it was least influenced, and Japan because it is so big.

The Bank of Canada announces targets for the growth rate of M-1. These targets, to which the Bank of Canada tries to adhere quite systematically, determine in principle the path of Canadian interest rates. Nevertheless, as noted above, Canadian interest rates are correlated significantly with U.S. rates. In a press release accompanying the increase in the Bank of Canada's Bank Rate on October 9, 1979, Governor Bouey cited the new Federal Reserve operating procedure as an important factor behind the Bank Rate action. Governor Bouey argued that a depreciation of the Canadian dollar would have added to inflation without benefiting the real economy, since the key export sectors (excluding automobiles) were at full capacity. The perceived need to follow U.S. interest rates persisted in 1980.

In addition, the sharp swings in U.S. interest rates in the spring caused problems for the Bank of Canada. Rather than suffer the announcement effects that would have accompanied frequent changes in the Bank Rate (which must change with market rates to keep it a penalty rate), the Bank of Canada gave up its discretionary setting of the Bank Rate and on March 13 tied it to market rates. Subsequently, when U.S. interest rates fell the Bank of Canada tried to moderate the Canadian interest rate decline;[1/] the Bank felt that the U.S. decline would be reversed (at least partially) and wanted to avoid an excessive swing in Canadian rates, which Canadian authorities viewed as undesirable. Similarly, when U.S. interest rates increased again during the fall, Canadian rates rose but less rapidly and by a smaller amount. Analysis of Canadian exchange market intervention behavior conducted in connection with the investigation summarized in Section III.C yielded no evidence of a change in behavior since October 1979.

[1/] From April to June, 3-month interest rates declined about 450 basis points in Canada, while U.S. 3-month CD rates declined 750 basis points. Again from July to November, 3-month interest rates rose about 200 basis points in Canada, while U.S. 3-month CD rates rose 700 basis points.

The new Federal Reserve operating procedure almost certainly did not significantly affect British policy. British macroeconomic policy throughout the past year has been concerned with achieving a monetary growth strategy upon which the government had embarked before the Federal Reserve's October announcement. However, the Federal Reserve's new operating procedure has become involved in the internal U.K. debate on techniques of monetary control.

In Japan, various monetary policy actions were adopted last November and again in February-March. These actions were linked both to domestic inflation and to strong selling pressure on the yen that developed when dollar interest rates rose. However, one must be careful about drawing any strong conclusions about the effect on Japan or Japanese policymaking of the System's new procedure on the basis of these two episodes. It is certainly the case that the yen's value has been quite variable over the past year, but much of that variability appears to reflect the behavior of Japan's external accounts and other events not directly related to U.S. policies.[1/] Nevertheless, some tendencies in the Japanese policy response have developed that may bear watching in future episodes.

The Japanese authorities are inclined to reserve their conventional monetary measures -- i.e., discount rate changes, adjustment in money stock growth, the use of credit controls -- for domestic

[1/] The results reported in Section III.A for the yen exchange rate (spot and forward) against the dollar point most consistently in the direction of an increase in variability for that currency.

objectives, such as reducing inflation. The important implications for monetary policy of external events -- including capital flows and exchange market pressures generated by international interest rate differentials -- are, of course, acknowledged. However, the preferred response to such external influences seems to be to rely on official exchange market intervention and capital controls -- in the latter case, by relaxation first of controls currently in place to encourage capital flows in the (officially) desired direction and _in extremis_ by placement of new controls to limit capital movements.

This principle of policy assignment appears to have been maintained roughly intact during the recent episodes. Although the successive tightening of monetary policy between October 1979 and March appears to have been directed largely at control of inflation, it is noteworthy that the effect on the yen has been given a more-than-usual prominence in official characterizations of the measures. Whether this development constitutes anything more than a minor innovation remains to be seen, however, as the tightening was consistent with both internal and external objectives at the time. It is interesting to note that the Bank of Japan allowed interest rates to decline significantly from August to November although dollar interest rates were rising. The relative stability of the yen against the dollar during this period may have contributed to this relaxed attitude. Nevertheless, the Japanese also appear to be willing to tolerate fairly wide swings in interest differentials and in the yen's exchange rate before resorting to extraordinary measures, such as capital controls There is some evidence, however, that the Japanese authorities have felt that their economic policy decisions have been complicated by the greater unpredictability of dollar interest rates which they associate with the Federal Reserve's new operating procedure.

D. Reactions in Developing Countries

The impact of the new Federal Reserve operating procedure on the problems confronting policymakers in the developing countries during the past year was somewhat different from that discussed above for the developed countries. As in the industrial world, inflation increased sharply during 1979 and 1980 in most developing countries. At the same time, the high level and the variability of dollar interest rates on world capital markets created difficulties for those developing countries that are major commercial borrowers internationally. In addition, local institutional problems arose in some of the developing countries in Latin America and elsewhere whose exchange rates are pegged to the dollar.

The generally high level of world interest rates during the first months of 1980 raised the cost to developing countries of funds obtained abroad and added to their balance of payments problems. Since the need for tighter monetary conditions and higher interest rates at that time was felt in many of the developed countries, it is not clear to what extent the new operating procedures per se added to the burdens of the developing countries. At least one country, Brazil, ceased new borrowing during early 1980 in part because the authorities viewed interest rates at that time as excessively high. It should be noted, however, that the interest rates on most such borrowings float, so Brazil would not have been obliged to continue high interest payments once world rates came down. Moreover, the international reserves Brazil expended in lieu of additional borrowing would have earned the current market rate had they remained invested.

The increased variability of interest rates in world capital markets creates additional uncertainty for borrowing countries as they attempt to plan government budgets and manage their balance of payments flows. More experience with the new procedure and its impacts may enable them to forecast better their expected borrowing costs over, for example, a year or more.

Since many developing countries have fixed or crawling-peg exchange rate regimes, the increased variability of world interest rates has the potential for creating large, unwanted, short-term capital flows and disintermediation at local financial institutions. Some countries (Venezuela and Mexico) prevented such flows during 1980 by allowing greater flexibility of domestic interest rates. The induced movements in domestic rates were welcomed by authorities in Mexico, but less so in Venezuela, because of differences in the underlying domestic economic situations at the time. Many other developing countries, however, have fixed (or at least somewhat inflexible) domestic interest rates and were forced by the rise in world interest rates to take actions they would most likely not otherwise have taken. Some, such as the Dominican Republic and Guatemala, itensified exchange controls. Brazil slowed the rate of crawl of its exchange rate -- even though its inflation rate rose -- and introduced a tax on domestic borrowings. Thailand, which had flexible domestic interest rates but legislated ceilings on them, changed some financial market regulations and taxes and adjusted the ceilings in order to prevent large capital outflows. Many authorities of developing countries regard stable interest rates as necessary for the health of domestic financial institutions and to promote sustained levels of domestic investment. They view as troublesome a change toward greater volatility of interest rates on world markets.

Section V -- U.S. International Capital Flows[1/]

The Federal Reserve's adoption of its new operating procedure could have influenced the structure of U.S. international capital flows by changing private investors' expectations concerning, in particular, interest rates, exchange rates, or inflation rates. Changes in private investors' expectations would be manifested in revised portfolio preferences which, in turn, would be observed as net private capital flows (including changes in the statistical discrepancy) to the extent that central banks chose to accommodate such revised preferences through intervention in the foreign exchange market rather than allowing exchange rates to absorb the changes.

During the four quarters commencing in October 1979 and ending in September 1980, the G-10 countries reduced their net reserve asset holdings in the United States by $15.2 billion. See Table 13. This official net capital outflow was accounted for by four countries -- Germany, Switzerland, Japan, and Italy. In addition, the reserve assets of the United States increased (an outflow) by $4.5 billion during this period.[2/] With the exception of Italy, most of this activity took place during the fourth quarter of 1979 and the first quarter of 1980, an interval of time over which the weighted-average exchange value of the dollar appreciated on balance about 10 percent.

1/ The principal contributor to this section was Patrick Parkinson
2/ About $2.2 billion of this total consisted of an SDR allocation and Carter notes issued in the first quarter of 1980.

Table 13

U.S. International Capital Flows

(Billions of dollars, outflow = (-), not seasonally adjusted)

	1979Q4	1980Q1	1980Q2	1980Q3 p/	1979Q4-1980Q3	1978Q4-1979Q3
Change in net foreign positions of banking offices in U.S. 1/	-5.0	9.0	-23.1	-12.1	-31.2	6.4
Net private securities transactions	-1.1	4.9	-2.0	-0.8	1.0	2.8
Change in foreign official reserve assets	- .3	-7.4	7.0	7.7	7.0	3.5
G-10 countries and Switzerland	-7.2	-10.7	1.3	1.4	-15.2	1.7
OPEC	6.0	3.3	4.3	3.9	17.5	1.4
All other countries	.9	*	1.4	2.4	4.7	.4
Change in U.S. reserve assets	- .6	-3.3	.5	-1.1	-4.5	- .3
Trade balance	-7.9	-11.1	-5.8	-5.8	-30.6	-27.3
All other transactions	6.0	.8	4.7	3.8	15.3	.3
Statistical discrepancy	8.9	7.1	18.7	8.3	43.0	14.6
Memo: Current-Account Balance	.5	-2.5	- .7	.5	-2.2	-1.5

*/ Less than 50 million.
1/ Excluding liabilities to foreign official institutions.
p/ Preliminary.

An examination of the intervention behavior of monetary authorities, reported in Section III.C of this study, found little evidence that the official capital outflows starting in the fourth quarter of 1979 resulted from significant changes in historical patterns of intervention. If no change occurred in intervention behavior following the adoption of the new operating procedure by the Federal Reserve, and there was no change in the average level of the exchange rate as a consequence of the new procedure, the new procedure could not have had a large impact on net private capital flows. The sum of private and official capital flows (including the statistical discrepancy) is by definition the mirror image of the balance on current transactions. The current-account balance is largely predetermined in the short run by past developments in real exchange rates and the levels of U.S. and foreign economic activity. Hence, the sum of net private and official capital transactions is largely predetermined.

To the extent that the adoption of the new procedure did not affect the average level of the exchange rate after October 1979, but the new procedure did affect the month-to-month variability of the exchange rate, one would expect to observe periods of substantial official capital inflows and outflows even if intervention behavior were unchanged. For example, from the end of December 1979 to the end of March 1980, the dollar appreciated by about 8 percent. The examination of intervention behavior in Section III.C suggests that a 1 percent appreciation of the dollar results in between $0.9 billion and $1.5 billion in intervention sales of dollars by the major G-10 countries (including the United States). This is consistent with their recorded volume of net intervention and net official capital outflow in the first quarter of 1980. See Table 13. Of course, given this net official outflow and an essentially unchanged current-account position,[1/] net private capital flows had to compensate, as they did.

To the extent that the new operating procedure resulted in slower growth in U.S. real economic activity, the U.S. current-account deficit, assuming an unchanged exchange rate, was smaller and the sum of net private and official capital inflows was smaller.[2/] To the extent that the dollar appreciated, this would have reduced the current account deficit somewhat further in the short run (J-curve effect). The net effects on U.S. international transactions would depend on the size and timing of the effect on the current account, on the size of any tendency for the dollar to appreciate, and on the vigor of any intervention response to such an appreciation. It is likely that for the U.S. economy over a period as short as one year the increase in the official capital outflow associated with the stronger dollar would more than compensate for the lower U.S. current-account deficit.

1/ In fact, the current account did move into deficit in the first quarter reflecting sharply higher prices for imported oil.

2/ It should be emphasized that the discussion in this paragraph concerns monetary policy results that might have been brought about by the new procedure rather than the operation of the procedure itself.

Even in the absence of any exchange market intervention induced directly or indirectly by the change in operating procedure, the change could have affected the structure of private capital flows. As shown in Table 13, in the four quarters following adoption of the new operating procedure, the notable elements in the private component of the capital account were a reported net outflow of $31.2 billion from banking offices in the United States, reversing a trend of net inflows that began in early 1979, and a $17.5 billion increase (inflow) in the reserve assets held in the United States by the OPEC countries. In addition, the statistical discrepancy totaled $43 billion during this period. The most likely source of the discrepancy is net unrecorded private capital inflows.

These developments probably were caused by factors other than but coincident with the change in operating procedure. One factor that clearly influenced the structure of private capital flows was the imposition, at the time of the change in operating procedure, of a marginal reserve requirement on Eurodollar borrowing and other managed liabilities of member banks and U.S. agencies and branches of foreign banks. The introduction of this marginal reserve requirement had a pronounced effect on the observed capital-account transactions of banks. In particular, U.S. agencies and branches of foreign banking offices found it profitable to reduce their liabilities to foreign banking offices and, in turn, shift the booking of loans to nonresidents to their offshore offices. The outflow from U.S. banking offices totaled $5.0

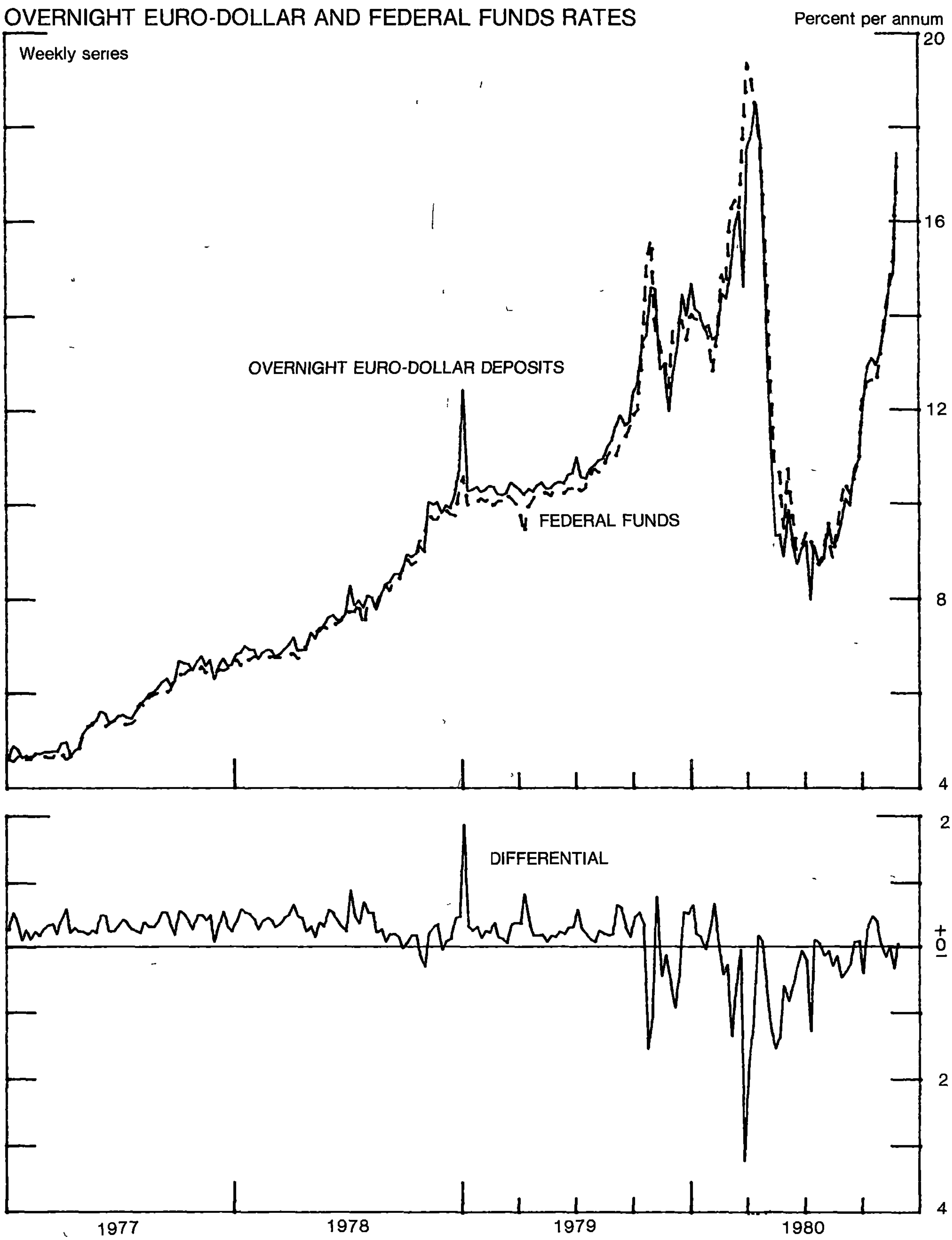
billion in the fourth quarter of 1979. In early 1980 the banks were largely able to avoid the program's impact. The subsequent tightening of the program in March 1980 partially accounts for the $23.1 billion outflow from U.S. banking offices in the second quarter of 1980.

A second factor that possibly influenced the structure of private capital flows was the freezing of Iranian assets in the United States and in foreign branches of U.S. banks by President Carter in November 1979. This action may have discouraged nonresidents from holding financial assets at domestic and foreign offices of U.S. banks or otherwise in the United States where their ownership was identifiable. Such a response by nonresidents would have reduced bank-reported capital inflows and also might have increased the volume of unrecorded capital inflows.

A third factor that possibly influenced the structure of private capital flows was the anticipation and implementation of the U.S. credit restraint program. This program may have induced partially unrecorded, roundtrip capital flows as U.S. borrowers went abroad to borrow funds, through unrecorded channels, including funds that had been deposited abroad by U.S. residents. In the second quarter of 1980, the period when this program had its impact, the statistical discrepancy indicated unrecorded inflows totaling $18.7 billion.

Finally, as illustrated in Chart 4, since October 1979 there has been a sharp increase in the variability of the differential between the interest rate on overnight Eurodollar deposits and the federal funds rate -- weekly average in both cases. Again most of this increase

CHART 4


OVERNIGHT EURO-DOLLAR AND FEDERAL FUNDS RATES
Percent per annum
Weekly series
OVERNIGHT EURO-DOLLAR DEPOSITS
FEDERAL FUNDS
DIFFERENTIAL
20
16
12
8
4
2
+
0
−
2
4
1977
1978
1979
1980

reflects the imposition (October 1979), avoidance (end 1979), tightening (March 1980), and elimination (July 1980) of the marginal reserve program. However, a residual amount may have reflected the influence of the new operating procedure per se through its effect on the variability of the federal funds rate.[1/] The increase in the week-to-week variability of the federal funds rate, in turn, appears to have discouraged weekend Eurodollar reserve avoidance activity somewhat. A bank does not realize its reserve reduction until two weeks after it has paid its accomplice a share of the expected gain from avoiding reserves. The increased variability of the federal funds rate increased the variance of that expected gain.

In summary, no significant change in the intervention behavior of monetary authorities has been observed since the adoption of the new operating procedure. Given that the current-account balance is largely predetermined in the short run, this implies that the new procedure has had no direct effect on net private capital flows on average since October 1979. Changes in the structure of private capital transactions and in the statistical discrepancy have been observed, but these changes can be largely accounted for by other factors. However, to the extent that the new procedure may have indirectly facilitated a tighter Federal Reserve policy on average over the period, an appreciation of the dollar and a reduction in the U.S. current-account deficit may have resulted. Under such circumstances, one would expect an increase in the net official capital outflow to G-10 countries

1/ This phenomenon is another form of roundtrip flows, i.e., would not affect net flows.

and a smaller increase in the net private capital inflow (recorded and unrecorded). However, over periods longer than a year the size and direction of these influences depend on many other factors as was discussed in Section II above.

Section VI -- Concluding Topics

A. Consequences of Exchange Rate Variability

The evidence presented in Section III of this study indicates that the change in operating procedure probably led to some increase in the short-run variability of dollar exchange rates. On the assumption that this phenomenon persists, the question arises as to whether the additional variability attributable to the new procedure can be expected to have any perceptible adverse economic and financial effects on the U.S. economy. To provide an answer to this question, we examined the possible impact of increased variability of exchange rates on trade flows, on foreign direct investment and domestic fixed investment, on domestic prices, and on the attractiveness of dollar-denominated assets for private and official holders. Our review of the existing literature, as well as our own examination of some of the data, did not uncover any evidence suggesting that these effects are likely to be strong and significant.

1. Impact on Trade Flows 1/

A number of contributions have been made to the theoretical and empirical literature on the effects of exchange rate variability on export and import volumes and prices. The theoretical work in this area, e.g., Clark (1973) and Hooper and Kohlhagen (1978), indicates that an increase in the variance of nominal exchange rates *per se* will reduce the volume of international trade if firms are risk averse.

Empirical verification of this effect to date has been only partially successful. Four studies (Clark and Haulk (1972), Makin (1976), Hooper and Kohlhagen (1978), and Kenen (1979)) found no significant negative effect of exchange rate variability in equations explaining

---

1/ The principal contributor to this and the following section was Peter B. Clark.

trade volume, although the next-to-last study did find a significant impact on prices of traded goods. A study published by GATT (Blackhurst and Tumlir (1980)) found no significant change in the ratio of the growth in world exports to the growth in world output over the past 25 years. One recent study (Abrams (1979)), however, has found a significant negative effect of exchange rate variability on trade volume using annual cross-section and time-series data. In addition, another study (Cushman (1980)) using a methodology similar to that of Hooper and Kohlhagen did find some evidence of a negative impact on trade volume. Nevertheless, given the difficulties in interpreting the results of these studies it seems reasonable to conclude that there is no firm evidence relating adverse effects on trade flows to exchange rate variability. One reason these studies may not have uncovered much evidence is that they may have underestimated the time period over which an increase in exchange rate variability must be recorded in order to affect trade flows.

Based on our review of the literature, we would conclude that the adoption of the new operating procedure in October 1979 has not had a significant negative impact on the volume of U.S. trade flows to date. First, the results presented in Section III.A do not indicate an unambiguous increase in exchange rate volatility beyond the short run (measured in weeks) in the post-October 1979 period. There is also no strong empirical evidence that increased exchange rate variability has a significant negative impact on trade flows, and the large exchange rate movements in 1980 were concentrated in a few months, which was probably too short a time period to affect the longer-run considerations that presumably influence the extent to which a firm will engage in international trade. An additional piece of information is that, since the adoption of the Federal Reserve's new operating procedure, the equations used by the Board's staff to help to forecast the volume of non-oil imports and non-agricultural exports have underpredicted the level of real trade flows, with the exception of the prediction of the volume of non-agricultural exports in the fourth quarter of 1979. These in-sample errors can be viewed as weak evidence that exchange rate variability (a variable that does not appear in the equations) has not had a negative impact on U.S. trade.

2. Impact on Foreign Direct Investment and Domestic Fixed Investment

Very little theoretical or empirical work exists on the possible effects of exchange rate volatility on foreign direct investment or domestic fixed investment. Therefore, firm conclusions on the basis of existing work are not possible at this point.

On the theoretical side, one might conjecture that an increase in exchange rate variability would reduce the level of foreign direct investment to the extent that the exchange risk cannot be directly hedged or is not offset by variations in other prices. However, the only direct examination of this question, that by Cushman (1980), indicates that the impact of increased exchange rate variability on foreign direct investment is ambiguous when a firm can substitute foreign investment for exporting in order to exploit a foreign market. In other words, it is possible that a firm might engage in foreign direct investment and produce abroad rather than export from the home market in the face of greater exchange rate volatility. In his empirical work Cushman does in fact find some weak empirical evidence indicating that foreign investment may be positively affected by fluctuations in exchange rates.

The evidence is also very scanty regarding the effects of exchange rate volatility on domestic fixed investment. From a theoretical point of view one might expect that such volatility could reduce domestic investment for at least two reasons: (1) larger exchange rate fluctuations could increase the variance of both domestic and/or foreign sales, thereby increasing the risk associated with the profits arising from a given level of fixed investment, and (2) greater volatility in exchange rates could increase the variance of both input and output prices, and to the extent that these price movements are not offsetting, increase the variance of the profit stream associated with domestic investment. These considerations were among the reasons for the formation of the European Monetary System, which has as one of its objectives a reduction in exchange rate uncertainty among the major European currencies.

The empirical evidence linking exchange rate variability directly to the level of domestic investment is limited to one study by Kenen (1979). He finds some weak evidence of a negative impact of such variability (the average of the absolute monthly change in real and nominal exchange rates over a 36-month interval) on a country's real gross capital formation. As Kenen himself admits, however, these results are far from definitive since in the cross-country regression for 16 advanced countries the only explanatory variables he uses are measures of the trend and variability in exchange rates.

3. Impact on Domestic Prices: Ratchet Effects[1]

The ratchet hypothesis states that domestic prices rise when a currency depreciates, but do not fall (or do not fall proportionately as much) when the currency appreciates, resulting in net inflationary pressure when the currency fluctuates. The results of our empirical tests of this hypothesis for the United States were mixed. Based on quarterly data over the floating rate period to date (1973 Q3-1980 Q2), weak evidence of a ratchet effect in the impact of the exchange rate on U.S. non-oil import prices was found. However, no significant direct or indirect link between this ratchet effect and domestic prices was evident.

Recent published work on ratchet effects is limited to a study by Morris Goldstein (1977). Goldstein tested for ratchet effects in the impact of fluctuations in aggregate import prices on domestic prices in five industrial countries using annual data over the period 1958-73. In a model relating changes in U.S. domestic prices (GDP deflator) to changes in wages (or unemployment), productivity, and import prices he obtained mixed results -- under some specifications of the model ratchet effects were found, and under others they were not.

However, Goldstein's work is not directly relevant to the question of ratchet effects with respect to exchange rate movements since his model does not test directly the relationships between exchange rates and either import prices or domestic prices. Moreover, his empirical analysis covered a period of relative stability in exchange rates.

In our analysis we tested for the existence of ratchet effects at three different levels. The first test (I) used an import price model

---

1/ The principal contributor to this section was Peter Hooper.

relating changes in nonoil import prices to changes in (1) a weighted average of foreign consumer prices, (2) an index of world coffee and sugar prices, and (3) the weighted-average value of the dollar. The second test (II) involved a domestic price model that relates changes in (alternatively) the absorption deflator and the CPI to changes in (1) domestic unit labor cost, as measured by the domestic wage rate divided by a 5-quarter moving-average index of productivity, (2) the oil import price, and (3) non-oil import prices. The third test (III) employs the same domestic price model but with changes in foreign prices and the exchange rate substituted for non-oil import prices.1/

The tests for ratchet effects were performed including in the models an additional exchange rate variable times a 1, 0 dummy variable which took the value 1 when the dollar depreciated and 0 when it appreciated.2/ Given that the exchange rate is expressed in terms of foreign currency units per dollar, the expected sign of its coefficient in the price equations is negative. The existence of a ratchet effect would be indicated by a significantly negative coefficient on the additional exchange rate variable.

The results for the import price model (I) are summarized in Table 14. Equation IA, which excludes the test for a ratchet effect, shows significant current and lagged exchange rate coefficients with the expected sign. In equation IB, the last two coefficients indicate the

---

1/ In each test it is assumed that macroeconomic policy is unaffected, or is affected symmetrically, by exchange rate depreciation or appreciation. For example, if higher inflation associated with depreciation leads to faster money growth and lower inflation associated with appreciation does not lead to slower growth, the tests are biased in favor of finding a ratchet effect.

2/ In the second model the 1, 0 dummy variable was applied to the non-oil import price variable, taking the value 1 when these import prices rose.

Table 14

Tests for Ratchet Effects in the Impact of Exchange Rate Changes on U.S. Non-oil Import Prices[1/]
(Estimated coefficients; t-ratios in parentheses)

Explanatory variables	IA	IB
Constant	-2.3 (-1.83)	-2.4 (-2.04)
% ΔForeign consumer prices	1.90 (3.67)	1.71 (3.38)
% ΔWorld coffee-sugar price	.09 (3.41)	.08 (3.09)
% ΔExchange rate	-.35 (-2.82)	-.48 (-1.97)
% ΔExchange rate (t-1)	-.46 (-3.63)	-.02 (-.07)
% ΔExchange rate (depreciation only)		.26 (.71)
% ΔExchange rate (t-1) (depreciation only)		-.73 (-1.97)
$\bar{R}^2$	.5495	.5967
DW	2.00	1.97
Rho	0.00	-.05

1/ Dependent variable is quarterly percentage changes in U.S. nonfuel import unit value; equations estimated over 1973 Q2-1980 Q2, corrected for 1st-order autocorrelation. Exchange rate and foreign price data are 10-country weighted averages, using multilateral trade weights. Exchange rate is expressed in terms of foreign currency units per dollar.

additional impact on U.S. non-oil import prices of the exchange rate change when a depreciation takes place. The results suggest the presence of a weakly significant ratchet effect in the 1-quarter lagged impact of exchange rate changes, but no significant ratchet effect with respect to contemporaneous exchange rate changes. However, this empirical result may reflect the fact that there were very few episodes of sustained dollar appreciation during the sample period. Moreover, while the coefficient on the lagged exchange rate changes was weakly significant, the combined current and lagged effects were not statistically significant.

Table 15 presents the results of attempts to relate ratchet effects of exchange rate changes directly to domestic prices. This connection was not supported by the data. First, as shown in equation II, nonoil import prices have only a marginally significant impact on domestic prices.[1/] No evidence was found of ratchet effects in the impact of non-oil import prices on domestic prices, perhaps because during 1973 Q2-1980 Q2 those prices actually fell quarter-to-quarter only twice. Second, the last coefficient in equation IIIB indicates the absence of significant ratchet effects in the direct impact of exchange rate changes on domestic prices.

The results for equations IIIA and IIIB presented in Table 15 are problematical in that the foreign price variable has a marginally significant coefficient with the wrong sign. This result may reflect

---

1/ The results reported use the domestic absorption deflator as the dependent variable. Very similar results were obtained when the CPI was employed. The equation numbers in Table 15 correspond to the second and third levels of analysis outlined above.

Table 15

Tests for Rachet Effects in the Impact of Exchange Rate Changes on U.S. Domestic Prices[a]

(Estimated coefficients; t-ratios in parentheses)

Explanatory variables	Equation II	Equation IIIA	Equation IIIB
Constant	0.8 (3.23)	1.3 (4.98)	1.3 (4.70)
% ΔU.S. unit labor cost[b]	.44 (2.70)	.47 (4.29)	.46 (3.99)
% ΔU.S. oil import price[c]	.02 (2.57)	.03 (4.22)	.03 (2.98)
% ΔNon-oil import price[c]	.06 (1.36)		
% ΔForeign consumer prices[c]		-.23 (-1.82)	-.22 (-1.60)
% ΔExchange rate[c]		-.04 (-1.76)	-.06 (-1.05)
% ΔExchange rate[c] (depreciation only)			.03 (.49)
$\bar{R}^2$	.6947	.8535	.8317
DW	2.00	2.26	2.17
Rho	-.06	-.41	-.27

a/ Dependent variable is quarterly percent change in U.S. absorption deflator; see footnote 1/ to Table 14.

b/ Four-quarter distributed lag on U.S. wage rate divided by "normal" productivity index.

c/ Three-quarter distributed lag.

the effects of collinearity with either the oil import price or the unit labor cost variables. In an effort to correct for these possible sources of bias in the estimates, equation IIIB in Table 15 was reestimated, first, using domestic prices excluding energy as the dependent variable and dropping the oil import price, and second, splitting the normal unit labor cost variable into wages and normal productivity variables and substituting the unemployment rate for wages in a reduced-form specification. These adjustments (not reported here) yielded positive (though not significant) coefficients on the foreign price variable, but did not provide any further evidence of ratchet effects.

4. Impact on Official and Private Dollar Holdings

The new operating procedure has apparently led to an increase in fluctuations in dollar interest rates, and this has caused greater fluctuations in international interest rate differentials and increased the short-run volatility of dollar exchange rates. It is difficult to judge the likely effects of these developments on the incentives of official and private dollar holders to diversify their portfolios. It is possible that increased exchange rate variability could lead to diversification away from dollar assets. However, this is by no means necessarily the case.

Theoretical work, e.g., Dooley (1975), shows that the effect of an increase in the variance of exchange rates on the optimal shares of assets in a portfolio is ambiguous; the effect depends on the initial conditions as well as the character of the asset holder's utility function.

Hence, it is not clear on theoretical grounds whether any increase in exchange rate volatility generated by the new operating procedure would lead to diversification away from dollar assets.

There is little empirical evidence on the impact of exchange rate variability on private asset demands. One study by Akhtar and Putnam (1980) did find some evidence that exchange rate variability (the standard deviation of daily dollar-DM spot rates) had a negative effect on the demand for money in Germany. Yet even if this diversification effect were widespread, the impact on the demand for dollar assets is unclear, since presumably increased variability in dollar exchange rates causes some diversification out of non-dollar assets into dollar assets, as well as diversification out of dollar assets into other currencies.

Furthermore, fluctuations in interest rates must also be taken into account in assessing the impact of exchange rate variability on portfolio demands. It is not clear that the real earnings on dollar-denominated assets have become more uncertain than the earnings on, say, mark-denominated assets. The nominal earnings on dollar-denominated assets have become more uncertain because of the increase in interest rate variability, but so have the nominal earnings (expressed in dollars) on mark-denominated assets because of the exchange rate volatility. However, if these nominal earnings are expressed in real terms by deflating by the rate of change of an index of, say, U.S. and German prices, then part of the variability in the real rate of return on mark-denominated assets is offset to the extent that German goods have a weight in the deflator. The variability in the real rate of return on the dollar-asset earnings depends on the correlation between the movements in U.S. interest rates and the exchange rate. Consequently, the effect of the new procedure on the attractiveness of the dollar denominated-assets is ambiguous.

Other factors may also affect central banks' incentives to diversify away from the dollar. For example, some OPEC investors still may be nervous about the precedent set by the freezing of Iranian assets, and the way in which this situation is resolved is likely to affect their attitude toward dollar assets in the future. Germany, Japan, and Switzerland are now faced with current-account deficits, and this seems to have caused them to reconsider their position against the use of their currencies as reserve assets. Germany and Japan are reported to have had some direct dealings with Saudi Arabia and other OPEC investors, and both countries have been taking steps to make assets denominated in their currencies more attractive or available to countries with current-account surpluses.

Although reliable data on global reserve diversification trends are not available past the first quarter of 1980, available evidence does not support the conclusion that the System's change in operating procedure has had much effect on reserve preferences of foreign central banks.

For the five major foreign reserve centers, data through October 1980 show that their foreign exchange reserves continue to be overwhelmingly held in dollar-denominated assets, with little sign of a change in proportions since the end of September 1979. Data collected by the IMF for non-reserve-center countries indicate their reserves were about

58 percent in dollars at the end of the third quarter of 1979, with German marks accounting for around 14 percent, and other currencies much smaller shares. Figures for most of the non-reserve centers through the first quarter of 1980 suggest that the dollar's share rose to about 61 percent of the total.[1/] Developments since the first quarter are more impressionistic, but aside from periodic reports about purchases of mark- and yen-denominated securities by some OPEC investors, there is little evidence of increased diversification. The amount of these OPEC transactions may total several billions of dollars equivalent, but this probably will not have a major effect on the share of dollar assets in global central bank portfolios.

B. The Exchange Rate as Information Variable and Policy Instrument[2/]

1. The Exchange Rate as Information Variable

Data on financial variables become available before data on the variables that are the ultimate targets of monetary policy. Financial data contain information about the disturbances that are affecting the economy and, therefore, about the likely values for ultimate target variables. For many years the investigation of how best to extract the information contained in financial data focused on the search for a single indicator of the stance of monetary policy. More recently it

---

1/ This estimate may overstate the rise in the dollar's share because it does not take account of valuation effects. The dollar appreciated from the end of September 1979 to the end of March 1980.

2/ The principal contributor to this section was Dale W. Henderson.

has been recognized that more information can be obtained if movements in a number of financial variables are analyzed simultaneously. According to that more recent approach, the authorities select desired values for their ultimate target variables; the actual values of these ultimate target variables are unobservable in the current period. The authorities then choose some financial variables as policy instruments. Another group of financial variables is regarded as information variables. Values for the policy instruments consistent with desired values for the ultimate target variables are selected and forecasts of the information variables are made. Unanticipated movements in the information variables are used to make inferences about the disturbances that are affecting the economy and, therefore, about the values of the unobservable ultimate target variables that are likely to emerge if monetary policy remains unchanged. On the basis of these inferences the values of the policy instruments are changed to increase the likelihood that the desired values of the ultimate targets will be attained.

Under the Federal Reserve's old operating procedure increases in the demand for output and increases in the demand for money would have caused little or no change in the value of the dollar in the short run because they would have been accommodated at an unchanged nominal interest rate. However, shifts in desired asset holdings away from the dollar and increases in expected inflation would have led to dollar depreciation. Thus the second pair of disturbances could have been distinguished from the first pair on the basis of exchange rate movements. Under the new operating procedure the first pair of disturbances causes dollar appreciation while the second pair of disturbances leads to dollar depreciation.[1/] Thus, the adoption of the new operating procedure neither reduced nor enhanced the role of the exchange rate as an information variable.

First consider an increase in the demand for U.S. output.[2/] As a result of this disturbance output tends to rise. Under the old operating procedure with the interest rate held constant the money stock would have risen but there would have been little or no change in the value of the dollar in the short run.[3/] Under the new operating procedure with nonborrowed reserves held constant, the money stock increases, and the interest rate rises. Dollar-denominated securities become more attractive, so the dollar would appreciate in the short run.[4/] The money stock increases because the rise in output causes private agents to raise their demand for transactions balances at the expense of other reservable deposits even though the interest rate rises.

1/ A similar point has been made Frenkel and Mussa (1980).

2/ It is assumed that this and the next two disturbances considered leave the expected future value of the dollar unchanged. For example, the expected future spot exchange rate would be unaffected if market participants regarded the disturbances as temporary.

3/ The dollar would have appreciated in the short run if the rise in the transactions demand for money had come at the expense of the demand for foreign securities to any significant extent. Over time as current-account developments became more important the dollar would have tended to appreciate or depreciate depending on whether the demand for U.S. output increased because of a decrease in the demand for foreign output or a drop in U.S. savings.

4/ Over time the dollar would tend to appreciate further or depreciate depending on the reason for the shift up in the demand for U.S. output as explained in the preceding footnote.

Now consider an increase in the demand for money. Previously this disturbance would have been accommodated, so the money stock would have been increased with no change in the interest rate or in the value of the dollar. There would have been no change in output. Under the new procedure the money stock and the interest rate rise. Dollar-denominated securities become more attractive, so the dollar appreciates. However, output tends to fall. This comparison of the implications of an increase in money demand with those for an increase in the demand for U.S. output indicates that under each operating procedure the effect of the two disturbances on the value of the dollar is the same.

Next consider a shift in asset preferences away from dollar-denominated securities and toward foreign-currency-denominated securities. Under the old procedure this disturbance would have led to a depreciation of the dollar. This depreciation would have caused an increase in output and, therefore, a rise in the money stock. Under the new procedure the dollar still depreciates, but the interest rate tends to be pushed up. It seems likely that the depreciation of the dollar would be large relative to the rise in the interest rate, at least initially. Both of these adjustments would work to equilibrate the market for dollar securities, but, as long as output remains constant, the interest rate can only rise to the extent that the depreciation of the dollar increases the demand for nonborrowed reserves. The demand for nonborrowed reserves is probably not very sensitive to changes in the value of the dollar, so the interest rate would probably not rise very much initially. Thereafter, output would tend to rise, the interest rate would then rise, and the money stock would probably rise.

Finally, consider an increase in expected inflation in the United States relative to inflation abroad. This disturbance would, of course, lead to an increase in the expected future price level and a depreciation of the expected future exchange rate. At the initial nominal interest rate, price level, and exchange rate there would be an increase in aggregate demand because of the drop in the real interest rate and a decrease in the demand for dollar-denominated securities since foreign-currency-denominated securities would be relatively more attractive.[1/] Under the old procedure the increases in output and, perhaps, the price level would have raised the money stock. The rise in output would have further decreased the demand for dollar-denominated securities, so the dollar would have depreciated. Under the current procedure the nominal interest rate would rise. This increase would partially, but probably not completely, offset the drop in demand for dollar-denominated securities, so the dollar would probably depreciate. This comparison of the implications of a shift in asset preferences away from the dollar with those for an increase in expected inflation indicates that under each operating procedure the effect of the two disturbances on the value of the dollar is the same.

Under the old operating procedure all four disturbances increase the money supply and the demand for nonborrowed reserves. However, the first pair of disturbances (the increase in the demand for U.S. output and the increase in money demand) leave the value of the

---

1/ The demand for money would be decreased if the expected rate of inflation were a separate argument in the demand for money. In that case the final result could be a lower or higher money stock depending on whether this effect or the net impact of those mentioned in the next sentence was more important.

dollar unchanged while the second pair of disturbances (the shift in asset preferences away from the dollar and the increase in expected inflation) lead to dollar depreciation. Under the new operating procedure all four disturbances increase the money supply and the interest rate. However, the first pair leadsto dollar appreciation while the second pair leads to dollar depreciation. Thus, the information contained in exchange rate movements makes it possible to distinguish between the two pairs of disturbances under both operating procedures.

2. The Exchange Rate as Policy Instrument

It has been reported above that the dollar's spot exchange rates, forward exchange rates, and the differentials between U.S. and foreign interest rates have been more variable in the period since the adoption of the Federal Reserve's new operating procedure than they were in previous periods. This increase in variability has led some to suggest that the authorities should undertake through intervention to reduce or eliminate variation in the spot exchange rate at least over short intervals such as a month or a quarter. That is, according to some there is a good case for adopting the spot exchange rate as a policy instrument. It is not at all obvious that it is feasible or desirable to follow this course of action especially under the new operating procedure.

It is likely that larger variations in the foreign exchange reserves of the United States or of other countries would have been required to reduce or eliminate the larger spot exchange rate variation experienced under the new procedure. If spot exchange rate variation remains larger than otherwise would be the case, substantial swings in foreign exchange reserves could be required to stabilize spot rates in the future. In addition, doubt remains regarding the efficacy of exchange market intervention that leaves bank reserves unchanged -- so-called sterilized intervention -- in affecting the spot exchange rate. Even quite substantial variations in foreign exchange reserve might not be sufficient to reduce significantly variations in spot exchange rates.

Even if it were possible to reduce spot exchange rate variation through sterilized intervention, it might not be desirable to do so. If this strategy were adopted, less of the variation in differentials between the U.S. and foreign interest rates would be reflected in spot exchange rates and more would be reflected in forward exchange rates. For the major currencies so-called covered interest parity holds fairly exactly. That is, the difference between the U.S. interest rate and a foreign interest rate is approximately equal to the forward discount on the foreign currency. Sterilized intervention probably has little or no effect on interest rate differentials. Thus, if sterilized intervention is employed to stabilize spot rates in the face of substantial variations in interest rate differentials, forward rates will become more variable.

Whether private agents would be better off if spot exchange rates were less variable and forward exchange rates were more variable is unclear. If spot exchange rates were less variable, there would be less incentive for private agents whose transactions involve the payment or receipt of foreign currencies to hedge against exchange risk. However, some hedging would continue to occur either because the authorities did not attempt completely to fix spot exchange rates or because private agents would doubt that the authorities could be successful in keeping spot exchange rates fixed even though they indicated their intention to do so. Those who chose to cover would have more variable forward exchange rates. If forward contracts for all, including quite long, maturities were readily available at low cost and forward exchange needs could be very accurately anticipated, variable forward rates would constitute no problem. On the day that transactions were undertaken forward rates for all available maturities would be known, and all anticipated transactions could be covered. However, neither of these conditions is met. Forward markets for maturities beyond one year are thin or non-existent and needs for forward exchange are no easier to forecast than other variables relevant to business decisions. Thus an agent making a decision involving substantial fixed costs at a given time would face the prospect of having to choose at a later date either to hold an open position in foreign currency or to cover that position at a forward rate that is unknown at the time of the original decision.

In Section VI.A above the limited evidence that is available on the effects of the exchange rate uncertainty on U.S. international transactions was discussed. The conclusion was that there is little conclusive evidence that an increase in exchange rate variability has important negative effects on the types of transactions that have been studied. Here it has been argued that for a given amount of variation in interest rate differentials, the stabilization of spot exchange rates implies the destabilization of forward rates. There are no studies of the effects of this kind of redistribution of exchange rate uncertainty, but it is by no means self-evident that it would be beneficial.

Appendix Table 1

Weekly Exchange Rate Variability

(Number of 5-day series showing increases (+) or decreases (-) in variability in the 10/79-11/80 period compared with the previous periods. The number of series showing statistically significant (.05 level) changes is in parentheses.)

	10/79 - 11/80 compared with 3/73 - 9/79		10/79 - 11/80 compared with 11/78 - 9/79	
	+	-	+	-
SPOT				
Weighted-average dollar	4(2)	1(0)	5(2)	0(0)
German mark	5(2)	0(0)	5(5)	0(0)
Swiss franc	3(0)	2(0)	5(1)	0(0)
Japanese yen	5(5)	0(0)	5(5)	0(0)
Canadian dollar	5(3)	0(0)	5(0)	0(0)
Sterling	5(3)	0(0)	3(1)	2(0)
1-YEAR FORWARD				
Weighted-average dollar	5(1)	0(0)	0(0)	5(2)
German mark	2(0)	3(2)	4(0)	1(0)
Swiss franc	1(0)	4(2)	1(0)	4(0)
Japanese yen	5(5)	0(0)	5(1)	0(0)
Canadian dollar	4(3)	1(0)	4(0)	1(0)
Sterling	0(0)	5(0)	0(0)	5(3)
5-YEAR FORWARD				
German mark	5(3)	0(0)	4(0)	1(0)
Swiss franc	5(1)	0(0)	1(0)	4(0)

Appendix Table 2

Monthly Exchange Rate Variability

(Number of 21-day series showing increases (+) or decreases (-) in variability in the 10/79-11/80 period compared with the previous periods. The number of series showing statistically signficant (.05 level) changes is in parentheses.)

	10/79 - 11/80 compared with 3/73 - 9/79		10/79 - 11/80 compared with 11/78 - 9/79	
	+	-	+	-
SPOT				
Weighted-average dollar	20(11)	1(0)	21(8)	0(0)
German mark	18(1)	3(0)	21(9)	0(0)
Swiss franc	19(2)	2(0)	19(4)	2(0)
Japanese yen	21(2)	0(0)	21(17)	0(0)
Canadian dollar	15(4)	6(0)	11(0)	10(0)
Sterling	10(4)	11(0)	4(0)	17(0)
1-YEAR FORWARD				
Weighted-average dollar	18(3)	3(0)	11(0)	10(0)
German mark	7(0)	14(0)	12(0)	9(0)
Swiss franc	3(0)	18(1)	6(0)	15(0)
Japanese yen	21(8)	0(0)	21(1)	0(0)
Canadian dollar	9(5)	12(6)	5(0)	16(0)
Sterling	0(0)	21(11)	0(0)	21(8)
5-YEAR FORWARD				
German mark	17(10)	4(0)	11(0)	10(0)
Swiss franc	11(0)	10(0)	10(0)	11(0)

Appendix Table 3

Variability of Foreign and Eurodollar Three-Month Interest Rates

(Number of 5-day and 21-day series showing increases (+) or decreases (-) in variability in the 10/79-11/80 period compared with the previous periods. The number of series showing statistically significant (.05 level) changes is in parentheses.)

	10/79 - 11/80 compared with 3/73 - 9/79		10/79 - 11/80 compared with 11/78 - 9/79	
	+	-	+	-
WEEKLY				
Germany	0(0)	5(5)	5(1)	0(0)
Switzerland	5(4)	0(0)	5(5)	0(0)
Japan	5(5)	0(0)	5(5)	0(0)
Canada	5(5)	0(0)	5(5)	0(0)
U.K.	1(0)	4(0)	3(2)	2(0)
Eurodollar	5(5)	0(0)	5(5)	0(0)
MONTHLY				
Germany	0(0)	21(6)	17(3)	4(0)
Switzerland	20(4)	1(0)	21(10)	0(0)
Japan	21(21)	0(0)	21(21)	0(0)
Canada	21(21)	0(0)	21(21)	0(0)
U.K.	7(0)	14(0)	17(1)	4(0)
Eurodollar	21(21)	0(0)	21(21)	0(0)

REFERENCES

Abrams, Richard K., "Actual and Potential International Trade Flows and Flexible Exchange Rates." unpublished paper, Federal Reserve Bank of Kansas City, August 1979.

Akhtar, M.A., and Bluford Putnam, "Money Demand and Foreign Exchange Risk: The German Case, 1972-1976," The Journal of Finance, Vol. 25, June 1980, pp. 787-794.

Blackhurst, Richard, and Jan Tumlir, "Trade Relations Under Flexible Exchange Rates," GATT Studies in International Trade, number 8, Geneva, September 1980.

Clark, Peter B., "Uncertainty, Exchange Risk, and the Level of International Trade," Western Economic Journal, Vol. 11 (September 1973), pp. 302-13.

________, and Charles J. Haulk, "Flexible Exchange Rates and the Level of Trade: A Preliminary Analysis of the Canadian Experience," unpublished paper, Federal Reserve Board, 1972.

Cushman, David O., "The Effects of Exchange Rate Risk on International Trade and Direct Investment," unpublished Ph.D dissertation, Vanderbilt University, 1980.

Frenkel, Jacob A., and Michael L. Mussa, "Monetary and Fiscal Policies in an Open Economy," National Bureau of Economic Research Working Paper No. 575, National Bureau of Economic Research, October 1980.

Dooley, Michael,"Exchange Rate Expectations, Portfolio Balance and the Reflow Hypothesis," Proceedings of the Southwestern Finance Association, Bureau of Business Research, University of Texas at Austin, March 1975.

Goldstein, Morris, "Downward Price Inflexibility, Ratchet Effects and the Inflationary Impact of Import Price Changes: Some Empirical Tests," IMF Staff Papers, November 1977, pp. 569-612.

Hooper, Peter, and Steven Kohlhagen, "The Effects of Exchange Rate Uncertainty on the Prices and Volume of International Trade," Journal of International Economics, Vol. 8, November 1978, pp. 483-511.

Hooper, Peter, and John Morton, "Fluctuations in the Dollar: A Model of Nominal and Real Exchange Rate Determination," International Finance Discussion Paper, No. 168, November 1980.

Kenen, Peter B., "Exchange-Rate Variability -- Measurement and Implications," memorandum for Consultative Group on International Economic and Monetary Affairs, International Finance Section, Department of Economics, Princeton University, June 20, 1979.

Makin, John, "Eurocurrencies and the Evolution of the International Monetary System," Eurocurrencies and the International Monetary System, edited by Carl Stem, et al., Washington, D.C.: American Enterprise Institute, 1976, pp. 17-52.