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The Lag in Monetary Effects on Interest Rates and Aggregate Expenditures

The theory of monetary effects on interest rates developed in the preceding chapter implies a particular pattern for those effects. With an increase in the rate of monetary growth, interest rates first decline and subsequently move back toward their initial level. In the particular model displayed there, the effect on real rates of interest is not permanent, and they eventually return to their starting point, though overshooting and oscillations may occur on the path to the final equilibrium. In addition, the Fisher effect of anticipated inflation on nominal interest rates increases them further, though the complete effect may take a long time.

In this chapter, the lag pattern is examined statistically for its conformity to the theory. In the second part of the chapter these results are compared with the related lag of monetary effects on aggregate expenditures.

THE LAGGED EFFECT ON INTEREST RATES

The statistical analysis presented here does not impose any particular shape beforehand on the time pattern of the lag, but for simplicity we assume that it remains the same. This requires that the regression observations be dated at equal intervals. The reference-stage averages used in previous chapters vary in duration of coverage and would be applicable here if the lag time at each point varied in proportion to the duration of the concomitant reference phase. Instead, fixed, rather than variable, lags are used here.

The regressions are of the form

$$\Delta i_t = \alpha + \beta_1 \Delta m_t + \beta_2 \Delta m_{t-1} + \beta_3 \Delta m_{t-2} + \cdots + \beta_{n+1} \Delta m_{t-n},$$

where i is the interest rate, m_t is the monetary growth rate in month or quarter t (adjusted to include deposits of unlicensed banks March 1933 to June 1935), α and β are regression coefficients, and the operator Δ indicates the first differences of the variables. The equation relates the change in the interest rate during period t to changes in monetary growth rates in t and previous periods back to $t-n$. A permanent change in the monetary growth rate affects the interest rate by β_1 in the first period, by β_2 in the second period, and so on. The sum of the coefficients gives the total effect of an increase in the monetary growth rate which starts in period $t-n$ and remains at the augmented rate for the subsequent n periods.

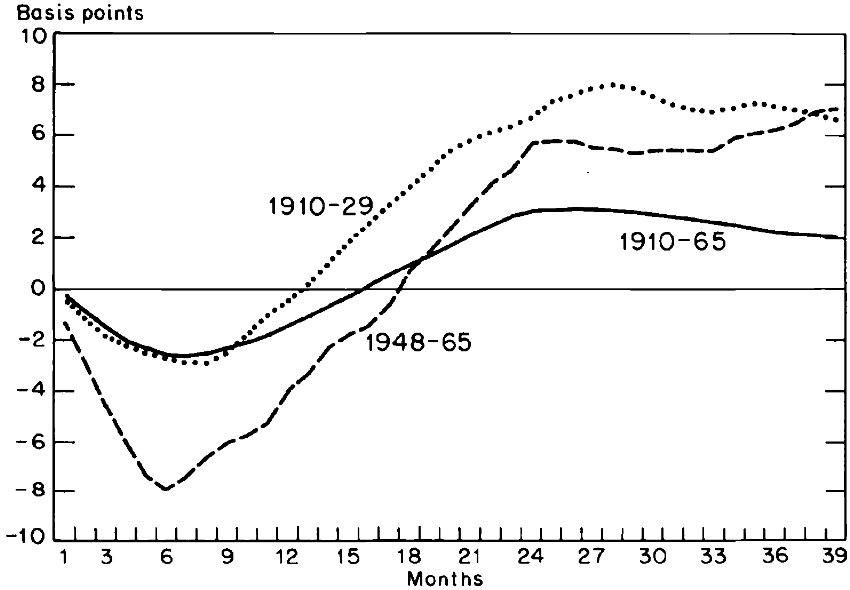
First differences are used to abstract from long-run influences on interest rates. Taking first differences does not affect the economic interpretation of the coefficients except for the constant term.

Chart 7-1 presents the cumulative lag pattern of the commercial paper rate for the period 1910–65 and for two subperiods. These patterns are based on regressions of monthly data, which for the money stock begin in the middle of 1907. The first observation of the independent variable included in the regressions is the change in the monetary growth rate from June to July 1907, and the first observation included of the interest rate is the change from August to September 1910, thirty-nine months later. Monetary growth is expressed as an annual percentage rate.

The chart should be interpreted as follows: Suppose the annual rate of monetary growth increases by one percentage point. At first the interest rate declines and later begins to rise. For the regression of the full period 1910–65, the initial decline continues for six months and reaches 2.6 basis points. The ensuing rise in the interest rate takes

CHART 7-1

Lag Distribution of Monetary Effects on Commercial Paper Rate, Various Periods, 1910–65



Note: Regression equation shown in text. Units are basis points per one percentage point change in annual rate of monetary growth (100 basis points = 1 percentage point of interest rate).

it past its starting level by the sixteenth month.[1] The coefficients and *t* values are given in Table 7-1.

The other plots in Chart 7-1 show how the pattern differs between the earlier and later subperiods. There is a smaller initial decline in the earlier than in the later period, and a more rapid rise thereafter.[2] All three curves reveal a strong positive effect still remaining after thirty-nine months.

[1] Nineteen of the first 23 coefficients are significant at the .05 level in the full-period regression (see Table 7-1). None of the last 16 are. R is .37 and R^2 adjusted for degrees of freedom is .08. A low correlation coefficient here should not be surprising, since the regression measures only one of the many influences on interest rates and is in first differences.

[2] An F test of differences between regression coefficients (not shown) for the 1910–42 and 1942–65 periods was not significant, however.

TABLE 7-1

Regression of Commercial Paper Rate on Lagged Values of Monetary Growth Rate, First Differences of Monthly Data, 1910–65

Regression Coefficients		t Values	Cumulative Sum of β Coefficients
Constant	2.20	0.03	
β_1	−0.35	−5.5	−0.35
β_2	−0.57	−6.8	−0.92
β_3	−0.60	−5.9	−1.52
β_4	−0.50	−4.5	−2.02
β_5	−0.33	−2.8	−2.35
β_6	−0.22	−1.8	−2.57
β_7	−0.06	−0.5	−2.63
β_8	0.07	0.6	−2.56
β_9	0.22	1.8	−2.34
β_{10}	0.28	2.3	−2.06
β_{11}	0.28	2.3	−1.78
β_{12}	0.34	2.8	−1.44
β_{13}	0.39	3.2	−1.05
β_{14}	0.37	3.0	−0.68
β_{15}	0.34	2.7	−0.34
β_{16}	0.43	3.5	+0.09
β_{17}	0.41	3.4	+0.50
β_{18}	0.37	3.0	+0.87
β_{19}	0.40	3.3	+1.27
β_{20}	0.41	3.3	+1.68
β_{21}	0.43	3.5	+2.11
β_{22}	0.38	3.1	+2.49
β_{23}	0.32	2.6	+2.81
β_{24}	0.19	1.5	+3.00
β_{25}	0.12	1.0	+3.12
β_{26}	0.06	0.5	+3.18
β_{27}	−0.01	−0.1	+3.17
β_{28}	−0.03	−0.2	+3.14
β_{29}	−0.07	−0.6	+3.07
β_{30}	−0.14	−1.2	+2.94
β_{31}	−0.11	−0.9	+2.83
β_{32}	−0.11	−0.9	+2.72

(continued)

TABLE 7-1 (concluded)

Regression Coefficients		t Values	Cumulative Sum of β Coefficients
β_{33}	−0.11	−1.0	+2.61
β_{34}	−0.09	−0.8	+2.52
β_{35}	−0.15	−1.3	+2.37
β_{36}	−0.14	−1.4	+2.23
β_{37}	−0.09	−0.9	+2.12
β_{38}	−0.05	−0.5	+2.07
β_{39}	−0.06	−1.0	+2.01

Note: For the form of the regression equation, see text equation. Units of the coefficients are basis points per one percentage point change in annual rate of change of money stock. $R = .367$. Adj. $R^2 = .081$.

Source: See the data appendix. Money is currency outside banks plus demand and time deposits.

With so many lagged terms, the problem of collinearity among the independent variables is a matter of concern. Here, however, only 109 of the 741 elements of the correlation matrix have values over 0.1, and the vast majority of these are under 0.2. That is one advantage of running the regression in first-difference form. Experimentation with various lengths of lag suggests that the point at which the pattern rises above zero is little affected by extending the lag beyond twenty months, nor is the position of the minimum point greatly affected. The lag with thirty-nine terms that is used in Chart 7-1 should therefore be long enough to give reliable estimates of at least the first part of the pattern.

It is important to emphasize that these lag patterns were not imposed upon the data in any way. The least-squares procedure minimizes the variance of the residual terms but does not constrain the regression coefficients. Yet the patterns generally conform to theoretical suppositions, showing first a decline and then a rise which carries the interest rate above its starting level.[3]

[3] Regressions (not shown) with bond yields and with Treasury bill rates for the post-World War II period have a shorter lag, in which the cumulative lag pattern crosses the zero line several quarters sooner than is shown here for the commercial paper rate. Similar results are reported by William Gibson, "The Lag in the Effect of Monetary Policy on Income and Interest Rates," *Quarterly Journal of Economics*, May 1970, pp.

The amplitude of the effect is small, however. During a typical business cycle, commercial paper rates can fluctuate over several hundred basis points. Monthly monetary growth fluctuates cyclically over a range of from perhaps five to ten percentage points at an annual rate, apart from any extreme rates for a short period. This would imply (according to the regression for the full period, which shows a maximum decline of 2.6 basis points) an effect on paper rates of at most 26 basis points, which is only a small part of their actual total fluctuation. As noted previously, this regression equation obviously explains only part of the cyclical fluctuation in interest rates.

A technical reason for the small amplitude of the estimated effect may be that the lag varies in length over the business cycle. Because the regression assumes a fixed lag, the estimated lag will be an average of the actual patterns. The maximum amplitude of the estimated pattern will then be less than a straight average of the maximum amplitudes of individual patterns.

Aside from reducing the amplitude of a changing lag, the estimated pattern does not in any direct way bias the average length. We may therefore take the estimates as a first approximation to the actual length. The Chart 7-1 patterns cross the zero line in 13 to 18 months. At the point of this crossover, the initial decline in the interest rate has been completely reversed. The rise in the pattern above zero thereafter can be attributed to the Fisher effect of anticipated inflation (which theoretically would eventually raise the interest rate 100 basis points above its original level).

We might expect the Fisher effect to show up more strongly after World War II, when prices were generally rising and expectations of inflation became widespread. Yet Chart 7-1 shows a lower pattern for the later than for the earlier period. This puzzling difference appears to reflect the behavior of time deposits. The rising interest rates following World War II tended to draw savings deposits from commercial banks

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288–300, Table II. See also Gibson, "Interest Rates and Monetary Policy," *Journal of Political Economy,* May/June 1970.

Bond yields are much less responsive to short-run monetary effects than are short-term rates. And Treasury bill rates, compared with the commercial paper rate, are more volatile and more influenced by Federal Reserve and Treasury short-run supply changes. For these reasons the commercial paper rate has been used here for the analysis of lags.

to savings and loan associations because the associations paid a relatively more attractive return during most of the period, thanks in part to interest rate ceilings on time deposits at commercial banks, which were adjusted upward by the authorities with a lag. The associations had no ceilings until 1966 and could pay steadily more as their earnings (mostly on mortgages) rose. The money stock, including time deposits (as used in Chart 7-1), thus often grew less rapidly when interest rates were rising, which added to the inverse relationship produced by the effect of monetary growth on interest rates. As a result, the inverse relationship is stronger in the regression for the post-World War II

TABLE 7-2

Regression of Commercial Paper Rate on Lagged Monetary Growth Rate, for Three Definitions of Money, Various Post-World War II Periods, First Differences of Quarterly Data, 1948–69

	Cumulative Sum of Lag Coefficients		
Lag Term in Months	Incl. Time Deposits, 1948–67	Incl. Time Deposits But Not CD's,[a] 1953–69	Excl. Time Deposits, 1953–65
1½	−8.7	−11.9	−7.0
4½	−11.0	−14.9	−3.0
7½	−9.8	−14.0	4.9
10½	−7.2	−11.9	12.9
13½	−4.5	−10.0	19.5
16½	−2.2	−8.5	24.8
19¼	−0.5	−7.2	29.5
22½	0.8	−5.9	34.3
25½	1.2	−5.5	38.5
28½	0.5	−7.6	39.7
R^2	.44	.48	.57

Note: Lag distributions were fitted to a fifth-degree polynomial with no end-point constraints. Constant term is not shown. Coefficients are expressed in units of basis points per one percentage point change in annual rate of change of money stock.

[a] Large ($100,000 and over) negotiable certificates of deposit.

period, and this could delay the appearance of a positive lagged relationship due to the Fisher effect.

Table 7-2 presents some additional regressions for the post-World War II period which support this interpretation. These regressions use three different definitions of money and start and end in different years in order to avoid certain "problem" periods. The data are quarterly rather than monthly. To allow more degrees of freedom in the short periods covered, the lag terms were constrained to follow a polynomial distribution. The fitted distributions were of fifth degree with no constraints at either end, and with ten (quarterly) lag terms. The table gives the cumulative sum of the lag coefficients, which are dated in the middle of the quarter to which the sums apply; this form of presentation allows comparison with the monthly lag distributions shown in Chart 7-1. In all cases monetary growth is expressed as an annual percentage rate; so the units of measurement are comparable.

The lag pattern for the money stock including time deposits is approximately the same as that in Chart 7-1 for the later period. The small difference results from the two extra years covered here and the use of the polynomial distribution.

When time deposits are excluded altogether, the initial decline in the lag pattern is shorter and rises thereafter quite rapidly. In ten quarters it rises by four-tenths of the theoretical maximum of 100 basis points above zero. That points to a strong and rapid response of the Fisher effect. Indeed, it suggests a much more rapid response than has been found by other studies for earlier periods.

One component of time deposits exhibited a positive response to rising interest rates. Time certificates of deposit grew rapidly after 1960, particularly in the middle 1960's, when interest rates rose steeply. When large certificates of deposit are excluded from the money stock, the estimated lag pattern rises from its initial decline more slowly than in Chart 7-1 and fails to reach the zero line even after ten quarters. This confirms the importance in these estimates of the effect of interest rates on time deposits.

The effect of interest rates on time deposits helps to explain the different results among these regressions, but it does not imply which one gives the truest picture of economic behavior. To the extent (not easy to determine) that monetary policy offsets interest-rate effects on time deposits by keeping the growth of total deposits the same as it otherwise would have been, the wider definition is proper; and to the extent it does not, the narrow definition is proper. Also, to the extent that time deposits are substituted in the public's portfolios for demand deposits, the wider definition is proper. And to the extent that savings deposits in other institutions are substituted for time deposits, an even wider definition may be proper. These are unsettled issues.

There is another problem with the estimated rapid response of the Fisher effect in the regression for the narrow definition of money. The period covered was one of generally rising interest rates and prices. The increases in monetary growth which lie behind the price increases also tend to correlate positively, as the results show, with subsequent increases in interest rates. To attribute this correlation to the Fisher effect implies that the inflation was wholly responsible for the increase in interest rates. This overstates the Fisher effect to the extent that real rates of interest rose over this period. Certainly real rates of interest rose from the very low levels reached during the 1940's. They may have risen further during the subsequent period for a variety of reasons. The regression with the narrow money stock was terminated in 1965 to avoid the steep increases in interest rates in the years following, but this shortening of the period only partly circumvents the problem.

There are good reasons, therefore, for interpreting these results with caution and for not attributing the rapid rise in the pattern for the narrow money stock in Table 7-1 entirely to the Fisher effect. Yet, despite these imperfections, the equation with the narrow definition seems the most plausible of the three. After all, the economic climate of this period does suggest that the public was sensitive to inflation, and such sensitivity is consistent with a rising tail to the lag pattern.

The upshot of this discussion is that the post-World War II period does not give a clear picture of the lag pattern for *real* rates of interest. All the regressions conform to the general pattern implied by the portfolio and Fisher effects, but the full-period regression in Chart 7-1 probably gives the more reliable estimate. On that evidence short-term real rates of interest typically decline for two quarters following an increased rate of monetary growth, and then return to their original levels in about five quarters.

These results support the portfolio theory over the credit theory because the latter does not explain a return to the original level. Of course, a reformulated credit theory, in which the increased rate of monetary growth is deemed to have only a temporary effect, would be consistent with this evidence, as would a credit theory in combination with the Fisher effect. But given the relative importance of the portfolio effect found in Chapter 4, the initial part of the lag patterns estimated here should be attributed to portfolio adjustments.

THE LAGGED EFFECT ON AGGREGATE EXPENDITURES

In the Chapter 6 model of the portfolio effect, both aggregate expenditures and interest rates are affected by the portfolio adjustments set in motion by a monetary disturbance. The resulting movements in expenditures and interest rates are part of the same adjustment. The relation between aggregate expenditures and monetary growth therefore contains further evidence on the dynamic characteristics of the model.

In the theory, monetary growth affects income growth with a lag which is no longer, and may be shorter, than that for interest rates, though the two variables should reach a new long-run equilibrium at the same time. (Income and aggregate expenditures are considered to be the same here.) The income lag will be no longer because the return of interest rates to their original level requires corresponding changes in income. The income lag may be shorter because the effect of monetary growth on income growth involves overshooting, since the level of income first lags behind its long-run equilibrium relation with the money stock and then must grow faster than money for a time in order to catch up. A dependence of desired money balances on permanent income also contributes to overshooting (Appendix to Chapter 6). The income lag may also be shorter because a discrepancy between actual and desired money balances may be partly erased by direct expenditures on goods and services.

On the other hand, any credit effect on interest rates, though not likely to be permanent, can nonetheless continue on after the full effects on aggregate expenditures have been completed. A credit effect would tend to make the observed lag pattern for interest rates longer. In interpreting the results, we must also take account of the Fisher effect in speeding up the return time for interest rates. The return time for *real* rates of interest will be longer than the estimated time for nominal rates, though we cannot say by how much.

The relation between aggregate expenditures (represented by GNP or final sales) and monetary growth has been studied in a series of papers by the research staff of the Federal Reserve Bank of St. Louis and published in the bank's *Review*.[4] The regression presented in Table 7-3 reproduces the kind of equation they have publicized. It follows St. Louis in using the narrow definition of the money stock, which for this period gives the best fit among alternative definitions. The form of this regression, however, differs in certain respects from the "St. Louis equation." The variables in Table 7-3 are expressed as percentage rates of change rather than the change in dollar amounts; high-employment federal expenditures (the other independent variable used in the St. Louis equation) are excluded; and ten lag terms are included rather than only three or four. The purpose of including the extra terms here is to estimate the shape of the lag pattern over a fairly long period. The first of these differences affects the general shape of the pattern.[5] The use of dollar rather than percentage changes results in much less overshooting.

The estimated pattern indicates that monetary effects on aggregate expenditures are quite rapid. In Table 7-3 the cumulative effect reaches

[4] See Leonall C. Andersen and Jerry Jordan, "Monetary and Fiscal Actions: A Test of Their Relative Importance in Economic Stabilization," November 1968; and Michael W. Keran, "Monetary and Fiscal Influences on Economic Activity—The Historical Evidence," November 1969.

This work was undertaken to test the relative importance of monetary and fiscal influences on aggregate expenditures, following the earlier work of Friedman and Meiselman. Andersen and Jordan found the fiscal influence to be temporary and to contribute only modestly to the total correlation. The equation has subsequently been widely used for forecasting. In this respect it has clear limitations. R^2 in Table 7-3 is only .41. (As usually presented, with the variables expressed as changes in dollar amounts, R^2 is appreciably higher.) But the equation is certainly not bad, considering that it relies on only two time series for the independent variables.

[5] The positive constant term (1.06 per cent per quarter or 4.24 per cent per year) mainly represents the upward trend in GNP velocity over the period covered. The ratio of GNP to money stock over this period grew 3.5 per cent per year.

TABLE 7-3

Regression of Percentage Change in GNP on Lagged Values of Monetary Growth Rate, Quarterly Data, 1953–69

Lag Term in Months	Regression Coefficients	t Values	Cumulative Sum of β Coefficients up to Last Significant Term
Constant	1.06	4.8	
1½	0.40	2.6	0.40
4½	0.43	5.5	0.83
7½	0.31	3.7	1.15
10½	0.14	2.2	1.28
13½	−0.02	−0.4	1.26
16½	−0.13	−1.8	1.13
19½	−0.16	−2.5	0.98
22½	−0.12	−1.8	
25½	−0.06	−0.7	
28½	−0.05	−0.6	
31½	−0.18	−1.0	

Note: Lagged coefficients are constrained by polynomial of fourth degree with no end-point constraints. Money stock excludes time deposits. Units of coefficients are pure numbers; constant term, per cent per quarter. $R^2 = .412$. GNP is published series from Department of Commerce National Income Accounts.

unity six months after the initial change in monetary growth.[6] Unity is the total long-run effect.[7] There is overshooting, however, and the cumulative effect settles back close to unity by the eighteenth month,

[6] This seems surprisingly quick. It is usually contended that money has some effect on business activity within six months, but it is seldom claimed that the maximum effect occurs so quickly.

There may, however, be a statistical bias toward a shorter lag in these results because of a dependence of monetary growth on concurrent changes in business activity. Andersen ("Additional Empirical Evidence on the Reserve-Causation Argument," Federal Reserve Bank of St. Louis, *Review*, August 1969) shows that this dependence cannot account for the total correlation between aggregate expenditures and the lag in monetary growth, but the concurrent dependence is not shown to be zero and may spuriously produce some shortening of the estimated lag.

[7] On the assumption that the income elasticity of demand for money balances is unity.

after which the lag terms are no longer statistically significant but suggest further small oscillations around the long-run equilibrium. Most published versions of the St. Louis equation are cut off after the third or fourth lag term. For this reason and also because those versions are expressed in dollar changes, where the theoretically complete effect is not obvious, the overshooting has not been emphasized.[8]

The eighteen months taken for the cumulative effect to settle back close to unity is an estimate of the minimum time to reach a new equilibrium. According to the Chapter 6 model, this time should coincide with the return of real interest rates to their original level. Commercial paper rates cross the zero line in seventeen months for the 1948–65 period in Chart 7-1, and the time would be longer if we could adjust for the upward pull of the Fisher effect. In Table 7-2 the number of months is greater for the two regressions including time deposits. These lag times are not inconsistent with the theoretical relationship. With time deposits excluded, the zero crossover is six months, far less than the return to unity for GNP of eighteen months in Table 7-2 (which also excludes time deposits), but the six-month interest-rate crossover is shortened considerably by a strong upward pull of the Fisher effect as indicated by the subsequent rise of the pattern.

We cannot be sure from these mixed results that the estimated lag patterns for commercial paper rates and GNP are fully consistent with the model of the portfolio effect in Chapter 6. Some of the patterns suggest a delay in the adjustment of interest rates relative to that for GNP which could be due to the credit effect, and some do not. But the general path of the adjustment process estimated here bears out the Chapter 6 model, though there is undoubtedly much room for its elaboration and improvement.

[8] Overshooting is nevertheless apparent in many of the published historical charts of the lag pattern. See especially Keran, "Monetary and Fiscal Influences," Chart II.