

# Monetary Policy and Economic Performance: Evidence From Single Equation Models

*By Bryon Higgins and V. Vance Roley*

Economists and other analysts generally agree that monetary policy actions taken by the Federal Reserve have an important impact on the economy. This agreement is not, however, accompanied by a consensus on how best to analyze and measure the effects of policy actions. An increasing number of observers argue that policy actions should be measured by movements in the money supply and that the Federal Reserve should focus on the money supply in the implementation of monetary policy. These observers emphasize the money supply because they believe that monetary policy actions affect the economy primarily through their impact on the money supply. Monetarists have presented theoretical and empirical evidence of a close relationship between the money supply and nominal gross national product (GNP) to support this view. Empirical results derived from direct estimation of the relationship between the money supply and GNP using single equation econometric models have been a particularly influential type of evidence provided by monetarists to bolster their position.

Neither monetarists nor others, however, have made extensive use of the single equation approach to investigate the relationship between GNP and financial variables other than the money supply, such as interest rates. Theoretical considerations, however, suggest that interest rates as well as the money supply

have important effects on the economy. Thus, economic theory supports the nonmonetarist view that the Federal Reserve should consider the effect of policy actions on interest rates as well as the money supply. In light of these theoretical considerations, the single equation approach is employed in this article to investigate and compare the empirical relationships between GNP and a number of financial variables, including interest rates as well as the money supply. The first section of the article presents a general overview of the way monetary policy actions affect the economy, analyzes the advantages and disadvantages of the single equation approach, and discusses alternative financial variables that may usefully be included when employing the single equation econometric technique. The second section presents empirical evidence derived from use of the single equation approach to compare the relationships between GNP and alternative financial variables.

## MONETARY POLICY AND GNP

Researchers have investigated the impact of monetary policy actions on nominal **GNP**—which measures aggregate spending on goods and services by households, businesses, government, and foreigners—because it is generally believed that policy actions affect the economy primarily by influencing aggregate spending.

Aggregate spending, in turn, directly affects the production of goods and services and the unemployment and inflation rates. Thus, the primary goal of monetary policy is to achieve GNP growth that is consistent with the ultimate objectives of monetary policy—high employment, economic growth, price stability, and a sustainable pattern of international transactions.

### **General Overview of the Effects of Monetary Policy Actions**

Federal Reserve policy actions affect GNP by influencing a wide range of financial and nonfinancial variables that affect spending decisions of households and businesses. The Federal Reserve most directly affects financial variables that are closely related to the reserve positions of banks. The Federal funds rate and the monetary base, for example, are so directly affected by policy actions that they could be controlled with a considerable degree of precision by the Federal Reserve. Financial variables that are less closely related to banks' reserve positions, such as monetary and credit aggregates and market interest rates, are less directly affected by monetary policy actions and are therefore subject to somewhat less precise control by the Federal Reserve. The effects of policy actions on nonfinancial variables are even more remote.

The effects of policy actions are reflected first in financial variables such as the Federal funds rate and the monetary base and are subsequently transmitted to other financial and nonfinancial variables. After affecting the Federal funds rate and the monetary base, policy actions affect banks' willingness to expand loans, investments, and deposits. The adjustment in banks' portfolios results in a change in the yield on a whole spectrum of real and financial assets. These changes in relative yields induce portfolio realignments by other

financial and nonfinancial businesses and by households. The resulting changes in the cost of credit and the implicit yields on real assets affect spending behavior of both businesses and households directly. The change in the level of interest rates also affects the market value of the existing stock of bonds, equities, and other assets. The resulting effect on total wealth also influences the spending decisions of consumers. Finally, because of institutional arrangements that constrain lending rates in certain sectors of the economy, a change in the level of interest rates may affect the availability as well as the cost of credit. This credit availability effect also influences spending decisions, particularly in the housing sector.

The response of aggregate spending to monetary policy actions leads to a change in aggregate production and income, which results in further changes in the demand for money and credit. This feedback effect generates additional changes in portfolio choices, the cost and availability of credit and total wealth, which lead to further changes in spending and additional feedback effects.

Because of lagged adjustment of businesses and households and the complexity of the interrelations among various sectors of the economy, the ultimate impact of monetary policy actions on the aggregate demand for goods and services may occur over a period of several months or even years. Thus, it is difficult to predict the timing as well as the magnitude of the effects of alternative policy actions.

### **Structural Versus Single Equation Approaches to Measuring the Impact of Monetary Policy**

There are several possible methods of investigating relationships between GNP and those financial variables that are potentially useful as measures of the effects of monetary

policy actions. One method is to employ a disaggregated structural model of the economy to analyze the response of each of the components of aggregate spending to monetary policy actions. This is done by estimating the parameters of several major economic relations thought to be important in the transmission mechanism for monetary policy. The resulting equations are combined to form a structural model of the economy. The model provides a consistent set of empirical relationships that reflects spending responses of economic decisionmakers to policy actions. After the parameters are estimated, the model may be used to predict the effects of policy actions on GNP and on each of the components of aggregate spending.

Another method of analyzing relationships between GNP and financial variables is the single equation approach. In recent years, single equation models of total spending have become increasingly popular as tools for investigating the impact of policy actions. This approach has been used extensively by researchers at the Federal Reserve Bank of St. Louis. As the term implies, a single equation model uses one equation containing one or more key variables to explain movements in GNP without attempting to explain its separate components. A single equation model may be viewed as a summary of, or a "reduced form" solution to, a structural model. Thus, the single equation implicitly incorporates all of the complex interrelationships that are explicitly allowed for in a structural model. In this sense, the single equation and structural approaches to policy analysis and economic prediction are consistent in principle.<sup>1</sup>

---

<sup>1</sup> There can be serious statistical problems in estimating a single equation model when the financial variable used as an explanatory variable was not the variable policymakers tried to control during the period for which the equation is estimated. For a discussion of potential simultaneity bias,

A disadvantage of the single equation approach is that it cannot be used to analyze the impact of policy actions on the individual components of aggregate spending.<sup>2</sup> Furthermore, the mechanisms by which policy actions are transmitted to spending behavior of households and businesses cannot be determined within the framework of a single equation model. Thus, it is impossible to discriminate precisely between alternative theories of the exact channels through which monetary policy actions affect the economy using the single equation approach. For some purposes, however, detailed information about the transmission mechanism of policy actions may not be as important as a reliable indication of their total effect on aggregate spending.

One of the primary advantages of the single equation approach is that it does not require detailed knowledge of the structure of the economy. Those who advocate the single equation approach to policy analysis believe that the interrelationships in the economy are too complex to be represented in an econometric model of the economy.<sup>3</sup> If so, it may be preferable to base predictions on the direct relationship between policy actions and total spending rather than risk omission of an important link in the transmission mechanism. Once the relationships between aggregate

---

see Edward M. Gramlich, "The Usefulness of Monetary and Fiscal Policy as Discretionary Stabilization Tools," *Journal of Money, Credit and Banking*, Vol. 3 (May 1971).

<sup>2</sup> If policymakers have a policy horizon long enough to allow for changes in the capital stock, for example, they may sometimes prefer additional investment spending, which increases the capital stock, rather than consumption spending. In this situation, analysis of the effect of policy actions on aggregate demand disguises the possible benefits that would result from changing the current composition of aggregate demand toward greater investment in capital goods.

<sup>3</sup> See, for example, Michael W. Keran, "Monetary and Fiscal Influences on Economic Activity—The Historical Evidence," *Federal Reserve Bank of St. Louis Review*, Vol. 51, No. 11 (November 1969).

spending and financial variables have been estimated empirically by a single equation model, the model may be used to predict the level (or growth) of aggregate demand that would result from particular values of the variables used to measure the influence of monetary policy actions.

### **The Single Equation Approach and Alternative Financial Variables**

Those who use the single equation approach to policy analysis frequently rely on a single financial variable to measure the total influence of monetary policy on aggregate spending. It is very important that the financial variable used in a single equation model be the best single measure of the various influences of monetary policy actions on spending decisions. There is nothing inherent in the single equation approach that dictates the choice of a particular financial variable. Those who advocate the single equation approach to policy analysis, however, have generally favored the use of a monetary aggregate. Thus, the single equation approach has come to be identified with the monetarist view of policy analysis.

Most of the studies that have estimated single equation models of aggregate demand have used the narrowly defined money stock (**M1**) as the sole financial variable. Some have included a measure of fiscal policy, though, and a few have included a measure of strike activity.<sup>4</sup> The analysts using this approach have generally concluded that the relationship between **M1** and aggregate spending is sufficiently reliable to warrant use of a monetary growth target as the method of implementing monetary policy. Since the Federal Reserve cannot control monetary

growth directly, however, some analysts have advocated use of the monetary base as the monetary control **variable**.<sup>5</sup> The monetary base is composed of currency and reserves and is often considered to be a primary determinant of the money supply. Evidence from single equation models indicates that movements in aggregate spending are related almost as closely to the monetary base as to the money stock.

The evidence from single equation models of the close relationship between the growth of aggregate spending and the growth of the money supply has been interpreted by many as strong support of the monetarist belief that the Federal Reserve should focus on monetary and reserve aggregates in the implementation of monetary policy. Indeed, if GNP growth is closely related to monetary growth, it seems plausible for the Federal Reserve to set targets for these aggregates that appear to be consistent with the desired growth in aggregate spending. Thus, the evidence from single equation models has undoubtedly contributed to the Federal Reserve's increased emphasis on monetary aggregates in recent years.

Existing single equation studies, with few exceptions, have not considered the possibility that financial variables other than monetary aggregates may also be closely related to aggregate spending. The relationship between interest rates and aggregate spending, for example, has not been extensively explored within the framework of single equation models. Although there is no theoretical reason for preferring the use of a monetary or reserve aggregate to the use of an interest rate in a single equation model of aggregate demand, those who emphasize the importance of interest

---

<sup>4</sup> See, for example, Michael Hamburger, "Behavior of the Money Stock: Is There a Puzzle?" *Journal of Monetary Economics*, Vol. 3, 1977.

---

<sup>5</sup> See, for example, Leonall C. Andersen and Denis S. Karnosky, "Some Considerations in the Use of Monetary Aggregates for the Implementation of Monetary Policy," *Federal Reserve Bank of St. Louis Review*, Vol. 59, No. 9 (September 1977).

rates have generally believed that a more extensive model should be used to analyze their effects on economic activity. One study did, however, compare the explanatory power of a long-term interest rate and the money supply in single equation models of aggregate **spending**.<sup>6</sup> The empirical evidence led the author to conclude that "changes in interest rates do not give a systematic or consistent indication of monetary influences on economic activity and thus are not a reliable indicator" of the effects of policy actions on total demand.<sup>7</sup> The author concluded that policymakers should rely on movements in the money stock rather than movements in interest rates to measure the effects of policy actions on the economy.

The question of whether there is a close relationship between a short-term interest rate and aggregate spending has been neglected by previous studies employing the single equation approach. There is some reason to believe that movements in money market rates might be a better measure of the short-run effect of policy actions on spending than are movements in long-term rates. While monetary policy actions are reflected quickly in the money market and dominate movements in short-term rates, policy actions are only one of several important factors affecting longer term rates. In particular, the Federal funds **rate—the** rate on very short-term funds borrowed by commercial banks—is very sensitive to policy actions. Moreover, movements in the Federal funds rate have a major impact on expectations of the future course of monetary policy because the Federal Reserve establishes ranges for the Federal funds rate that seem consistent with attainment of policy objectives. Finally, the

extent to which depository institutions ration credit has been determined during several critical periods by the relation of ceiling rates on time and savings deposits to short-term market rates—which are directly affected by the Federal funds rate.

### A COMPARISON OF INTEREST RATES AND MONETARY AGGREGATES IN PREDICTING THE IMPACT OF MONETARY POLICY ACTIONS

In this section, the single equation approach is used to empirically investigate and compare the relationships between GNP and four financial variables that may potentially be used to measure the impact of policy actions. The variables are the narrowly defined money stock (**M1**), the monetary base, the corporate bond yield, and the Federal funds rate. The comparison is based on the relative ability of single equation models of the four relationships to predict changes in GNP. To use the equations to predict changes in GNP, the parameters of the equations were first estimated. The estimation procedures and results are discussed in the next subsection, followed by a discussion of the results of the predictions.

#### Estimation Results

The four equations are simple relations that have GNP as the dependent variable and the four financial variables as independent variables. In the equations, all variables are annualized quarterly percentage changes, with all variables except the interest rates being seasonally adjusted.<sup>8</sup> Each equation contains a

---

<sup>8</sup> Percentage changes of the form  $\frac{X_t - X_{t-1}}{X_t}$  were used

in computing growth rates for GNP and each of the financial variables. The results for the simple specification of Federal funds rate equation vary somewhat when alternative methods are used to compute growth rates. When positive and negative values of the first differences of logarithms of the Federal funds rate are entered as separate

---

<sup>6</sup> Michael W. Keran, "Selecting a Monetary Indicator—Evidence from the United States and Other Developed Countries," Federal Reserve Bank of St. Louis *Review*, Vol. 52, No. 9 (September 1970).

<sup>7</sup> Keran, "Selecting a Monetary Indicator— . . .," p. 12.

constant term that is intended to capture the average effects on GNP of variables omitted from the **equations**.<sup>9</sup> Because the changes in a **financial** variable may have an impact on spending decisions for a considerable time, each equation contains a distributed lag. The lag allows GNP growth to be explained by movements in the financial variable over a number of past periods.

The equation for the narrowly defined money stock (**M1**) is:

$$\% \Delta \text{GNP}_t = a_0 + \sum_{i=0}^N b_i (\% \Delta \text{M1}_{t-i}) + e_t$$

where  $\% \Delta \text{GNP}_t$  = percentage change in GNP at time t

$\% \Delta \text{M1}_{t-i}$  = percentage change in M1 at time t-i

$e_t$  = residual of estimated relationship at time t

$a_0, b_i$  = estimated parameters or coefficients

N = number of past periods a variable is assumed to affect GNP

$\sum_{i=0}^N b_i$  = sum of  $b_i$  parameters over the current period and N past periods.

The other three equations are similar to the **M1** equation.

---

variables in an equation explaining GNP growth, however, the results are similar to those reported for the Federal funds rate equation in this article. For a more detailed discussion of this issue, see **Bryon Higgins** and **V. Vance Roley**, "Reduced-Form Equations and Monetary Policy," Working Paper No. **79-1**, Federal Reserve Bank of Kansas City, **1979**. Growth rates are frequently used in estimating simple relationships between economic time series variables for statistical reasons. See, for example, **Michael J. Hamburger**, "Indicators of Monetary Policy: The Arguments and the Evidence," **American Economic Review**, **Vol. 62** (May **1970**); **Keith M. Carlson**, "Does the St. Louis Equation Now Believe in Fiscal Policy?" **Federal Reserve Bank of St. Louis Review**, **Vol. 60** (February **1978**).

<sup>9</sup> The estimated equations do not include any other potential explanatory variables—such as fiscal policy or strike variables—so that the predictive power of the individual financial variables can be isolated.

Each of the equations was estimated for a number of **sample** periods. The estimation results for the **period** from the first quarter of **1962** through the fourth quarter of **1977** are representative of the results in all the estimation **periods**.<sup>10</sup> The results for this period show that the equations for **M1** and the base generally conform to those reported in other research." In particular, the positive sums of

the **coefficients** ( $\sum_{i=0}^N b_i$ ) in the **M1** and base

equations indicate that increases in **M1** or the base are consistent with increases in GNP. (See Table 1.) Also, the **higher** corrected multiple correlation coefficient,  $\bar{R}^2$ , of **0.28** for **M1** indicates that **M1** is slightly better than the base in terms of ability to explain the changes that occurred in GNP within the **1962-77** sample period. The equation using the corporate bond yield also performs about as expected based on the results of other research." In particular, the equation's  $\bar{R}^2$  is

---

<sup>10</sup> The estimated equations reported are those that resulted from a systematic search procedure over unconstrained and polynomial lags. The properties of the Federal funds rate equation are somewhat more sensitive to the length of the lag than are the properties of the monetary base and **M1** equations, perhaps because a large fraction of the explanatory power of the **aggregates'** equations results from the contemporaneous correlation between the growth of GNP and the growth of the monetary base and **M1**. For a more detailed discussion of the procedure used to estimate the equations and other issues concerning the estimation results, see **Bryon Higgins** and **V. Vance Roley**, "Reduced-Form Equations." The starting date of the period was chosen primarily due to the starting date of the number of past values used to test for the appropriate lag length in the Federal funds rate equation.

<sup>11</sup> See, for example, **Leonall C. Andersen**, "Selection of a Monetary Aggregate for Use in the FOMC Directive," Board of **Governors** of the Federal Reserve System, **Open Market Policies and Operating Procedures**, **1971**.

<sup>12</sup> See, for example, **Michael W. Keran**, "Selecting a Monetary Indicator—Evidence from the United States and Other Developed Countries," **Federal Reserve Bank of St. Louis Review**, **Vol. 52** (September **1970**).

**Table 1**  
**SUMMARY OF ESTIMATION RESULTS FOR**  
**THE ALTERNATIVE NOMINAL GNP EQUATIONS**  
**(Sample Period: 1962:Q1-1977:Q4)**

Alternative Independent Variables	Estimated Coefficients			SE	DW
	Constant ( $a_0$ )	Sum of Lag Coefficients ( $\sum_{i=0}^N b_i$ )	$-2R$		
Narrowly Defined Money Stock (M1)	3.914 (3.3)	0.822 (3.6)	0.28	2.88	1.87
Adjusted Monetary Base	0.724 (0.4)	1.00 (4.0)	0.24	2.96	2.05
Moody's Aa Utility Bond Yield	8.531 (20.0)	-0.097 (-2.6)	0.13	3.18	1.51
Federal Funds Rate	14.53 (11.5)	-0.555 (-5.4)	0.36	2.72	2.37

NOTES:  $\bar{R}^2$  equals multiple correlation coefficient corrected for degrees of freedom. SE equals standard error of estimate. DW equals Durbin-Watson statistic.

The M1 equation includes the current and past four quarters of observations estimated with a fourth degree polynomial lag with the left-hand tail constrained to equal zero. The base equation includes the current and past 25 quarters of observations estimated with a third degree polynomial lag. The bond yield equation includes the past four quarters of observations estimated unconstrained. The Federal funds rate equation includes the past 24 quarters of observations estimated with a sixth degree polynomial lag with both tails constrained to equal zero.

Numbers in parentheses below coefficient estimates are t-statistics.

relatively low. The sum of the  $b_i$  coefficients has a negative sign as expected, indicating that increases in the bond yield are accompanied by decreases in the growth of aggregate spending.

The equation using the Federal funds rate is especially interesting because a short-term interest rate previously has not been considered in single equation models of aggregate spending. As shown by the sum of the  $b_i$  coefficients, the estimation results indicate that increases in the Federal funds rate result in decreases in GNP growth. (See Table 1) Additional results not shown in Table 1 indicate that increases in the Federal funds rate over the preceding 24 quarters have a uniformly

negative impact on GNP.<sup>13</sup> Finally, the  $\bar{R}^2$  is higher for the Federal funds rate equation than for equations using M1, the base, and the corporate bond yield, indicating that the Federal funds rate has a slightly greater ability

<sup>13</sup> The finding that the total interest rate effects occur with long lags is not unique to this study. See, for example, Dale W. Jorgenson, "Capital Theory and Investment Behavior," *American Economic Review*, Vol. 53 (May 1963). Andersen and Karnosky also find that lags of 24 quarters may be appropriate when considering the total impact of changes of M1. See Leonall C. Andersen and Denis S. Karnosky, "The Appropriate Time Frame for Controlling Monetary Aggregates: The St. Louis Evidence," Federal Reserve Bank of Boston, *Controlling Monetary Aggregates II: The Implementation*, 1973.

to explain changes in GNP within the sample period.<sup>14</sup>

### A Comparison of Predictive Performance

This section compares the four single equation models of GNP in terms of their ability to predict GNP growth a year in advance. The predictive performance for yearly periods is particularly relevant because the Federal Reserve currently uses a one-year planning horizon in establishing growth ranges for the monetary aggregates. The procedure used in the comparison of the predictions of GNP growth may be illustrated by reference to the predictions for 1970. To predict the growth of GNP in 1970, the equations were estimated using data only through 1969. These estimated equations, along with actual values of the financial variables in 1970, were then used to predict GNP growth in 1970.<sup>15</sup> Finally, the predicted values for GNP were compared with actual GNP for 1970. This procedure was

followed for each year during the period from 1965 through 1977.

For each yearly prediction period, two statistical measures were used to compare the predictive performance of the four equations. One measure is the prediction error, which is the arithmetic average of the quarterly differences between actual and predicted GNP growth. The second measure is the root-mean-square error, which reflects the variability of the individual quarterly prediction errors within each year.<sup>16</sup> In 1977, for example, the **M1** equation had the smallest prediction error with a value of  $-1.42$ —that is, the quarterly GNP growth rates, predicted using the **M1** equation, averaged 1.42 percentage points lower than actual average GNP growth. (See Table 2.) The corporate bond rate equation had the lowest quarterly root-mean-square error with a value of 2.81, indicating that the variability of the four individual quarterly prediction errors within 1977 were the smallest for this equation. In other years, however, the base or the Federal funds rate equations had the lower prediction or root-mean-square errors. Thus, no firm

<sup>14</sup> As is common with highly aggregative single equation models of aggregate spending, all of the estimated equations have some theoretical and statistical problems. For example, the current values of both **M1** and the base are included in their respective equations (Table 1), which may result in simultaneity bias. That is, the direction of causation between neither **M1** and GNP nor the monetary base and GNP is readily apparent. This problem is particularly troublesome in these equations because of the large values of the current quarter coefficients ( $b_0 = 0.59$  for **M1**,  $b_0 = 0.58$  for the base). The corporate bond rate equation is plagued by extremely poor explanatory power and an implausible lag structure. The Federal funds rate equation has an implausibly large constant term, implying untenable long-run properties of the relationship between changes in the funds rate and GNP growth.

<sup>15</sup> This procedure using historical values of the alternative financial variables may bias the results because it assumes implicitly that the values of each financial variable could have been controlled with equal precision. The possible bias is especially prevalent for **M1** and the long-term bond yield because of the Federal Reserve's inability to exercise precise control over their values.

<sup>16</sup> Let  $\% \Delta \text{GNP}_i^p$  and  $\% \Delta \text{GNP}_i^a$  be the predicted and actual values, respectively, of GNP growth during the  $i$ -th quarter of a given year. The prediction error (PE) for the year is computed as

$$\text{PE} = \sum_{i=1}^4 \{(\% \Delta \text{GNP}_i^p) - (\% \Delta \text{GNP}_i^a)\} / 4,$$

where the individual quarterly values are divided by 4 because all data were annualized for estimation and prediction purposes. In 1977, for example, the individual quarterly prediction errors—  $(\% \Delta \text{GNP}_i^p) - (\% \Delta \text{GNP}_i^a)$  — using the **M1** equation were  $-2.82$ ,  $-5.11$ ,  $1.16$ , and  $1.09$ , implying an annual prediction error of  $-1.42$ .

The quarterly root-mean-square error is computed as

$$\text{RMSE (quarterly)} = \sum_{i=1}^4 \{[(\% \Delta \text{GNP}_i^p) - (\% \Delta \text{GNP}_i^a)]^2 / 4\}^{1/2}$$

Again using the individual quarterly prediction errors in 1977 for the **M1** equation, the root-mean-square error equals 3.02.



**Table 2**  
**ERRORS IN PREDICTING GROWTH RATES OF NOMINAL GNP**  
**USING AGGREGATES AND INTEREST RATES**

Prediction Period	Measures for Annual Prediction Periods							
	Prediction Error				Root-Mean-Square Error			
	M1	Base	Corporate Bond Rate	Federal Funds Rate	M1	Base	Corporate Bond Rate	Federal Funds Rate
1968	1.04	-1.94	-2.54	-1.14	1.82	2.82	4.04	1.99
1969	1.79	-0.97	1.66	-1.92	2.20	2.11	2.83	2.49
1970	2.20	1.54	2.62	1.44	3.32	2.82	3.02	3.27
1971	-0.77	-1.75	-2.48	1.39	3.60	4.03	4.86	4.81
1972	-2.50	-2.91	-3.57	-0.87	2.77	3.57	3.82	2.62
1973	-1.85	-0.54	-2.90	-1.97	3.41	2.65	3.85	3.41
1974	0.86	3.08	-0.05	1.50	2.59	3.52	2.06	2.16
1975	-3.28	0.01	-2.97	-0.09	5.93	5.34	7.07	4.92
1976	-0.63	0.30	-0.43	0.51	2.18	2.10	2.57	1.86
1977	-1.42	-2.32	-2.33	-1.45	3.02	3.81	2.81	3.46
Summary Measures								
Average Absolute Prediction Error					Root-Mean-Square Error (Annual Predictions)			
	1.63	1.54	2.16	1.23	1.82	1.84	2.40	1.35

conclusion can be made about the predictive performance of the four equations on the basis of the individual yearly prediction periods. Firm conclusions require examining the results for the **1965-77** period as a whole.

For the **1965-77** period as a whole, two summary statistical measures were used to compare the predictive performance of the equations. One is the average absolute prediction error, which is the average of the absolute values of the prediction errors for all of the years. The other measure is the root-mean-square error of the yearly predictions, which reflects the variability of the prediction errors for the **1965-77** period as a whole." These summary measures uniformly favor the equation using the Federal funds rate as the best predictor of **GNP**. In particular, the average absolute prediction error is lower for

the Federal funds rate equation than for the other equations. This measure indicates that the predicted values of annual GNP growth differed from actual GNP growth by an average of **1.23** percentage points during the **1965-77** period. (See Table 2.) The annual root-mean-square error of **1.35** indicates that the

17 Let  $PE_j$  represent the prediction error for the  $j$ -th year. The average absolute prediction error (AAPE) is then computed as

$$AAPE = \frac{\sum_{j=1}^{10} PE_j}{10}.$$

The root-mean-square error for the annual predictions is computed as

$$RMSE \text{ (annual predictions)} = \left[ \frac{\sum_{j=1}^{10} (PE_j)^2}{10} \right]^{1/2}.$$

variability of the annual predictions was also the lowest for the Federal funds rate equation. The aggregates equations do the next best, but the evidence is mixed concerning whether **M1** or the base performs better. The equation using the corporate bond yield is the least desirable as judged by either summary measure of predictive performance.

## CONCLUSION

There are a number of methods for determining the impact of monetary policy actions on the economy. One method that has become increasingly popular in recent years is to include a single financial variable that is thought to summarize the total effect of policy actions in a single equation model of aggregate spending. Those who employ the single equation approach have generally restricted their attention to the relative ability of monetary aggregates to explain changes in aggregate spending. Because of theoretical considerations indicating that interest rates may have an important impact on aggregate spending, the single equation approach was adopted in this study to explore the potential usefulness of interest rates as well as monetary and reserve aggregates in the implementation

of monetary policy.

The empirical results of this study indicate that predictions of aggregate spending based solely on past movements in the Federal funds rate are more accurate than predictions based solely on current and lagged movements in **M1**, the monetary base, or a long-term interest rate. Although different specifications of the single equation models might alter the results, the empirical evidence in this study indicates that the Federal funds rate is the best single financial variable for the Federal Reserve to use as a measure of the effects of monetary policy actions.

The empirical results also indicate, however, that all of the financial variables tested leave a large percentage of the variation in total spending unexplained. Thus, the evidence does not support the proposition that aggregate spending depends exclusively on a single financial variable. Fortunately, the Federal Reserve need not rely exclusively on a single financial variable in determining the appropriate course for monetary policy. Information on a large number of economic variables is available to the Federal Reserve, and judicious use of the information **from** all of these variables may be preferable to exclusive focus on any single financial variable.