The Lag in the Effect of Monetary Policy: A Survey of Recent Literature

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During the last ten years the views of economists—both monetarists and nonmonetarists—on the lag in the effect of monetary policy on the economy have changed considerably. This article examines some of the recent evidence which has served as the basis for these changes.

Prior to 1960, quantitative estimates of the lag in the effect of monetary policy were rare. While there had always been disagreement on the effectiveness of monetary policy, a substantial number of economists seemed to accept the proposition that there was sufficient impact in the reasonably short run for monetary policy to be used as a device for economic stabilization. Although this view did not go unquestioned—see, for example, Mayer [26] and Smith [29][1]—the main challenge to the conventional thinking came from Milton Friedman. He argued that monetary policy acts with so long and variable a lag that attempts to pursue a contracyclical monetary policy might aggravate, rather than ameliorate, economic fluctuations. In summarizing work done in collaboration with Anna Schwartz, he wrote [16]: "We have found that, on the average of 18 cycles, peaks in the rate of change in the stock of money tend to precede peaks in general business by about 16 months and troughs in the rate of change in the stock of money precede troughs in general business by about 12 months. . . . For individual cycles, the recorded lead has varied between 6 and 29 months at peaks and between 4 and 22 months at troughs."

Many economists were simply not prepared to believe Friedman's estimates of either the length or the variability of the lag. As Culbertson [11] put it, "if we assume that government stabilization policies . . . act with so long and variable a lag, how do we set about explaining the surprising moderateness of the economic fluctuations that we have suffered in the past decade?" Culbertson's own conclusion was that "the broad record of experience support[s] the view that [contracyclical] monetary, debt-management, and fiscal adjustments can be counted on to have their predominant direct effects within three to six months, soon enough that if they are undertaken moderately early in a cyclical phase they will not be destabilizing".

Kareken and Solow [5] also appear to have been unwilling to accept Friedman's estimates. They summarized their results as follows: "Monetary policy works neither so slowly as Friedman thinks, nor as quickly and surely as the Federal Reserve itself seems to believe. . . . Though the *full* results of policy changes on the flow of expenditures may be a long time coming, nevertheless the chain of effects is spread out over a fairly wide interval. This means that *some* effect comes reasonably quickly, and that the effects build up over time so that some substantial stabilizing power results after a lapse of time of the order of six or nine months."

However, as Mayer [27] pointed out, this statement is inconsistent with the evidence presented by Kareken and Solow. They reported estimates of the complete lag in the effect of monetary policy on the flow of expenditures for only one component of gross national product (GNP), namely, inventory investment, and this lag is much longer than Friedman's lag. For another sector—producers' durable equipment—they provided data for only part of the lag, but even this is longer than Friedman's lag. Thus,

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[1] The numbers in brackets refer to the works cited at the end of this article.

Mayer noted that Kareken and Solow "should have criticized Friedman, not for overestimating, but for underestimating the lag".

More recently, it is the *monetarists* who have taken the view that the lag in the effect of monetary policy is relatively short, and the nonmonetarists who seem to be claiming longer lags. This showed up in the reaction to the St. Louis (Andersen and Jordan) equation [4]. According to this equation, the total response of GNP to changes in the money supply is completed within a year.

In his review of the Andersen and Jordan article, Davis [12] wrote "the most surprising thing about the world of the St. Louis equation is not so much the force, but rather the speed with which money begins to act on the economy". If the level of the money supply undergoes a $1 billion once-and-for-all rise in a given quarter, it will (according to the St. Louis equation) raise GNP by $1.6 billion in that quarter and by $6.6 billion during four quarters. In contrast, Davis found that in the Federal Reserve Board-Massachusetts Institute of Technology model—which was estimated by assuming nonborrowed reserves to be the basic monetary policy variable—a once-and-for-all increase in the money supply of $1 billion in a given quarter has almost no effect on GNP in that quarter and, even after four quarters, the level of GNP is only about $400 million higher than it otherwise would be. Thus, he concluded, "what is at stake in the case of the St. Louis equation is not merely a 'shade of difference' but a strikingly contrasting view of the world—at least relative to what is normally taken as the orthodox view roughly replicated and confirmed both in methods and in result by the Board-MIT model".[2]

The Federal Reserve Board-MIT model (henceforth called the FRB-MIT model) is not the only econometric model suggesting that monetary policy operates with a long distributed lag. Indeed, practically every *structural* model of the United States economy which has been addressed to this question has arrived at essentially the same answer.[3]

The most recent advocates of short lags are Arthur Laffer and R. David Ranson [25]. They have argued that: "Monetary policy, as represented by changes in the conventionally defined money supply [demand deposits plus currency], has an immediate and permanent impact on the level of GNP. For every dollar increase in the money supply, GNP will rise by about $4.00 or $5.00 in the current quarter, and not fall back [or rise any further] in the future. Alternatively, every 1 percent change in the money supply is associated with a 1 percent change in GNP."

This article reviews some of the recent professional literature on the lag in the effect of monetary policy, with the objective of examining the factors which account for differences in the results. Among the factors considered are: (1) the type of statistical estimating model, i.e., structural versus reduced form equations; (2) the specification of the monetary policy variable; and (3) the influence of the seasonal adjustment procedure. For the most part, the analysis is confined to the results obtained by others. New estimation is undertaken only in those instances where it is considered necessary to reconcile different sets of results.

STRUCTURAL VERSUS REDUCED FORM MODELS

We turn first to the question of whether it is more appropriate to use structural or reduced form models to estimate the effects of stabilization policy on the economy. A structural model of the economy attempts to set forth in equation form what are considered to be the underlying or basic economic relationships in the economy. Although many mathematical and statistical complications may arise, such a set of equations can, in principle, be "reduced" (solved). In this way key economic variables, such as GNP, can be expressed directly as functions of policy variables and other forces exogenous to the economy. While the difference between a structural model and a reduced form model is largely mathematical and does not necessarily involve different assumptions about the workings of the economy, a lively debate has developed over the advantages and disadvantages of these two approaches.

Users of structural models stress the importance of tracing the paths by which changes in monetary policy are assumed to influence the economy. Another advantage often claimed for the structural approach is that it permits one to incorporate *a priori* knowledge about the economy, for example, knowledge about identities, lags, the mathematical forms of relationships, and what variables should or should not be included in various equations (Gramlich [20]).

On the other hand, those who prefer the reduced form approach contend that, if one is primarily interested in explaining the behavior of a few key variables, such as

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[2] The properties of the Federal Reserve-MIT model are discussed by de Leeuw and Gramlich [13, 14] and by Ando and Modigliani [6].

[3] See Hamburger [21] and Mayer [27]. For a recent discussion of why the lag should be long, see Davis [12], Gramlich [19], and Pierce [28]. The alternative view is presented by White [31], who also gives reasons for believing that the procedures used to estimate the parameters of large-scale econometric models, particularly the FRB-MIT model, may yield "greatly exaggerated" estimates of the length of the lag.

GNP, prices, and unemployment, it is unnecessary to estimate all the parameters of a large-scale model. In addition, it is argued that, if the economy is very complicated, it may be too difficult to study even with a very complicated model. Hence, it may be useful simply to examine the relationship between inputs such as monetary and fiscal policy and outputs such as GNP.

Considering the heat of the debate, it is surprising that very little evidence has been presented to support either position. The only studies of which I am aware come from two sources: simulations with the FRB-MIT model, reported by de Leeuw and Gramlich [13, 14], and the separate work of de Leeuw and Kalchbrenner [15]. The latter study reported the estimates of a reduced form equation for GNP, using monetary and fiscal policy variables similar to those in the FRB-MIT model. The form of the equation is:

Equation 1

$$\Delta Y_t = a + \sum_{i=0}^{7} b_i \Delta NBR_{t-i} + \sum_{i=0}^{7} c_i \Delta E_{t-i} + \sum_{i=0}^{7} d_i \Delta RA_{t-i} + u_t$$

where

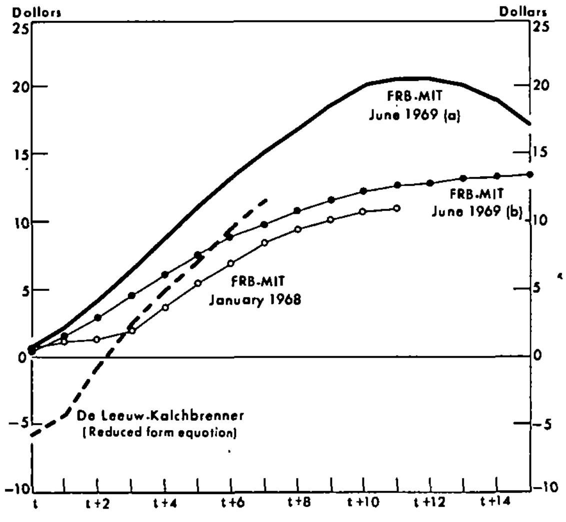
ΔY = Quarterly change in GNP, current dollars.
ΔNBR = Quarterly change in nonborrowed reserves adjusted for reserve requirement changes.
ΔE = Quarterly change in high-employment expenditures of the Federal Government, current dollars.
ΔRA = Quarterly change in high-employment receipts of the Federal Government in current-period prices.
u = Random error term.

All variables are adjusted for seasonal variation, and the lag structures are estimated by using the Almon distributed lag technique.[4]

Chart I illustrates the lag distributions of the effect on GNP of nonborrowed reserves—the principal monetary variable used in the studies just mentioned. The chart shows the cumulative effects of a one dollar change in nonborrowed reserves on the level of GNP as illustrated by four experiments, the reduced form equation of de Leeuw and Kalchbrenner and three versions of the FRB-MIT model. The heavy broken line traces the sum of the regression coefficients for the current and lagged values of nonborrowed reserves in the de Leeuw-Kalchbrenner equation (i.e., the sum of the b_i's). The other lines show the results obtained from simulations of the FRB-MIT model; FRB-MIT 1969(a) and FRB-MIT 1969(b) represent simulations of the 1969 version of the model, with two different sets of initial conditions.[5] FRB-MIT 1968 gives the simulation results for an earlier version of the model.

Although there are some large short-run differences in the simulation results, these three experiments suggest similar long-run effects of nonborrowed reserves on in-

Chart I
CUMULATIVE EFFECTS OF A ONE DOLLAR CHANGE IN NONBORROWED RESERVES ON GNP



Note: FRB-MIT = Federal Reserve Board-Massachusetts Institute of Technology econometric model.

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[4] Use of the Almon [1] procedure has become quite popular in recent years as it imposes very little *a priori* restriction on the shape of the lag structure, requiring merely that it can be approximated by a polynomial. In the applications discussed in this article, it is generally assumed that a second- or a fourth-degree polynomial is sufficiently flexible to reproduce closely the true lag structure.

[5] For the FRB-MIT 1969(a) simulation, the values of all exogenous variables in the model, except nonborrowed reserves, are set equal to their actual values starting in the first quarter of 1964. For the FRB-MIT 1969(b) simulation, the starting values for these variables are their actual values in the second quarter of 1958. The obvious difference between these two sets of initial conditions is the difference in inflationary potential. The quarters during and after 1964 were ones of high resource utilization, and an expansion of reserves at such a time might be expected to stimulate price increases promptly. On the other hand, there was substantial excess capacity in 1958 and a change in reserves under such conditions would be expected to have a minimal short-run effect on prices. The difference in these price effects is significant since it is movements in *current*-dollar GNP which are being explained.

come. Such a finding is not very surprising; what is significant, in view of the debate between those who prefer structural models and those who prefer reduced forms, is that after the first three or four quarters the de Leeuw-Kalchbrenner results lie well within the range of the simulation results.[6]

Thus, we find that when nonborrowed reserves are chosen as the exogenous monetary policy variable, i.e., the variable used in *estimating* the parameters of the model, it makes very little difference whether the lag in the effect of policy is determined by a structural or a reduced form model. There is, to be sure, no assurance that similar results would be obtained with other monetary variables or with other structural models (including more recent versions of the FRB-MIT model). In the present case, however, the use of reduced form equations does not lead to estimates of the effects of monetary policy on the economy that differ from those obtained from a structural model. For the purposes of our analysis, this finding implies that the type of statistical model employed to estimate the lag in the effect of monetary policy may be less important than other factors in explaining the differences in the results that have been reported in the literature.

SPECIFICATION OF THE MONETARY POLICY VARIABLE

Another important difference among the various studies of the lag is the variable used to represent monetary policy. The aim of this section is not to contribute to the controversy about the most appropriate variable, but rather to summarize the arguments and spell out the implications of the choice for the estimate of the lag in the effect of policy.

In recent years, three of the most popular indicators of the thrust of monetary policy have been the money supply, the monetary base, and effective nonborrowed reserves.[7] Monetarists prefer the first two variables on the grounds that they provide the most appropriate measures of the impact of monetary policy on the economy. Critics of the monetarist approach contend that these variables are deficient because they reflect the effects of both policy and nonpolicy influences and hence do not provide reliable (i.e., statistically unbiased) measures of Federal Reserve actions. The variable most often suggested by these economists is effective nonborrowed reserves.[8] In reply, the monetarists have argued that, since the Federal Reserve has the power to offset the effects of all nonpolicy influences on the money supply (or the monetary base), it is the movements in the money variable and not the reasons for the movements which are important (Brunner [7] and Brunner and Meltzer [8]). However, this sidesteps the statistical question of whether the money supply or the monetary base qualify as exogenous variables to be included on the right-hand side of a reduced form equation. (For a further discussion, see Gramlich [20] and Hamburger [22].)

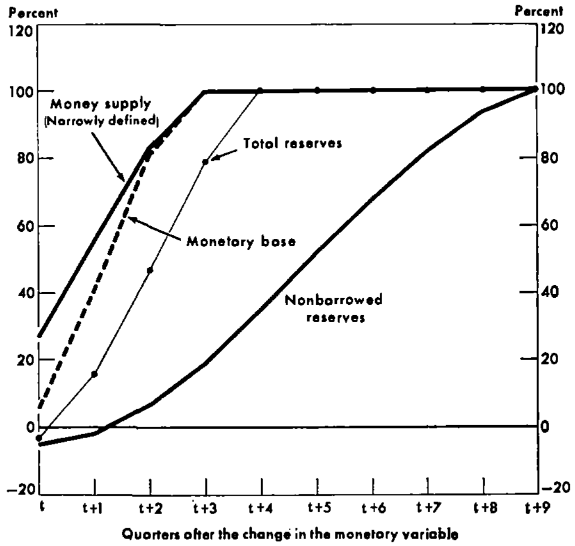
Chart II presents the cumulative percentage distributions of the effects of various monetary variables on nominal GNP, as implied by the parameter estimates for equations similar to equation 1, that is, reduced form equations relating quarterly changes in GNP to quarterly changes in monetary and fiscal policy variables. The monetary variables are effective nonborrowed reserves, the monetary base, the narrowly defined money supply (private holdings of currency and demand deposits), and total reserves. The latter is defined as effective nonborrowed reserves plus member bank borrowings from the Federal Reserve. It is also approximately equal to the monetary base less the currency holdings of nonmember banks and of the nonbank public. Once again, the lag structures for the monetary and fiscal policy variables are estimated using the Almon distributed lag technique. In all cases, with the possible exception of the monetary base, the lags chosen are those which maximize the $\bar{R}^2$ (coefficient of determination adjusted for degrees of freedom).

[6] De Leeuw and Kalchbrenner do not estimate lags longer than seven quarters. While it is conceivable that the curve representing their results could flatten out (or decline) after period t-7, the shape of the curve up to that point and the results obtained by others, such as those shown in Chart II, make this possibility seem highly unlikely. The initial negative values for the de Leeuw-Kalchbrenner curve arise because of the large negative estimate of b_0 in equation 1; the estimates for all other b's are positive. As de Leeuw and Kalchbrenner pointed out, it is difficult to provide an economic explanation for changes in nonborrowed reserves having a negative effect on GNP in the current quarter. It seems more reasonable, therefore, that the result reflects "reverse causation", running from GNP to nonborrowed reserves—that is, the Federal Reserve's attempt to pursue a contracyclical monetary policy. This point is discussed at greater length in Hamburger [22].

[7] Nonborrowed reserves adjusted for changes in reserve requirements. A similar adjustment is made in computing the monetary base, which is defined as total member bank reserves plus the currency holdings of nonmember banks and the nonbank public. The reserve figure included in the base is also adjusted to neutralize the effects of changes in the ratio of demand deposits to time deposits and changes in the distribution of deposits among banks subject to different reserve requirements.

[8] Among others, see de Leeuw and Kalchbrenner [15], Gramley [18], and Hendershott [23].

Chart II
CUMULATIVE PERCENTAGE DISTRIBUTIONS OF THE EFFECTS OF VARIOUS MONETARY AGGREGATES ON GNP



Sources: See footnote 9.

of the equation. Percentage distributions are used to highlight the distribution of the effects over time as opposed to their dollar magnitudes.[9]

The results indicate that the choice of the exogenous monetary policy variable has a significant effect on the estimate of the lag in the effect of policy. If the money supply, the monetary base, or total reserves are taken as the monetary variable, the results suggest that the total response of GNP to a change in policy is completed within four or five quarters. On the other hand, those who consider nonborrowed reserves to be the appropriate variable would conclude that less than 40 percent of the effect occurs in five quarters and that the full effect is distributed over two and a half years.[10]

Thus, the evidence suggests that the relatively short lags that have been found by the monetarists in recent years depend more on their specification of the monetary policy variable than on the use of a reduced form equation. Whether or not these estimates understate the true length of the lag, they seem roughly consistent with the prevailing view among economists in the early 1960's. They are, for example, essentially identical with Mayer's [26] results which suggested that most of the effect of a change in policy occurs within five quarters. As indicated above, wide acceptance of the proposition that monetary policy operates with a long lag—i.e., a substantial portion of the impact of a policy change does not take place until a year or more later—is of relatively recent vintage and appears to have been heavily influenced by the results of those who do not consider the money supply to be an appropriate measure of monetary policy impulses.

THE SEASONAL ADJUSTMENT PROBLEM

One of the most recent investigations of the effects of monetary and fiscal policy on the economy is that conducted by Laffer and Ranson for the Office of Management and Budget [25]. Perhaps the most striking finding of this study is that every change in the money supply has virtually all its effect on the level of GNP in the quarter in which it occurs. Or, to put this differently, there is little evidence of a lag in the effect of monetary policy. This finding which stands at odds with most other evidence, both theoretical and empirical, is attributed by Laffer and Ranson largely to their use of data that are *not* adjusted for seasonal variation.[11] They contend that the averaging (or smoothing) properties of most seasonal adjustment procedures tend to distort the timing of statistical relationships. Hence, specious lag structures may be introduced into the results.

As shown below, however, the results reported by Laffer and Ranson are much more dependent on their choice of time period (1948-69) than on the use of seasonally unadjusted data. For, if their nominal GNP equation is reestimated for the period 1953-69 (the period employed in the current version of the St. Louis model [3]

[9] The estimates shown in Chart II are derived from the equations reported by Corrigan [10] and by Andersen and Jordan [4]. Corrigan's results are used for the nonborrowed reserves, total reserves, and money supply curves (the nonborrowed reserves equation is not shown in his article but is available on request). He did not estimate an equation for the monetary base. The fiscal policies variables used in all three equations are the changes in the Government spending and tax components of the "initial stimulus" measure of fiscal policy. The monetary base curve is derived from the Andersen and Jordan results. The fiscal measures used in this study are the Government expenditure and receipt components of the high-employment budget. The criterion used by Andersen and Jordan to select their lag structures is described by Keran [24].

[10] A similar conclusion was reached by Andersen [2], who found even longer lags when nonborrowed reserves are used as the monetary policy variable.

[11] Other studies which find very short lags in the effect of monetary policy are cited by Laffer and Ranson [25].

and in most other recent investigations), it makes very little difference whether one uses seasonally adjusted or unadjusted data. They both indicate that a significant portion of the effect of a change in money does not occur for at least two quarters.

The equation selected by Laffer and Ranson to explain the percentage change in nominal GNP is:[12]

Equation 2

$$\begin{array}{l} \%\Delta Y = 3.21 + 1.10\%\Delta M_1 + .136\%\Delta G - .069\%\Delta G_{-1} \\ \qquad\quad (4.9) \quad (5.5) \qquad\quad (6.9) \qquad\quad (3.3) \\ \qquad - .039\%\Delta G_{-2} - .024\%\Delta G_{-3} - .046\Delta SH \\ \qquad\quad (1.9) \qquad\quad (1.2) \qquad\quad (3.7) \\ \qquad + .068\%\Delta S\&P_{-1} - 9.8\, D_1 + 2.5\, D_2 - 3.0 D_3 \\ \qquad\quad (2.2) \qquad\quad (12.1) \quad (2.6) \quad (4.1) \\ \bar{R}^2 = .958 \qquad SE = 1.31 \qquad \text{Interval: 1948-I to 1969-IV} \end{array}$$

[12] The numbers in parentheses are t-statistics for the regression coefficients. SE is the standard error of estimate of the regression. A subscript preceded by a minus sign indicates that the variable is lagged that many quarters. In estimating their model, Laffer and Ranson use quarterly changes in the natural logarithms of the variables. This is roughly equivalent to using quarter-to-quarter percentage changes.

where

- $\%\Delta Y$ = Quarterly percentage change in nominal GNP.
- $\%\Delta M_1$ = Quarterly percentage change in M_1 (the narrowly defined money supply).
- $\%\Delta G$ = Quarterly percentage change in Federal Government purchases of goods and services.
- ΔSH = Quarterly change in a measure of industrial man-hours lost due to strikes.
- $\%\Delta S\&P$ = Quarterly percentage change in Standard and Poor's Composite Index of Common Stock Prices (the "S&P 500").
- D_1 = Seasonal dummy variable for the first quarter.
- D_2 = Seasonal dummy variable for the second quarter.
- D_3 = Seasonal dummy variable for the third quarter.

All data used in the calculations are unadjusted for seasonal variation. The three dummy variables (D_1, D_2, and D_3) are introduced to allow for such variation and to permit estimation of the seasonal factors. In principle, joint estimation of the seasonal factors and the economic parameters of a model is preferable to the use of data generated by the standard type of seasonal adjustment procedure. However, in having only three dummy variables, Laffer and Ransom assume that the seasonal pattern in income is constant over the entire sample period. If this assumption is not correct, it becomes a purely empirical question as to whether their procedure is any better or

Table I

REGRESSIONS EXPLAINING THE PERCENTAGE CHANGE IN GROSS NATIONAL PRODUCT

Quarterly seasonally unadjusted data

Equation	Constant	$\%\Delta M_1$	$\%\Delta M_{1_{-1}}$	$\%\Delta M_{1_{-2}}$	$\%\Delta M_{1_{-3}}$	$\%\Delta M_{1_{-4}}$	$\%\Delta G$	$\%\Delta G_{-1}$	$\%\Delta G_{-2}$	$\%\Delta G_{-3}$	ΔSH	$\%\Delta S\&P_{-1}$	D_1	D_2	D_3	$\bar{R}^2$ / SE
1948-I to 1969-IV																
2	3.21	1.10					.136	—.069	—.039	—.024	—.046	.068	—9.8	2.5	—3.0	.958
	(4.9)	(5.5)					(6.9)	(3.3)	(1.9)	(1.2)	(3.7)	(2.2)	(12.1)	(2.6)	(4.1)	1.31
3	3.36	1.03	—.41	.49	—.31	.30	.136	—.073	—.034	—.024	—.045	.095	—9.5	1.3	—2.9	.961
	(3.9)	(4.4)	(1.7)	(2.1)	(1.3)	(1.3)	(7.1)	(3.7)	(1.7)	(1.3)	(3.6)	(2.9)	(7.6)	(0.9)	(2.4)	1.26
1948-I to 1952-IV																
2a	5.05	.61					.125	—.119	—.022	—.015	—.050	.221	—11.0	—1.5	—2.7	.983
	(4.8)	(1.6)					(5.7)	(5.6)	(1.2)	(0.6)	(3.3)	(3.2)	(8.8)	(0.8)	(2.3)	0.86
3a	2.38	1.11	—.29	—.18	—.24	.66	.121	—.122	—.024	—.030	—.036	.171	—7.2	3.7	1.0	.983
	(1.06)	(2.0)	(0.5)	(0.2)	(0.3)	(1.4)	(3.7)	(4.0)	(0.9)	(0.9)	(1.9)	(2.0)	(2.3)	(0.8)	(0.3)	0.86
1953-I to 1969-IV																
2b	4.16	.73					.143	—.008	—.042	—.048	—.022	.061	—11.2	1.8	—4.2	.964
	(5.1)	(3.1)					(3.8)	(0.2)	(1.1)	(1.3)	(1.4)	(1.8)	(10.2)	(1.6)	(4.2)	1.20
3b	5.18	.64	—.40	.88	—.07	—.05	.160	.002	—.044	—.068	—.026	.079	—11.6	—1.8	—5.2	.968
	(5.1)	(2.4)	(1.3)	(3.1)	(0.3)	(0.2)	(4.4)	(0.1)	(1.2)	(1.9)	(1.7)	(2.1)	(7.8)	(1.0)	(3.6)	1.13

Note: Values of "t" statistics are indicated in parenthesis. For explanation of the symbols other than those shown below, see equation 2 above.

$\bar{R}^2$ = Coefficient of determination (adjusted for degrees of freedom).

SE = Standard error of estimate of the regression.

Table II

SELECTED REGRESSION RESULTS FOR EQUATIONS EXPLAINING THE PERCENTAGE CHANGE IN GROSS NATIONAL PRODUCT

Quarterly data

Equation	Time period	Data	Regression coefficients					$\bar{R}^2$ SE
			$\%\Delta M_1$	$\%\Delta M_{1_{-1}}$	$\%\Delta M_{1_{-2}}$	$\%\Delta M_{1_{-3}}$	$\%\Delta M_{1_{-4}}$	
3	1948-I to 1969-IV	NSA	1.03 (4.4)	−.41 (1.7)	.49 (2.1)	−.31 (1.3)	.30 (1.3)	.961 1.26
3b	1953-I to 1969-IV	NSA	.64 (2.4)	−.40 (1.3)	.88 (3.1)	−.07 (0.3)	−.05 (0.2)	.968 1.13
3b′	1953-I to 1969-IV	SA	.37 (1.8)	−.08 (0.3)	.53 (1.9)	.32 (1.2)	−.21 (1.1)	.541 0.71

Note: Values of "t" statistics are indicated in parenthesis. For explanation of the symbols other than those shown below, see equation 2 on page 294.

$\bar{R}^2$ = Coefficient of determination (adjusted for degrees of freedom).

SE = Standard error of estimate of the regression.

NSA = Not seasonally adjusted.

SA = Seasonally adjusted data are used for M_1, GNP, and G.

worse than the use of seasonally adjusted data.

Stock market prices are included in the equation on the assumption that the current market value of equities provides an efficient forecast of future income. The variable representing the percentage of man-hours lost due to strikes (SH) is included for institutional reasons.

Aside from these factors, the Laffer-Ranson equation is quite similar to the St. Louis equation. The most important difference is that the former contains only the current-quarter value of money. This implies that a change in the money supply has a once-and-for-all effect on the level of income. Equation 3 shows the results obtained when four lagged values of the percentage change in M_1 are included in the model. Only the coefficients of the money variables are shown below; the rest of the results for this equation as well as those for equation 2 are reproduced in the first portion of Table I.

Equation 3

$$\begin{array}{l} \%\Delta Y = \underset{(3.9)}{3.36} + \underset{(4.4)}{1.03}\%\Delta M_1 - \underset{(1.7)}{.41}\%\Delta M_{1_{-1}} + \underset{(2.1)}{.49}\%\Delta M_{1_{-2}} \\ \qquad - \underset{(1.3)}{.31}\%\Delta M_{1_{-3}} + \underset{(1.3)}{.30}\%\Delta M_{1_{-4}} \ldots . \end{array}$$

$\bar{R}^2 = .961 \qquad SE = 1.26 \qquad$ Interval: 1948-I to 1969-IV

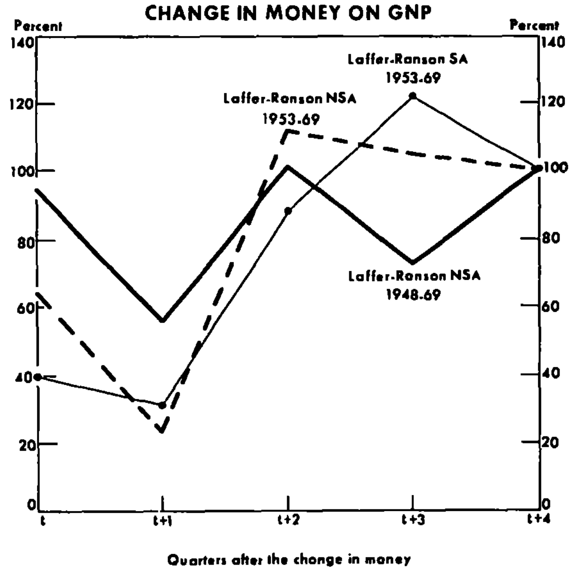
Following Laffer and Ranson, the coefficients of this equation are estimated without the use of the Almon distributed lag technique. Although some of the lagged money coefficients approach statistical significance, equation 3—like equation 2—implies that the current and long-run effects of money on income are, for all practical purposes, the same. An increase of 1 percent in M_1 is associated with a roughly 1.0 percent rise in income in the current quarter and a 1.1 percent rise in the long run.

To test the hypothesis, suggested above, that it is the time interval used by Laffer and Ranson which is largely responsible for this result, equations 2 and 3 were reestimated for the subperiods 1948-I to 1952-IV and 1953-I to 1969-IV. The results (see the two lower sections of Table I) show that: (a) the relationship between money and income in the 1948-52 period is not statistically significant (equations 2a and 3a)[13] and (b) there is a significant lag in the effect of money on income during the more recent period. Indeed, the largest single change in income as a result of a change in money during this period occurs after a lag of two quar-

[13] The contribution of the five money variables to the explanatory power of equation 3a may be evaluated by using the statistical procedure known as the F-test. When this is done, we find that the relationship between money and income is not significant even at the .20 confidence level. It should also be noted that the poor showing of the money variables in the 1948-52 period cannot be attributed simply to the shortness of the period and hence the limited number of degrees of freedom. These conditions do not prevent us from finding statistically significant relationships for most of the other variables included in equations 2a and 3a.

Chart III

CUMULATIVE EFFECTS OF A ONE PERCENT CHANGE IN MONEY ON GNP



Note: NSA = not seasonally adjusted; SA = seasonally adjusted.

ters (equation 3b).[14]

Perhaps the most interesting feature of the results is the similarity between the "money coefficients" for the period 1953-69 (equation 3b) and those which have been obtained by other researchers using seasonally adjusted data for the same period. To demonstrate this, equation 3b was re-estimated with seasonally adjusted data for M_1, GNP, and G. The coefficients for the current and lagged money variables for this equation (3b′) and for equations 3 and 3b are reported in Table II. Once again the equations are estimated *without* the use of the Almon distributed lag technique. Chart III shows the cumulative percentage distribution of the effects of money on income as implied by these equations. It is clear from the chart that it is the time period chosen by Laffer and Ranson which is largely responsible for their controversial result rather than the use of seasonally unadjusted data. This shows up even more dramatically when the equations are estimated with the Almon procedure. When this is done there is very little difference between the distributed lag implied by the Laffer-Ranson equations (using seasonally unadjusted data but fitted to the 1953-69 period) and that implied by the St. Louis equation [3], see Chart IV.[15] Thus, once the period through the Korean war is eliminated from the analysis, it makes no difference at all whether the relationship between money and income is estimated with seasonally adjusted data or unadjusted data and dummy variables. Both procedures yield a relatively short, but nevertheless positive, lag in the effect of monetary policy.[16]

THE ALMON LAG TECHNIQUE

Finally, it seems worthwhile to say a few words about the use of the Almon technique and its effect on the estimates of the structure (or distribution) of the lag. As noted earlier, this procedure has become quite popular in recent years. It tends to smooth out the pattern of the lag coefficients and makes them easier to rationalize. However, the extent of the differences in the estimates obtained for individual lag coefficients, with and without the use of the technique, provides some reason for concern.

For example, in his experiments with the St. Louis equation, Davis found that either 29 percent or 46 percent of the ultimate effect of money on income could be attributed to the current quarter. The lower number was obtained when the equation was estimated using the Almon technique, while the higher value occurred when the Almon constraint was not imposed on the equation. The explanatory power of the equation was essentially the same in

[14] In fairness to Laffer and Ranson, it should be noted that even for equation 3b we are unable to reject the hypothesis (at the .05 confidence level) that the current-quarter money coefficient is less than 1.0. However, there appears to be no necessary reason why the current-quarter effect should be singled out for special consideration. Thus, equation 3b also implies that after six months the cumulative effect of money on income is not significantly different from zero.

The hypothesis that the same regression model fits the entire Laffer-Ranson sample period (1948-69) may be evaluated by means of a procedure developed by Chow [9]. Doing this, we find that the hypothesis may be rejected at the .01 confidence level, that is, the differences in the parameter estimates of equations 2a and 2b and equations 3a and 3b are statistically significant.

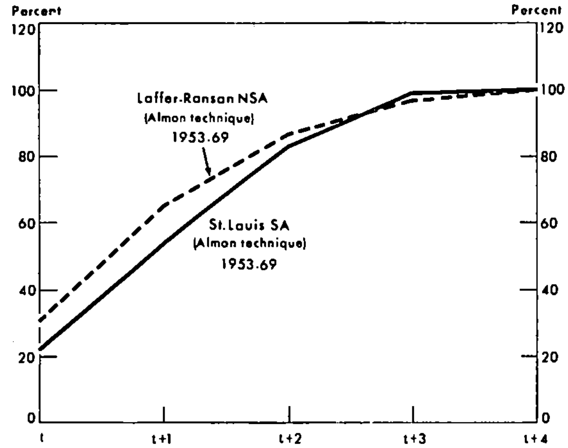
[15] For comparative purposes, the constraints imposed in estimating the Laffer-Ranson equations with the Almon procedure are the same as those used in the St. Louis equation, i.e., a fourth-degree polynomial with the t+1 and t—5 values of the money coefficients set equal to zero.

[16] An almost identical conclusion is reached in a forthcoming paper by Johnson [23a]. Laffer and Ranson provide an alternative explanation of the difference between their own lag results—shown in equation 3—and the St. Louis results. However, there is no mention in their article that the time period employed to estimate their equations is considerably different from that used in the St. Louis model and most other recent studies.

both cases.[17] In the Laffer-Ranson model as well, substantially different estimates of the lag structure are consistent with about the same $\bar{R}^2$. In this model the estimates of the current-quarter effect of money on income are 31 percent with the Almon technique and 64 percent with unconstrained lags (compare the Laffer-Ranson NSA curves for the 1953-69 period in Charts III and IV). On the other hand, over the first six months it is the *Almon* technique which yields a faster response of income to money, for both the Davis experiments and the Laffer-Ranson model, than is obtained with unconstrained lags.

The wide divergence in these estimates of the impact of monetary variables over short periods, depending on the nature of the estimating procedure employed, suggests that existing estimates of the underlying lag structure are not very precise. One reason for this may be that the pattern of the lag varies over time.[18] In any event, the uncertainties surrounding the structure (distribution) of the lag are not eliminated by the Almon technique. Thus, use of any existing estimates of the lag structure as a firm basis for short-run policy making would seem rather hazardous at this time.

Chart IV
CUMULATIVE PERCENTAGE DISTRIBUTION OF THE EFFECTS OF MONEY ON GNP



Note: NSA = not seasonally adjusted; SA = seasonally adjusted.

CONCLUDING COMMENTS

One finding stands out from the results presented above, namely, that there is a lag in the effect of monetary policy. Nevertheless, estimates of the length of the lag differ considerably. Of the three factors considered in this paper that might account for these differences, the most important is the specification of the appropriate monetary policy variable (or variables) in the construction of econometric models. Use of nonborrowed reserves as the exogenous monetary variable suggests that less than 40 percent of the impact of a monetary action occurs within five quarters and that the full effect is distributed over two and a half years. On the other hand, use of the money supply, the monetary base, or total reserves suggests that most of the effect occurs within four or five quarters. The latter estimate of the lag may appear to be relatively short. However, it does not seem to be grossly out of line with the view held by the majority of economists in the early 1960's.

The two other factors considered and found to be less important in explaining the differences in the estimates of the length of the lag are (1) the type of statistical estimating model (structural versus reduced form equations) and (2) the seasonal adjustment procedure. In both of these instances, though, there is not enough evidence available to draw very firm conclusions; hence further work might prove fruitful.

Finally, more work is also needed to help refine estimates of the distribution of the lag. Existing estimates of the lag structure do not appear to be sufficiently precise to justify large or frequent short-run adjustments in the growth rates of monetary aggregates.

[17] See Davis [12]. The estimates of R^2 are .46 and .47, respectively. The period used to estimate the equation was 1952-I to 1968-II.

[18] Some support for this hypothesis is provided by the simulation results for the FRB-MIT model shown in Chart I as well as the results obtained by Warburton [30] and Friedman and Schwartz [17] in their analyses of the timing relations between the upswings and downswings in money and economic activity.

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