Because the trends are masked by cyclical and other temporary random fluctuations. In chart 1 we have plotted the correlation coefficients calculated between the M-1B growth in period t and each of the changes in the GNP deflator in period t and the 16 quarters following. Few of the correlation coefficients are greater than two standard deviations. Only the correlations calculated at 7, 8, 9, and 10 quarters are significant at a 95 percent confidence level.

We have included some results using regression analysis in the appendix. To summarize briefly—regardless of the definition of the money supply used—the best fitting specifications are those including 16 lagged differences of money supply growth. To be sure, significant impacts of money growth on inflation occur in the sixth through the twelfth lagged quarters. These results are consistent with the correlations presented in chart 1.

The evidence indicates that we should expect to wait a substantial period of time between the achievement of slower money growth and subsequent reports of lower inflation rates. Precisely how long will depend on the speed with which people recognize the change in money supply growth and adjust their expectations. If slower money growth results in rapidly changing expectations, reported inflation will fall more quickly. Past inflation is embedded in contracts that may tend to slow the inflation-suppressing effects of reduced money growth. Even the most optimistic estimates indicate a lag well in excess of one year before reduced money supply growth has a significant effect on inflation. It may be as long as four years before the full effect is felt. It is possible that the negative short-run output and unemployment effects of the slower money growth will be substantial. However, these short-run effects are both less certain and less enduring than the adverse long-run price effects of fast money growth.

### Appendix

Using regression analysis, we have estimated the relationship between the growth rate of the GNP deflator and various definitions of the money supply. Both theory and evidence suggest that the short-term (quarter-to-quarter) change in the aggregate price level depends on many factors other than the money supply. However, the non-monetary shocks have only a temporary effect unless they are accommodated by an increasing money supply.

The model used to generate the results in table 2 is given in equations 1 and 2:

\[(1) \Delta \pi_t = \beta_0 + \beta_1 \Delta M_{1B} \Delta t + \epsilon_t\]

\[(2) U_t = \beta_2 \Delta M_{1B} \Delta t + \epsilon_t\]

In equation 1, the GNP deflator (\(\pi\)) was represented as the change in the logarithm of the GNP deflator. In equation 2, the coefficient calculated between \(\Delta M_{1B}\) growth and subsequent reports of lower inflation was significant in every instance. This systematic behavior of the error term suggests that there are variables missing from equation 1. This is a quarterly model of inflation. All of the non-monetary variables that affect price indexes through demand or supply in the short run have been omitted. This point here is not to forecast or "explain" short-run growth in the GNP deflator; rather, it is to show a long-term relationship between money growth and this inflation index.


### Table 2: Estimates of the Price Equation

<table>
<thead>
<tr>
<th>Year</th>
<th>(n)</th>
<th>(\bar{M}_{1B})</th>
<th>(\bar{M}_{1B} - \bar{M}_0)</th>
<th>(\Delta \pi)</th>
<th>(\Delta M_{1B})</th>
<th>(U_t)</th>
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</thead>
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<tr>
<td>1964</td>
<td>10</td>
<td>0.883</td>
<td>0.107</td>
<td>1.474</td>
<td>0.637</td>
<td></td>
</tr>
<tr>
<td>1965</td>
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<td>0.905</td>
<td>0.116</td>
<td>1.473</td>
<td>0.639</td>
<td></td>
</tr>
<tr>
<td>1966</td>
<td>16</td>
<td>0.885</td>
<td>0.120</td>
<td>1.480</td>
<td>0.637</td>
<td></td>
</tr>
<tr>
<td>1967</td>
<td>18</td>
<td>0.864</td>
<td>0.125</td>
<td>1.472</td>
<td>0.667</td>
<td></td>
</tr>
</tbody>
</table>

### Table 3: Regression Results

<table>
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<th>Year</th>
<th>(I)</th>
<th>(I^I)</th>
<th>(I^II)</th>
<th>(I^III)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1964</td>
<td>0.883</td>
<td>0.107</td>
<td>1.474</td>
<td>0.637</td>
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<tr>
<td>1965</td>
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<td>1967</td>
<td>0.864</td>
<td>0.125</td>
<td>1.472</td>
<td>0.667</td>
</tr>
</tbody>
</table>

### References

On October 6, 1979, the Federal Reserve System changed its operating procedures for monetary policy. The period following that change has been one of turbulence in the money market. Interest rates may no less than previously be expected to change in the short run than the relationship between interest rates and the money supply. However, if there is a change, the operation of the new procedure indicates adjustments in bank reserves and subsequently market interest rates that tend to return the money supply growth to its desired path. The desired paths, or, more accurately, the target ranges for each of the monetary aggregates, are set by the Federal Open Market Committee (FOMC). Each year the FOMC must report its plans to Congress pursuant to the Full Employment and Balanced Growth Act of 1978 (the Humphrey-Hawkins Act). Because the Federal Reserve has selected targets that are low enough to slow inflation, we can expect increased pressure in the credit markets.

### Inflation

Inflation is defined as "an increase in the volume of money and credit relative to available goods, resulting in a substantial and permanent increase in prices." 1 The opinions stated herein are those of the author and not necessarily those of the Federal Reserve Bank of Cleveland or of the Board of Governors of the Federal Reserve System.


Federal Reserve Bank of Cleveland
February 23, 1981

Inflation Interest Rates, and Monetary Growth

William T. Gavin

Under the new procedures, the relationship between the supply of reserves and money is estimated, and operating targets are set. These are reserved for the relationship between monetary targets and the money supply. Interest rates may now be expected to change less than previously in the short run than the relationship between interest rates and the money supply. However, if there is a change, the operation of the new procedure indicates adjustments in bank reserves and subsequently market interest rates that tend to return the money supply growth to its desired path. The desired paths, or, more accurately, the target ranges for each of the monetary aggregates, are set by the Federal Open Market Committee (FOMC). Each year the FOMC must report its plans to Congress pursuant to the Full Employment and Balanced Growth Act of 1978 (the Humphrey-Hawkins Act). Because the Federal Reserve has selected targets that are low enough to slow inflation, we can expect increased pressure in the credit markets. To see why this pressure is necessary, it is important to understand the basic relationships between inflation, interest rates, and the money supply.

Inflation is defined as "an increase in the volume of money and credit relative to available goods, resulting in a substantial and permanent increase in prices." 1 The opinions stated herein are those of the author and not necessarily those of the Federal Reserve Bank of Cleveland or of the Board of Governors of the Federal Reserve System.

The farm-product component of food will result in a substantial and continuing rise in the general price level. There is an important distinction between this definition and a popular misconception that results from our attempts to measure the general price level. By necessity, the general price level is measured as the increasing prices of individual goods and services and constructing indexes, such as the consumer price index (CPI), the wholesale price index (WPI), and the GNP deflator. Through this procedure, we tend to think of inflation as an increase in the price index so that any increase in an index is labeled "inflation." Yet many individual price increases that affect the CPI or the WPI are not truly inflationary. As an example, the drop in food prices in 1980 decreased the supply of many farm products. As food prices rose, so did all the price indexes that include food. In one sense, the increased prices of food caused inflation. In another and more important sense, they did not. If we do not have a drought in 1981 and if everything else is unchanged, the price of the farm-product component of food will return to its previous level.

Inflation causes a continuing increase in the general price level. Such an increase is not likely to occur unless it causes or is accompanied by a substantial increase in the volume of money and credit relative to available goods. Moreover, inflation is generally reflected in corresponding movements in the prices of all goods and services. Like other prices, interest rates fluctuate with changes in supply and demand. The market interest rate has two components—a premium for expected inflation and the real interest rate. The premium for expected inflation is the amount that borrowers must pay lenders so that the real rate of interest is maintained over the life of the contract. The real interest rate is the market interest rate minus the expected inflation premium.

Open market operations of the Federal Reserve System are a major determinant of the short-run supply function for loanable funds. A purchase of government securities through the open market operation will cause the market interest rate to rise (see table 1, column 4). The Federal Reserve System uses the open market operations to control the supply of loanable funds. Like other prices, interest rates fluctuate with changes in supply and demand. The market interest rate has two components—a premium for expected inflation and the real interest rate. The premium for expected inflation is the amount that borrowers must pay lenders so that the real rate of interest is maintained over the life of the contract. The real interest rate is the market interest rate minus the expected inflation premium.

The money supply is a difficult variable to define empirically, because the word money has many meanings. The way the money supply is calculated depends on the way the calculations will be used. As a measure of transaction balances, the money supply usually is defined as currency plus checkable deposits (M-1B). As a measure of the store-of-value function, savings and various time deposits also are included (M-2). As a measure of the money supply in theoretical economic models, the monetary base is often used, because it represents government supply of fiat money and a control variable of the monetary authorities. The monetary base is the sum of currency in circulation plus bank reserves on deposit with the Federal Reserve System.

Practical problems in defining money have led the Federal Reserve to adopt multiple targets. Each aggregate moves differently over seasonal and cyclical periods. Even in the long run, the trends in each of the aggregates can vary, as many of the individual components respond differently with respect to technology, interest rates, and income. However, differences in long-run trends can be observed and incorporated into the target-setting stage in policy formulation. High inflation today reflects the fact that all of the aggregates have grown too rapidly in the past. Reversing this trend will cause interest rates to go down in the short run, but it will not have an immediate effect on prices. The lag between decreases in money growth and decreases in inflation is lengthy and variable. Moreover, it depends on how quickly people recognize the reduction in money supply growth and come to believe that it will persist. In other words, inflation expectations will not drop until a substantial and continual decrease in the money supply occurs. If money supply growth is reduced in the face of continuing inflation, interest rates rise and marginal credit demands are crowded out of the marketplace.