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The Statistical Association Between Monetary Growth and Interest Rates

This and the following two chapters investigate the empirical issues raised in the preceding chapter. In this chapter the relation between monetary growth and interest rates is examined, to see whether an inverse monetary effect can be found. The next two chapters present specific tests of the credit theory.

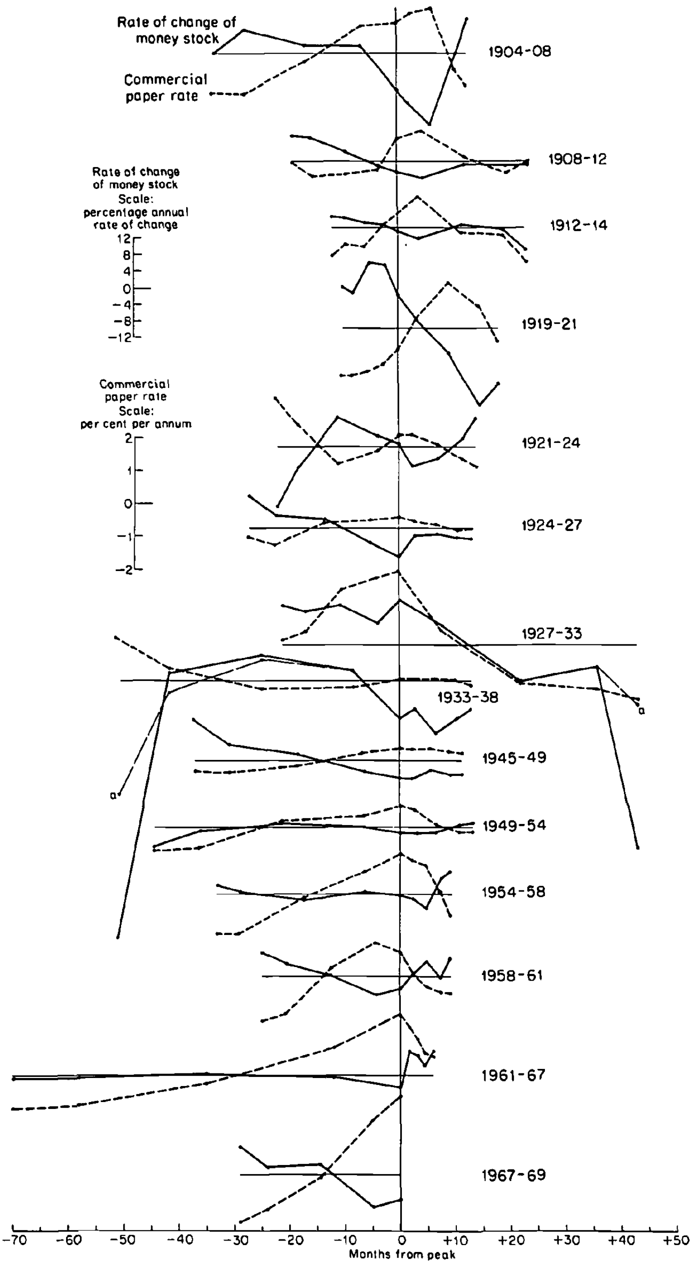
OVERVIEW OF THE TIME SERIES EVIDENCE

Short-run cycles in interest rates conform fairly closely to general business activity largely because of cyclical fluctuations in the total demand for credit. Interest rates do not conform perfectly, however, and many of the deviations are related to the rate of growth of the money stock. The relation is brought out by Chart 3-1, which shows the patterns of commercial paper rates and the rate of monetary growth over National Bureau reference cycles[1] since 1904. Money comprises commercial bank demand and time deposits and currency outside banks. Although the money series is available monthly only after May 1907, it was possible to extend the series with annual data

[1] Reference cycles are divided into nine stages; the terminal stage of one cycle and the initial stage of the next are the same. Trough (I and IX) and peak (V) stages are averages of the three months surrounding the reference trough and peak months, respectively. Stages II–IV divide the period from trough to peak into thirds, and stages VI–VII divide the contraction phase into thirds.

CHART 3-1

Nonwar Cyclical Patterns of Commercial Paper Rate and Monetary Growth Rate, Reference Cycle Stages, 1904–69
(numerical deviations from cycle averages)



Source: See the data appendix.
[a] Including unlicensed banks, 1933–34.

to cover all stages of the 1904–08 cycle. One and a half additional cycles beyond 1961 were constructed by hypothesizing a business peak in December 1966, when industrial production began a moderate decline; a trough in June 1967, when production turned sharply upward; and a peak in November 1969. The 1967 contraction in business seems too small and too short to qualify as a full-fledged downturn, but it has the earmarks of a borderline recession.

The chart reveals a negative association between the two series, particularly in their deviations from general business activity in the timing of peaks and troughs. Many turning points in commercial paper rates came much later than the reference turn, and the lagged timing was often associated with a similar discrepancy in the corresponding inverse turn of the monetary growth rate. The frequent occurrence of corresponding *deviations* provides strong support of a direct link between the variables.

The inverse association is far from perfect, to be sure. The largest exceptions, however, reflect special episodes: the short contraction phase of the World War I cycle, when monetary growth declined erratically from the high wartime levels (in part because the stages were relatively short, which emphasizes the volatility of the monthly changes); and the severe 1929–33 contraction in business, when short-term interest rates and high-grade bond yields fell despite sharp declines in monetary growth. The 1929–33 episode may be explained by the financial crisis: Banks and the public sold risky assets to acquire high-grade securities and money. Potential borrowers with prime ratings tried to avoid incurring debt. In consequence, rates on prime commercial loans and high-grade securities fell sharply while medium- and low-grade bond yields rose. The standard money figures exclude banks not licensed to reopen immediately after the 1933 panic and so overstate the reduction in the money stock appropriately defined.[2] For the affected stages, the chart also shows the money stock adjusted to include the deposits in unlicensed banks. The adjustment lessens the exceptional nature of that period.

The extreme observations on the chart should not draw attention away from the association prevailing in ordinary periods. It is apt to

[2] See Milton Friedman and Anna Schwartz, *A Monetary History of the United States, 1867–1960,* Princeton for NBER, 1963, pp. 422–33.

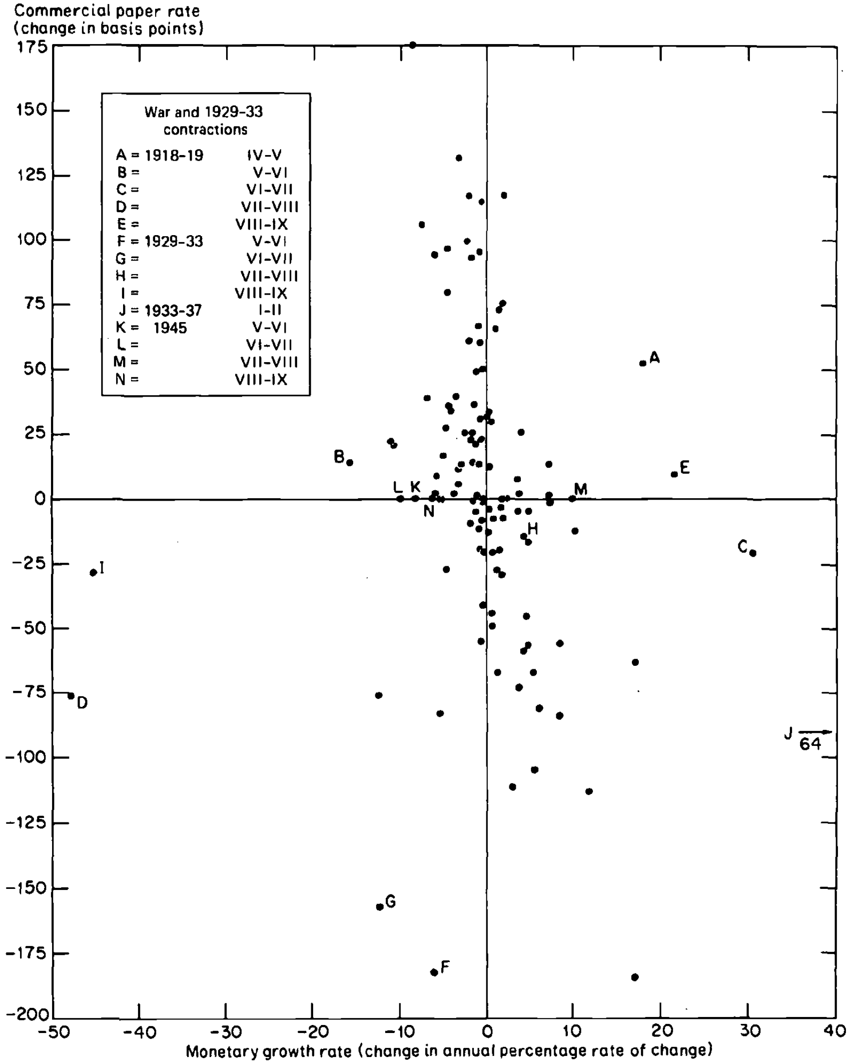
be overlooked because of other distracting movements in the series owing to the strong influence on interest rates of other economic variables. Three statistical difficulties summarize the problems of substantiating the association: First, the volatility of the monthly rate of change of the money stock requires smoothing in some way to bring out its intermediate-run association with interest rates. Second, interest rates exhibit long-run swings lasting fifteen to thirty years or longer which should be distinguished from cyclical movements. Third, these variables have similar cyclical fluctuations, which can produce the appearance of correlation between them even though they may not be directly interrelated.

The use of reference cycle stages helps to overcome these difficulties and to isolate the association. Averaging the data for reference stages substantially reduces the volatility in the monthly rate of change of money. The stage averages sharply reduce the number of observations otherwise available from monthly data, but not more than seems desirable to avoid the high serial dependence in monthly time series. If we take changes between stages, the long-run movements in the data are largely eliminated, allowing the analysis to focus on the short-run relation between the series. Chart 3-2 presents a scatter diagram of the stage-to-stage changes of the series in Chart 3-1 through the 1966 peak. (Later stages were not available when this chart and the subsequent statistical analysis were done.)

Reference cycle stages may be viewed as an irregular transformation of the time scale to reduce autocorrelation and short-run random fluctuations. The linear transformation produced by quarterly or semiannual averages would be conceptually simpler, but would not get at the main problem. Usually the most common source of spurious correlation between economic series apart from trend is cyclical fluctuations. A time unit based on the duration of cyclical stages makes it much easier to determine whether two series are correlated solely because of their tendency to rise and fall with business activity. One indication of such spurious correlation between two series is a sharp decline in correlation when they are converted into deviations from average reference cycle patterns. That decline does not occur here, however, as is shown in the next chapter by the use of dummy variables for each stage change to take account of the average cyclical pattern.

CHART 3-2

Monetary Growth Rate and Commercial Paper Rate, Changes Between Successive Reference Cycle Stages (Special Periods Dated), 1904–66



Source: See the data appendix (same as Chart 3-1; not adjusted for unlicensed banks, 1933–35).

To be sure, reference stage averages are a crude way to eliminate spurious correlation. Ideally, it would be better to include in the regression other variables which account for part of the common fluctuations in the other two. But there are not always satisfactory proxies for these other variables, while the reference cycle is a handy substitute, easy to apply and to interpret. The stage averages also act as a weighting scheme for time series, giving the highest weight to movements covering a cyclical stage and the lowest to movements very short relative to reference stages. This seems preferable to treating each month as equally significant. No doubt the weighting scheme could be improved,[3] but it seems adequate to bring out the relation over business cycles between monetary growth and interest rates. In the appendix to this chapter, the purposes and consequences of averaging the data by reference stages are discussed.

REGRESSION ANALYSIS

To demonstrate the statistical significance of the association, Table 3-1 presents correlation coefficients between the monetary growth rate and various interest rates. The series for the top panel are first differences of reference stage averages, as in Chart 3-2. That is, the monthly *level* of the interest rates and the month-to-month *percentage change* in the money stock, both seasonally adjusted, were first averaged for reference stages. The changes between these successive stage averages were then used in the regressions. The interest series are market rates on prime commercial paper of four to six months, on Treasury notes and certificates of three to six months before 1929, linked to Treasury bills of three months thereafter (full series referred to here simply as Treasury bills), on bank loans (an average of varying coverage), on long-term U.S. bonds, on high-grade corporate and municipal bonds (Standard and Poor's), on Macaulay's adjusted average of railroad bonds, and on low-grade

[3] In particular, it would be preferable to use stages of equal length for each complete phase, and not shorter ones for troughs and peaks as here, though the results from omitting these stages made little difference. A more sophisticated refinement might be to vary the length of stages according to the time span of autocorrelation in the data.

TABLE 3-1

Relation Between Interest Rates and Monetary Growth Rate, Various Periods, 1868–1966

Interest Rate and Period	Correlation Coefficient	t Value [a]
	Changes Between Reference Cycle Stages [b]	
1919–66		
Commercial paper	–.42	3.9
Treasury bills	–.44	4.1
U.S. bonds	–.45	4.3
Corporate and municipal bonds	–.16	1.4
1919–61		
Bank loans	–.40	3.6
Low-grade bonds	–.38	3.5
	Annual Changes [c]	
Commercial paper		
1868–1914	–.55	4.4
1919–66	–.67	5.4
Treasury bills		
1920–66	–.57	4.0
U.S. bonds		
1919–66	–.47	3.2
Railroad bonds		
1868–1914	–.25	1.7
Corporate and municipal bonds		
1919–66	–.48	3.2

Source: See the data appendix.

[a] Signs of t values, which pertain to the regression coefficient and are all negative, have been omitted. $t \geq 2.0$ is significant at the .05 level.

[b] Changes between nine successive reference-cycle stage averages of monthly interest rates (for bank loans, quarterly data after 1938) and of month-to-month percentage change in money stock.

For all regressions, except with low-grade bonds, coverage excludes changes between stages V and IX of 1914–18 and 1938–45 war contractions and between V and II of the 1929–33 contraction and subsequent revival (to omit the 1933 trough stage); with bank loans, coverage also excludes stage changes I–II and II–III of the 1938–45 expansion (because of a break in the series). With low-grade bonds, only stages VIII–IX of 1927–33 and I–II of the 1933–38 cycles are excluded to omit the extreme decline in money stock in March 1933. Treasury bill series begins with the peak stage of the 1919–21 cycle; bank loans and U.S. and Baa bonds begin with the initial trough stage of that cycle. Bank loans and low-grade bonds end with the 1961 trough; others, with the assumed peak in 1966.

[c] Year-to-year change in interest rates (fiscal-year average of monthly data) and June-to-June percentage change in money stock, excluding 1930–33 and 1940–46.

bonds (Moody's Baa average). Sources are given in the data appendix.

The 1929–33 contraction and the two war contractions of 1918–19 and 1945 are the source of the extreme observations lettered in Chart 3-2; they distort the over-all association between monetary growth and interest rates and have been excluded in Table 3-1. Unlike the other series, yields on low-grade bonds rose in the 1929–33 contraction, and that period was *not* excluded in the regression for that series. When 1929–33 and the war contractions are included for the other rate series, the correlation (not shown) is reduced, but it is still significant. The adjustment to include unlicensed banks 1933–34 was not used for the regressions.

To indicate whether the reference-stage averages produce quite special results, the bottom panel of the table gives corresponding correlations using changes in annual data, that is, the average monthly level of the interest rates for fiscal years and the June-to-June percentage change in the money stock were converted to first differences —year-to-year changes—for use in the regressions. The Great Depression and World War II (1930–33 and 1940–46) were excluded.[4] The results in the two panels of the table are similar.

Although not large, the correlation coefficients in Table 3-1 are on the whole highly significant. Most interest rates exhibit similar short-run movements; if monetary growth correlates with one series, it will correlate with all of them, though the correlation tends to be higher for rates on commercial paper and U.S. securities than for the others. High coefficients are not to be expected, simply because the regressions omit all the nonmonetary factors affecting financial markets. Monetary growth accounts for 3 to 44 per cent—typically about 25 per cent—of the cyclical variation in interest rates, depending on the interest rate and the period. (This range corresponds to correlation coefficients of between .16 and .67.)

The remainder of this variation in interest rates can be attributed to other supply and demand factors. These would be difficult to identify and measure, but many of them were clearly associated with the business cycle, as is shown by adding to the previous regressions a proxy or dummy variable to represent movements in general business ac-

[4] The regressions for bank loans and low-grade bonds were computed before the data after 1961 became available.

tivity. Several such proxies for demand influences (industrial production, personal income, gross national product) were experimented with. The partial correlation coefficients of these variables with interest rates (not shown) were all highly significant and positive, suggesting the strong influence of cycles on the demand for loanable funds. (Supply factors with positive conformity to business cycles would tend to produce negative coefficients.) These proxies were only slightly correlated with the money variable, however (partly because the series have been expressed as first differences); consequently, their inclusion had little effect on the correlation found between monetary growth and interest rates.

A few unusually large observations can sometimes account for most of an observed correlation. Omitting all the stage changes with extreme values of the money series, however, made little difference. The regressions with those exclusions are presented in Table 3-2 for reference stage changes. Column 1 shows the correlations omitting just the 1929–33 and war contractions. The coefficients differ slightly from those in Table 3-1 for the corresponding interest rates because Table 3-1 was based on a later revised version of the money series and excludes stages I and II of the 1933–38 cycle, included here in column 1. Also, Table 3-2 excludes the stages after 1961 (not available at the time of computation) and includes the years 1904 to World War I for those interest-rate series which were available for that period.

Column 2 excludes seven other observations with extremely large rates of monetary growth or decline; the results are practically the same. When we also omit the period of unusually low interest rates after 1933 and the subsequent pegging of rates by the Federal Reserve from 1942 to the early 1950s (column 3), the correlation is even higher.

It can be argued that time deposits at commercial banks should be excluded from the money series. The argument based on the credit theory would be that, if they are a closer substitute for savings bank deposits than for demand deposits, the addition to total credit supplied by commercial banks when they gain time deposits will usually be largely offset by a decrease in credit supplied by other financial intermediaries losing deposits. Hence an expansion of time deposits does not augment the net supply of credit by an equal amount. The portfolio

TABLE 3-2

Correlation Coefficients Between Interest Rates and Monetary Growth Rate, Changes Between Reference Cycle Stages, Various Periods, 1904–61

Interest Rate and Period	Period Covered Excluding: War Contractions and 1929–33 (1)	Period Covered Excluding: Other Stages with Extreme Values[a] (2)	1919–29 and 1953–61 Only (3)
	Including Time Deposits in Money Series		
Commercial paper, 1904–61	−.47	−.48	−.56
Treasury bills, 1920–61[b]	−.46	−.48	−.61
Bank loans, 1919–61	−.46	−.38	−.51
U.S. bonds, 1919–61	−.42	−.42	−.47
Corp. and municipal bonds, 1904–61	−.38	−.43	−.39
	Excluding Time Deposits From Money Series[c]		
Commercial paper, 1914–61	−.38	−.44	−.49
Treasury bills, 1920–61[b]	−.40	−.43	−.52
U.S. bonds, 1919–61	−.36	−.39	−.40
Corp. and municipal bonds, 1914–61	−.32	−.36	−.32

Source and coverage: Same as for Table 3-1, except that all regressions end with 1961 trough, and some begin earlier.

[a] Excluded stage changes: 1904–08, VII–VIII; 1914–19, I–II and IV–V; 1919–21, VII–VIII; 1921–24, II–III; and 1933–38, I–II and IV–V; as well as those noted for column 1.

[b] Excluding the 1919–20 expansion stages; not available for Treasury bill rate.

[c] Not computed for bank loans.

theory argument would be that time deposits may not be a part of money balances.

The sharp fluctuation in growth of time deposits during the 1960s because of deposit-rate ceilings argues for their exclusion. But earlier periods are a different matter. During the 1920s and 1930s, differences in the relative growth of demand and time deposits reflected shifts between them by the public on a large scale.[5] Excluding time deposits then would misrepresent the net changes in funds commercial banks supplied to the credit market. Also, before the 1930s some time deposits could be transferred by check and were not clearly distinguished from demand deposits.

It is difficult to settle this question by time series regressions for the period covered here. Some slight support for including time deposits is provided by correlation coefficients (bottom panel of Table 3-2) for which time deposits were excluded (the data, however, cover just the post-1914 period, when time and demand deposits could be separated in the monthly data). The exclusion of time deposits lowers the correlation, though, as expected, only slightly and not significantly.

AN ALTERNATIVE INTERPRETATION OF THE ASSOCIATION

The preceding evidence supports the view that changes in the rate of monetary growth affect interest rates. Before accepting this interpretation, however, we should examine the possibility of an influence running in the opposite direction, in which interest-rate movements produce changes in the money stock.

Interest rates can affect monetary growth in various ways which might account for the observed correlation and contradict the preceding interpretation. The importance of such effects can be assessed by examining the relation between interest rates and the principal sources of change in the money stock, namely, the actions of the federal government, the banks, and the public.[6] Attributing money-stock changes to the influence of these sectors is traditional.[7] Therefore, the derivation of a formula for measuring these influences need be sketched here only briefly.

The federal government is responsible for changes in high-powered money, H (the monetary base which serves partly as bank reserves

[5] Discussed in Phillip Cagan, *Determinants and Effects of Changes in the Stock of Money, 1875–1960*, New York, NBER, 1965, pp. 171–73.

[6] Time deposits are included throughout this section.

[7] See, for example, Friedman and Schwartz, *Monetary History*, App. B; and Cagan, *Determinants and Effects*, Chap. 1.

and partly as circulating hand-to-hand currency, and consists of currency, Federal Reserve deposit liabilities, and, before 1934, gold outside the Treasury). The money stock publicly held, M, equals currency outside banks, C, plus commercial bank deposits, D; $M \equiv C + D$. High-powered money outstanding that is not held as currency by the public is held by banks as reserves, R; $H \equiv C + R$. From these definitions it follows that

$$M \equiv \frac{H}{(C/M) + (R/D) - (C/M)(R/D)}$$

in which the money stock depends on high-powered money issued by the monetary authorities (the Treasury and Federal Reserve banks), the currency ratio of the public, C/M, and the reserve ratio of banks, R/D. High-powered money affects the money stock positively, while the two ratios have inverse effects. Writing both sides in terms of natural logarithms and differentiating with respect to time gives, after collecting terms,

$$\frac{d \ln M}{dt} \equiv \frac{d \ln H}{dt} + \frac{M}{H}\left(1 - \frac{R}{D}\right)\frac{d(-C/M)}{dt} + \frac{M}{H}\left(1 - \frac{C}{M}\right)\frac{d(-R/D)}{dt}$$

$$m \equiv h + c + r.$$

In this form, the rate of change of the money stock is the sum of three parts representing changes in high-powered money, the currency ratio, and the reserve ratio. Here r denotes the contribution of the reserve ratio to monetary growth (not, as in Chapter 2, the reserve ratio itself). The derivatives may be approximated by discrete monthly changes. This introduces a slight error, since the three parts do not then add exactly to the total rate of monetary growth. However, the approximation is close enough for practical purposes.

The correlation between interest rates and the monetary growth rate implies, by the foregoing identity, a correlation between interest rates and the three sources of the growth rate. Different theories of the direction of influence, however, imply different relations between interest rates and each of the three sources. If interest-rate effects are largely responsible for the inverse association with monetary growth, the effects on the three sources should be in different directions. A rise in interest rates tends to reduce the reserve ratio and therefore to increase the money stock. A rise in interest rates also tends to reduce the public's desire to hold currency, and thus also to increase the money stock. To be sure, such effects are limited; hence higher interest rates would be expected to raise the *growth rate* of the money stock only temporarily. Nevertheless, we still expect the main effect on the rate of change to be positive or zero.

The above formulation treats member bank borrowing from the Federal Reserve as part of the contribution of high-powered money, on the grounds that the volume of such borrowing is taken into account and offset by the monetary authorities in conducting open-market operations. Another point of view looks upon borrowed reserves as determined by member banks and implicitly disregards any offset by open-market operations. The preceding identity can incorporate this second view, if reserves borrowed by member banks are excluded from high-powered money and subtracted from bank reserves. (The subtraction from reserves in excess of requirements gives the free reserves of banks, which are always less than excess money reserves and often negative.) Even on this formulation, interest rates are still expected to affect monetary growth positively. A well-known study of free reserves[8] argues that a rise in interest rates (relative to the discount rate at which member banks can borrow from the Federal Reserve) lowers the desired level of free reserves and makes the actual level temporarily too high. To close the gap, banks step up their rate of expansion of earning assets. The result is to produce a positive association between interest rates and the rate of deposit growth.

Given these positive effects, the observed *negative* correlation between interest rates and monetary growth suggests two alternative explanations. Either (1) interest rates have a sufficiently strong negative effect on the contribution to monetary growth of the unborrowed portion of high-powered money to overcome their positive effect on the other sources, or (2) the negative correlation between interest rates and monetary growth should be attributed largely to monetary effects, interest effects on monetary growth being relatively minor.

Table 3-3 presents correlation coefficients of interest rates with each

[8] A. J. Meigs, *Free Reserves and the Money Supply,* Chicago, University of Chicago Press, 1962.

TABLE 3-3

Correlation Coefficients Between Sources of Monetary Growth and Interest Rates, Changes Between Reference Cycle Stages, Various Periods, 1904–61

Contribution to Monetary Growth Rate [a]	Period Covered Excluding: War Contractions and 1929–33 (1)	Period Covered Excluding: Other Stages with Extreme Values [b] (2)	1919–29 and 1953–61 Only (3)
	Commercial Paper Rate, 1904–61		
h_t	.08	.06	−.14
h_u	−.06		
c	−.39 *	−.25 *	−.24
r	−.13	−.18	−.16
	Treasury Bill Rate, 1920–61 [c]		
h_t	−.10	−.05	.00
h_u	−.05		
c	−.29 *	−.33 *	−.40 *
r	−.13	−.16	−.22
	U.S. Bond Rate, 1919–61		
h_t	−.11	−.02	−.05
h_u	.02		
c	−.10	−.11	−.33 *
r	−.25 *	−.27 *	−.12
	Corporate and Municipal Bond Rate, 1904–61		
h_t	−.05	−.02	−.06
h_u	−.01		
c	−.17	−.09	−.23
r	−.18	−.22	−.10

Source: Same as for Table 3-2, with time deposits included. Member bank borrowing from *Banking and Monetary Statistics* and *Federal Reserve Bulletin.*

[a] The contributions to the rate of monetary growth are h_t for high-powered money, h_u for h_t excluding member bank borrowing, c for the currency ratio, and r for the reserve ratio.

[b] Same exclusions as for Table 3-2.

[c] Excluding 1919–20 expansion stages, which are not available for Treasury bill rate.

* Significant at the .05 level.

of these sources of monetary growth. The contribution of high-powered money is shown both in total (h_t) and with member bank borrowing excluded (h_u). To be comparable with Table 3-2, the observations are changes between reference cycle stages and cover the same periods. The coefficients do not reveal a strong negative relation between interest rates and the rate of change of high-powered money either including or excluding borrowing, contrary to the first explanation above. Indeed, those coefficients are virtually zero.

Most of the correlation with the contributions of the two ratios is negative, though generally not significant. This cannot reflect the response of bank reserves and the public's currency holdings to interest-rate movements, because in theory their contribution to monetary growth should have a positive association with interest rates. (Remember that the signs of changes in the currency and reserve ratios are reversed in measuring their contributions to growth in the money stock.) Although the table does not include the free reserve ratio, in theory its relation here to interest rates should also be positive. These contributions cannot, therefore, account for the much higher negative correlation between interest rates and the growth rate of the total money stock. The negative correlations in the table apparently reflect the opposite direction of influence, in which the separate sources, acting through the total money stock, affect interest rates.[9]

It might be argued that, if the Federal Reserve persistently and successfully pursued a policy of controlling total high-powered money so as to make the monetary growth rate move inversely to interest rates, the observed correlation could be produced, even though monetary growth had no effect on interest rates and even though interest rates showed little or no association with each of the three sources of monetary growth. In that case much of the movement in high-powered money would have been devoted to offsetting fluctuations in the currency and reserve ratios. Since the two ratios were not themselves influenced by interest rates, high-powered money might

[9] My study "Interest Rates and the Reserve Ratio: A Reinterpretation of the Statistical Association," in Jack M. Guttentag and Phillip Cagan (eds.), *Essays on Interest Rates*, New York, NBER, 1969, Vol. I, confirms a negative effect of interest rates on the free reserve ratio, but a much weaker one than usually reported if loan demand is held constant. Even then, fluctuations in the free reserve ratio are not large, and the effect of interest rates on deposit growth through this channel appears to be negligible.

not show an inverse association with interest rates. Reserve officials, for example, might have regarded a steep rise in interest rates as evidence of an overheated economy and taken steps to reduce monetary growth, in the process offsetting contrary movements in the currency and reserve ratios, and, conversely, for declines in interest rates.

But this implies that Federal Reserve policy was guided primarily by interest rates and was intended to reinforce their movements, whereas in fact they often tried to moderate them. That the Federal Reserve consistently followed such a limited guide is hardly credible in view of the variety of policies it actually pursued over the years.[10]

Moreover, the negative association between monetary growth and interest rates for the period 1868–1914 (Table 3-1) must run from money to the rates, since there was then no central bank authority to control the money supply nor any mechanism to make it *inversely* responsive to interest rates. The same correlation in the post-1914 period cannot plausibly be given a contrary interpretation.

CONCLUSIONS

The evidence points to an inverse effect of monetary growth on interest rates. The effect is not overpowering, and volatility in the money series and other strong influences on interest rates tend to hide it. But it appears not to be a spurious reflection of the common influence of business cycles on the variables or an effect of interest rates on the amount of money supplied. The most plausible inference is that changes in the growth rate of the money stock shift the supply curve of loanable funds and produce inverse movements in interest

[10] Other recent work on the supply of money reaches the same conclusion. Regressions of Federal Reserve credit supplied to the market show that it is related to a variety of variables and that interest rates actually have a small *positive* effect. See John H. Wood, "A Model of Federal Reserve Behavior," in G. Horwich (ed.), *Monetary Process and Policy: A Symposium,* Homewood, Ill., R. D. Irwin, 1967, pp. 135–66.

Similarly, in studies of the effect of aggregate expenditures on the money supply, this feedback is found to be weak. See Leonall C. Andersen, "Additional Empirical Evidence on the Reverse-Causation Argument," Federal Reserve Bank of St. Louis *Review,* August 1969, pp. 19–23. See also David I. Fand, "Some Implications of Money Supply Analysis," *American Economic Review,* May 1967. I made a similar argument in *Determinants and Effects,* pp. 273–75.

rates. That proposition in various forms has long been a part of monetary theory. Two theories to explain this association are tested in the next chapter.

APPENDIX: THE USE OF REFERENCE CYCLE STAGES IN REGRESSION ANALYSIS

Cycles in general business activity impart fluctuations to nearly all economic time series. From trough to trough or from peak to peak the cycles vary in duration from two to five years or so. Such fluctuations pose two problems for regression analysis. First of all, the assumption of standard regression analysis that the residual error term is random or serially independent usually does not hold. The main reason is that regression equations are rough approximations of complex market behavior and disregard numerous influences which are difficult to measure or are thought to be of secondary importance. The residual term incorporates the omitted variables, which usually contain cyclical fluctuations. Such fluctuations produce serial correlation. Also, even some of the included variables may be only proxies for other hard-to-measure variables, which have cyclical fluctuations not perfectly reproduced in the proxies. As a result, the error term is not random over time but contains the difference between the cyclical fluctuation in the proxy and the omitted variables. For these reasons the residual term typically is autocorrelated in time series regressions. First differences and models of the autocorrelated disturbance can be introduced to remove the serial dependence in the error term. By the Durbin-Watson statistic and other tests, these procedures are generally successful, though their appropriateness can be questioned, since the implicit assumption of these procedures is that two successive error terms are linearly related. Actually, they are more likely to be related by a sinusoidal function of varying periodicity.

In any event, autocorrelation in the residuals and methods to eliminate it are not likely to pose disabling obstacles unless precise estimates of the regression coefficients are needed. Usually we only want to test the significance of a relationship and the direction of certain effects.

A second problem is in my view more serious: Cycles in the included independent variables can serve as proxy for similar cycles in omitted variables. Then a spuriously high correlation can be obtained even though the equation is misspecified and some crucial variables are omitted from it. The similar cyclical fluctuations in economic time series make such spurious correlation between the dependent and each independent variable a common occurrence. Treatment of the error term for autocorrelation does not help here; indeed, it may remove fluctuations from the error term and lead us to infer that autocorrelation is absent when in fact the omission of certain variables means that it should be present.

It seems desirable, therefore, to test all questionable time series regressions for the influence of common cyclical fluctuations. It is not that relationships observed in the form of cyclical fluctuations are not meaningful; they are—if the correlation indeed reflects the particular influence that the regression is designed to measure. Many economic variables correlate with each other, however, solely because of common cyclical patterns. If two variables are genuinely related to each other, they should display related movements which are not a common reflection of cycles in general business activity.

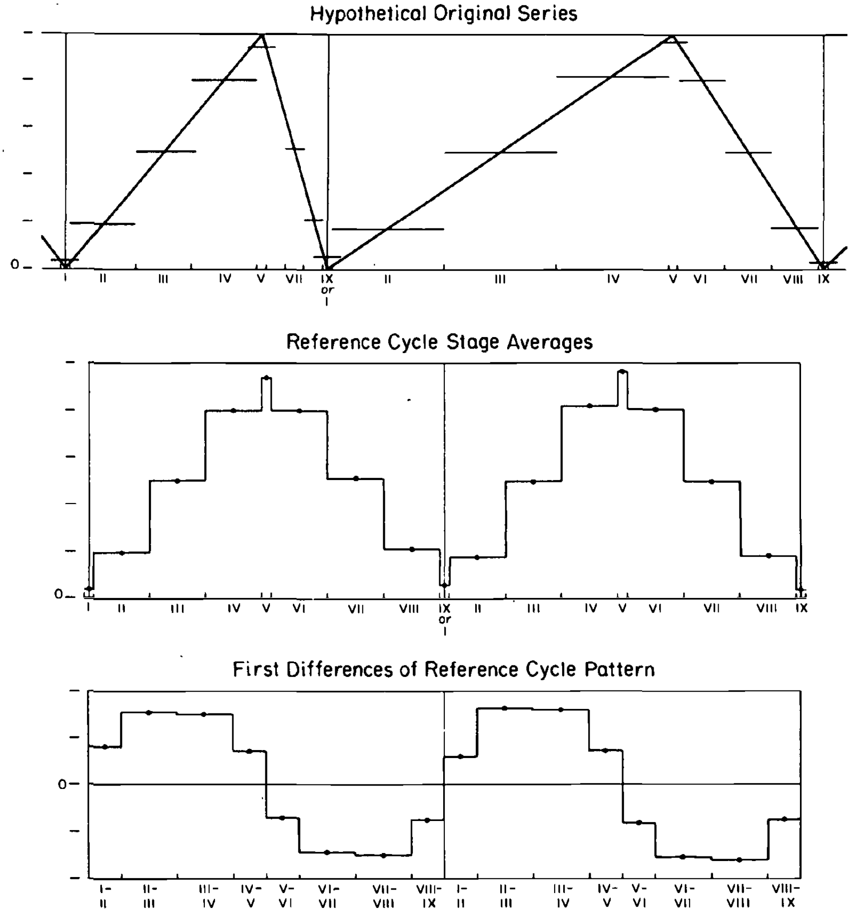
Averages of the data for stages of reference cycles can be used to highlight common cyclical fluctuations in the data. The average has the advantage of smoothing out very short-run fluctuations in the data. What remains are trend and intermediate-run movements. Trends can be removed by taking first differences of the stage averages.

The effect of stage averages on a trendless series which conforms perfectly to reference cycles of varying lengths is illustrated in Figure 3-1. The figure was drawn on the assumption that the varying length of the phases stretches or squeezes the horizontal shape of the curve but does not change its average amplitude. Consequently, when we average by stages, dividing each phase into trough, peak, and three equal intervening stages, the curve has the same general shape in every expansion and contraction. Any series affected by business cycles in this way will show after the averaging a very similar pattern for every cycle.

The effect of taking first differences of the stage averages is illustrated at the bottom of Figure 3-1. Evenly spaced first differences of a triangular pattern would yield a step function: a constant positive value during the expansions and constant negative value during the contrac-

FIGURE 3-1

Transformation of a Trendless, Perfectly Conforming Linear Series into Reference Cycle Patterns



tions, with steps at the turning points. The first differences of stage averages are not evenly spaced, however. Trough and peak stages overlap the adjacent stages, and the stages within each phase differ by one month when the number of months within the phase is not divisible by three. As a result, the first differences resemble a somewhat jagged curve more than a step pattern. Nevertheless, the first differences have no trend and transform a smooth, perfectly conforming series into a succession of symmetrical and very similar cyclical patterns, even if the slope of the original series flattens out in longer phases and steepens in shorter ones.

In a regression where the economic variables are in the form of changes between successive reference cycle stages, dummy variables can be added to absorb the common cyclical fluctuations in the economic variables (this technique is used in Chapter 4). Seven dummy variables are added to the regression equation, one for each stage-to-stage change but the last (to avoid overdetermining the regression). For each stage change, the corresponding dummy variable is unity and the other six are zero. This is equivalent to fitting the regressions without dummies to the data for the stage change I–II separately, II–III separately, and so on for each of the eight stage changes, under the condition that the regression coefficients be the same for all fits.

The dummies in effect hold constant the regular cyclical fluctuation. What is not held constant are deviations from this pattern, including responses to the business cycle which vary in timing or amplitude from cycle to cycle or occur over time at a rate not in proportion to the duration of the concurrent reference phase. Two variables may be highly correlated in a simple regression, but when we hold the common cyclical component constant they will not be correlated unless the irregular cyclical movements are related.

The stage averages allow each stage equal influence on the regression fit, no matter how long the actual period of time covered by the stage. Thus, long expansions, which would otherwise contribute many more observations than short ones, carry no extra weight. Although unusually long phases have been infrequent before 1961, ordinary expansions were still two to four times longer than most contractions. The disadvantage of calendar time weighting is that a long, comparatively smooth business expansion tends to induce trendlike movements in most economic variables, which then appear to be correlated with each other even though their behavior is otherwise dissimilar. The largely unidirectional movements of variables during reference expansions receive much more weight on a calendar time scale than do the often sharp but short movements during reference contractions. With stage averages the movements in the two phases receive equal weight, though if it is desired, they could be weighted in some other way.

Reference cycle averages, therefore, are a desirable supplement to standard calendar time data, but not a substitute. There are obvious disadvantages to the stage changes: They may suppress some relevant short-run movements; they may give too much weight to relatively short and erratic movements in contractions, when errors of measurement may be relatively large; and they cannot be used for lag patterns unless the length of the lags varies with the duration of the business cycle phases. To check on these possible drawbacks of reference stage data, annual or monthly regressions have been used in this study to supplement the stage changes and to estimate lags.