# Forecasting Currency in Circulation *

Currency in circulation is one of the more important factors that absorb or supply member bank reserves.[1] The short-term movements in this and other reserve factors which are outside the direct control of the Federal Reserve System are capable of absorbing or adding substantial amounts to the reserves available to member banks.[2] These fluctuations could be disturbing to the credit and money markets and might create mistaken impressions regarding the current posture of monetary policy. The Federal Reserve generally attempts to minimize these problems by offsetting the changes in these reserve factors through appropriate open market operations. In order to assist the Manager of the System Open Market Account in determining and anticipating the need for such operations, forecasts have been prepared at this Bank for many years.[3] An earlier article discussed the techniques for forecasting one of these factors—float[4]—while this article describes forecasting methods for currency in circulation and discusses some of the principal factors causing variations in this factor.

Changes in the amount of currency in circulation affect the reserve positions of member banks, because their accounts with the Reserve Banks are debited when they withdraw currency from the Reserve Banks and credited when they return it.[5] To be sure, the effect on bank reserves of such withdrawals and deposits is not immediate if there is a compensating change in vault cash. But aggregate vault cash holdings, which can be counted in the banks' reserves,[6] do not normally fluctuate greatly over time. Hence, movements of currency in circulation principally reflect the effect on bank reserves of changes in public demand for currency.[7]

## PREDICTABILITY OF CURRENCY MOVEMENTS

Of the major operating factors that affect member bank reserve positions, the periodic changes in the demand for currency are the least difficult to predict. Seasonal changes in currency demand are not highly volatile and remain relatively stable from year to year. Unlike float, the amount of currency in circulation is generally not influenced by such erratic factors as weather or work overloads in bank transit departments. Furthermore, the flows of currency to and from Reserve Banks are determined to some extent by the forecasts each member bank makes of its own currency needs, and since these individual forecasts are in turn largely based on past experience, there is a natural tendency toward repetitiveness.

Cyclical or longer run factors do, however, influence the demand for currency. These influences are more dif-

* Irving Auerbach had primary responsibility for the preparation of this article.

[1] As used in Federal Reserve statistics, the term "currency in circulation" includes paper bills and subsidiary coin issued by the Treasury and the Federal Reserve Banks and held either by the public or in bank vaults, but excludes currency held by the Treasury or the Reserve Banks themselves. In comparison, the term "currency outside banks" represents currency in circulation less vault cash held by commercial banks.

[2] The other factors are float, Treasury operations, vault cash (if considered separately from total currency in circulation), and required reserves. Actual changes in each of the major factors affecting bank reserves for the preceding month appear regularly in this *Review* in the article on the money market.

[3] For a description of the role served by the reserve projections in the System's decision-making processes, see Robert V. Roosa, *Federal Reserve Operations in the Money and Government Securities Markets* (Federal Reserve Bank of New York, 1956), Chapter VII.

[4] See "Forecasting Float", this *Review*, February 1963, pp. 30-35.

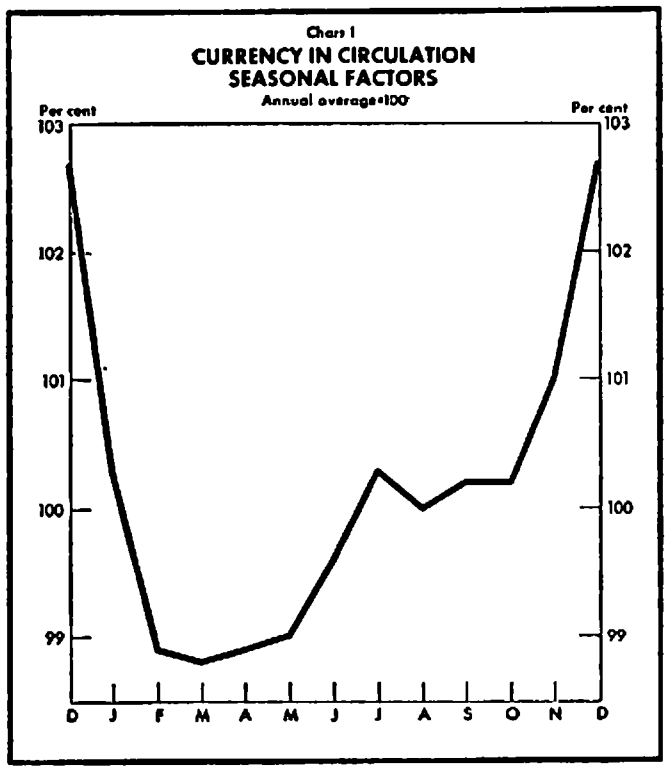
[5] When Treasury currency increases, the amount of currency in circulation expands without affecting bank reserve positions because the reserves absorbed when this currency is first issued accrue to the Treasury and are later returned to the banking system as the Treasury uses the funds to meet Government expenditures.

[6] In December 1959, member banks were permitted to count part of their vault cash as reserves. Since November 24, 1960, all vault cash has been eligible.

[7] For determining the reserve effects of currency flows, estimating the change in currency outside banks (i.e., currency in circulation minus vault cash) would be more direct and require less effort. However, it has been found that more accurate results can be obtained by estimating changes in vault cash and total currency in circulation separately.

ficult to anticipate than seasonal movements; they do not constitute a major forecasting obstacle, however, since such demand shifts tend to be gradual and spread over a period of months or years. There have been only two periods since the 1920's when unusual influences caused large fluctuations in currency in circulation. The first was during the Great Depression (mid-1931 to early 1934) and the second during World War II. There is some question whether recent larger than usual month-to-month changes may portend a third period of extraordinary changes in demand. This intriguing question—which is easier to come by than the answer—is discussed in a later section.

With these exceptions, the month-to-month fluctuations in seasonally adjusted levels since 1929 have seldom been larger than 3/10 of a percentage point. In terms of today's levels, this means that seasonally adjusted figures for currency in circulation rarely change by more than $110 million from one month to the next. Thus, even if the change in the demand for currency attributable to special factors is not correctly predicted, it is unlikely that forecasts of the current month's level will be off by more than about $100 million. Furthermore, whatever error exists will probably be distributed over the daily estimates for the month as a whole rather than be concentrated in a brief period. With Federal Reserve float, in contrast, forecasting errors of as much as $200 million in one week are fairly common.




### FORECASTING TECHNIQUES

The technique used in forecasting the daily changes in currency in circulation is almost identical to that used for estimating float movements. Seasonally adjusted monthly averages are derived by extrapolating the observed trend for recent months and multiplying the results by an appropriate seasonal factor for each month. Intramonthly patterns are then applied to these adjusted monthly totals, and the resulting daily levels are adjusted by an intraweekly term. Finally, daily changes are derived from these estimated levels and compared with the actual changes for analogous days in previous years. Whenever the current estimate differs widely from the figures for past years and there appears to be no ready explanation, the estimates are re-examined and sometimes adjusted.

DERIVING THE BASE LEVEL. The basic demand for currency is influenced by a number of factors. The most important of these is the growth of business activity and of population, although other influences—general habits with regard to the amount of pocket money carried, the degree of public confidence in the banking system, shifts in bank policies with respect to vault cash, and hoarding currency for tax evasion—can at times also have a significant effect on the demand for currency. Even the relationship between currency demand and the growth in population and economic activity is not precise, however, and the influence of some of the other factors is frequently difficult to measure or to predict. The estimated base level for short-run forecasts of changes in currency, therefore, is derived by using a straight-line projection of the current rate of increase. Only in long-range forecasts is an attempt made to relate the demand for currency to longer run factors of varying predictability.

OBTAINING THE MONTHLY AVERAGE LEVELS. The average estimated level of currency outstanding for any given month is prepared by applying the appropriate seasonal factor to the estimated base level.[8] As Chart I indicates, there are strong seasonal influences on the demand for currency; the three most pronounced are summer vaca-

[8] The seasonal factors are obtained by using the Census X-9 computer method. This program provides moving seasonals, but the patterns have not changed significantly from year to year.

tions, Christmas, and the usual business lull during the winter months.

The amount of currency in circulation is at its annual peak in December at the height of the Christmas shopping rush. It declines sharply during January and February—as cash spent by holiday shoppers and vacationers flows back to the banks—and more moderately in March. The revival of economic activity in the spring, combined with Easter spending, stimulates a modest rise in April and May. Demand becomes much larger in June with the advent of the vacation season and the Independence Day holiday, and for July the seasonal factor reaches a secondary peak of 100.3. The needs for currency ease off in August, but with the beginning of fall they increase steadily. The monthly seasonal factors rise from 100.2 in October to 101.0 in November and then to 102.7 in December.[9]

INTRAMONTHLY PATTERNS. Within any given month, the primary influences on the demand for currency are payrolls and bills. For both purposes the increase in demand tends to be concentrated at the turn of the month. Thus, as shown in Chart II, currency begins to flow out from the Reserve Banks on or about the eighteenth working day of the month, partly because the banks are then increasing their stock of currency in anticipation of the public's needs. By the eighth working day of the following month, the outflow typically reaches the monthly peak and cash begins to flow back. The net outflow from one month's low to the next month's peak generally amounts to about $220 million.

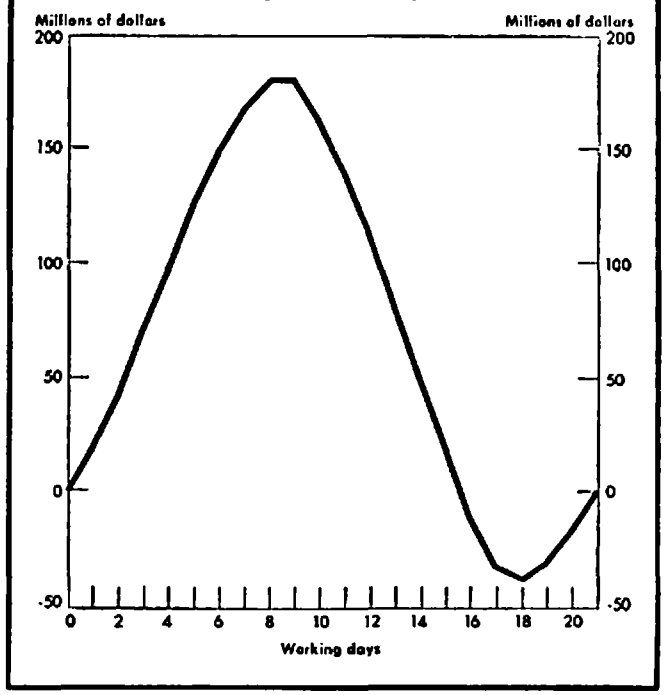
Demands within a month are also influenced, however, by holidays and by the seasonal forces noted earlier. As a result, each month has its own pattern, and there is considerable variation among them. In January, the post-Christmas return flow outweighs all other influences. The patterns for May, June, July, and September are skewed by the demands accompanying the Memorial Day, Independence Day, and Labor Day holidays. Thanksgiving has a marked effect on the November pattern, and that for December, of course, primarily reflects Christmas.

As a first step in developing a pattern for a particular month, a chart is plotted showing each working day's value for that month over at least the five preceding years as a percentage of the monthly average, after adjusting the daily totals by an intraweekly "seasonal" to remove

Chart II

**CURRENCY IN CIRCULATION**
**TYPICAL MONTHLY PATTERN**

Cumulated changes from first working day of month




the influence of the day of the week. The mode of each day's observations is then selected by inspection. If the points do not fall within a narrow area, greater weight is given to the observations for the most recent years. These modal points are then adjusted to make their average value equal to 100. The results are multiplied by the estimated daily average for the month in order to obtain an estimated level of currency in circulation for each day of the month.

The most typical of all the monthly patterns, that for August, is shown in Chart III. Even in that case, it is obvious that at the beginning and the end of the month the points plotted for the past five years are widely dispersed. The differences at the beginning of the month cannot be readily explained. Those at the end are related to the Labor Day holiday. In each instance, the upturn starts on the Monday prior to the holiday, whatever that date may be.

HOLIDAYS. Since holidays are usually determined by calendar days and the monthly charts are based on the working days, a major holiday tends to obscure the alignment of the daily observations on the charts. To overcome this problem, separate charts are prepared for each ma-

[9] The movements of the seasonal factors are small in relative terms but large in absolute terms, since the amount of currency in circulation today exceeds $36 billion.

jor holiday. The data are then aligned in terms of the days preceding and following the holiday, and the modal points for the days influenced by the holiday are selected. These points are superimposed on the monthly chart and integrated into the other observations.

The effect of holidays on the demand for currency varies, depending on how generally the holiday is observed, the amount of increased spending associated with the day, and the proximity to a week end. The special demand for currency generated by the holiday generally begins to develop about five days in advance and extends for one day after the holiday itself. The duration of the return flow varies so widely that it is not readily subject to generalization. Holidays frequently serve as the starting point for a large seasonal change in cash demands; when this occurs, the post-holiday movement cannot be isolated from other seasonal influences.

ADJUSTING FOR INTRAWEEKLY FACTORS. To adjust the forecasts for the influence of the day of the week, the appropriate intraweekly arithmetic term is added to the estimated level for each day that is read off the monthly chart, and estimated daily changes are then computed. Absolute, rather than relative, values are used for the intraweekly factors, because they are a function of the day of the week and are not closely related to changes in the size of currency movements or to intramonthly, seasonal, or trend forces.

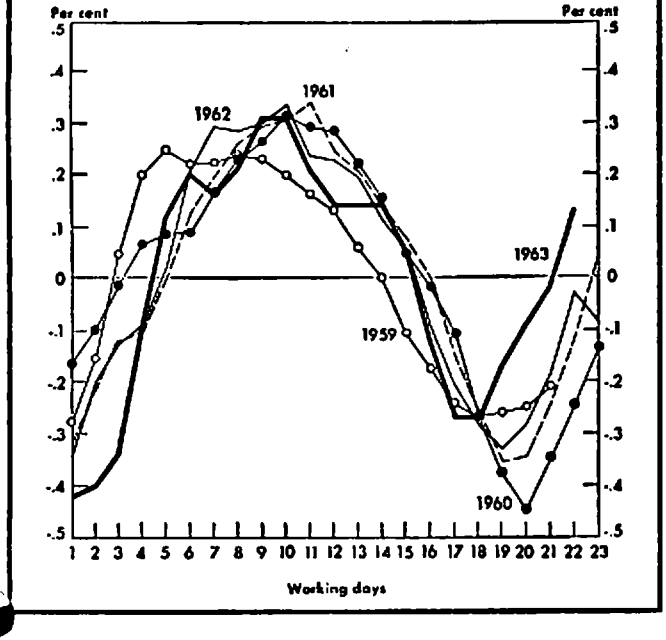
The intraweekly currency factors have been modified considerably since banks were permitted to count their vault cash as part of their reserve balances in 1960. Previously, there was a heavy outflow of currency from the Reserve Banks on Thursdays, when the banks prepared to meet large cash withdrawals on Fridays for payrolls and week-end needs. Now the Thursday outflow is down to only $5 million, since banks no longer have an incentive to keep their vault cash at minimum levels in order to maximize their reserve balances. On Fridays, about $30 million usually flows back as banks with excess currency return the cash to avoid having it in their vaults over the week end. Cash withdrawals on that day are negligible, because most banking offices would receive supplies too late to meet their depositors' needs.

On Mondays, there is a $25 million outflow to banks, probably to replenish the vault cash holdings of banks that experienced heavy pre-week-end drains. The final two days of the Federal Reserve statement week—Tuesday and Wednesday—have no consistent pattern. In the past, a large decline in currency outstanding occurred on Tuesdays, when the banks returned the cash deposits they had received on Mondays in order to replenish their reserve accounts.

Chart III

CURRENCY IN CIRCULATION
AUGUST INTRAMONTHLY PATTERN

Percentage deviation from working-day average; adjusted data, 1959 - 63




ADJUSTING FOR FORECASTING ERRORS. The daily forecasts of changes in the amount of currency in circulation are reviewed as actual figures become available. If there was a large error in the estimate for a particular day, a decision must be made whether to alter the estimated changes for the days ahead—in order to keep the same net outflow or inflow over a week or a month—or to assume the level has changed. Ordinarily, the subsequent daily estimates are routinely adjusted to retain the same net flow for the period, unless sufficient evidence has accumulated to indicate that the original target level for the longer period is off. Determining what is "sufficient evidence" requires considerable knowledge of the behavior of the data, but even with that the correct choice is not always made.

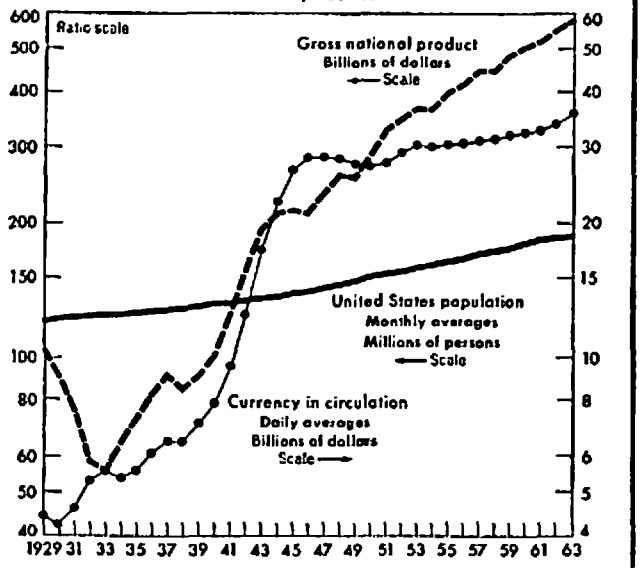
## TRENDS IN THE BASIC DEMAND FOR CURRENCY

Most of the long-term increase in currency, as noted earlier, is accounted for by growth in population and in the dollar volume of economic transactions. But the rates of expansion have seldom been parallel over consecutive long periods (see Chart IV). During the early 1930's, when bank failures reached record levels and fearful de-

Chart IV

**CURRENCY IN CIRCULATION, GROSS NATIONAL PRODUCT, AND TOTAL POPULATION**

Annually 1929 - 63




Note: Gross national product estimated for fourth quarter 1963, and population estimated for October - December 1963.

positors preferred cash, currency outstanding increased rapidly despite the economic contraction. In World War II, the sharp rise in prices, the large number of transient soldiers and defense workers, and hoarding to cover up black market activities and tax evasion combined to produce a larger relative increase in currency than in gross national product. During most of the postwar period, on the other hand, the increase in currency has been considerably slower than the growth in economic activity partly because redundant amounts put into circulation during the war were gradually absorbed into active use. Most recently—beginning in late 1961—the demand for currency began to accelerate, suggesting that some special factors may again be at work.

Over the past two years the rate of growth in GNP has been considerably less than the rates experienced during the Korean war years and in 1955 and 1959, which were years of economic boom. Yet the average annual increase of currency in circulation in 1962 and 1963 (4.5 per cent) was more than twice the 1959 and 1950-53 increases and over six times the 1955 increase; moreover, it was triple the 1.5 per cent average annual rate of increase for the 1950's as a whole. As a result, the postwar decline of currency in circulation as a percentage of GNP virtually stopped in 1963. At the end of 1946, currency in circulation was equal to 13.4 per cent of GNP for that year. By 1962 the ratio had declined to 6.1 per cent, and it remained there in 1963. Nevertheless, this is a fairly high level by historical standards—the 1929 ratio, for example, was 4.3 per cent. Measured as a proportion of the money supply, currency in circulation has actually begun to show a modest increase. The significance of this observation, however, needs to be qualified—a considerable proportion of the recent large increases in bank credit has been reflected in rising time deposits rather than in either demand deposits or currency in circulation.[10]

There is no single clear-cut explanation of the recent increase in the demand for currency, but several factors that may have contributed are worth noting. For one thing, economizing on the use of cash may have gone as far as is possible within present institutional patterns. If so, any given increase in economic activity now or in the near future may require a somewhat larger rise of currency in circulation than formerly.[11]

A second factor is undoubtedly the increased amount of vault cash currently being held by banks. This increase may, in turn, have several causes: a rising demand for currency on the part of the general public and hence a need for the banks to maintain larger working balances; an attempt by the banks to lay in additional supplies of coin in the face of the current coin shortage; and possibly a continuing adjustment to the change in the Federal Reserve Act which permitted banks to count vault cash as part of their legal reserves. However, if the $480 million increase in vault cash during 1962 and 1963 (9 per cent per year) is subtracted from the increase in total currency in circulation, the absolute increase in that part of the total held by the public is still substantially larger than in any other postwar year except 1952 and 1953. In comparison with those two previous years of rapid growth in the public's demand for currency, the current increase is somewhat greater in absolute terms but about equal in relative terms.

A third factor is the rapid rate of growth in the demand for coins, in conjunction with the phenomenal expansion in the use of vending machines. There has also been a

[10] For a discussion of the long-range relationship between currency and the money supply, and the factors influencing this relationship, see Phillip Cagan, *The Demand for Currency Relative to Total Money Supply*, (Occasional Paper 62, National Bureau of Economic Research, 1958).

[11] Unfortunately, it is not feasible to measure the rate of turnover of currency in circulation. If this could be done and a recent substantial rise in that rate be established, the point might become more nearly subject to proof, although no obvious upper limit to such a velocity increase necessarily exists.

large increase in the demand for silver dollars, apparently reflecting the hope that a further rise in the price of silver will make it profitable to sell these coins as bullion. Coin shortages themselves encourage hoarding, thus adding to the demand. Coins, however, usually represent only some 8 per cent of currency in circulation.

But the increases in vault cash and coin are only part of the story, for the expansion in the public's demand for bills also appears to have exceeded the rise that might be attributed to increased transactions needs. Two explanations for this new demand have been suggested. One is the marked increase in the relative number of teen-agers, many of whom earn and spend quite a bit of money but few of whom have checking accounts. The proportion of youngsters in the 15-19 age group in the total population rose from 7.5 per cent in 1961 to 8.0 per cent in 1962 and to 8.2 per cent last year. Between 1950 and 1956, in contrast, the proportion of teen-agers in the total population declined, and it rose by only 1/10 to 3/10 of a percentage point annually from 1956 through 1960.

Another suggested explanation is an increase in the demand for currency by would-be income tax evaders who seek cash payments in attempting to conceal current income or who are converting into cash other more readily traceable assets in what would probably be a vain attempt to hide past delinquencies. It is possible that these attempts may be related to recent Congressional and administrative moves to enforce fuller reporting of certain kinds of income.

## CONCLUDING COMMENT

It is readily apparent that forecasting currency, while a highly technical problem, cannot be considered in isolation from the more general monetary, economic, and institutional factors that affect buying and spending habits. For this reason and because of the inherent variability of the data, the accuracy of the forecasts should not be expected to attain perfection, although further refinements and other improvements of the forecasts are subjects of constant study.