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Volume Author/Editor: Burns, Arthur F. and Wesley C. Mitchell

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Chapter Author: Arthur F. Burns, Wesley C. Mitchell

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CHAPTER 6

# Effects of the Time Unit on Cyclical Measures

In Chapter 1 and more explicitly in Chapter 3 we have explained why we deem it necessary to analyze many time series, why we wish each to cover many cycles, and why we should like to include more countries than we do. By using annual data we could have approximated this far-reaching program better than we have. But we could not meet it nearly so well as we have, if we had spent our resources in elaborating treatment of a relatively small number of monthly or quarterly series; for example, by making one analysis of the raw data adjusted merely for seasonal variations, another of data adjusted for secular trend as well, a third of data adjusted for both erratic and seasonal movements, and perhaps still a fourth of data adjusted in all three respects. The aim of this and the two following chapters is to explain why we have chosen to lavish effort in certain directions and to economize in others. These explanations will not carry conviction to a discerning reader, unless supported by empirical evidence. Hence the chapters abound in detailed demonstrations of the manner in which alternative decisions affect the cyclical measures we make.

## I The Problem of This Chapter

Annual data are more abundant than monthly or quarterly. Many important series are available only by years, and the monthly or quarterly series we analyze can often be had for much longer periods in annual form. Also, annual data are simpler to handle; there are no seasonal variations to deal with, and the other computations we make are much abbreviated. By confining ourselves strictly to annual data from the outset, it is not improbable that we could have doubled the number of series analyzed and performed the work in half the time we are taking.

The reason we have not adopted this labor-saving course is that we do not trust pictures of cyclical movements drawn from annual series, except when the process represented consists of operations such as the production of staple crops harvested once a year. Though we think this distrust is justified by experience, there is still sufficient difference of opinion and practice among time-series analysts to call for a thorough examination of the influence of the time unit upon measures of cyclical behavior.[1] This examination will not only make clear why we prefer monthly data despite their relative scarcity and the heavy costs of analyzing them, but will also provide a basis for criticizing the results we get ourselves when, in default of better materials, we resort to series that run by years. We shall take this occasion to deal also with the less acute issue of quarterly versus monthly data.

## II Why the Time Unit Matters

The largest number of observations we can make upon a cycle in annual data is one more than the number of years covered. If the cycle lasts two years we can observe only the initial trough, peak, and terminal trough; we treat the last as an observation also upon the initial trough of the following cycle. Quarterly data enable us to make roughly four times and monthly data roughly twelve times as many observations. One-fourth of the business cycles marked off by our monthly reference dates lasted three years or less; more than half of the reference expansions and contractions lasted two years or less, and nearly one-sixth lasted one year or less. Specific cycles have similar durations. The few observations on these short movements yielded by annual data are obviously crude materials for comparing the behavior of different processes in the same cycle, or for comparing the behavior of the same process in different cycles.

Summation by years hides many of the cycles revealed by monthly data, sometimes introduces spurious cycles, and influences the amplitude, pattern, and other features of all cyclical movements. These effects, which we shall presently examine in detail, depend upon the duration of cyclical expansions and contractions in monthly data, their amplitude, and the steepness of the trend. But a less obvious factor also counts heavily: the time of the year when cyclical turns occur.

Suppose that a monthly series has regular two-year cycles that start from 0 at the initial trough, rise by the monthly increment $b$ to $11b$, maintain this peak value for two months, then decline by $b$ each month

[1] We have been influenced most by the experience of one of the authors who in an earlier investigation relied largely upon annual data in trying to get a comprehensive view of 'the rhythm of business activity'. See Wesley C. Mitchell, *Business Cycles* (University of California Press, 1913). For a recent example of reliance upon annual data, see J. Tinbergen, "A Method and Its Application to Investment Activity" and "Business Cycles in the United States of America, 1919–1932" (League of Nations, *Statistical Testing of Business-cycle Theories,* I and II, Geneva, 1939).

to 0 at the terminal trough. So long as we deal with specific cycles of monthly data, it does not matter in what months the troughs and peaks occur. But if the data are summarized by years, the results depend upon the months of the cyclical turns.[2] Calendar-year summation or averaging will wipe out the cycles completely if they make turns in January: [3] for the series will rise one year from 0 to $11b$, it will fall the next year from $11b$ to 0, and the successive annual totals will therefore remain constant. If the turns come in any other month, the cycles in monthly data will be reflected in the calendar-year summations, and their amplitude will be largest when the turning points are at the middle of the year. If the turning month is April, the trough values of monthly averages by years will be $3.25b$ and the peak values $7.75b$. If the turning month is July, the trough values will be $2.5b$ and the peak values $8.5b$. Summation or averaging by years ending June, on the other hand, will wipe out the cycles whose turns come in July, and give maximum amplitude to the cycles with turns in January.

Suppose next that the series has regular three-year cycles and a rising trend, the expansions lasting two years and the contractions one year. A cycle 'starts' from 0 at the initial trough, rises by the monthly increment $b$ to $23b$, maintains this peak value for two months, declines by $b$ each month to $12b$ at the terminal trough, maintains this value for two months, rises again by the monthly increment $b$ to a peak of $35b$, and so on. In this as in the preceding example, summation or averaging by calendar years will wipe out the cycles completely if the turns come in January, and yield maximum amplitudes if the turns come in July. But the results are very

2 The way in which the monthly dates of cyclical turn affect the cyclical movements of annual data can be instructively shown by a formula, for which we are indebted to Edward E. Lewis.

Let $Q_1$ be the sum of a time series in one calendar year and $Q_2$ the sum in the next year. Let $q_1$ represent the January value in the first year, $q_2$ the February value, etc.; $q_{24}$ represents the December value in the second year. Finally, let $d_1 = q_2 - q_1$, $d_2 = q_3 - q_2$, etc. Then

$$q_{13} - q_1 = d_1 + d_2 + d_3 + \dots + d_{12}$$
$$q_{14} - q_2 = d_2 + d_3 + d_4 + \dots + d_{13}$$
$$\dots$$
$$q_{24} - q_{12} = d_{12} + d_{13} + d_{14} + \dots + d_{23}$$

If these twelve equations are summed, we get $Q_2 - Q_1$ on the left of the equal sign. On the right we have a weighted sum of the month-to-month differences: $d_1$ enters this sum just once, $d_2$ enters twice, $d_3$ enters three times, and so on through $d_{12}$ which enters twelve times. After that the weights decrease successively by unity.

It is plain that in the hypothetical series discussed in the text, annual data will show a much more substantial movement if the cyclical turns come in the middle of the year than if they come near the boundaries. In the former case the month-to-month movements during the rising phase (which extends from the middle of one year to the middle of the next) will receive a substantially larger weight than the month-to-month movements during the declining halves of the first and second years. This excess will progressively diminish as the cyclical turns come closer to the yearly boundaries.

3 We describe the second of the two months reaching identical peak or trough values as the peak or trough month; or in general, as the month of turn. Similarly, the second of two years having identical maxima or minima is treated as the year of turn. These conventions are adhered to throughout.

TABLE 49

Illustrations of the Dependence of Specific Cycles in Annual Data on the Months of Cyclical Turn

*Case A.* Cycle period 3 years: expansion 27 months, contraction 9 months, peak and trough values maintained 2 months. Rise per month is *b*; rise per month equals fall per month. Value at trough month in Year I is 0.

*Case B.* Cycle period 3 years: expansion 30 months, contraction 6 months, peak and trough values maintained 2 months. Rise per month is *b*; rise per month equals fall per month. Value at trough month in Year I is 0.

*Case C.* Cycle period 3 years: expansion 34 months, contraction 2 months, peak and trough values maintained 2 months. Rise per month is *b*; total rise equals total fall. Value at trough months in Years I, IV, etc. is 0.

| Dates of possible specific cycles in monthly data | | | Total during calendar year (in units of *b*) | | | | Amplitude of specific cycle in annual totals (in units of *b*) | | |
|---|---|---|---|---|---|---|---|---|---|
| Trough | Peak | Trough | Year I | Year II | Year III | Year IV | Rise | Fall | Rise & fall |
| | | | | **Case A** | | | | | |
| Jan. I | Apr. III | Jan. IV | 66 | 210 | 273 | 282 | ... | ... | ... |
| Feb. I | May III | Feb. IV | 55 | 198 | 278 | 271 | 223 | 7 | 230 |
| Mar. I | June III | Mar. IV | 46 | 186 | 281 | 262 | 235 | 19 | 254 |
| Apr. I | July III | Apr. IV | 39 | 174 | 282 | 255 | 243 | 27 | 270 |
| May I | Aug. III | May IV | 34 | 162 | 281 | 250 | 247 | 31 | 278 |
| June I | Sep. III | June IV | 31 | 150 | 278 | 247 | 247 | 31 | 278 |
| July I | Oct. III | July IV | 30 | 138 | 273 | 246 | 243 | 27 | 270 |
| Aug. I | Nov. III | Aug. IV | 31 | 126 | 266 | 247 | 235 | 19 | 254 |
| Sep. I | Dec. III | Sep. IV | 34 | 114 | 257 | 250 | 223 | 7 | 230 |
| Oct. I | Jan. IV | Oct. IV | 39 | 102 | 246 | 255 | ... | ... | ... |
| Nov. I | Feb. IV | Nov. IV | 45 | 90 | 234 | 261 | ... | ... | ... |
| Dec. I | Mar. IV | Dec. IV | 51 | 78 | 222 | 267 | ... | ... | ... |
| | | | | **Case B** | | | | | |
| Jan. I | July III | Jan. IV | 66 | 210 | 318 | 354 | ... | ... | ... |
| Feb. I | Aug. III | Feb. IV | 55 | 198 | 317 | 343 | ... | ... | ... |
| Mar. I | Sep. III | Mar. IV | 46 | 186 | 314 | 334 | ... | ... | ... |
| Apr. I | Oct. III | Apr. IV | 39 | 174 | 309 | 327 | ... | ... | ... |
| May I | Nov. III | May IV | 34 | 162 | 302 | 322 | ... | ... | ... |
| June I | Dec. III | June IV | 31 | 150 | 293 | 319 | ... | ... | ... |
| July I | Jan. IV | July IV | 30 | 138 | 282 | 318 | ... | ... | ... |
| Aug. I | Feb. IV | Aug. IV | 30 | 126 | 270 | 318 | ... | ... | ... |
| Sep. I | Mar. IV | Sep. IV | 30 | 114 | 258 | 318 | ... | ... | ... |
| Oct. I | Apr. IV | Oct. IV | 30 | 102 | 246 | 318 | ... | ... | ... |
| Nov. I | May IV | Nov. IV | 30 | 90 | 234 | 318 | ... | ... | ... |
| Dec. I | June IV | Dec. IV | 30 | 78 | 222 | 318 | ... | ... | ... |
| | | | | **Case C** | | | | | |
| Jan. I | Nov. III | Jan. IV | 66 | 210 | 318 | 66 | 252 | 252 | 504 |
| Feb. I | Dec. III | Feb. IV | 55 | 198 | 341 | 55 | 286 | 286 | 572 |
| Mar. I | Jan. IV | Mar. IV | 78 | 186 | 330 | 78 | 252 | 252 | 504 |
| Apr. I | Feb. IV | Apr. IV | 102 | 174 | 318 | 102 | 216 | 216 | 432 |
| May I | Mar. IV | May IV | 126 | 162 | 306 | 126 | 180 | 180 | 360 |
| June I | Apr. IV | June IV | 150 | 150 | 294 | 150 | 144 | 144 | 288 |
| July I | May IV | July IV | 174 | 138 | 282 | 174 | 144 | 144 | 288 |
| Aug. I | June IV | Aug. IV | 198 | 126 | 270 | 198 | 144 | 144 | 288 |
| Sep. I | July IV | Sep. IV | 222 | 114 | 258 | 222 | 144 | 144 | 288 |
| Oct. I | Aug. IV | Oct. IV | 246 | 102 | 246 | 246 | 144 | 144 | 288 |
| Nov. I | Sep. IV | Nov. IV | 270 | 90 | 234 | 270 | 180 | 180 | 360 |
| Dec. I | Oct. IV | Dec. IV | 294 | 78 | 222 | 294 | 216 | 216 | 432 |

The second of two months (years) reaching identical peak or trough values is treated as the month (year) of turn. Blank spaces in the last three columns signify that the cycle is skipped.

different if we change one assumption—make the expansions last 27 months and the contractions 9 months. In this case summation by calendar years will wipe out the cycles that have troughs in October, November, December or January; the maximum amplitude will be reached when the troughs occur in May or June, the minimum when they occur in February or September.[4] If we make the contractions last 6 months and the expansions 26 months, the other assumptions being left unchanged, the cycles will disappear regardless of the months of turn. If we change the assumptions by supposing that the trend is horizontal, the fall will equal the rise, and even a two-month contraction will be preserved in annual data.

Table 49 shows the last case, as well as the two preceding ones, worked out in detail. The two-month contraction is reflected in the calendar-year summations no matter in what month the turns come; the maximum amplitude is yielded if the trough occurs in February, and the minimum amplitude if the trough occurs any month from June to October. Another result, not so explicit in the table, is that the two-month contraction is transformed into a one-year contraction if the trough comes between January and May or between October and December, and into a two-year contraction if the trough comes between June and September.[5]

Table 50 shows what combinations of monthly turning points favor the preservation of cyclical contractions (or expansions) lasting 12 months or less, when calendar-year summations are struck. The table is made on the assumption that both the cyclical rise and fall are continuous and linear; also that the rate of rise equals the rate of fall. We see that a contraction starting or ending in January is wiped out in annual data, whether the movement lasts one month or twelve. On the other hand, a contraction starting or ending in July is preserved in annual data, provided it lasts 8 months or longer. July 1 is more favorable to the preservation of cyclical contractions than any other date. This result is reasonable, since a mid-year peak favors a high average for the year and a mid-year trough favors a low average. A contraction lasting 7 months or less is skipped by our imaginary series whatever the months of turn. A contraction lasting 8 to 12 months is skipped if it starts in certain months, but not if it starts in others. As shown in Section XI, a shift from calendar to fiscal years would merely change the months of cyclical turns that are favorable or unfavorable to the preservation of cycles in annual summations.

[4] We consider amplitudes here in absolute units, not in units of cycle relatives; see Table 49, and notes 2 and 3.

[5] This example makes no assumption in regard to the absolute amplitude of the cycles. The successive observations are expressed in units of $b$, which may be any positive number. The example is also free from special assumptions with respect to the relative amplitude (that is, the total rise and fall expressed as a percentage of the average value during a cycle); for if we use $x$ instead of 0 at the trough month in Year I, where $x$ stands for any positive number, the general results are unchanged.

TABLE 50

How Months of Cyclical Turn Determine Whether Brief Cyclical Phases Remain or Disappear in Calendar-year Summations

ASSUMPTIONS: Cycle period, 3 years. Contraction (or expansion) lasts 12 months or less. The rise is continuous and linear from the trough to the peak; the fall is continuous and linear from the peak to the trough; and the *rate* of rise equals the *rate* of fall. The months are treated as if they were equal in length.

In view of the assumption of continuity, calendar-year totals were obtained by summing areas under the curve. Movements preserved in annual data are marked X. A blank space indicates that the phase is wiped out. If the table is read for contractions, a rising trend is implied; if read for expansions, a declining trend is implied.

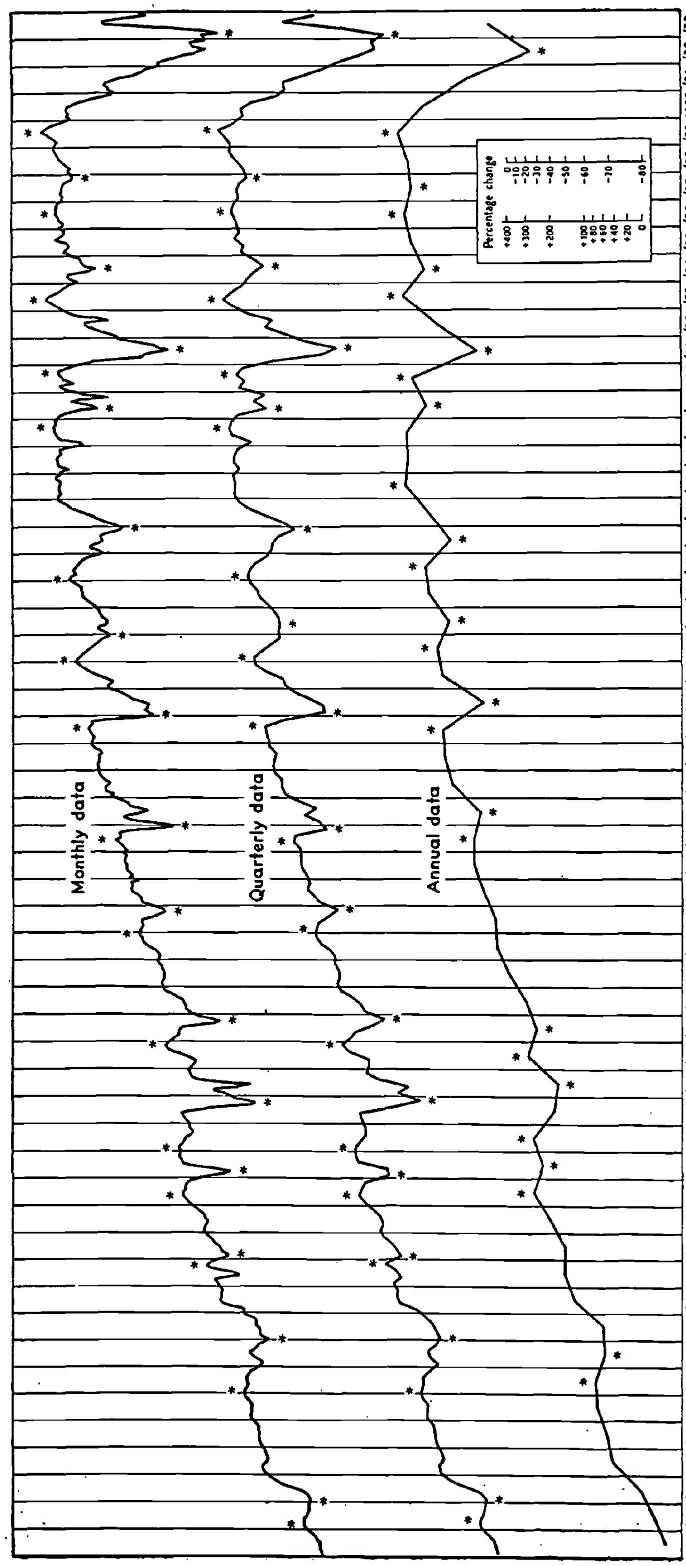
| Contraction (or expansion) *begins* on the first of | Contraction (or expansion) *ends* on the first of | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. |
| Jan. | | | | | | | | | | | | |
| Feb. | | X | | | | | | | | | | |
| Mar. | | X | X | | | | | | | | | |
| Apr. | | X | X | X | | | | | | | | |
| May | | X | X | X | X | | | | | | | |
| June | | | X | X | X | X | | | | | | |
| July | | | X | X | X | X | X | | | | | |
| Aug. | | | | X | X | X | X | X | | | | |
| Sep. | | | | | X | X | X | X | X | | | |
| Oct. | | | | | | X | X | X | X | X | | |
| Nov. | | | | | | | X | X | X | X | X | |
| Dec. | | | | | | | | | X | X | X | X |

An investigator working with annual data does not know in what months the cyclical turns come, the duration in months of the expansions and contractions, or other features of the basic cyclical movements. He therefore cannot allow for the influence of these factors upon the number of specific cycles that appear in annual data, or upon their duration and amplitude. The most he can do is to make a vague allowance for the influence of the secular trend relatively to the amplitude of the cyclical movements. Whether or not these limitations of annual data are serious in practice cannot be settled by imaginary series. The proper method is to take records of experience and compare cyclical measures made from one observation a year with measures made from four or twelve.

Towards this end we have made quarterly and annual averages or totals for six long monthly series for the United States, and compared in detail cyclical measures derived from these records. The series include pig iron production, 'deflated' bank clearings outside New York City, railroad stock prices, number of shares traded on the New York Stock Exchange, call money rates, and railroad bond yields. Chart 23 illustrates

CHART 23
Pig Iron Production, United States, 1877–1933
Monthly, Quarterly and Annual

CHART 23
Pig Iron Production, United States, 1877–1933
Monthly, Quarterly and Annual




The monthly and quarterly figures are seasonally adjusted. Asterisks identify peaks and troughs of specific cycles. For sources of data, see the note at the end of Sec. II.

the movements of the three forms of pig iron production.[6] Whatever differences appear among the measures made from the three forms of the same data must be due solely to differences in the time unit, provided our methods of analysis are kept strictly uniform. That proviso we observe as far as possible.[7]

## III The Direction of Movements in Time Series

Annual data cannot reveal changes within a year; they reveal only changes between years. A like remark applies to monthly and quarterly data. But data that reveal changes between months enable us to learn what happens within quarters, and data that reveal changes between quarters enable us to learn what happens within years.

It is necessary to insist upon these distinctions because they are frequently obscured by the charts we draw and the words we use in describing the movements of time series. For example, we are apt to say on the basis of annual data that the output of iron 'rose in 1910', though the data merely tell that output in the calendar year 1910 was larger than in the calendar year 1909. We do not know whether this difference is due to a continuous rise in both years, or to a fall within 1909 and a greater rise within 1910, or to a rise within 1909 and a slower fall within 1910, or to some combination of irregular movements. Charts may prove equally misleading. To represent outputs of successive years, the statistician commonly plots points in the middle of the years at heights indicated by the vertical scale and connects the points by straight lines. The chart therefore pictures a continuous rise during the fiscal year 1910, that is, from the end of June 1909 to the end of June 1910. This graphic presentation not only is more brazen than the verbal statement but also conflicts with it, since the latter suggests that the rise occurred during the calendar year

6 See also Charts 29-31. The monthly data of all six series are shown in Chart 53. Cycle-by-cycle measures of the monthly data are presented in Appendix B.

7 All monthly series are adjusted for seasonal variations, except railroad bond yields and stock prices; the seasonal correction of call money rates stops in May 1931. The annual figures were derived from monthly data unadjusted for seasonal variations, which is the form in which they would come to an investigator concerned with annual figures. However, the quarterly figures were derived from seasonally adjusted monthly data. That step saved time and ensured that comparisons between quarterly and monthly data were not confused by differences in seasonal adjustments. (The latter objective could have been achieved another way; viz., computing quarterly seasonal indexes for the same period and by the same method as in the monthly data, and removing the seasonal variations directly from the quarterly data.)

The series on pig iron production and deflated clearings are on an average daily basis.

For the series on call money rates, railroad bond yields and railroad stock prices, see Frederick R. Macaulay, *The Movements of Interest Rates, Bond Yields and Stock Prices in the United States since 1856* (National Bureau of Economic Research, 1938), Appendix A, Table 10, col. 1, 5, and 6, pp. A142-61. For the series on pig iron production and deflated clearings (continued after 1918 with bank debits in 140 centers outside N.Y.City, adjusted to the level of 'outside' clearings in Jan. 1919, and deflated throughout by Snyder's index of the general price level), see *ibid.*, Appendix A, Table 27, col. 4 and 2, pp. A255-69. The series on number of shares of stock traded through 1897 comes from *Commercial and Financial Chronicle;* since 1898, *New York Stock Exchange Bulletin,* Aug. 1934, pp. 10A-B.

1910.[8] Of course if we read our tables and charts by saying, as cautious students often will, that 'yearly output rose between 1909 and 1910' or 'from 1909 to 1910', instead of saying that output (the time unit unspecified) 'rose in 1910', our words are less misleading, in that they do not conceal our ignorance concerning what happened within either year.

Perhaps the investigators who rely upon annual data in studying cyclical movements remember most of the time that they are dealing solely with changes between years and know nothing of what happens within years. But investigators like ourselves, who use monthly data when available and fall back upon annual data only when nothing better can be had, may be betrayed by their words into assuming that both forms of data show the direction of cyclical movements 'in' successive years. As a sample of the errors that arise in practice from this assumption, we have made the comparisons summarized in Table 51 between the directions in which the monthly and annual data of our six test series move.

The direction of movement *within* years can be judged from the specific cycles marked off in the monthly data. In other words, we consider the direction as upward throughout a specific-cycle expansion and as downward throughout a contraction; the month-to-month flutterings within a specific-cycle phase are disregarded. When a specific-cycle expansion continues for a major fraction of a year, or when there are at least seven months of expansion interrupted by a brief contraction, we say that the 'prevailing' direction within the year is upward. When cyclical contraction covers seven or more months, we say that the prevailing direction within the year is downward. Under this rule, some 8 or 10 per cent of the years covered by our sample lack a prevailing direction; we may speak of them as 'neutral' years. In this way we have classified both the calendar and the fiscal years (that is, years ending in June) covered by the monthly data of each of the six test series.

The direction of movement *between* years has been judged similarly from the specific-cycle expansions and contractions we recognize in the annual data. Two interpretations may be placed on these year-to-year changes. First, it may be assumed that the change from one calendar year to the next indicates the prevailing direction of movement *within* the second year. Let us call this assumption I. Its graphic equivalent is that the annual entries are plotted at the ends of calendar years. Comparisons of annual movements between calendar years with the monthly movements prevailing within calendar years appear in columns (4) to (6) of Table 51. Second, it may be assumed that the change from one calendar year to the next indicates the prevailing direction of movement *within* the 'fiscal year' that begins in July of the first and ends in June of the second year. Call this assumption II. Its graphic equivalent is that the annual data are

8 But the customary graphic presentation leads to errors less frequently than the verbal statement, as is demonstrated later.

TABLE 51
Comparison of the Directions of Movement of Monthly and Annual Data
Six American Series

| Series | Period covered | No. of years covered | No. of years in which prevailing direction of monthly data: During a given calendar year: Agrees with change of annual data from preceding cal. year | Disagrees with change of annual data from preceding cal. year | Is lacking | During a given fiscal year: Agrees with change of annual data between overlapping cal. years[a] | Disagrees with change of annual data between overlapping cal. years[a] | Is lacking |
|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| Deflated clearings | 1878–1933 | 55 | 41 | 9 | 5 | 47 | 4 | 4 |
| Pig iron production | 1879–1933 | 54 | 33 | 15 | 6 | 41 | 4 | 9 |
| Railroad stock prices | 1857–1932 | 75 | 52 | 14 | 9 | 69 | 3 | 3 |
| Shares traded | 1878–1933 | 55 | 35 | 16 | 4 | 42 | 9 | 4 |
| Call money rates | 1858–1931 | 73 | 54 | 13 | 6 | 64 | 3 | 6 |
| Railroad bond yields | 1860–1931 | 71 | 53 | 9 | 9 | 61 | 4 | 6 |
| Six series | | | | | | | | |
| Absolute number | | 383 | 268 | 76 | 39 | 324 | 27 | 32 |
| Percentage | | 100.0 | 70.0 | 19.8 | 10.2 | 84.6 | 7.0 | 8.4 |

The first entry in col. (2) is the year of the initial trough of the first full cycle covered by the monthly analysis; the second entry is the year in which the terminal trough of the last full cycle occurs. The heading of col. (4)-(6) relates to the period in col. (2) except the first year. The heading of col. (7)-(9) relates to a period starting and ending six months earlier than is covered by col. (4)-(6). In making this table we took account of several peaks at the ends of the series.

As explained in the text, the 'prevailing' direction of monthly data during a year is that which dominates seven months or more of the year. The rise or fall during the year need not be continuous; for example, if the monthly data reach a specific-cycle peak in April and a trough three months later, the prevailing direction during the calendar year is considered as upward. A rise from a trough in January to a peak in July is counted as six months, although seven monthly entries fall within the segment including the trough and peak dates. Similarly, if the rise begins before the given calendar year, culminates in a July peak, and is followed by a decline during the remainder of the year, six months are allotted to expansion and five months to contraction. We consider such a year as not having a prevailing direction of movement. Like rules govern the movements of monthly data in fiscal years, that is, years ending in June.

[a]That is, between the calendar years overlapping the fiscal year.

plotted at the centers of the calendar years. Comparisons of annual movements between calendar years with the monthly movements prevailing within the overlapping fiscal years appear in columns (7) to (9). Of course the results of both sets of comparisons are subject to the uncertainties that beset efforts to identify the specific cycles of time series. Revisions might remove some of the differences between the directions in which the annual and monthly data are said to move; but they might equally well introduce some differences where we now find agreements.

The table demonstrates that the prevailing direction of the monthly data differs from the direction of the annual data in an appreciable fraction of the years covered by our sample, but that the differences are more numerous if we make assumption I than if we make assumption II. If we interpret the changes between calendar-year figures as representing the prevailing direction of movement within calendar years, our test series indicate that we shall be right in 70 per cent of the years. But if we interpret the changes between calendar-year figures as representing the prevailing direction of movements within fiscal years, we shall be right 85 per cent of the time. For future guidance we add an obvious inference:

when forced to work with data that run by fiscal years ending in June, we shall err frequently if we interpret their year-to-year changes as showing the prevailing direction of movement within calendar years, but less frequently than if we interpret them as showing the prevailing direction of movement within fiscal years.

The reason assumption I leads to more serious errors than assumption II is easily explained. Suppose (a) that a series reaches a peak in some month within two calendar years, but makes no other turn in this period; (b) that the series rises to a peak by uniform increments, then falls away by uniform decrements; (c) that the rates of rise and fall need not be the same; and (d) that the average value of the series is higher in the second calendar year than in the first. If the peak comes in May of the second year or some earlier month, the prevailing direction of the monthly data during the second calendar year will be downward under our seven-month rule, and thus contradict the rise assumed in the annual data. A contradiction can occur whether the monthly rate of decline exceeds, is less than, or equals the rate of rise. But to produce a seven-month decline in the monthly data during the fiscal year overlapping the two calendar years, the peak must come not later than November of the first calendar year; under our assumptions this can happen only if the rate of rise to the peak exceeds by some margin the rate of decline after the peak. It follows that comparisons of monthly and annual data based on assumption II are less likely to show differences of direction than comparisons based on assumption I. A similar argument may be formulated regarding declines in annual data associated with troughs in monthly data. Of course, the path of the cyclical expansions and contractions of our test series is usually not linear, erratic movements diversify the expansions and contractions, and two cyclical turns occur in some years; but these differences from our imaginary series are not more favorable to the comparisons based on assumption II than to the comparisons based on assumption I.

Granted the representativeness of our sample, it appears from Table 51 that assumption I leads to wrong conclusions concerning the direction of the cyclical tide prevailing within years three times out of ten, while assumption II leads to wrong conclusions three times out of twenty. Wrong conclusions are likely to be drawn in a still greater proportion of years if annual data are used to compare the direction of cyclical movements of two or more series *within* successive years. In line with the results yielded by assumption I, let us suppose that series *A* and *B* both cover 100 years, that the prevailing movement within 20 calendar years of each series runs counter to the change of annual data from the preceding year, and that in another ten years of each series there is no prevailing movement. Call the changes in the annual data in these 30 years 'errors', though the real error lies in treating year-to-year movements as showing the direction of movements within years. If the errors in the two series all occur in different years, which is unlikely, there will be 60 errors in the comparison. If the years of error in the two series coincide, which is still less likely, only 15 errors in the comparison are to be expected.[9] If the errors in the two series are not correlated, which seems the most reasonable assumption, the expectation is that invalid comparisons will number about 46 in 100, or nearly half of the total.[10] Table 52 shows the actual number of valid and invalid comparisons for every possible pair of our six series. The number of invalid comparisons ranges from 36 to 56 per cent for the individual pairs, and is 45 per cent on the average.[11]

[9] Of the 30 years in which errors occur in $A$, 10 have no prevailing direction. The like applies to $B$. The probability that both $A$ and $B$ will have no prevailing direction in any year of the 30 is therefore 1/9; the probability that both will have a prevailing direction in any year is 4/9; the probability that $A$ or $B$ but not both will have a prevailing direction in any year is also 4/9.

In the years of error in which the monthly data of both $A$ and $B$ have a prevailing direction, the comparison of annual data must be valid despite the errors in each series taken separately; that is, the comparisons will show correctly the presence or absence of agreement in prevailing directions. The number of such years is 4/9 of 30. On the other hand, the comparison of annual data must be invalid in years in which one of the two series has no prevailing direction; for annual data invariably move up or down, our criteria of movement being the expansions and contractions of the specific cycles distinguished in the annual series. The number of such invalid comparisons is also 4/9 of the total. The remaining 1/9 are years in which both $A$ and $B$ have no prevailing direction. We may expect these years to be divided equally between valid and invalid comparisons: the annual comparison will be valid if the changes in $A$ and $B$ are in the same direction, it will be invalid if the changes are in opposite directions. The expected number of wrong annual comparisons is therefore $30\,(4/9 + 1/18)$ or 15, which is also the expected number of valid comparisons in the 30 years considered.

[10] The expected number of years in which an error occurs in $A$ but not in $B$ is $100\,(3/10 \times 7/10) = 21$. The expected number of years in which an error occurs in $B$ but not in $A$ is likewise 21. In these 42 years the annual comparison is invalid. The expected number of years in which an error occurs in both is $100\,(3/10 \times 3/10) = 9$. As explained in the preceding note, the comparison will be valid in one-half of the 9 years, and invalid in the remaining half. Hence the expected number of invalid comparisons is 46.5 per 100. This result is based on what we have called assumption I. If, instead, we adopt assumption II, the expected number of invalid comparisons is 26.6 per 100. See also the next note.

[11] The comparison of year-to-year changes in direction of two annual series is considered valid in Table 52 if (a) the direction of movement in each annual series of the pair is correct according to the monthly data; or (b) if the direction of movement of each annual series is opposite to that of the monthly data (for in that case the annual comparison will still show correctly whether the two monthly series moved in the same or opposite directions); or (c) if both annual series show the same direction while both monthly series lack a 'prevailing' direction (for, once again, the annual series indicate agreement when agreement, in a technical sense, exists in fact according to monthly data). The comparison of year-to-year changes in direction of two annual series is considered invalid if (d) the direction of one is opposite to that of the monthly data while the direction of the other is the same as that of the monthly data; or (e) if one monthly series of the pair lacks a prevailing direction (for in that case annual data will show that both series moved in similar or opposite directions, whereas in fact one series lacks a prevailing direction); or (f) if the two annual series move in opposite directions when both monthly series lack a prevailing direction.

Of course, the calculations could be made on a different principle. Thus the number of valid comparisons might be restricted to type (a), in which case the annual showing would be still worse. On the other hand, the inevitable failure of two annual series to match a 'quasi-inverted' relation of the corresponding monthly series (that is, one having and the other lacking a prevailing direction) might be given a smaller weight than the failure of annual series to report correctly similar or opposite movements of monthly series; if this were done the showing of annual data would be improved.

Note, finally, that the calculations in Table 52 are restricted to what we have called assumption I, that the results are roughly consistent with the expectations developed in the preceding note, and that the expectation based on assumption II is also stated in that note.

TABLE 52

Comparison of the Directions of Movement of Two Series in Annual Form with the Directions of the Same Series in Monthly Form

Every Pair of Six American Series

| Paired series | Period covered | No. of years covered | Agreement or disagreement in direction of year-to-year changes of two annual series is | | | |
|---|---|---|---|---|---|---|
| | | | Confirmed by monthly data | | Contradicted by monthly data | |
| | | | No. of years | Per cent of years | No. of years | Per cent of years |
| Clearings & iron output | 1880–1933 | 54 | 33 | 61.1 | 21 | 38.9 |
| Clearings & stock prices | 1879–1932 | 54 | 31 | 57.4 | 23 | 42.6 |
| Clearings & shares traded | 1879–1933 | 55 | 30 | 54.5 | 25 | 45.5 |
| Clearings & call rates | 1879–1931 | 53 | 34 | 64.2 | 19 | 35.8 |
| Clearings & bond yields | 1879–1931 | 53 | 32 | 60.4 | 21 | 39.6 |
| Iron output & stock prices | 1880–1932 | 53 | 32 | 60.4 | 21 | 39.6 |
| Iron output & shares traded | 1880–1933 | 54 | 24 | 44.4 | 30 | 55.6 |
| Iron output & call rates | 1880–1931 | 52 | 24 | 46.2 | 28 | 53.8 |
| Iron output & bond yields | 1880–1931 | 52 | 23 | 44.2 | 29 | 55.8 |
| Stock prices & shares traded | 1879–1932 | 54 | 31 | 57.4 | 23 | 42.6 |
| Stock prices & call rates | 1859–1931 | 73 | 39 | 53.4 | 34 | 46.6 |
| Stock prices & bond yields | 1861–1931 | 71 | 39 | 54.9 | 32 | 45.1 |
| Shares traded & call rates | 1879–1931 | 53 | 28 | 52.8 | 25 | 47.2 |
| Shares traded & bond yields | 1879–1931 | 53 | 29 | 54.7 | 24 | 45.3 |
| Call rates & bond yields | 1861–1931 | 71 | 42 | 59.2 | 29 | 40.8 |
| *Total* | | 855 | 471 | 55.1 | 384 | 44.9 |

See text, especially note 11; also note to Table 51.

## IV The Number of Specific Cycles

An investigator who relies upon annual data must mark off specific cycles on the basis of what he can see in these materials. To find what effect the time unit has upon cyclical measurements, we should subject ourselves to the conditions under which such an investigator works; that is, when analyzing annual data we should not use the fuller knowledge supplied by monthly figures. We have attempted to follow this rule in marking off specific cycles in annual data; and our decisions have already been applied in the preceding analysis of the direction of cyclical movements.

In marking off specific cycles in annual data our general rule is to treat every rise or fall as cyclical, except when it is well below the typical range of movements characteristic of the series. We ignored only five movements in our test series, in each instance on the ground that the movement seemed to be a trifling pause within a cyclical expansion or contraction. After the work had been done, we found that two of these exceptions were valid according to our analysis of the monthly series; that is, there seems to be only a single cycle between 1914 and 1919 in pig iron production, and between 1899 and 1905 in railroad bond yields. The remaining three exceptions come in railroad bond yields, and our decisions in these instances are wrong if the decisions based on the monthly data are right.[12] If we had treated every rise or fall in annual data, however slight, as a cyclical movement, we should have a slightly different set of specific cycles. A shift in the method of marking off cycles would therefore blur some of our detailed results; but it could not affect the substance of the argument in this chapter.[13]

When annual data fail to reflect two consecutive cyclical turns in monthly data, they skip a contraction or an expansion and therefore have one cycle less than the monthly data. Of the 218 cyclical turns [14] in our six series, 39 are skipped and there is a resulting loss of 20 specific cycles in the annual records.[15] But annual data sometimes show 'extra' cycles, and they may do so frequently if erratic movements are very large in relation to the cyclical movements. When war broke out in 1914, the interest rate on call loans shot up from 2.88 in July to 6.87 the following month, but

[12] The magnitude of the movements disregarded in bond yields is shown by the following figures:

| Year | Average yield (per cent) | Per cent change |
|---|---|---|
| *1872* | 6.185 | |
| *1873* | 6.214 | +0.5 |
| *1876* | 5.168 | |
| *1877* | 5.178 | +0.2 |
| *1900* | 3.182 | |
| *1901* | 3.181 | −0.03 |
| *1913* | 4.057 | |
| *1914* | 4.046 | −0.3 |

The rise between 1917 and 1918 in iron production, which we have also disregarded, is 0.8 per cent. Its magnitude in relation to that of other fluctuations in the series may be judged from Chart 23.

[13] To test the consequences of a shift in method, we took another sample of sixteen long series. We recognized 228 specific cycles in this group, and disregarded 17 trifling movements. Upon checking the latter against the lists of specific cycles in the monthly series, we found that nine were cyclical and eight were not. Thus the larger sample confirms the one analyzed in this chapter: by treating every movement in annual data, however small, as cyclical, we would increase the number of specific cycles, but about half of the increase would consist of spurious movements. (For the analysis of this additional sample, we are indebted to Julius Shiskin.)

The recognition of every rise or fall in annual data as a cyclical movement dispenses with judgment. Further, in series with slight or no erratic movements, the 'mechanical' method is superior to ours in that it tends to make the average duration of specific cycles approach more closely the average yielded by monthly data. Our method, on the other hand, tends to give closer approximations to the average amplitudes of monthly data. When a series is characterized by erratic movements that are violent relatively to the cyclical movements, numerous changes in annual data may not be cyclical; so that the mechanical method may yield poorer estimates of both the average duration and the average amplitude of specific cycles.

[14] This count is based on complete positive cycles. If the first full specific-cycle phase of the monthly data is a contraction or if the last full phase is an expansion, it is ignored in the analysis of this chapter. The exclusions may be identified from Chart 53. For the periods covered in our analysis of the six series, see Table 55.

[15] In pig iron production the annual data skip the initial trough but reflect the peak of the 'first' cycle (1879–85) in the monthly data; that means, of course, that they skip also the peak preceding the first cycle, and explains why an odd number of turns in our monthly analysis is skipped. See Chart 23.

by December it was lower than in July.[16] Annual data convert this violent random movement into a bulge that looks like a genuine cycle: the annual average is raised from 3.19 in 1913 to 3.46 in 1914, after which it declines to 1.91 in 1915. Thus the specific cycle with a trough in November 1911, peak in December 1912, and trough in November 1915 gets subdivided in the annual series into two cycles: 1911 (trough), 1912 (peak), 1913 (trough), 1914 (peak), 1915 (trough). The extra cycle plus 20 skipped cycles make 21 discrepancies between the specific cycles in the monthly and annual data; the net difference is 19.

In general, when annual summations are struck the fate of a cyclical movement depends on (1) its duration, (2) its amplitude, (3) the timing of the turns, (4) the pattern of the movement, (5) the steepness of the underlying trend, (6) the nature of the erratic fluctuations. The basic factor is the duration of the cyclical phase. Other things equal, a phase lasting twelve months has a better chance of turning up in annual data than one lasting nine months, and a phase lasting nine months than one lasting six. A phase lasting well over a year is reasonably certain to appear in annual data whatever its other characteristics may be. Factors (2)-(5) are important in short phases; and the shorter the phase the greater is their importance. Given the duration, a brief phase has a better chance of turning up in annual figures if it begins or ends around the middle of the year than if it begins or ends at the boundaries of the year.[17] A cyclical phase that laps over two years has a better chance of turning up in the annual data if the peak and trough zones are gently rounded than if they are sharply angular. The chances are also better if its amplitude is large than if it is small relatively to a given trend; or if the trend is moderate than if it is steep relatively to a given amplitude.[18] Since no one can be sure what annual figures will do to a cyclical movement unless he knows exactly how the six factors combine to shape the movement, no one can tell with any certainty by examining annual data alone whether they skip many or few cycles; or which cyclical movements are larger and which are smaller than the hidden movements, or which movements, if any, spring from erratic fluctuations.

In our sample the expansions or contractions skipped by annual data are usually brief and mild (Tables 53-54). No movement lasting over 16 months or having an amplitude of more than 66 points is erased by annual data. On the other hand, 9 of the 15 phases lasting less than 9 months and

16 The figures cited are monthly averages, seasonally adjusted.

17 See above, Sec. II.

18 This is the only way in which the secular trend influences directly the number of cycles in annual data unadjusted for trend, the form in which we usually analyze time series. But secular trends influence the number of cycles also indirectly, since the retention of trends tends to reduce durations and amplitudes—of contractions in monthly series if the trend is rising, of expansions if the trend is declining. These effects are already allowed for in factors (1) and (2). See Ch. 7, especially Sec. VII, where cycles of monthly and annual data are compared in trend-adjusted form.

TABLE 53
Characteristics of Cyclical Phases Skipped by Annual Data
Six American Series

| Series and skipped phase | Characteristics of skipped phase | | | Number of expansions or contractions that are not skipped although they are of | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Nature[a] | Duration (mos.) | Amplitude in specific-cycle relatives | Equal or shorter duration | | Equal or smaller amplitude | | Shorter duration & smaller amplitude | Smaller size[d] |
| | | | | In same series | In six series | In same series | In six series | In six series | |
| DEFLATED CLEARINGS | | | | | | | | | |
| June 1887 – Mar. 1888 | C | 9 | 6 | 4 | 20 | 2 | 11 | 1 | 4 |
| July 1903 – May 1904 | C | 10 | 6 | 5 | 23 | 2 | 11 | 1 | 4 |
| Mar. 1910 – Oct. 1910 | C | 7 | 3 | 4 | 14 | .. | 1 | .. | .. |
| Aug. 1918 – Dec. 1918 | C | 4 | 5 | 1 | 3 | .. | 4 | .. | .. |
| May 1923 – Sep. 1923 | C | 4 | 6 | 1 | 3 | 2 | 11 | .. | 1 |
| PIG IRON PRODUCTION[b] | | | | | | | | | |
| Oct. 1887 – Mar. 1888 | C | 5 | 26 | .. | 4 | 2 | 66 | 1 | 19 |
| Dec. 1899 – Oct. 1900 | C | 10 | 30 | 5 | 23 | 2 | 74 | 9 | 43 |
| RAILROAD STOCK PRICES | | | | | | | | | |
| Oct. 1857 – Mar. 1858 | E | 5 | 18 | .. | 4 | 12 | 50 | .. | 11 |
| Apr. 1900 – Sep. 1900 | C | 5 | 5 | .. | 4 | .. | 4 | .. | 1 |
| CALL MONEY RATES | | | | | | | | | |
| Jan. 1876 – Sep. 1876 | C | 8 | 52 | 1 | 18 | 7 | 110 | 8 | 62 |
| Jan. 1878 – Sep. 1878 | C | 8 | 66 | 1 | 18 | 10 | 129 | 12 | 72 |
| May 1882 – Sep. 1882 | E | 4 | 60 | 1 | 3 | 7 | 116 | 1 | 35 |
| Aug. 1918 – Dec. 1918 | C | 4 | 31 | 1 | 3 | 1 | 75 | 1 | 19 |
| RAILROAD BOND YIELDS | | | | | | | | | |
| Jan. 1864 – July 1864 | C | 6 | 13 | .. | 10 | 22 | 36 | .. | 10 |
| Nov. 1866 – Dec. 1867 | E | 13 | 3 | 7 | 48 | 1 | 1 | .. | 1 |
| July 1872 – Nov. 1873[c] | E | 16 | 5 | 13 | 73 | 4 | 4 | 1 | 11 |
| Aug. 1876 – Apr. 1877[c] | E | 8 | 2 | 2 | 18 | .. | .. | .. | .. |
| Dec. 1913 – June 1914[c] | C | 6 | 2 | .. | 10 | .. | .. | .. | .. |
| Sep. 1918 – Nov. 1918 | C | 2 | 8 | .. | 1 | 12 | 17 | .. | .. |

For periods covered, see Table 55. There are no entries for shares traded, since annual data reflect every specific cycle in this series.
[a] C stands for specific-cycle contraction, E for expansion.
[b] See note 15.
[c] See note 12.
[d] See note 19.

having an amplitude under 20 points, and all 3 phases lasting less than 5 months and with an amplitude under 10 points, are wiped out. But we also find that for every movement skipped by a series, there are usually several, sometimes many, phases of equal or shorter duration, or of equal or smaller amplitude, that are not skipped. Some skipped phases are both longer and larger movements than other phases that are not skipped. To cite an example, annual data on pig iron production wipe out the contraction of 1899–1900, which lasted 10 months and attained an amplitude of 30 points. Fully 9 movements in our six series are reflected in annual records although they have both shorter durations and smaller amplitudes than this contraction in the iron series. And the number swells to 43 if the 'size' of cyclical movements is judged from an index that assigns equal

TABLE 54

Joint Distribution of Durations and Amplitudes of All Cyclical Phases and Those Skipped by Annual Data

| Amplitude of phase in specific-cycle relatives | Duration of phase in months | | | | | |
|---|---|---|---|---|---|---|
| | Under 5 | 5–8 | 9–12 | 13–16 | Over 16 | Total |
| Under 10 | 3 (3) | 7 (4) | 5 (2) | 8 (2) | 7 (0) | 30 (11) |
| 10 - 19 | 0 (0) | 5 (2) | 4 (0) | 8 (0) | 19 (0) | 36 (2) |
| 20 - 29 | 1 (0) | 3 (1) | 0 (0) | 2 (0) | 13 (0) | 19 (1) |
| 30 - 39 | 1 (1) | 0 (0) | 2 (1) | 5 (0) | 10 (0) | 18 (2) |
| 40 - 49 | 0 (0) | 2 (0) | 4 (0) | 1 (0) | 11 (0) | 18 (0) |
| 50 - 59 | 0 (0) | 3 (1) | 0 (0) | 2 (0) | 6 (0) | 11 (1) |
| 60 - 69 | 2 (1) | 3 (1) | 2 (0) | 1 (0) | 9 (0) | 17 (2) |
| Over 69 | 1 (0) | 1 (0) | 6 (0) | 10 (0) | 45 (0) | 63 (0) |
| Total. . . . . . . . . | 8 (5) | 24 (9) | 23 (3) | 37 (2) | 120 (0) | 212 (19) |

Based on six American series. The figures in parentheses show the number of expansions or contractions skipped by annual data; those not in parentheses show the full number, whether skipped or not, in complete positive cycles. For the periods covered, see Table 55; see also note 15.

weight to their duration and amplitude.[19] The use of annual data is sometimes defended on the ground that they wipe out movements that are too small 'to matter'. Of course, everyone is free to decide what movements matter for his purposes; but the investigator who takes annual data as his guide will be frequently misled—he will ignore the contraction of 1899–1900 in iron production and lavish attention on 43 smaller movements in our test series.

Table 55 shows the number of specific cycles in the monthly, quarterly, and annual forms of each of our series. The fraction of the net number of cycles lost in annual data ranges in different series from zero to one-third; the fraction lost in the six series is nearly one-fifth.[20] The shift from monthly to quarterly data affects the number of specific cycles in the

[19] The 'size' of a cyclical movement depends on its duration, amplitude, and pattern. A rough index of size may be obtained by multiplying the duration of a phase by its amplitude. This index is 300 for the contraction in iron production from 1899 to 1900. In all, 43 cyclical movements that are not skipped by the annual data of our six test series have smaller indexes. The entries in the last column of Table 53 are made on this plan. See also below, Sec. XI.

[20] In the sample referred to in note 13, there are 249 specific cycles in the monthly and 226 cycles in the annual data. The annual data 'skip' 37 cycles in the monthly data, but show 14 'extra' specific cycles; hence the net loss of specific cycles is only about one-tenth. This sample is dominated by series of narrow coverage characterized by large erratic fluctuations. In series of this type spurious cycles may easily appear in annual data. (The number of annual cycles given in this note differs slightly from that in note 13. Here the count starts and ends with specific cycles having corresponding turns in the annual and monthly series.) A sample of six series analyzed in the next chapter (see Table 103) shows 8 per cent fewer cycles in annual than in monthly series when both are adjusted for secular trend. The corresponding loss in annual data not adjusted for trend is 26 per cent. (Three series in the latter group are included in the sample analyzed in this chapter.)

same direction as the shift from monthly to annual data but in much slighter degree.[21] Only two specific-cycle movements are lost, the contractions in clearings and call money rates in 1918. Both contractions are exceptionally brief and mild: we might have disregarded them even in the monthly series, were it not for our practice of relaxing rules in the case of dubious but conforming movements in series that on the whole conform well to business cycles.

TABLE 55
Number of Specific Cycles in Monthly, Quarterly and Annual Data
Six American Series

| Series | Period covered by monthly cycles | Number of specific cycles | | | | | |
|---|---|---|---|---|---|---|---|
| | | Actual numbers | | | Relatives of monthly | | |
| | | M | Q | A | M | Q | A |
| Deflated clearings | 1878–1933 | 15 | 14 | 10 | 100 | 93 | 67 |
| Pig iron production | 1879–1933 | 15 | 15 | 12 | 100 | 100 | 80 |
| Railroad stock prices | 1857–1932 | 18 | 18 | 16 | 100 | 100 | 89 |
| Shares traded | 1878–1933 | 15 | 15 | 15 | 100 | 100 | 100 |
| Call money rates | 1858–1931 | 23 | 22 | 20 | 100 | 96 | 87 |
| Railroad bond yields | 1860–1931 | 20 | 20 | 14 | 100 | 100 | 70 |
| Total | | 106 | 104 | 87 | 100 | 98 | 82 |

M stands for monthly data, Q for quarterly, A for annual. The number of cycles in the quarterly and annual data is the number of complete cycles, taken positively, within the periods covered by the monthly cycles. See Table 57.

## V Duration of Specific Cycles

Just as lengths of objects are known less precisely if measured to the nearest foot than to the nearest inch, so measures of cyclical duration are less precise if made to the nearest year than to the nearest month. But there is this difference between the two: telegraph poles are the same poles whether measured in feet or in inches, but cycles are not the same cycles when measured in years as when measured in months, except, of course, when an investigator merely 'rounds' observations of monthly data. The measures of duration made from annual data are thus less precise in two senses: first, they are expressed in a coarser unit; second, this unit changes the form of the cycles—a substantial number of specific cycles are obliterated and those that are left are modified. We may call the first the 'precision effect', and the second the 'twisting effect'.

The two effects are illustrated in Table 56. The table presents three types of duration measures for successive specific cycles in pig iron production: the monthly measures as they come, the monthly measures read

21 In marking off cycles in quarterly data we took full notice of our monthly decisions. That step is not inconsistent with our treatment of annual data. Borderline cases in monthly data may or may not match borderline cases in annual data. But a borderline case in a monthly series is usually a borderline case also in a quarterly series, and vice versa. To isolate the influence of the time unit upon cyclical measures, it seemed best to treat the borderline cases similarly.

TABLE 56
Duration of Specific Cycles Measured by Different Methods
Pig Iron Production, United States, 1879–1933

| Specific cycle[a] | Duration in months ascertained from | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Monthly data | | | Monthly durations read to the nearest year | | | Annual data | | |
| | Expansion | Contraction | Full cycle | Expansion | Contraction | Full cycle | Expansion | Contraction | Full cycle |
| 1879–1885 | 49 | 23 | 72 | 48 | 24 | 72 | ([c]) | 12[d] | ([c]) |
| 1885–1888 | 33 | 5 | 38 | 36 | 0 | 36 | {72 | 12 | 84} |
| 1888–1891 | 26 | 11 | 37 | 24 | 12 | 36 | | | |
| 1891–1893 | 10 | 20 | 30 | 12 | 24 | 24 or 36 | 12 | 24 | 36 |
| 1893–1896 | 25 | 11 | 36 | 24 | 12 | 36 | 12 | 12 | 24 |
| 1896–1900 | 38 | 10 | 48 | 36 | 12 | 48 | {84 | 12 | 96} |
| 1900–1903 | 32 | 6 | 38 | 36 | 0 or 12 | 36 | | | |
| 1903–1908 | 43 | 6 | 49 | 48 | 0 or 12 | 48 | 36 | 12 | 48 |
| 1908–1910 | 24 | 11 | 35 | 24 | 12 | 36 | 24 | 12 | 36 |
| 1910–1914 | 25 | 23 | 48 | 24 | 24 | 48 | 24 | 12 | 36 |
| 1914–1919 | 45 | 8 | 53 | 48 | 12 | 48 | 24 | 36 | 60 |
| 1919–1921 | 16 | 10 | 26 | 12 | 12 | 24 | 12 | 12 | 24 |
| 1921–1924 | 22 | 14 | 36 | 24 | 12 | 36 | 24 | 12 | 36 |
| 1924–1927 | 24 | 16 | 40 | 24 | 12 | 36 | 24 | 12 | 36 |
| 1927–1933 | 20 | 44 | 64 | 24 | 48 | 60 | 24 | 36 | 60 |
| Average[b] | | | | | | | | | |
| All cycles | 28.8 | 14.5 | 43.3 | 29.6 | 15.2 | 42.0 | 31.0 | 17.0 | 48.0 |
| 10 corresponding cycles | 25.4 | 16.3 | 41.7 | 26.4 | 17.4 | 40.2 | 21.6 | 18.0 | 39.6 |

[a] Years of the initial and terminal troughs of the specific cycles in monthly data.
[b] Where double entries occur, we used their mean in computing the mean of the column.
[c] See note 15.
[d] Excluded from average.

to the nearest year—which show the 'precision effect', and the annual measures taken as they come—which show the 'precision' and 'twisting' effects in combination. If cyclical durations of monthly data are read to the nearest year, we cannot distinguish between a duration of 7 months and one of 17 months or between a duration of 19 months and one of 29; the loss of information may be serious but at least the margins of error are clearly defined. When cyclical durations are measured directly from annual data, the margins of error are indefinite and may be enormous. For example, the 45-month expansion of the 1914–19 cycle in iron production is replaced by a 2-year expansion, the 8-month contraction by a 3-year contraction, and the 53-month cycle by a 5-year cycle.

The mean 'precision effect' may be gauged by averaging, without regard to sign, the differences between cyclical durations of monthly data and the corresponding durations read to the nearest year.[22] This average is 2.4 months for the 45 observations covering all expansions, contractions, and full cycles in iron production, and 2.5 months for the 10 cycles

22 Where double entries occur in Table 56, we use both, each weighted one-half. Thus a duration of 6 months is '0 or 12' when read to the nearest year; hence the difference between '0 or 12' and 6 is 6 months. The expected 'precision effect' is 3 months in general, or somewhat higher than in our sample.

that match the cycles in annual data. Similarly, the 'twisting effect' may be gauged from the differences between the cyclical durations of annual data and the corresponding monthly measures read to the nearest year; this average is 4.8 months for the 10 cycles common to the monthly and annual lists. In other words, the twisting effect is nearly twice as large as the precision effect even if the most flagrant form of twisting—the obliteration of cycles—is disregarded. Averages made on the above plan do not allow opposite errors in single cycles to cancel out; the averages for all cycles at the bottom of Table 56 show that when such cancellation is allowed, the twisting effect remains larger than the precision effect.

Table 57 shows the effects of the annual time unit on average cyclical durations in each of our six series. One effect is obvious: the average dura-

TABLE 57
Average Duration of Specific Cycles in Monthly, Quarterly and Annual Data
Six American Series

| Series and form of data | Period covered | No. of specific cycles | Duration of specific cycles in months: Average, Expansion | Average, Contraction | Average, Full cycle | Average deviation, Expansion | Average deviation, Contraction | Average deviation, Full cycle |
|---|---|---|---|---|---|---|---|---|
| DEFLATED CLEARINGS | | | | | | | | |
| Monthly | 1878–1933 | 15 | 32.6 | 11.4 | 44.0 | 9.9 | 6.5 | 11.6 |
| Quarterly | 1878–1932 | 14 | 34.7 | 12.0 | 46.7 | 10.8 | 6.4 | 14.3 |
| Annual | 1878–1933 | 10 | 49.2 | 16.8 | 66.0 | 27.6 | 7.7 | 30.0 |
| PIG IRON PRODUCTION | | | | | | | | |
| Monthly | 1879–1933 | 15 | 28.8 | 14.5 | 43.3 | 9.0 | 7.1 | 9.9 |
| Quarterly | 1879–1933 | 15 | 28.6 | 14.6 | 43.2 | 9.1 | 6.8 | 9.6 |
| Annual | 1884–1932 | 12 | 31.0 | 17.0 | 48.0 | 16.5 | 7.5 | 18.0 |
| RAILROAD STOCK PRICES | | | | | | | | |
| Monthly | 1857–1932 | 18 | 28.8 | 21.0 | 49.8 | 16.0 | 12.1 | 22.6 |
| Quarterly | 1857–1932 | 18 | 28.8 | 20.8 | 49.7 | 16.4 | 11.8 | 22.1 |
| Annual | 1859–1932 | 16 | 30.0 | 24.8 | 54.8 | 20.2 | 10.2 | 28.2 |
| SHARES TRADED | | | | | | | | |
| Monthly | 1878–1933 | 15 | 17.9 | 26.2 | 44.1 | 8.0 | 9.1 | 11.0 |
| Quarterly | 1878–1933 | 15 | 16.6 | 27.4 | 44.0 | 9.3 | 10.1 | 11.6 |
| Annual | 1878–1932 | 15 | 20.8 | 22.4 | 43.2 | 10.6 | 5.5 | 12.8 |
| CALL MONEY RATES | | | | | | | | |
| Monthly | 1858–1931 | 23 | 19.9 | 18.0 | 37.9 | 7.6 | 6.4 | 8.6 |
| Quarterly | 1858–1931 | 22 | 21.7 | 18.0 | 39.7 | 8.0 | 6.8 | 10.2 |
| Annual | 1858–1931 | 20 | 25.2 | 18.6 | 43.8 | 7.9 | 7.3 | 11.8 |
| RAILROAD BOND YIELDS | | | | | | | | |
| Monthly | 1860–1931 | 20 | 21.0 | 21.4 | 42.4 | 9.0 | 11.3 | 12.6 |
| Quarterly | 1860–1931 | 20 | 20.6 | 21.9 | 42.4 | 8.7 | 11.0 | 12.4 |
| Annual | 1860–1931 | 14 | 27.4 | 33.4 | 60.9 | 15.2 | 18.6 | 20.1 |
| | | | Percentage excess of annual over monthly | | | | | |
| Deflated clearings | | | +51 | +47 | +50 | +179 | +18 | +159 |
| Pig iron production | | | +8 | +17 | +11 | +83 | +6 | +82 |
| Railroad stock prices | | | +4 | +18 | +10 | +26 | −16 | +25 |
| Shares traded | | | +16 | −15 | −2 | +32 | −40 | +16 |
| Call money rates | | | +27 | +3 | +16 | +4 | +14 | +37 |
| Railroad bond yields | | | +30 | +56 | +44 | +69 | +65 | +60 |

tion of full cycles is increased, the ratio of the average derived from annual data to the average derived from monthly data being approximately equal to the reciprocal of the fraction of specific cycles preserved by the annual data. Another and less obvious result is that annual data make the durations more uneven than they are in the monthly data. The 'precision' and 'twisting' effects combine to produce this result. An opposite result is conceivable; but it cannot be very frequent since the tendency of annual data to combine two and sometimes three cycles in monthly data into a single unit is unrelated to the length of the monthly cycles. In every series covered by our sample, annual data increase the average deviations of full cycles both absolutely and in proportion to the means. The effects of annual data on the phases of expansion and contraction are less predictable than the effects on full cycles. For they depend on the way in which specific cycles are lost—whether by skipping expansions or contractions—as well as on the number lost. Both the precision and twisting effects of annual data tend to be proportionately larger in short than in long durations, hence in cycle phases than in full cycles.

Just as annual measures of duration are less precise than monthly measures, so also are quarterly measures, though in much smaller degree. Sometimes the twisting effect stands out clearly; for example, the two-month contraction of clearings in 1907 becomes a six-month contraction in the quarterly data. At other times monthly and quarterly durations differ still more, but it is problematical whether the quarterly summation or the erratic movements in the vicinity of the turns are principally at fault. In any event, the differences between the monthly and quarterly durations of single cycles practically disappear when averages are struck for all cycles in a series. The only noticeable differences are in clearings and call money rates, which lose one cycle by the shift from monthly to quarterly data.

## VI Timing of Specific Cycles

We distrust leads or lags determined from annual data and use them sparingly. The reason is that leads or lags of specific-cycle turns at reference dates are usually minor fractions of a year. More than half of the leads and lags in our test series are six months or shorter; only about a sixth exceed a year (Table 58). Since the shortest lead or lag that an annual series can show is 12 months, most cyclical turns of well conforming annual series coincide with the annual reference dates and the rest usually lead or lag 12 or 24 months. These measures can no more help the economist trace the relations in time of different activities during business cycles than lengths in feet can help the physician trace the growth of infants.

TABLE 58

Frequency Distribution of Leads or Lags of Specific Cycles in Monthly Data
Six American Series

| Lead or lag at reference turn (mos.) | Number of leads or lags in monthly data | | | | | | |
|---|---|---|---|---|---|---|---|
| | Deflated clearings | Pig iron production | Railroad stock prices | Shares traded | Call money rates | Railroad bond yields | Six series |
| Under 4.... | 16 | 19 | 11 | 9 | 19 | 4 | 78 |
| 4 - 6.... | 6 | 3 | 3 | 4 | 10 | 7 | 33 |
| 7 - 9.... | .. | 6 | 8 | 6 | 3 | 5 | 28 |
| 10 - 12.... | 5 | 2 | 6 | 4 | 3 | 5 | 25 |
| Over 12.... | 2 | 1 | 7 | 8 | 3 | 11 | 32 |
| Total...... | 29 | 31 | 35 | 31 | 38 | 32 | 196 |

In this table leads are not distinguished from lags; in other words, we consider merely the number of months that a specific-cycle turn deviates from a corresponding reference turn.

See Table 55 for the periods covered. The grand total (196) is smaller than the full number of cyclical turns (218), because noncorresponding turns are omitted. For the measures of timing, cycle by cycle, see Appendix Table B3.

In practice, the 'twisting effect' of annual data accentuates the difficulties caused by the 'precision effect'. A few examples may help the reader realize how serious these difficulties can be. (1) In 1929 call money rates reached a peak in March, iron production in July, railroad stock prices and bond yields in September, share trading in October, deflated clearings in November. Annual data tell nothing about the sequence of these changes, since all six series reach peaks in 1929. (2) In nine business cycles clearings lag at downturns but lead at upturns; annual data show similar behavior just once. (3) In eleven business cycles share trading leads at both upturns and downturns; annual data show only four such instances. (4) Clearings lead iron production at upturns in twelve instances, lag in one; in another two instances both series turn up the same month. Annual data show coincident upturns in every instance, except one in which clearings lag in the face of a coincidence in the monthly data. (5) Share trading reaches a peak in May and railroad stock prices in June 1881. Annual data convert the one-month lead into a one-year lag, stock prices showing a peak in 1881 and share trading in 1882. (6) At the reference trough in 1904 stock prices lead the procession of upturns, followed in two months by iron production, in seven months by clearings and share trading, in nine months by call money rates, and in sixteen months by bond yields. Annual data, on the other hand, put share trading in the lead, obliterate the turn in clearings, make iron production, stock prices, and call money rates follow in one year, and bond yields in two years. (7) Monthly data on iron production lag one month at the reference peak of 1918; annual data lead by two years. (8) Monthly data on railroad stock prices show two troughs in the vicinity of the reference trough in 1858, a deep trough in October 1857 and a moderate one in May 1859; annual data manage to skip the deep but not the moderate trough.

Table 59 shows compactly how wide are the discrepancies between the individual timing measures of monthly and annual data. The table is restricted to corresponding turns, that is, turns for which timing observations in monthly and annual data match. If the annual timing measures were merely 'less precise' than the monthly measures, the entries in the table would be restricted to the diagonal cells: monthly measures of −6 to +6 months would be matched invariably by annual measures of 0, monthly measures of −6 to −18 months by annual measures of −12, and so on. In fact, the diagonal cells include only about two-thirds of the entries, even if skipped turns are left out of account. The remaining third are due to the twisting of cycles by annual data.

TABLE 59
Joint Distribution of Corresponding Leads or Lags of Monthly and Annual Data

| Lead (−) or lag (+) of monthly data at reference turn (mos.) | Corresponding lead (−) or lag (+) of annual data at reference turn (mos.) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | −36 | −24 | −12 | 0 | +12 | +24 | +36 | Total |
| −42 to −30.... | ... | 1 | ... | ... | ... | ... | ... | 1 |
| −30 to −18.... | ... | 2 | 2 | ... | ... | ... | ... | 4 |
| −18 to −6.... | 1 | 1 | 19 | 22 | 1 | ... | ... | 44 |
| −6 to +6.... | ... | 1 | 9 | 74 | 6 | 1 | ... | 91 |
| +6 to +18.... | ... | ... | ... | 6 | 21 | 2 | ... | 29 |
| +18 to +30.... | ... | ... | ... | ... | ... | 2 | 2 | 4 |
| +30 to +42.... | ... | ... | ... | ... | ... | ... | ... | ... |
| Total......... | 1 | 5 | 30 | 102 | 28 | 5 | 2 | 173 |

Based on specific-cycle turns of the monthly and annual data of six American series within the periods shown in Table 55. The monthly data are compared with the monthly reference dates, the annual data with the annual reference dates.

Items falling at the boundaries of the monthly classes (for example, −6) were distributed equally between adjacent classes in a column. There were eleven such items. The fractions that resulted in certain cases were rounded up or down in a manner most advantageous to the showing of annual data.

Quarterly data once again produce effects similar but smaller than those produced by annual data. The number of coincidences is much larger in quarterly than in monthly data, as Table 60 shows in detail. The result is that the quarterly data frequently cover up differences in timing that appear in monthly data. According to the quarterly data all series except call money rates reached a peak in the third quarter of 1929; but the turns in monthly data are scattered from March to November. Further, the monthly data show the peak in call money rates in the first quarter of 1929, not in the second quarter as do the quarterly data. Again, the monthly data show peaks in clearings and share trading in the last quarter, not in the third quarter. These detailed differences are exhibited in Chart 24. With the possible exception of the monthly data on share trading all cyclical turns on this chart are clearly defined. But when erratic movements are very pronounced the advantage of monthly data

TABLE 60

Frequency of Leads or Lags and Average Timing of Specific Cycles
Six American Series, Monthly, Quarterly and Annual

| Series and form of data | Timing at reference peaks | | | | | Timing at reference troughs | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Number of | | | | Average lead (−) or lag (+) in months | Number of | | | | Average lead (−) or lag (+) in months |
| | Leads | Lags | Coinci-dences | Total | | Leads | Lags | Coinci-dences | Total | |
| DEFLATED CLEARINGS | | | | | | | | | | |
| Monthly (I) | 1 | 10 | 3 | 14 | +3.2 | 14 | ... | 1 | 15 | −5.8 |
| Quarterly | ... | 4 | 9 | 13 | +2.5 | 12 | ... | 2 | 14 | −5.1 |
| Annual | ... | 1 | 8 | 9 | +1.3 | 1 | 1 | 8 | 10 | 0.0 |
| Monthly (II) | 1 | 7 | 1 | 9 | +3.3 | 9 | ... | 1 | 10 | −5.4 |
| PIG IRON PRODUCTION | | | | | | | | | | |
| Monthly (I) | 4 | 8 | 3 | 15 | +1.9 | 12 | 1 | 3 | 16 | −3.4 |
| Quarterly | 2 | 7 | 6 | 15 | +1.8 | 7 | ... | 9 | 16 | −2.2 |
| Annual | 1 | 1 | 11 | 13 | −0.9 | 1 | ... | 12 | 13 | −0.9 |
| Monthly (II) | 4 | 6 | 3 | 13 | +1.2 | 9 | 1 | 3 | 13 | −3.8 |
| RAILROAD STOCK PRICES | | | | | | | | | | |
| Monthly (I) | 13 | 3 | 1 | 17 | −5.6 | 14 | 4 | ... | 18 | −7.4 |
| Quarterly | 13 | 2 | 2 | 17 | −5.8 | 14 | 2 | 2 | 18 | −7.3 |
| Annual | 9 | ... | 7 | 16 | −7.5 | 5 | 3 | 9 | 17 | −2.1 |
| Monthly (II) | 13 | 2 | 1 | 16 | −6.6 | 13 | 4 | ... | 17 | −7.7 |
| SHARES TRADED | | | | | | | | | | |
| Monthly (I) | 14 | 1 | ... | 15 | −10.4 | 12 | 2 | 2 | 16 | −4.6 |
| Quarterly | 14 | 1 | ... | 15 | −11.8 | 10 | 1 | 5 | 16 | −3.8 |
| Annual | 10 | ... | 5 | 15 | −9.6 | 4 | ... | 12 | 16 | −3.0 |
| Monthly (II) | 14 | 1 | ... | 15 | −10.4 | 12 | 2 | 2 | 16 | −4.6 |
| CALL MONEY RATES | | | | | | | | | | |
| Monthly (I) | 8 | 8 | 3 | 19 | −0.1 | 9 | 10 | ... | 19 | +1.5 |
| Quarterly | 6 | 7 | 5 | 18 | 0.0 | 4 | 8 | 6 | 18 | +2.0 |
| Annual | 3 | 2 | 13 | 18 | −0.7 | 2 | 6 | 10 | 18 | +1.3 |
| Monthly (II) | 8 | 8 | 2 | 18 | −0.1 | 8 | 10 | ... | 18 | +1.8 |
| RAILROAD BOND YIELDS | | | | | | | | | | |
| Monthly (I) | ... | 16 | ... | 16 | +7.8 | 2 | 13 | 1 | 16 | +11.8 |
| Quarterly | ... | 15 | 1 | 16 | +7.7 | 2 | 13 | 1 | 16 | +12.4 |
| Annual | ... | 8 | 6 | 14 | +8.6 | ... | 13 | 1 | 14 | +17.1 |
| Monthly (II) | ... | 14 | ... | 14 | +8.8 | 1 | 12 | 1 | 14 | +12.4 |

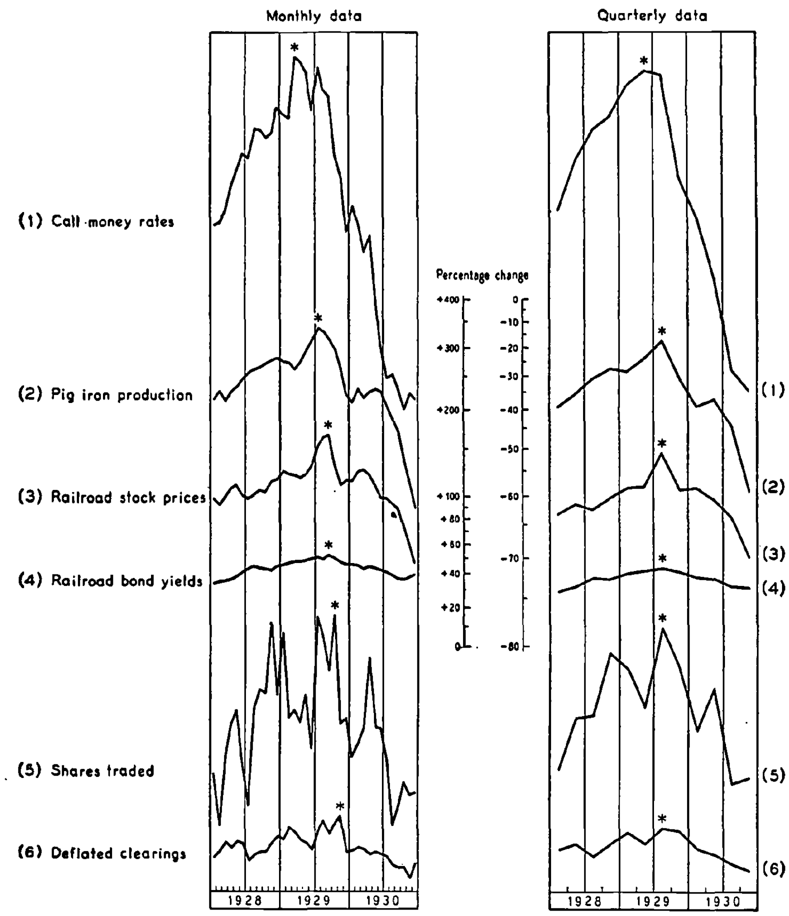
See Table 55 for the periods covered. The entries on line (I) include all timing measures for the monthly series within the periods shown in Table 55; the entries on line (II) are restricted to monthly timing measures that correspond to those in the annual series. The timing of the quarterly data is obtained by comparing their specific-cycle turns with the quarterly reference dates. Similarly, the timing of the annual data is obtained by comparing their specific-cycle turns with the annual reference dates. See the next table, and Table 48 in the preceding chapter.

is problematical; in such cases cyclical turns can be dated with greater assurance in quarterly data than in monthly.[23]

When averages are struck for all cycles the monthly and quarterly results agree remarkably well. The largest difference between their averages is only 1.4 months (Table 60). The small differences between the averages leave the rankings of the six series in quarterly form exactly the same as the rankings in monthly form at upturns and at downturns. The

[23] In handling highly erratic series a three-month moving total (or average) may be preferable to monthly or quarterly figures. Of course, quarterly data represent every third term of a three-month moving total (or average) of monthly figures.

CHART 24
Sequence of Cyclical Downturns in 1929
Six American Series, Monthly and Quarterly




Asterisks identify peaks of specific cycles. See the note at the end of Sec. II, for sources of data, etc.

annual averages, on the other hand, differ widely from the monthly averages in several instances. For example, monthly data on clearings show an average lead of six months at reference troughs; annual data show coincidence on the average. Monthly data on iron production show an average lag of two months at reference peaks; annual data show a lead of one month. Monthly data put share trading in third place at the turn from contraction to expansion; annual data put it first. These differences cannot be ascribed to the skipping of cycles by the annual data: for the monthly-annual discrepancies are about as large when judged from averages confined to corresponding turns as when judged from averages based on all turns.

So far we have compared annual specific-cycle turns with annual reference dates and quarterly specific-cycle turns with quarterly reference dates. This is the only method that can be used by an investigator working along our lines but relying exclusively upon annual or quarterly data. But in our own work, not being subject to this limitation, we can use the monthly reference dates as benchmarks for measuring the cyclical timing of all series regardless of the time unit in which they are expressed. Thus, instead of comparing the midpoints of annual specific-cycle turns with the midpoints of annual reference turns, we can relate the former to the midpoints of monthly reference turns.[24] Table 61 presents average timing

TABLE 61

Average Timing of Specific Cycles Computed in Different Ways
Six American Series, Monthly, Quarterly and Annual

| Series | Corresponding turns in monthly and quarterly data | | | | Corresponding turns in monthly and annual data | | | |
|---|---|---|---|---|---|---|---|---|
| | | Av. lead (−) or lag (+) in months | | | | Av. lead (−) or lag (+) in months | | |
| | No. of turns | Monthly spec.-cycle turn compared with monthly ref. turn | Quarterly spec.-cycle turn compared with *monthly* ref. turn | Quarterly spec.-cycle turn compared with quarterly ref. turn | No. of turns | Monthly spec.-cycle turn compared with monthly ref. turn | Annual spec.-cycle turn compared with *monthly* ref. turn | Annual spec.-cycle turn compared with annual ref. turn |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| | | | | Timing at reference peaks | | | | |
| Deflated clearings | 13 | +3.5 | +3.2 | +2.5 | 9 | +3.3 | +1.8 | +1.3 |
| Pig iron production | 15 | +1.9 | +2.2 | +1.8 | 13 | +1.2 | +0.3 | −0.9 |
| Railroad stock prices | 17 | −5.6 | −5.7 | −5.8 | 16 | −6.6 | −7.1 | −7.5 |
| Shares traded | 15 | −10.4 | −11.4 | −11.8 | 15 | −10.4 | −8.3 | −9.6 |
| Call money rates | 18 | −0.1 | −0.1 | 0.0 | 18 | −0.1 | −0.4 | −0.7 |
| Railroad bond yields | 16 | +7.8 | +7.6 | +7.7 | 14 | +8.8 | +9.0 | +8.6 |
| | | | | Timing at reference troughs | | | | |
| Deflated clearings | 14 | −5.9 | −5.9 | −5.1 | 10 | −5.4 | −3.8 | 0.0 |
| Pig iron production | 16 | −3.4 | −2.9 | −2.2 | 13 | −3.8 | −3.7 | −0.9 |
| Railroad stock prices | 18 | −7.4 | −7.7 | −7.3 | 17 | −7.7 | −4.9 | −2.1 |
| Shares traded | 16 | −4.6 | −4.4 | −3.8 | 16 | −4.6 | −5.9 | −3.0 |
| Call money rates | 18 | +1.8 | +1.5 | +2.0 | 18 | +1.8 | −1.8 | +1.3 |
| Railroad bond yields | 16 | +11.8 | +12.0 | +12.4 | 14 | +12.4 | +14.4 | +17.1 |

See Table 55 for the periods covered.

measures of annual data computed both ways, and similar measures for quarterly data. When the timing of annual or quarterly data is measured from the monthly reference dates, the resulting average usually approximates better the average determined from monthly data than when annual or quarterly chronologies are used exclusively. This result is not a peculiarity of our sample; it may be expected as a rule, since the use of monthly reference dates limits the error of the timing measures to the distorting effect of quarterly or annual data on the specific-cycle turns.

[24] See Table 48. Of course, if a series starts before the monthly reference dates, we must determine leads or lags of the early cycles from the annual reference dates.

Hence our standard practice when analyzing quarterly or annual series is to measure their timing from the monthly reference dates.[25]

It is important to recognize that monthly benchmarks merely *tend* to improve estimates of average cyclical timing. As Table 61 demonstrates, the estimates are sometimes worsened; also, some of the estimates made from annual series remain poor, though they are not quite so poor as those derived from the annual reference dates. Table 62 shows that when the period covered by an annual series is brief and no adjustment is made for the failure of its cycles to correspond to the monthly, measures of average timing derived from annual data frequently diverge sharply from the monthly measures. For this reason we rarely measure leads or lags of short annual series. We also insist that the series conform well to business cycles; for unless this condition is met it is extremely difficult to determine what cyclical turns correspond to what reference dates. Finally, we attach little value to individual leads or lags of an annual series: we use them chiefly as materials for estimating average timing.

## VII Amplitude of Specific Cycles in Annual Data

In annual series that represent continuous processes the standings at the peaks and troughs of specific cycles cover twelve months; in monthly and quarterly series they cover three months. When annual and quarterly data are expressed as monthly averages, and the cyclical peaks in all three forms come in the same year, the standing at the peak must be lower in the annual data than in the other forms; for in monthly series this standing covers the three months centered on the highest value attained during the cycle, and in quarterly series the standing is that of the highest quarter. The relations must be similar when the cyclical turns of the three forms of the data occur in different years, provided the cycles still correspond approximately in time. For the standing at the peak of a monthly series covers the three months centered on the apex of expansion, whether that expansion attained its highest annual average in the year preceding or the year following the monthly peak. Likewise the standing at the

25 Let $S$ be the average distortion of the timing of specific cycles produced by annual data, and $R$ the average distortion of the timing of reference cycles produced by annual data. Then $S$ is measured by col. (8) minus col. (7) of Table 61; $R$ is measured by col. (8) minus col. (9); while col. (9) minus col. (7) measures $(S-R)$.

Whether col. (8) will give a better approximation to col. (7) than will col. (9) turns on whether $|S| < |S-R|$. For any group of reference cycles $R$ may be plus, minus, or zero. If many series are analyzed for the period covered by these reference cycles, the expectation is that $S$ will be plus in as many series as it will be minus. Now if $R$ is zero, col. (8) must agree with col. (9). If $S$ is zero, the above inequality obviously holds, except, of course, when $R$ too is zero, in which case col. (8) agrees with col. (9). If $S$ and $R$ are of opposite sign, the inequality must again hold. And it will also hold when $S$ and $R$ are of the same sign, whenever $|R| > |2S|$. Hence there is a greater probability that $|S|<|S-R|$ than that $|S| > |S-R|$; in other words, the expectation is that col. (8) will more often approximate col. (7) than will col. (9).

With obvious changes of phrase, this argument applies to quarterly data. Also, as our colleague Geoffrey H. Moore points out, the above argument could be put more rigorously in terms of variances and covariances.

TABLE 62

Average Timing of Specific Cycles during Brief Periods
Six American Series, Monthly and Annual

| Series and period covered | No. of reference cycles | No. of observations on timing at reference | | | | Average lead (−) or lag (+) in months at reference | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Peaks | | Troughs | | Peaks | | Troughs | |
| | | M | A | M | A | M | A | M | A |
| Deflated clearings | | | | | | | | | |
| 1879–1897 | 5 | 5 | 4 | 5 | 4 | +3.8 | +0.8 | −6.2 | −4.2 |
| 1897–1914 | 5 | 5 | 3 | 5 | 3 | +4.2 | +2.5 | −7.4 | −5.5 |
| 1914–1933 | 5 | 4 | 2 | 5 | 3 | +1.2 | +3.0 | −3.8 | −1.5 |
| Pig iron production | | | | | | | | | |
| 1879–1897 | 5 | 5 | 4 | 5 | 3 | +0.8 | +0.8 | −3.2 | −2.8 |
| 1897–1914 | 5 | 5 | 4 | 5 | 4 | +3.4 | +5.5 | −7.2 | −4.8 |
| 1914–1933 | 5 | 5 | 5 | 6 | 6 | +1.4 | −4.3 | −0.3 | −3.3 |
| Railroad stock prices | | | | | | | | | |
| 1858–1888 | 6 | 5 | 5 | 5 | 5 | −7.6 | −6.7 | −13.4 | −8.3 |
| 1888–1908 | 6 | 6 | 5 | 6 | 5 | −2.2 | −5.1 | −1.2 | +0.7 |
| 1908–1933 | 7 | 6 | 6 | 7 | 7 | −7.3 | −9.2 | −8.6 | −6.4 |
| Shares traded | | | | | | | | | |
| 1879–1897 | 5 | 5 | 5 | 5 | 5 | −11.4 | −5.9 | −2.2 | −0.5 |
| 1897–1914 | 5 | 5 | 5 | 5 | 5 | −12.0 | −7.5 | −4.8 | −7.3 |
| 1914–1933 | 5 | 5 | 5 | 6 | 6 | −7.8 | −11.5 | −6.5 | −9.3 |
| Call money rates | | | | | | | | | |
| 1858–1888 | 6 | 6 | 6 | 6 | 6 | −3.3 | −3.5 | −1.2 | −7.8 |
| 1888–1908 | 6 | 6 | 6 | 6 | 6 | +4.2 | +1.8 | +3.0 | +1.7 |
| 1908–1933 | 7 | 7 | 6 | 7 | 6 | −1.0 | +0.5 | +2.6 | +0.7 |
| Railroad bond yields | | | | | | | | | |
| 1858–1888 | 6 | 6 | 5 | 6 | 5 | +9.2 | +8.5 | +17.8 | +18.1 |
| 1888–1908 | 6 | 5 | 5 | 5 | 5 | +9.2 | +9.3 | +14.4 | +15.1 |
| 1908–1933 | 7 | 5 | 4 | 5 | 4 | +4.8 | +9.2 | +1.8 | +8.8 |

M stands for monthly data, A for annual. The periods mark off successive thirds of the reference cycles covered by a series. Where the full number is not exactly divisible by 3, the odd item is placed in the last period.

The averages are made on our standard plan; that is, both monthly and annual specific-cycle turns are compared with the monthly reference dates. To avoid duplication, the timing at the terminal trough of the first period is excluded from the average for that period but included in the average for the second, and the timing at the terminal trough of the second period is excluded from the average for that period but included in the average for the third.

apex quarter should be higher than the average standing in the corresponding apex year, whether this year comes before or after the year including the apex quarter. On similar grounds, we expect the annual troughs to be higher than the monthly or quarterly troughs, whether they come in the same, the preceding, or the following year.[26]

Exceptions to these rules are rare. They may arise from disregarding a random peak or trough in marking off specific cycles in monthly or quarterly data.[27] They can scarcely arise from a violently low value in the

[26] Cf. note 44.

[27] For example, monthly data on the value of building plans filed in Manhattan show a rise from July 1927 to Feb. 1928, a decline to Dec. 1928, followed by an extraordinary rise to April 1929, and a sharp and protracted decline to July 1933. The data suggest that the rise from Dec. 1928 to April 1929 was a random interruption of a cyclical decline that began Feb. 1928; this suggestion is confirmed by other statistics and by the fact that the new Multiple Dwellings Act, with its more stringent provisions governing construction of apartment houses and hotels, was debated by the

month following or preceding a cyclical peak or from a violently high value in the month following or preceding a cyclical trough; for when such movements appear we omit them in computing the peak or trough standing. In the 70 specific cycles that correspond in the monthly, quarterly, and annual forms of our test series, the peak standings of the annual data are invariably lower and the trough standings invariably higher than the corresponding standings of the quarterly and monthly data. But the differences between the standings vary erratically, as may be seen from the detailed measures for pig iron production on lines 7-13 of Table 63.

Since the standings at the peaks of specific cycles are lower and the standings at troughs higher in the annual than in the quarterly or monthly data when these standings are expressed in the original units, the absolute rise and fall of specific cycles must be smaller in the annual than in the other data. There are no exceptions in our sample. Lines 19-25 in Table 63 show the discrepancies between the three forms of the data on iron production, and columns (1) to (4) in Table 64 summarize the monthly-annual discrepancies for all six series. In the first cycle of iron production the rise in the annual data is only 24 per cent of the rise in the monthly data; in the eighth cycle this ratio is 72 per cent. The range of the discrepancies is still larger in the cyclical falls. Other series show similar variations in the degree to which the monthly amplitudes are cut by a shift to annual data.

The reduction in amplitude produced by annual summarizing varies inversely with the duration of cyclical expansions and contractions. Chart 25 demonstrates this tendency; but also shows that it is crossed by other factors, and disappears when a phase lasts about four years or longer. As indicated in Section IV, the fate of a cyclical expansion or contraction in annual summations depends partly upon its duration, partly upon other things—the months in which the cyclical turns occur, the amplitude of the movement relatively to the underlying trend, its pattern and that of the erratic fluctuations diversifying it. These factors determine whether a given expansion or contraction will be preserved or wiped out in annual data; also, whether the fraction preserved is large or small. A student working solely with annual data must be ignorant of some of these factors and can have only rough knowledge of others; hence he can no more tell which cycles have lost a large and which a small portion of their amplitude by annual summarizing than he can tell which annual cycles correspond to single cycles in the monthly figures and which combine two or three cycles.

Legislature in the early months of 1929 and became law April 19, 1929. In analyzing the specific cycle from 1927 to 1933 we therefore take Feb. 1928 as the peak, and disregard the much higher value in April 1929. The annual figures are too rigid to be handled in a similar manner; they rise from 1927 to 1928 and again from 1928 to 1929, so that we are forced to recognize 1929 as the peak. The amplitude measures of the 1927-33 cycle come out +141, −252, 393 in the annual and +72, −184, 256 in the monthly data.

TABLE 63

Standings at Peaks and Troughs, Cycle Bases, and Amplitudes of Corresponding Specific Cycles in Monthly, Quarterly and Annual Data
Pig Iron Production, United States

| Line | Measure | Cycle 1 | | | Cycle 2 | | | Cycle 3 | | | Cycle 4 | | | Cycle 5 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | M | Q | A | M | Q | A | M | Q | A | M | Q | A | M | Q | A |
| 1 | DATE OF TURNS | | | | | | | | | | | | | | | |
| 2 | Initial trough | Apr. 91 | 1Q 91 | 1891 | Oct. 93 | 4Q 93 | 1894 | Dec. 03 | 4Q 03 | 1904 | Jan. 08 | 1Q 08 | 1908 | Dec. 10 | 2Q 11 | 1911 |
| 3 | Peak | Feb. 92 | 1Q 92 | 1892 | Nov. 95 | 4Q 95 | 1895 | July 07 | 3Q 07 | 1907 | Jan. 10 | 1Q 10 | 1910 | Jan. 13 | 1Q 13 | 1913 |
| 4 | Terminal trough | Oct. 93 | 4Q 93 | 1894 | Oct. 96 | 4Q 96 | 1896 | Jan. 08 | 1Q 08 | 1908 | Dec. 10 | 2Q 11 | 1911 | Dec. 14 | 4Q 14 | 1914 |
| 5 | STANDING AT TURNS | | | | | | | | | | | | | | | |
| 6 | *In thousand long tons* | | | | | | | | | | | | | | | |
| 7 | Initial trough | 15.12 | 17.17 | 21.08 | 11.03 | 11.85 | 17.62 | 30.77 | 36.14 | 44.25 | 37.32 | 36.74 | 42.72 | 60.37 | 62.45 | 63.94 |
| 8 | Peak | 25.31 | 25.31 | 23.56 | 29.72 | 29.72 | 25.24 | 75.05 | 74.20 | 69.39 | 86.38 | 84.88 | 73.66 | 93.19 | 91.34 | 84.24 |
| 9 | Terminal trough | 11.03 | 11.85 | 17.62 | 16.69 | 17.87 | 22.72 | 37.32 | 36.74 | 42.72 | 60.37 | 62.45 | 63.94 | 51.75 | 52.30 | 63.19 |
| 10 | *As relatives of M* | | | | | | | | | | | | | | | |
| 11 | Initial trough | 100 | 114 | 139 | 100 | 107 | 160 | 100 | 117 | 144 | 100 | 98 | 114 | 100 | 103 | 106 |
| 12 | Peak | 100 | 100 | 93 | 100 | 100 | 85 | 100 | 99 | 92 | 100 | 98 | 85 | 100 | 98 | 90 |
| 13 | Terminal trough | 100 | 107 | 160 | 100 | 107 | 136 | 100 | 98 | 114 | 100 | 103 | 106 | 100 | 101 | 122 |
| 14 | CYCLE BASE | | | | | | | | | | | | | | | |
| 15 | *In thousand long tons* | 22.41 | 21.74 | 20.47 | 21.42 | 21.60 | 22.71 | 60.20 | 59.38 | 60.69 | 62.40 | 63.10 | 65.52 | 72.96 | 74.63 | 76.02 |
| 16 | *As relatives of M* | 100 | 97 | 91 | 100 | 101 | 106 | 100 | 99 | 101 | 100 | 101 | 105 | 100 | 102 | 104 |
| 17 | ABSOLUTE AMPLITUDE[a] | | | | | | | | | | | | | | | |
| 18 | *In thousand long tons* | | | | | | | | | | | | | | | |
| 19 | Rise | 10.19 | 8.14 | 2.48 | 18.69 | 17.87 | 7.62 | 44.28 | 38.06 | 25.14 | 49.06 | 48.14 | 30.94 | 32.82 | 28.89 | 20.30 |
| 20 | Fall | 14.28 | 13.46 | 5.94 | 13.03 | 11.85 | 2.52 | 37.73 | 37.46 | 26.67 | 26.01 | 22.43 | 9.72 | 41.44 | 39.04 | 21.05 |
| 21 | Rise & fall | 24.47 | 21.60 | 8.42 | 31.72 | 29.72 | 10.14 | 82.01 | 75.52 | 51.81 | 75.07 | 70.57 | 40.66 | 74.26 | 67.93 | 41.35 |
| 22 | *As relatives of M* | | | | | | | | | | | | | | | |
| 23 | Rise | 100 | 80 | 24 | 100 | 96 | 41 | 100 | 86 | 57 | 100 | 98 | 63 | 100 | 88 | 62 |
| 24 | Fall | 100 | 94 | 42 | 100 | 91 | 19 | 100 | 99 | 71 | 100 | 86 | 37 | 100 | 94 | 51 |
| 25 | Rise & fall | 100 | 88 | 34 | 100 | 94 | 32 | 100 | 92 | 63 | 100 | 94 | 54 | 100 | 91 | 56 |
| 26 | RELATIVE AMPLITUDE[b] | | | | | | | | | | | | | | | |
| 27 | *In specific-cycle relatives* | | | | | | | | | | | | | | | |
| 28 | Rise | 45.4 | 37.4 | 12.1 | 87.2 | 82.7 | 33.6 | 73.6 | 64.1 | 41.4 | 78.6 | 76.3 | 47.2 | 45.0 | 38.7 | 26.7 |
| 29 | Fall | 63.7 | 61.9 | 29.0 | 60.8 | 54.9 | 11.1 | 62.7 | 63.1 | 43.9 | 41.7 | 35.5 | 14.8 | 56.8 | 52.3 | 27.7 |
| 30 | Rise & fall | 109.1 | 99.3 | 41.1 | 148.0 | 137.6 | 44.7 | 136.3 | 127.2 | 85.3 | 120.3 | 111.8 | 62.0 | 101.8 | 91.0 | 54.4 |
| 31 | *As relatives of M* | | | | | | | | | | | | | | | |
| 32 | Rise | 100 | 82 | 27 | 100 | 95 | 39 | 100 | 87 | 56 | 100 | 97 | 60 | 100 | 86 | 59 |
| 33 | Fall | 100 | 97 | 46 | 100 | 90 | 18 | 100 | 101 | 70 | 100 | 85 | 35 | 100 | 92 | 49 |
| 34 | Rise & fall | 100 | 91 | 38 | 100 | 93 | 30 | 100 | 93 | 63 | 100 | 93 | 52 | 100 | 89 | 53 |

TABLE 63 – *Continued*

| Line | Measure | Cycle 6 | | | Cycle 7 | | | Cycle 8 | | | Cycle 9 | | | Cycle 10 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | M | Q | A | M | Q | A | M | Q | A | M | Q | A | M | Q | A |
| 1 | DATE OF TURNS | | | | | | | | | | | | | | | |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 29 | Fall | 63.7 | 61.9 | 29.0 | 60.8 | 54.9 | 11.1 | 62.7 | 63.1 | 43.9 | 41.7 | 35.5 | 14.8 | 56.8 | 52.3 | 27.7 |
| 30 | Rise & fall | 109.1 | 99.3 | 41.1 | 148.0 | 137.6 | 44.7 | 136.3 | 127.2 | 85.3 | 120.3 | 111.8 | 62.0 | 101.8 | 91.0 | 54.4 |
| 31 | *As relatives of M* | | | | | | | | | | | | | | | |
| 32 | Rise | 100 | 82 | 27 | 100 | 95 | 39 | 100 | 87 | 56 | 100 | 97 | 60 | 100 | 86 | 59 |
| 33 | Fall | 100 | 97 | 46 | 100 | 90 | 18 | 100 | 101 | 70 | 100 | 85 | 35 | 100 | 92 | 49 |
| 34 | Rise & fall | 100 | 91 | 38 | 100 | 93 | 30 | 100 | 93 | 63 | 100 | 93 | 52 | 100 | 89 | 53 |

TABLE 63 – *Continued*

| Line | Measure | Cycle 6 | | | Cycle 7 | | | Cycle 8 | | | Cycle 9 | | | Cycle 10 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | M | Q | A | M | Q | A | M | Q | A | M | Q | A | M | Q | A |
| 1 | DATE OF TURNS | | | | | | | | | | | | | | | |
| 2 | Initial trough | Dec. 14 | 4Q 14 | 1914 | May 19 | 2Q 19 | 1919 | July 21 | 3Q 21 | 1921 | July 24 | 3Q 24 | 1924 | Nov. 27 | 4Q 27 | 1927 |
| 3 | Peak | Sep. 18 | 3Q 18 | 1916 | Sep. 20 | 3Q 20 | 1920 | May 23 | 2Q 23 | 1923 | July 26 | 3Q 26 | 1926 | July 29 | 3Q 29 | 1929 |
| 4 | Terminal trough | May 19 | 2Q 19 | 1919 | July 21 | 3Q 21 | 1921 | July 24 | 3Q 24 | 1924 | Nov. 27 | 4Q 27 | 1927 | Mar. 33 | 1Q 33 | 1932 |
| 5 | STANDING AT TURNS | | | | | | | | | | | | | | | |
| 6 | *In thousand long tons* | | | | | | | | | | | | | | | |
| 7 | Initial trough | 51.75 | 52.30 | 63.19 | 72.96 | 72.96 | 83.91 | 32.33 | 31.56 | 45.45 | 73.35 | 75.70 | 85.08 | 91.10 | 91.10 | 99.32 |
| 8 | Peak | 112.73 | 113.42 | 106.68 | 105.85 | 104.81 | 99.50 | 121.88 | 121.88 | 109.74 | 109.80 | 110.93 | 107.04 | 128.03 | 128.07 | 115.86 |
| 9 | Terminal trough | 72.96 | 72.96 | 83.91 | 32.33 | 31.56 | 45.45 | 73.35 | 75.70 | 85.08 | 91.10 | 91.10 | 99.32 | 18.03 | 17.83 | 23.77 |
| 10 | *As relatives of M* | | | | | | | | | | | | | | | |
| 11 | Initial trough | 100 | 101 | 122 | 100 | 100 | 115 | 100 | 98 | 141 | 100 | 103 | 116 | 100 | 100 | 109 |
| 12 | Peak | 100 | 101 | 95 | 100 | 99 | 94 | 100 | 100 | 90 | 100 | 101 | 97 | 100 | 100 | 90 |
| 13 | Terminal trough | 100 | 100 | 115 | 100 | 98 | 141 | 100 | 103 | 116 | 100 | 100 | 109 | 100 | 99 | 132 |
| 14 | CYCLE BASE | | | | | | | | | | | | | | | |
| 15 | *In thousand long tons* | 98.52 | 97.58 | 94.27 | 80.87 | 79.28 | 82.09 | 82.80 | 84.09 | 82.85 | 99.80 | 100.33 | 99.69 | 73.86 | 74.74 | 83.42 |
| 16 | *As relatives of M* | 100 | 99 | 96 | 100 | 98 | 102 | 100 | 102 | 100 | 100 | 101 | 100 | 100 | 101 | 113 |
| 17 | ABSOLUTE AMPLITUDE[a] | | | | | | | | | | | | | | | |
| 18 | *In thousand long tons* | | | | | | | | | | | | | | | |
| 19 | Rise | 60.98 | 61.12 | 43.49 | 32.89 | 31.85 | 15.59 | 89.55 | 90.32 | 64.29 | 36.45 | 35.23 | 21.96 | 36.93 | 36.97 | 16.54 |
| 20 | Fall | 39.77 | 40.46 | 22.77 | 73.52 | 73.25 | 54.05 | 48.53 | 46.18 | 24.66 | 18.70 | 19.83 | 7.72 | 110.00 | 110.24 | 92.09 |
| 21 | Rise & fall | 100.75 | 101.58 | 66.26 | 106.41 | 105.10 | 69.64 | 138.08 | 136.50 | 88.95 | 55.15 | 55.06 | 29.68 | 146.93 | 147.21 | 108.63 |
| 22 | *As relatives of M* | | | | | | | | | | | | | | | |
| 23 | Rise | 100 | 100 | 71 | 100 | 97 | 47 | 100 | 101 | 72 | 100 | 97 | 60 | 100 | 100 | 45 |
| 24 | Fall | 100 | 102 | 57 | 100 | 100 | 74 | 100 | 95 | 51 | 100 | 106 | 41 | 100 | 100 | 84 |
| 25 | Rise & fall | 100 | 101 | 66 | 100 | 99 | 65 | 100 | 99 | 64 | 100 | 100 | 54 | 100 | 100 | 74 |
| 26 | RELATIVE AMPLITUDE[b] | | | | | | | | | | | | | | | |
| 27 | *In specific-cycle relatives* | | | | | | | | | | | | | | | |
| 28 | Rise | 61.9 | 62.6 | 46.2 | 40.7 | 40.2 | 19.0 | 108.3 | 107.6 | 77.5 | 36.5 | 35.2 | 22.1 | 50.0 | 49.5 | 19.8 |
| 29 | Fall | 40.3 | 41.4 | 24.2 | 91.1 | 92.6 | 65.8 | 58.6 | 55.0 | 29.7 | 18.7 | 19.8 | 7.8 | 148.9 | 147.5 | 110.4 |
| 30 | Rise & fall | 102.2 | 104.0 | 70.4 | 131.8 | 132.8 | 84.8 | 166.9 | 162.6 | 107.2 | 55.2 | 55.0 | 29.9 | 198.9 | 197.0 | 130.2 |
| 31 | *As relatives of M* | | | | | | | | | | | | | | | |
| 32 | Rise | 100 | 101 | 75 | 100 | 99 | 47 | 100 | 99 | 72 | 100 | 96 | 61 | 100 | 99 | 40 |
| 33 | Fall | 100 | 103 | 60 | 100 | 102 | 72 | 100 | 94 | 51 | 100 | 106 | 42 | 100 | 99 | 74 |
| 34 | Rise & fall | 100 | 102 | 69 | 100 | 101 | 64 | 100 | 97 | 64 | 100 | 100 | 54 | 100 | 99 | 65 |

M stands for monthly data, Q for quarterly, A for annual. The output figures refer to average daily production in all three forms of the data.

[a] That is, expressed in the unit of the original data.

[b] That is, our standard measure of amplitude as derived in Table S2 (see Table 31).

TABLE 64

Frequency Distribution of the Differences between Absolute Amplitudes, Cycle Bases, and Relative Amplitudes of Corresponding Specific Cycles in Monthly and Annual Data

| Deviation of annual figure from monthly (per cent) | Number of differences between | | | | | | |
|---|---|---|---|---|---|---|---|
| | Amplitudes expressed in original units | | | Cycle bases | Amplitudes expressed in specific-cycle relatives | | |
| | Rise | Fall | Rise & fall | | Rise | Fall | Rise & fall |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Under −90 | 2 | 1 | .. | .. | 2 | 1 | .. |
| −90 to −81 | 4 | 3 | 2 | .. | 3 | 4 | 2 |
| −80 to −71 | 5 | 6 | 1 | .. | 7 | 4 | 1 |
| −70 to −61 | 6 | 6 | 11 | .. | 7 | 7 | 9 |
| −60 to −51 | 12 | 19 | 14 | .. | 8 | 19 | 17 |
| −50 to −41 | 16 | 13 | 15 | .. | 18 | 12 | 13 |
| −40 to −31 | 10 | 7 | 14 | .. | 9 | 9 | 16 |
| −30 to −21 | 8 | 7 | 7 | .. | 10 | 7 | 7 |
| −20 to −11 | 5 | 8 | 6 | 1 | 5 | 7 | 5 |
| −10 to −1 | 2 | .. | .. | 26 | 1 | .. | .. |
| 0 to +9 | .. | .. | .. | 41 | .. | .. | .. |
| +10 to +19 | .. | .. | .. | 2 | .. | .. | .. |
| Total........ | 70 | 70 | 70 | 70 | 70 | 70 | 70 |

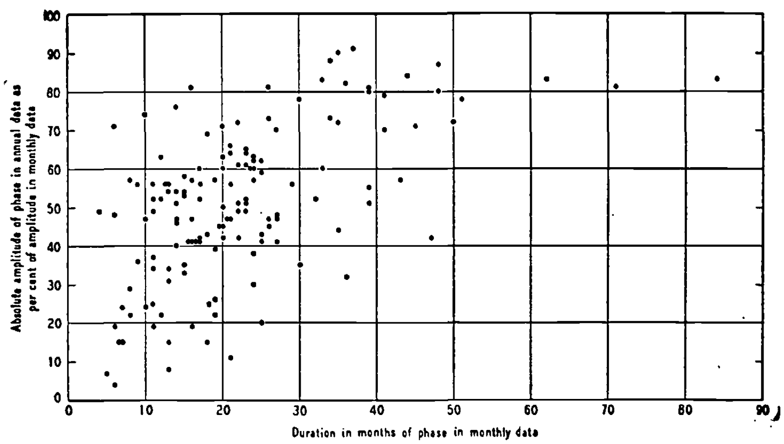
Based on six American series for periods shown in Chart 27.

The preceding remarks apply to cyclical amplitudes expressed in units of the original data, that is, to one stage in our computation. Our standard measures of amplitude convert the 'absolute amplitudes' into percentages of their respective cycle bases. The differences between 'relative amplitudes' made from annual and from monthly or quarterly data thus depend upon the differences between the cycle bases as well as upon the differences between the absolute amplitudes.[28] When the annual cycle base is higher than the monthly, the difference between bases works in the same direction as the difference between the absolute amplitudes; that is, both tend to make the annual measure of amplitude smaller than the monthly. When the annual cycle base is lower than the monthly, the difference between the bases works against the difference between the absolute amplitudes; the relative amplitude *may* therefore be larger in the annual data. Not a single instance of this sort appears in the comparisons afforded by our sample (Table 64). The reason is that the differences between cycle bases are smaller than the differences between absolute rises or falls. In railroad bond yields the largest difference between the

28 Let $a$ and $b$ be the standings, in units of the original data, of a monthly cycle at the initial trough and peak, respectively; and let $k$ be the average value of the data during the cycle. Then the relative amplitude of the rise is $100\left(\frac{b-a}{k}\right)$. Suppose that the absolute rise of the annual data is $x(b-a)$ and that the cycle base of the annual data is $yk$, where $x$ and $y$ are any positive numbers. Then the relative amplitude of rise of the annual data is $100\left(\frac{b-a}{k}\right)\left(\frac{x}{y}\right)$; that is, the annual amplitude differs from the monthly by the multiplier $\frac{x}{y}$. Similar statements apply to the cyclical fall and to the combined rise and fall.

CHART 25

Relation between the Cycle-dampening Effect of Annual Data and the Duration of Specific-cycle Phases




Based on 140 corresponding phases in monthly and annual data of six American series.
See Chart 26 for the period covered by shares traded, Chart 27 for periods of other series.

monthly and annual cycle bases is 2 per cent, while the smallest difference between the absolute amplitudes is 12 per cent. Even in share trading and call money rates, which have very large cyclical and erratic movements, the difference between monthly and annual cycle bases is 5 per cent or less in 23 out of 30 comparisons, and in no case exceeds 12 per cent. In contrast, the differences between the absolute rises range from 19 to 93 per cent in share trading and from 30 to 69 per cent in call money rates, while the differences between falls range from 30 to 96 per cent in the first series and from 19 to 75 per cent in the second.[29]

The importance of differences between the cycle bases of monthly and annual data relatively to the differences between their absolute amplitudes is still smaller in *average* measures of cyclical amplitude. The second set of differences practically always work in the same direction and therefore register with full force in the averages. But the first set raise the annual amplitudes of some cycles, lower the amplitudes of others, and thus tend to be self-effacing in averages. Table 65 shows these different effects in practice. Columns (3) to (5) present the average amplitudes in the monthly forms of our six series; columns (6) to (8) give corresponding averages for annual data on our usual plan, and columns (9) to (11) give annual averages made by substituting the monthly bases for the annual. The differences between columns (6) to (8) and (9) to (11) gauge the effects of differences between the cycle bases of monthly and annual data; these effects are practically nil. The differences between columns (3) to

[29] The difference between the absolute amplitudes of monthly and annual data exceeds the difference between their cycle bases in each of the 210 comparisons afforded by our tests.

TABLE 65
Average Amplitude of Corresponding Specific Cycles in Monthly and Annual Data, Six American Series

| Series | No. of corresponding specific cycles | Average amplitude in specific-cycle relatives of | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Monthly data | | | Annual data | | | | | |
| | | | | | Computed on base of annual cycle | | | Computed on base of corresponding monthly cycle | | |
| | | Rise | Fall | Rise & fall | Rise | Fall | Rise & fall | Rise | Fall | Rise & fall |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
| Deflated clearings | 5 | 28.1 | 12.8 | 40.9 | 20.0 | 5.4 | 25.4 | 20.3 | 5.3 | 25.7 |
| Pig iron production | 10 | 62.7 | 64.3 | 127.0 | 34.6 | 36.4 | 71.0 | 35.1 | 37.9 | 73.0 |
| Railroad stock prices | 15 | 35.4 | 34.9 | 70.3 | 24.7 | 23.9 | 48.6 | 24.8 | 23.8 | 48.6 |
| Shares traded | 15 | 98.1 | 92.4 | 190.5 | 49.9 | 39.3 | 89.2 | 48.9 | 39.2 | 88.1 |
| Call money rates | 15 | 134.8 | 136.1 | 270.9 | 67.6 | 69.1 | 136.7 | 67.9 | 69.6 | 137.5 |
| Railroad bond yields | 10 | 9.4 | 13.2 | 22.6 | 5.2 | 9.1 | 14.3 | 5.2 | 9.1 | 14.3 |
| Six series[a] | 70 | 69.8 | 68.4 | 138.2 | 37.6 | 35.2 | 72.8 | 37.6 | 35.5 | 73.1 |

See Chart 27 for the periods covered.

[a] The averages on this line are weighted averages of the above; that is, the unit observation is the amplitude of a cycle in a series, not the average amplitude in a series.

(5) and (9) to (11) gauge the effects of differences in absolute amplitudes; these effects are considerable, varying from about 30 to over 50 per cent of the monthly figures in different series.

If the monthly measures of amplitude are accurate, the annual measures not only understate the amplitude of cyclical fluctuations, but they do that unevenly. For example, Table 63 shows that in pig iron production the rise of monthly specific-cycle relatives during the second cycle is exceeded only by the rise in the eighth cycle; but in annual data the rise in the second cycle is exceeded in three additional cycles. The monthly rise in the ninth cycle is the smallest in the table; the annual rise in this cycle exceeds three others. The monthly fall in the second cycle is exceeded in four other cycles, the annual fall is exceeded in eight cycles. Such distortions of relations among the amplitudes of different cycles may be a serious matter to a student concerned with the characteristics of individual cycles. However, although annual data distort relations of magnitude, they by no means obliterate them so long as the annual cycles correspond roughly to the monthly. This fact is demonstrated by the coefficients of rank correlation in Table 66. Moreover, the dampening effect of annual data is more nearly uniform between than within series; hence the distortion of relative magnitudes may be of slight consequence to a student concerned with average cyclical behavior provided, once again, that the specific cycles in annual data match the cycles in monthly data.

This proviso is important. The differences we have so far discussed between annual and monthly amplitudes are restricted to corresponding

TABLE 66

Coefficients of Rank Correlation between Amplitudes
of Corresponding Specific Cycles in Monthly and Other Data
Six American Series

| Series | No. of corresponding specific cycles in | | Coefficient of rank correlation between | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Monthly and annual data[a] | Monthly and quarterly data[b] | Monthly and annual amplitudes[c] of | | | Monthly and quarterly amplitudes[c] of | | |
| | | | Rise | Fall | Rise & fall | Rise | Fall | Rise & fall |
| Deflated clearings | 5 | 13 | 1.00 | .70 | .90 | .97 | .96 | .97 |
| Pig iron production | 10 | 15 | .76 | .82 | .73 | .97 | .97 | .96 |
| Railroad stock prices | 15 | 18 | .99 | .90 | .91 | .99 | .99 | .99 |
| Shares traded | 15 | 15 | .79 | .88 | .90 | .91 | .88 | .95 |
| Call money rates | 15 | 21 | .90 | .92 | .87 | .97 | .96 | .97 |
| Railroad bond yields | 10 | 20 | .93 | .95 | .46[d] | .99 | 1.00 | .99 |

[a] See Chart 27 for the periods covered.

[b] The periods covered are shown in Table 57, except for the omission of the specific cycles during 1914–21 in deflated clearings and 1915–22 in call money rates.

[c] In specific-cycle relatives.

[d] The coefficient of correlation comes out +.95, when based on the actual values instead of the ranks.

cycles, and therefore take no account of the most serious distortions produced by annual summarizing—the elimination of a genuine cycle or the introduction of a spurious one. When annual data skip a cyclical expansion or contraction, two cycles in the monthly data occupy approximately the same period as one cycle in the annual data. When annual data skip two successive contractions, three cycles in the monthly data occupy the same period as one cycle in the annual data. Such 'noncorresponding' cycles account for 15 of the 87 specific cycles in the annual data and for 35 of the 106 cycles in the monthly data of our six series. In addition, two specific cycles in the annual data of one series (call money rates) occupy the same period as one cycle in the monthly data. If our analysis is sound, the noncorresponding cycles of monthly data are no less genuine than the corresponding. In annual data the two sets of cycles stand on a different footing: the 70 cycles that correspond to cycles in monthly data are genuine, the remaining 17 cycles are not. Since a student working solely with annual series cannot be sure which cycles in his data are genuine and which spurious, he may be gravely misled in his judgments of business history. For example, annual data suggest that within the periods covered by our analysis of iron production and clearings the largest cyclical rise occurred from 1884 to 1890; but this rise telescopes two cyclical expansions, from 1884 or 1885 to 1887 and from 1888 to 1890, both of moderate amplitude.

The mixed character of the cyclical units in annual data makes it necessary to distinguish three cases. (a) An annual cycle that corresponds to a monthly cycle is practically certain to be of smaller amplitude. (b) An annual cycle that combines two or three monthly cycles is likely to show an extraordinary rise if it skips contractions, or an extraordinary fall if it skips expansions. (c) On the other hand, if two annual cycles occupy the same period as one monthly cycle, they are likely to have especially small amplitudes; though the opposite may happen if the extra 'cycle' is generated by violent erratic movements in the monthly data. Since annual series skip cycles far more often than they insert cycles, it follows that the tendency of annual and monthly cycles to fall out of correspondence opposes the dampening effect of annual data on the amplitudes of corresponding cycles. Table 67 shows these opposite effects on the averages and their net resultants. In four out of five series the average rise of the noncorresponding cycles is larger in the annual than in the monthly data; in the remaining series the average rise of annual data is closer to

TABLE 67
Average Amplitude of Corresponding, Noncorresponding and All Specific Cycles in Monthly and Annual Data
Six American Series

| Series and group of cycles | Number of specific cycles | | Average amplitude in specific-cycle relatives | | | | | | Annual average as per cent of monthly | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Rise | | Fall | | Rise & fall | | | | |
| | M | A | M | A | M | A | M | A | Rise | Fall | Rise & fall |
| DEFLATED CLEARINGS | | | | | | | | | | | |
| Corresponding | 5 | 5 | 28.1 | 20.0 | 12.8 | 5.4 | 40.9 | 25.4 | 71 | 42 | 62 |
| Noncorresponding | 10 | 5 | 26.3 | 39.4 | 13.7 | 14.2 | 39.9 | 53.6 | 150 | 104 | 134 |
| All | 15 | 10 | 26.9 | 29.7 | 13.4 | 9.8 | 40.2 | 39.5 | 110 | 73 | 98 |
| PIG IRON PRODUCTION | | | | | | | | | | | |
| Corresponding | 10 | 10 | 62.7 | 34.6 | 64.3 | 36.4 | 127.0 | 71.0 | 55 | 57 | 56 |
| Noncorresponding | 5 | 2 | 60.8 | 73.9 | 35.6 | 12.0 | 96.4 | 85.8 | 122 | 34 | 89 |
| All | 15 | 12 | 62.1 | 41.1 | 54.8 | 32.4 | 116.8 | 73.5 | 66 | 59 | 63 |
| RAILROAD STOCK PRICES | | | | | | | | | | | |
| Corresponding | 15 | 15 | 35.4 | 24.7 | 34.9 | 23.9 | 70.3 | 48.6 | 70 | 68 | 69 |
| Noncorresponding | 3 | 1 | 36.6 | 78.8 | 16.1 | 18.6 | 52.7 | 97.4 | 215 | 116 | 185 |
| All | 18 | 16 | 35.6 | 28.1 | 31.8 | 23.5 | 67.3 | 51.6 | 79 | 74 | 77 |
| SHARES TRADED[a] | | | | | | | | | | | |
| All | 15 | 15 | 98.1 | 49.9 | 92.4 | 39.3 | 190.5 | 89.2 | 51 | 43 | 47 |
| CALL MONEY RATES | | | | | | | | | | | |
| Corresponding | 15 | 15 | 134.8 | 67.6 | 136.1 | 69.1 | 270.9 | 136.7 | 50 | 51 | 50 |
| Noncorresponding | 8 | 5 | 80.6 | 47.9 | 78.6 | 50.2 | 159.2 | 98.1 | 59 | 64 | 62 |
| All | 23 | 20 | 115.9 | 62.7 | 116.1 | 64.4 | 232.0 | 127.1 | 54 | 55 | 55 |
| RAILROAD BOND YIELDS | | | | | | | | | | | |
| Corresponding | 10 | 10 | 9.4 | 5.2 | 13.2 | 9.1 | 22.6 | 14.3 | 55 | 69 | 63 |
| Noncorresponding | 10 | 4 | 12.2 | 17.4 | 11.8 | 16.1 | 24.1 | 33.5 | 143 | 136 | 139 |
| All | 20 | 14 | 10.8 | 8.7 | 12.5 | 11.1 | 23.3 | 19.8 | 81 | 89 | 85 |
| SIX SERIES[b] | | | | | | | | | | | |
| Corresponding | 70 | 70 | 69 8 | 37.6 | 68.4 | 35.2 | 138.2 | 72.8 | 54 | 51 | 53 |
| Noncorresponding | 36 | 17 | 40.1 | 43.1 | 30.8 | 25.2 | 70.9 | 68.3 | 107 | 82 | 96 |
| All | 106 | 87 | 59.7 | 38.7 | 55.7 | 33.3 | 115.4 | 72.0 | 65 | 60 | 62 |

M stands for monthly data, A for annual. See Charts 26-27 for the periods covered.
[a]All cycles correspond in this series.
[b]See Table 65, note 'a'.

the monthly average in the noncorresponding than in the corresponding cycles. The results are similar for cyclical declines, though less striking because the annual forms of our test series skip few expansions. Bond yields have the distinction of skipping three expansions and three contractions, and the average fall of their annual noncorresponding cycles is no less conspicuous than the average rise.

The effects of cycle-skipping by annual data seem to be even more haphazard than the dampening effects. In iron production the inclusion of noncorresponding cycles in the averages reduces only slightly the discrepancy between the monthly and annual averages restricted to corresponding cycles. In clearings, on the other hand, the inclusion of noncorresponding cycles produces a larger average rise in the annual data than in the monthly and practically the same full-cycle average as in the monthly—an odd result, but one that may occur whenever annual data skip many cycles. Despite these uneven effects, the ranks of the averages of joint rise and fall, covering all cycles, are the same for the annual and

TABLE 68
Average Amplitude of Specific Cycles during Brief Periods
Six American Series, Monthly and Annual

| Series and period covered | Number of specific cycles | | Average amplitude in specific-cycle relatives | | | | | | Annual average as per cent of monthly | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | M | A | Rise | | Fall | | Rise & fall | | Rise | Fall | Rise & fall |
| | | | M | A | M | A | M | A | | | |
| Deflated clearings | | | | | | | | | | | |
| 1878–1893 | 5 | 4 | 29.6 | 27.0 | 12.5 | 5.0 | 42.1 | 32.0 | 91 | 40 | 76 |
| 1893–1910 | 5 | 3 | 27.3 | 26.7 | 10.0 | 5.4 | 37.3 | 32.0 | 98 | 54 | 86 |
| 1910–1933 | 5 | 3 | 23.7 | 36.2 | 17.6 | 20.7 | 41.3 | 56.9 | 153 | 118 | 138 |
| Pig iron production | | | | | | | | | | | |
| 1879–1896 | 5 | 3 | 62.3 | 42.4 | 44.4 | 18.2 | 106.7 | 60.6 | 68 | 41 | 57 |
| 1896–1914 | 5 | 4 | 64.4 | 45.4 | 48.3 | 23.9 | 112.8 | 69.4 | 70 | 49 | 62 |
| 1914–1933 | 5 | 5 | 59.5 | 36.9 | 71.5 | 47.6 | 131.0 | 84.5 | 62 | 67 | 65 |
| Railroad stock prices | | | | | | | | | | | |
| 1857–1889 | 6 | 5 | 45.8 | 41.0 | 30.6 | 23.1 | 76.4 | 64.1 | 90 | 75 | 84 |
| 1889–1907 | 6 | 5 | 29.2 | 24.4 | 22.7 | 14.5 | 51.9 | 38.9 | 84 | 64 | 75 |
| 1907–1932 | 6 | 6 | 31.7 | 20.4 | 42.0 | 31.4 | 73.7 | 51.8 | 64 | 75 | 70 |
| Shares traded | | | | | | | | | | | |
| 1878–1897 | 5 | 5 | 74.5 | 30.4 | 73.1 | 27.8 | 147.6 | 58.2 | 41 | 38 | 39 |
| 1897–1914 | 5 | 5 | 108.0 | 47.9 | 111.5 | 46.3 | 219.5 | 94.1 | 44 | 42 | 43 |
| 1914–1933 | 5 | 5 | 111.7 | 71.4 | 92.6 | 44.0 | 204.3 | 115.4 | 64 | 48 | 56 |
| Call money rates | | | | | | | | | | | |
| 1858–1880 | 7 | 5 | 109.9 | 59.6 | 108.2 | 52.8 | 218.1 | 112.4 | 54 | 49 | 52 |
| 1880–1904 | 8 | 7 | 141.6 | 75.3 | 147.9 | 85.0 | 289.5 | 160.3 | 53 | 57 | 55 |
| 1904–1931 | 8 | 8 | 95.6 | 53.6 | 91.2 | 53.6 | 186.8 | 107.2 | 56 | 59 | 57 |
| Railroad bond yields | | | | | | | | | | | |
| 1860–1876 | 6 | 3 | 12.3 | 12.5 | 14.4 | 23.9 | 26.6 | 36.4 | 102 | 166 | 137 |
| 1876–1905 | 7 | 6 | 7.4 | 4.5 | 12.8 | 7.4 | 20.2 | 11.8 | 61 | 58 | 58 |
| 1905–1931 | 7 | 5 | 13.0 | 11.5 | 10.8 | 7.9 | 23.7 | 19.4 | 88 | 73 | 82 |

M stands for monthly data, A for annual. The periods cover (approximately) successive thirds of the specific cycles in monthly data.

monthly data. This credit would be dimmed if our test series were not so dissimilar in the vigor of their cyclical fluctuations; it is dimmed even in our sample when the averages for all cycles are considered separately for expansions and contractions, or when any of the three amplitude measures are restricted to brief periods, as in Table 68. In the 54 comparisons provided by this table the annual average ranges from 38 to 166 per cent of the monthly average, being less than half of the monthly in 11 instances and exceeding the monthly in 6. Table 69 adds the information that in every series covered by our tests the variability of amplitudes relatively to their mean is larger in the annual than in the monthly measures.

TABLE 69

Variability of Amplitudes of Specific Cycles in Monthly and Annual Data

Six American Series

| Series and form of data | No. of specific cycles | Average deviation in specific-cycle relatives | | | Coefficient of variation[a] | | |
|---|---|---|---|---|---|---|---|
| | | Rise | Fall | Rise & fall | Rise | Fall | Rise & fall |
| DEFLATED CLEARINGS | | | | | | | |
| Monthly | 15 | 10.6 | 8.7 | 13.8 | 39 | 65 | 34 |
| Annual | 10 | 14.5 | 8.7 | 17.7 | 49 | 89 | 45 |
| PIG IRON PRODUCTION | | | | | | | |
| Monthly | 15 | 15.7 | 21.2 | 26.8 | 25 | 39 | 23 |
| Annual | 12 | 18.9 | 20.5 | 23.1 | 46 | 63 | 31 |
| RAILROAD STOCK PRICES | | | | | | | |
| Monthly | 18 | 20.5 | 17.0 | 35.9 | 58 | 53 | 53 |
| Annual | 16 | 24.1 | 16.2 | 38.9 | 86 | 69 | 75 |
| SHARES TRADED | | | | | | | |
| Monthly | 15 | 31.8 | 30.8 | 56.4 | 32 | 33 | 30 |
| Annual | 15 | 30.0 | 18.9 | 39.4 | 60 | 48 | 44 |
| CALL MONEY RATES | | | | | | | |
| Monthly | 23 | 52.0 | 56.7 | 105.9 | 45 | 49 | 46 |
| Annual | 20 | 32.2 | 33.0 | 59.4 | 51 | 51 | 47 |
| RAILROAD BOND YIELDS | | | | | | | |
| Monthly | 20 | 5.3 | 6.2 | 7.2 | 49 | 50 | 31 |
| Annual | 14 | 6.0 | 7.9 | 10.1 | 69 | 71 | 51 |

See Table 57 for periods covered.

[a] Here taken as the percentage ratio of the average deviation to the mean.

Finally, Table 70 demonstrates that amplitude measures on a per month basis reduce materially the difficulties caused by noncorresponding cycles and therefore have a special claim on the attention of students forced to work with annual data. The reason is simply that if, say, two cyclical expansions are telescoped by annual figures, we are likely to get an unusually large cyclical rise; but since the rise is also likely to be very long, the one tendency will counteract the other when the *rate* of rise is computed. In each series the average per month figure is considerably lower in annual than in monthly data, whether corresponding or noncorresponding cycles are compared. Not only that, but the discrepancies

TABLE 70

Average Per Month Amplitude of Corresponding, Noncorresponding and All Specific Cycles in Monthly and Annual Data

Six American Series

| Series and group of cycles | Number of specific cycles | | Average per month amplitude in specific-cycle relatives | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Rise | | Fall | | Rise & fall | |
| | M | A | M | A | M | A | M | A |
| DEFLATED CLEARINGS | | | | | | | | |
| Corresponding | 5 | 5 | 0.9 | 0.8 | 1.6 | 0.3 | 1.1 | 0.7 |
| Noncorresponding | 10 | 5 | 0.8 | 0.5 | 2.1 | 0.5 | 0.9 | 0.5 |
| All | 15 | 10 | 0.8 | 0.7 | 1.9 | 0.4 | 0.9 | 0.6 |
| PIG IRON PRODUCTION | | | | | | | | |
| Corresponding | 10 | 10 | 2.8 | 1.6 | 4.8 | 2.2 | 3.2 | 1.9 |
| Noncorresponding | 5 | 2 | 1.7 | 1.0 | 4.4 | 1.0 | 2.2 | 1.0 |
| All | 15 | 12 | 2.4 | 1.5 | 4.7 | 2.0 | 2.9 | 1.7 |
| RAILROAD STOCK PRICES | | | | | | | | |
| Corresponding | 15 | 15 | 1.3 | 0.8 | 1.7 | 0.9 | 1.4 | 0.9 |
| Noncorresponding | 3 | 1 | 2.2 | 1.1 | 1.4 | 0.8 | 1.6 | 1.0 |
| All | 18 | 16 | 1.4 | 0.8 | 1.7 | 0.9 | 1.4 | 0.9 |
| SHARES TRADED[a] | | | | | | | | |
| All | 15 | 15 | 7.6 | 2.5 | 4.1 | 1.7 | 4.6 | 2.1 |
| CALL MONEY RATES | | | | | | | | |
| Corresponding | 15 | 15 | 5.7 | 2.8 | 8.7 | 4.3 | 6.6 | 3.4 |
| Noncorresponding | 8 | 5 | 9.0 | 1.7 | 5.6 | 2.4 | 5.7 | 2.0 |
| All | 23 | 20 | 6.9 | 2.5 | 7.6 | 3.8 | 6.3 | 3.0 |
| RAILROAD BOND YIELDS | | | | | | | | |
| Corresponding | 10 | 10 | 0.5 | 0.2 | 0.6 | 0.3 | 0.5 | 0.3 |
| Noncorresponding | 10 | 4 | 0.7 | 0.5 | 1.1 | 0.4 | 0.7 | 0.4 |
| All | 20 | 14 | 0.6 | 0.3 | 0.9 | 0.3 | 0.6 | 0.3 |

The averages in this table are unweighted. M stands for monthly data, A for annual. See Charts 26-27 for the periods covered.

[a] All cycles correspond in this series.

between the monthly and annual averages for noncorresponding cycles are not very different as a rule from the discrepancies between the averages of corresponding cycles. As a result the relations between the all-cycle averages of the monthly and annual data of our series are roughly similar to the relations between averages restricted to corresponding cycles.[80]

## VIII Amplitude of Specific Cycles in Quarterly Data

Since the standings at the peaks and troughs of specific cycles cover three months in both quarterly and monthly series, they are not likely to differ so widely as the annual and monthly standings. Indeed, the monthly and quarterly standings are identical whenever the monthly peak or trough occurs in the middle month of the quarter that has the highest or lowest

80 We omit comparisons of per month amplitudes on the detailed basis of Table 68. In every one of the 54 comparisons, the average per month amplitude is lower in annual than in monthly data.

value.[31] When they cover different months the monthly peaks are nearly certain to be higher than the quarterly peaks and the monthly troughs lower than the quarterly, if the cyclical rise is symmetrical with the cyclical fall. When the two phases are not symmetrical, as is the rule in experience, the quarterly peak may easily reach higher than the monthly. This result is most probable if the peak comes in the last month of the quarter and is preceded by a moderate rate of rise and followed by a sharp rate of decline; or if it comes in the first month of the quarter and is preceded by a sharp rise and followed by a moderate decline. Similarly, the three months centered on the trough month may under certain conditions have a higher value than one of the conventional quarters. Again that result is most probable if the trough comes in the last month of the quarter and is preceded by a moderate decline and followed by a sharp rise; or comes in the first month of the quarter and is preceded by a sharp decline and followed by a moderate rise.

Table 63 illustrates in detail the effect of the quarterly time unit upon the standings at cyclical turns and the resulting amplitude measures of iron production, and shows how these effects differ from those produced by annual data. Table 71 summarizes the effects of the quarterly time unit

TABLE 71

Standings at Cyclical Turns and Amplitudes of Monthly Data Compared with Similar Measures of Corresponding Specific Cycles in Quarterly Data

| Measure | No. of instances in which monthly measure is | | |
|---|---|---|---|
| | Smaller than quarterly | Larger than quarterly | Same as quarterly |
| STANDING IN ORIGINAL UNITS | | | |
| At peak | 26 | 47 | 29 |
| At trough | 44 | 32 | 34 |
| AMPLITUDE IN ORIGINAL UNITS | | | |
| Rise | 39 | 55 | 8 |
| Fall | 34 | 55 | 13 |
| Rise & fall | 34 | 62 | 6 |
| AMPLITUDE IN SPECIFIC-CYCLE RELATIVES | | | |
| Rise | 35 | 61 | 6 |
| Fall | 35 | 62 | 5 |
| Rise & fall | 37 | 61 | 4 |

Based on specific cycles of six American series. The periods covered are shown in Table 57, except that we omit here the noncorresponding specific cycles during 1914–21 in deflated clearings and during 1915–22 in call money rates.

on all six series. The 102 specific cycles that correspond in the monthly and quarterly data make possible as many comparisons of standings at peaks and a slightly larger number at troughs. The monthly peaks are higher than the quarterly in more instances than they are lower; also the monthly troughs are lower than the quarterly in more instances than they are higher. In neither set of comparisons is there a clear majority, for

31 Except, of course, when the monthly standing is based on one or two months instead of three. See p. 132.

in about 30 per cent of the instances the monthly and quarterly standings are equal. But when differences are struck between the standings at peaks and troughs, the monthly and quarterly results diverge more sharply. Thus the absolute full-cycle amplitude of monthly data exceeds the quarterly in 62 instances, is lower in 34, and the same in 6. These results are not changed materially when the absolute amplitudes are expressed as relatives of their respective cycle bases, since the monthly-quarterly differences between cycle bases are slight.[32]

TABLE 72

Frequency Distribution of the Differences between Amplitudes of Corresponding Specific Cycles in Monthly, Quarterly and Annual Data

| Deviation of annual or quarterly amplitude from monthly (per cent) | No. of differences between annual and monthly amplitudes[a] | | | No. of differences between quarterly and monthly amplitudes[b] | | |
|---|---|---|---|---|---|---|
| | Rise | Fall | Rise & fall | Rise | Fall | Rise & fall |
| Under −40 | 45 | 47 | 42 | 1 | ... | ... |
| −40 to −31 | 9 | 9 | 16 | ... | 1 | ... |
| −30 to −21 | 10 | 7 | 7 | 4 | 7 | 3 |
| −20 to −11 | 5 | 7 | 5 | 12 | 13 | 11 |
| −10 to −1 | 1 | ... | ... | 41 | 37 | 44 |
| 0 to +9 | ... | ... | ... | 33 | 32 | 35 |
| +10 to +19 | ... | ... | ... | 9 | 7 | 7 |
| +20 to +29 | ... | ... | ... | 1 | 3 | 1 |
| +30 to +39 | ... | ... | ... | 1 | ... | 1 |
| Over +39 | ... | ... | ... | ... | 2 | ... |
| Total | 70 | 70 | 70 | 102 | 102 | 102 |

Based on amplitudes in specific-cycle relatives of six American series.

[a] See Chart 27 for the periods covered, and Table 64 for a more detailed breakdown.

[b] See note to Table 71 concerning the periods covered. Rounding figures produces some minor discrepancies between the results in this table and the preceding one. In this table the quarterly amplitude is expressed as a percentage deviation, to the nearest one per cent, from the monthly amplitude.

It appears, therefore, that the amplitudes of quarterly data tend to be biased in the same direction as the annual. But it is important to note carefully the differences between the quarterly and annual effects. (1) The annual amplitudes of our test series are invariably smaller than the corresponding monthly amplitudes; the quarterly amplitudes are frequently larger. (2) The differences between the quarterly and monthly amplitudes are usually much smaller than between the annual and monthly. The deviation of the quarterly amplitude from the monthly rarely exceeds 20 per cent (Table 72),[33] while the deviation of the annual

32 The quarterly base is within 1 per cent of the monthly in 77 of the 102 corresponding cycles. The difference between bases exceeds 3 per cent in share trading only; even in this volatile series only two differences exceed 5 per cent and the largest is 12 per cent.

33 Further, large percentage differences between the monthly and quarterly amplitudes as a rule arise only when the amplitudes are small. If the monthly rise is 2 points and the quarterly 3 points, the difference between them is 50 per cent; large percentages arising in this manner have slight significance.

from the monthly is rarely below this figure. (3) The relations among the amplitudes of individual cycles are highly similar in the quarterly and monthly forms of each series, but sometimes diverge considerably in the annual and monthly forms. Coefficients of correlation between monthly and quarterly amplitudes (Table 66) are invariably above .88 and usually well above .90, while the monthly-annual coefficients fall below .80 in five instances and below .50 in one. (4) In every series the average amplitudes of corresponding cycles are considerably lower in annual than in monthly data. The quarterly averages are somewhat lower than the monthly in five series, but higher in one (Table 73). Moreover, the differences between the quarterly and monthly measures are frequently dimmed or erased when the averages are read to the nearest one per cent. (5) Since non-corresponding cycles are few in quarterly and numerous in annual data, their effect on the relations among cycles and on the averages is slight in the quarterly but very marked in the annual measures. (6) The average joint rise and fall of all cycles in monthly data exceeds the annual average by margins of 1 to 105 points in different series; in percentages of the monthly averages the discrepancies range from −2 to −53. Thus the annual effects are usually in the same direction and of considerable size; they cannot be slighted. In contrast, the quarterly average rise and fall is within 1 point of the monthly in 4 series and the largest difference is 6 points; in percentages of the monthly averages the discrepancies range

TABLE 73
Average Amplitude of Specific Cycles in Monthly and Quarterly Data
Six American Series

| Series and group | Number of specific cycles | | Average amplitude in specific-cycle relatives | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Rise | | Fall | | Rise & fall | |
| | M | Q | M | Q | M | Q | M | Q |
| ALL CYCLES | | | | | | | | |
| Deflated clearings | 15 | 14 | 26.9 | 27.7 | 13.4 | 13.6 | 40.2 | 41.3 |
| Pig iron production | 15 | 15 | 62.1 | 59.1 | 54.8 | 51.4 | 116.8 | 110.5 |
| Railroad stock prices | 18 | 18 | 35.6 | 35.2 | 31.8 | 31.2 | 67.3 | 66.4 |
| Shares traded | 15 | 15 | 98.1 | 100.3 | 92.4 | 95.8 | 190.5 | 196.1 |
| Call money rates | 23 | 22 | 115.9 | 115.6 | 116.1 | 117.3 | 232.0 | 232.9 |
| Railroad bond yields | 20 | 20 | 10.8 | 10.5 | 12.5 | 12.2 | 23.3 | 22.7 |
| Six series[a] | 106 | 104 | 59.7 | 59.3 | 55.7 | 55.6 | 115.4 | 114.9 |
| CORRESPONDING CYCLES | | | | | | | | |
| Deflated clearings | 13 | 13 | 27.0 | 26.3 | 14.2 | 13.8 | 41.3 | 40.1 |
| Call money rates | 21 | 21 | 118.4 | 114.4 | 122.0 | 118.4 | 240.3 | 232.8 |
| Six series[a] | 102 | 102 | 59.8 | 58.6 | 56.6 | 55.7 | 116.4 | 114.3 |
| NONCORRESPONDING CYCLES | | | | | | | | |
| Deflated clearings | 2 | 1 | 25.8 | 45.5 | 7.9 | 12.0 | 33.7 | 57.5 |
| Call money rates | 2 | 1 | 90.6 | 139.8 | 54.2 | 94.7 | 144.8 | 234 5 |

M stands for monthly data, Q for quarterly. The periods covered by all cycles are shown in Table 57; the noncorresponding cycles cover 1914–21 in deflated clearings and 1915–22 in call money rates. In the other four series the specific cycles in monthly and quarterly data correspond throughout.

[a] See Table 65, note 'a'.

from −5 to +3. In view of the errors to which the monthly measures of amplitude are subject, these differences are so small that they may usually be disregarded. (7) When the amplitudes of all cycles in all six series are thrown together, the averages must be carried to a decimal to show a difference between quarterly and monthly data; so that the downward bias of the quarterly amplitudes, which is tenuous and slight even for corresponding cycles, almost disappears when noncorresponding cycles are included.

## IX The Secular Component of Specific Cycles

Measures of percentage change between the levels of successive cycles of monthly, quarterly, and annual data differ for two reasons: the specific cycles in different forms of the same series do not correspond invariably, and the boundaries even of corresponding cycles vary with the time unit. Both factors sometimes produce important differences in individual series; but while the effects of the second factor tend to cancel out in averages, those of the first do not.

Since annual data frequently run two or more monthly cycles together, they tend to show a larger average rise between successive cycles than do monthly data when the trend is upward, and a larger average fall when the trend is downward. When the trend changes direction the result depends in good part on the proportion of cycles skipped along the rising and the declining segments. When there is no clearly defined trend the annual and monthly averages should confirm each other. Quarterly data may be expected to differ from monthly much less but in the same direction as annual data. Table 74 illustrates these effects. The monthly-annual difference is largest in deflated clearings, a series whose annual summations skip one-third of the specific cycles. The difference is negligible in share trading and call money rates; in the first the annual cycles correspond throughout to the monthly, while the second has no clearly defined secular trend.

When the inter-cycle changes are put on a per month basis, an exceptionally large rise or fall that results from cycle-skipping is offset by a lengthened interval between the midpoints of the cycles; hence the systematic biases of annual data tend to disappear. Further, when the rates of change between the levels of successive cycles are weighted by the intervals between their midpoints, the monthly, quarterly, and annual averages become practically identical. In comparing secular movements of different series we rely usually on these weighted averages. That they are practically independent of the time unit attests the soundness of this measure.

The measures of secular movements demonstrate how difficult it is to judge merely from the steepness of the trend what proportion of the

TABLE 74

Average Secular Movement of Monthly, Quarterly and Annual Data
Six American Series

| Series and form of data | Number of specific cycles | Average per cent change from cycle to cycle | | |
|---|---|---|---|---|
| | | Total | Per month | |
| | | | Unweighted | Weighted |
| DEFLATED CLEARINGS | | | | |
| Monthly | 15 | +15.2 | +0.36 | +0.37 |
| Quarterly | 14 | +16.4 | +0.37 | +0.37 |
| Annual | 10 | +22.6 | +0.36 | +0.36 |
| PIG IRON PRODUCTION | | | | |
| Monthly | 14 | +12.9 | +0.32 | +0.32 |
| Quarterly | 14 | +12.8 | +0.33 | +0.32 |
| Annual | 12 | +14.5 | +0.28 | +0.32 |
| RAILROAD STOCK PRICES | | | | |
| Monthly | 18 | +10.4 | +0.20 | +0.21 |
| Quarterly | 18 | +10.4 | +0.20 | +0.21 |
| Annual | 16 | +11.4 | +0.16 | +0.21 |
| SHARES TRADED | | | | |
| Monthly | 15 | +14.1 | +0.37 | +0.34 |
| Quarterly | 15 | +14.1 | +0.37 | +0.34 |
| Annual | 15 | +14.3 | +0.33 | +0.35 |
| CALL MONEY RATES | | | | |
| Monthly | 23 | −0.1 | −0.02 | 0.00 |
| Quarterly | 22 | −0.3 | −0.05 | −0.01 |
| Annual | 20 | −0.5 | −0.03 | −0.01 |
| RAILROAD BOND YIELDS | | | | |
| Monthly | 20 | −1.6 | −0.01 | −0.04 |
| Quarterly | 20 | −1.6 | −0.01 | −0.04 |
| Annual | 14 | −2.1 | −0.03 | −0.03 |

See Table 57 for the periods covered. Note, however, that the cycle from 1879 to 1885 in pig iron production is excluded from the monthly and quarterly data, since the cycles in the annual series start in 1885. When this cycle is included, the monthly averages in successive columns are +14.5, +0.34, +0.35.

cycles in a series is skipped by annual data. The average rate of secular change is about the same in clearings and share trading, but annual data hide one-third of the monthly cycles in the former and none in the latter. Nor can the effects of the time unit be gauged very well from annual measures of both secular change and cyclical amplitude. For example, since the rate of secular change is larger relatively to the cyclical amplitude in clearings than in share trading, an investigator might expect the first series to skip a greater proportion of cycles than the second. That turns out to be correct; but by the same reasoning, share trading should skip more cycles than call money rates, and that is contrary to fact.

## X Specific-cycle Patterns

Charts 26 and 27 recapitulate many of the results established in preceding sections, and add information about the *form* of the mounting wave from trough to peak and of the receding wave from peak to trough. This in-

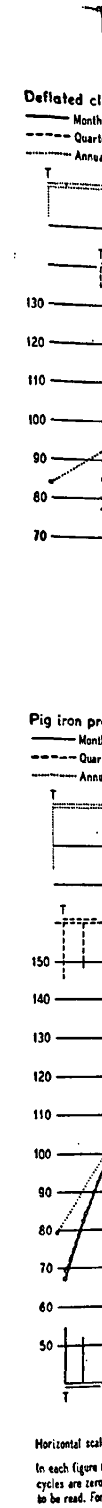
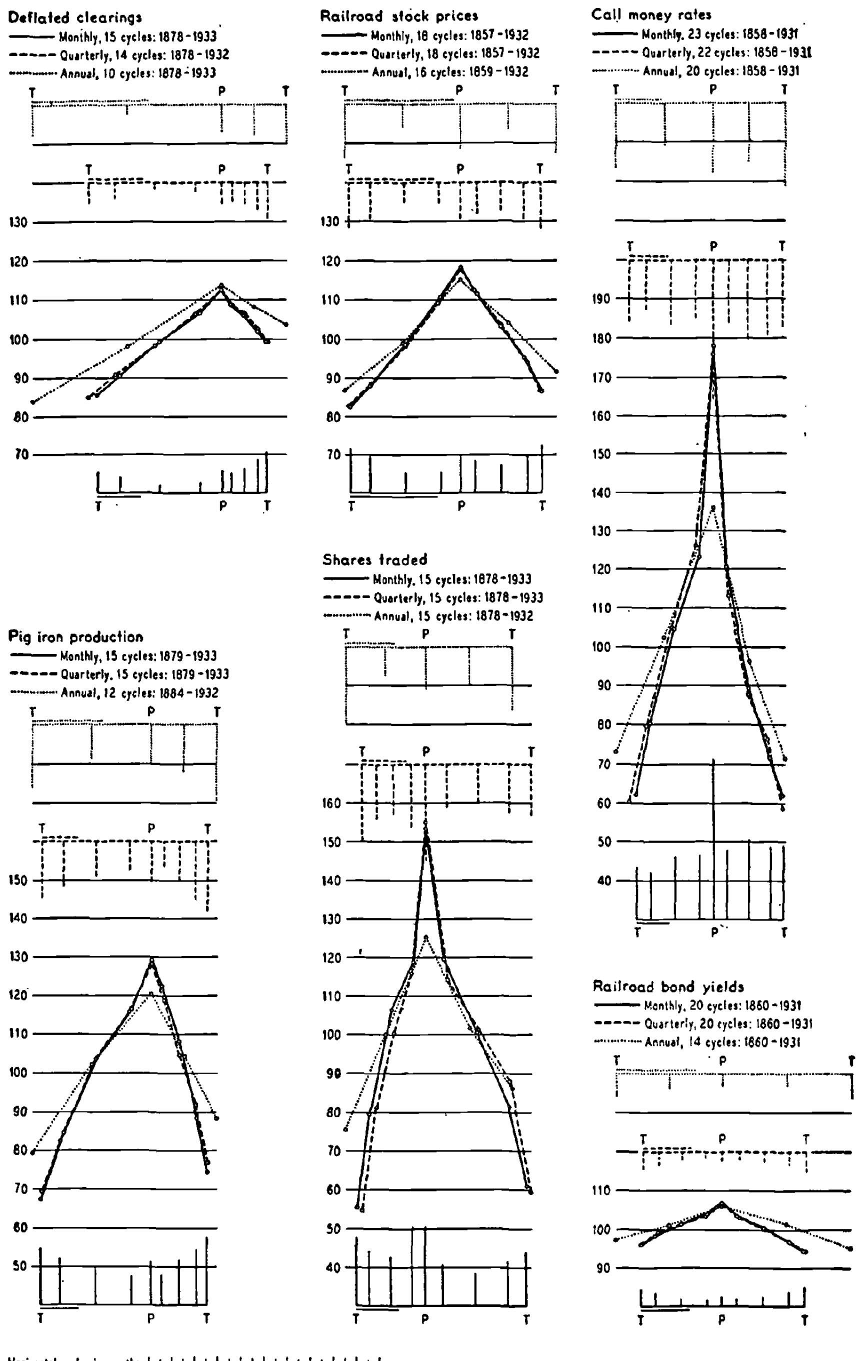


CHART 26

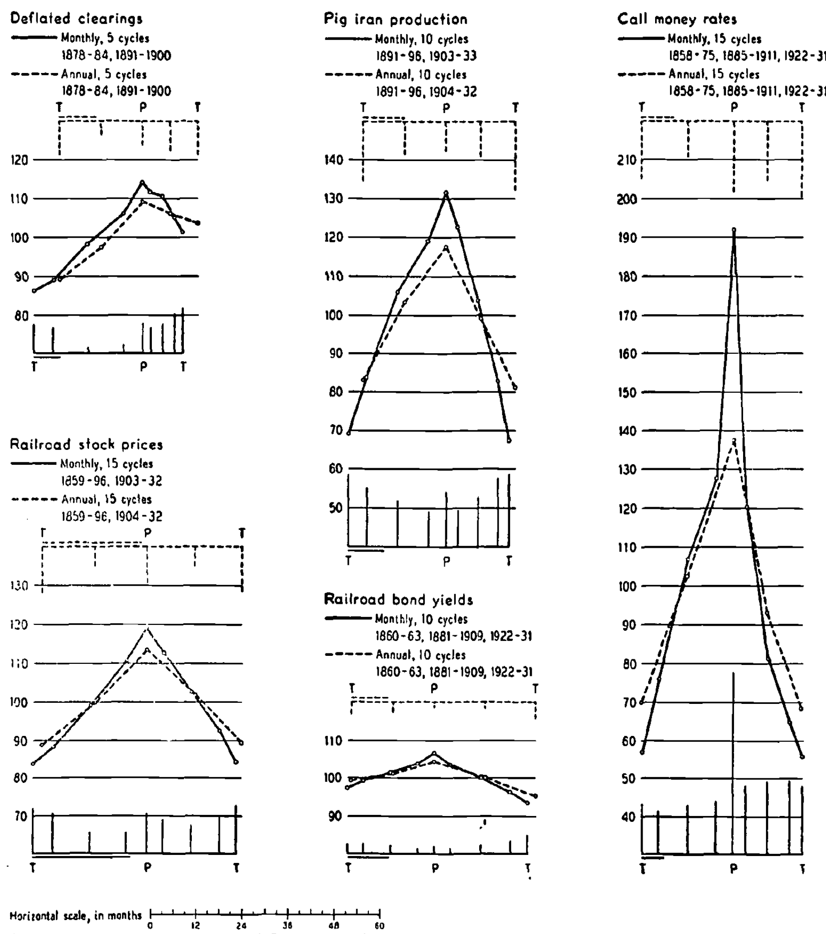
**Average Specific-cycle Patterns of Monthly, Quarterly and Annual Data**
**Six American Series**




In each figure the three horizontal lines representing the average duration of specific cycles are zero base lines from which the average deviations of the three patterns are to be read. For other explanations of chart, see Ch. 5, Sec. VI and XI. See also Table 75.

CHART 27

Average Patterns of Corresponding Specific Cycles in Monthly and Annual Data
Five American Series




For explanation of chart, see Ch. 5, Sec. VI and XI. For the patterns of shares traded, see Chart 26.

formation is both more detailed and reliable when derived from monthly or quarterly than when derived from annual data.

Two factors limit the detail in which the patterns of specific cycles can be measured: erratic movements and the number of observations available for each cycle. Our experience indicates that in monthly and quarterly data fairly satisfactory results are generally obtained by making nine-point patterns.[34] If a series is free from substantial erratic movements, the monthly patterns articulate the timing of the cycles better; for their framework is fixed by quarters centered on the lowest, highest, and

[34] See Ch. 8, Sec. VI.

TABLE 75
Average Specific-cycle Patterns of Monthly, Quarterly and Annual Data
Six American Series

| Series and form of data | No. of specific cycles | Average in specific-cycle relatives at stage | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | I | II | III | IV | V | VI | VII | VIII | IX |
| | | Initial trough | Expansion: First third | Expansion: Middle third | Expansion: Last third | Peak | Contraction: First third | Contraction: Middle third | Contraction: Last third | Terminal trough |
| DEFLATED CLEARINGS | | | | | | | | | | |
| Monthly | 15 | 85.7 | 90.5 | 99.2 | 106.7 | 112.6 | 108.7 | 106.0 | 101.9 | 99.2 |
| Quarterly | 14 | 85.0 | 90.9 | 98.4 | 106.4 | 112.6 | 108.7 | 106.5 | 102.7 | 99.0 |
| Annual | 10 | 84.0 | ... | 98.1 | ... | 113.6 | ... | 108.2 | ... | 103.8 |
| PIG IRON PRODUCTION | | | | | | | | | | |
| Monthly | 15 | 67.3 | 82.5 | 103.7 | 116.5 | 129.3 | 122.6 | 108.2 | 88.4 | 74.6 |
| Quarterly | 15 | 69.3 | 84.6 | 103.8 | 115.9 | 128.4 | 118.9 | 104.7 | 91.9 | 77.0 |
| Annual | 12 | 79.4 | ... | 102.2 | ... | 120.5 | ... | 104.2 | ... | 88.2 |
| RAILROAD STOCK PRICES | | | | | | | | | | |
| Monthly | 18 | 82.8 | 88.0 | 98.8 | 110.8 | 118.3 | 112.4 | 103.2 | 94.0 | 86.6 |
| Quarterly | 18 | 82.9 | 88.3 | 98.4 | 109.2 | 118.1 | 111.5 | 103.7 | 95.2 | 86.8 |
| Annual | 16 | 87.0 | ... | 99.0 | ... | 115.1 | ... | 103.0 | ... | 91.6 |
| SHARES TRADED | | | | | | | | | | |
| Monthly | 15 | 55.4 | 79.7 | 106.5 | 119.0 | 153.4 | 119.7 | 100.4 | 81.6 | 61.0 |
| Quarterly | 15 | 54.9 | 81.3 | 100.5 | 116.1 | 155.2 | 114.2 | 101.3 | 88.1 | 59.4 |
| Annual | 15 | 75.6 | ... | 100.1 | ... | 125.5 | ... | 101.8 | ... | 86.2 |
| CALL MONEY RATES | | | | | | | | | | |
| Monthly | 23 | 62.1 | 80.3 | 104.7 | 123.2 | 178.0 | 120.4 | 89.9 | 71.8 | 61.9 |
| Quarterly | 22 | 60.3 | 79.7 | 105.1 | 126.1 | 175.9 | 113.2 | 87.8 | 76.5 | 58.6 |
| Annual | 20 | 73.3 | ... | 102.6 | ... | 136.0 | ... | 96.4 | ... | 71.6 |
| RAILROAD BOND YIELDS | | | | | | | | | | |
| Monthly | 20 | 96.1 | 98.4 | 101.5 | 104.0 | 106.9 | 103.7 | 100.6 | 96.9 | 94.3 |
| Quarterly | 20 | 96.3 | 99.3 | 101.7 | 103.3 | 106.7 | 103.1 | 100.4 | 97.0 | 94.5 |
| Annual | 14 | 97.5 | ... | 101.1 | ... | 106.2 | ... | 101.4 | ... | 95.1 |

See Chart 26 for the periods covered.

lowest monthly dates of each cycle, while the framework of the quarterly patterns is fixed by the lowest, highest, and lowest calendar-year quarters. Since the durations of expansions or contractions [35] are not always exactly divisible by three, the successive 'thirds' tend to be more uneven in quarterly than in monthly data. Further, since many cyclical phases are shorter than a year, it is frequently necessary to interpolate standings at one or more cyclical stages in the quarterly data.[36] But the advantage is not always on the side of monthly data: if erratic movements are pronounced and cyclical phases short, quarterly data may trace out the cyclical pattern better than monthly data.

On the whole, the quarterly and monthly patterns agree remarkably well, although many differences of detail turn up in Table 75, some con-

[35] See pp. 145-6 and Table 48.

[36] We interpolated one or more standings during 40 of the 208 phases of expansion and contraction covered by the quarterly data of the six series, but during only 2 of the 212 phases covered by the monthly data.

sistently in the same direction. We pass by the differences between the standings in stages I, V and IX, since these standings are taken from the amplitude tables and we have already commented on them. The point that calls for notice is that the average monthly standing as a rule exceeds the quarterly in stages IV and VI and falls short of the quarterly in stages II and VIII; while the differences in stages III and VII seem random. These results arise from a slight difference in our method of making monthly and quarterly patterns, not from the time unit as such.[37] Imagine a monthly series that reaches cyclical turns in the middle month of the quarter in which the quarterly data make their turn. Then the period covered by stages II-IV will be two months longer in monthly data than in quarterly, since this period includes every month except the months of cyclical turn, but every quarter except the quarterly turns. One of the additional months is adjacent to the trough; it is included in stage II and tends to pull the standing for this stage below the quarterly. The second additional month is adjacent to the peak and therefore tends to pull the standing for stage IV above the quarterly. For similar reasons, the standing of monthly data in stage VI tends to be higher and in stage VIII lower than in quarterly data.[38] If we eliminated the one-month overlap of stages IV and VI upon stage V, and of stages VIII and II upon stage I (or IX), we would find that the quarterly standings agree better with the monthly than they do at present.[39]

The patterns of annual cycles cannot be measured in the same detail as the monthly or quarterly patterns, because annual data provide too few observations on individual cycles. To make nine-point patterns without recourse to interpolations, the annual cycles must cover at least 8 years, and their phases of expansion and contraction at least 4 years. Comparatively few specific cycles meet these specifications: in our six series there are only three, and one is spurious since it telescopes two cycles in monthly data. Hence, when working with annual data we simplify the method, and record merely the standing at the initial trough, mid-expansion, peak, mid-contraction, and terminal trough. Even these simplified patterns do violence to the raw data in many instances. For when an expansion or contraction lasts just one year in the annual data, the stand-

[37] That is to say, the monthly patterns could have been so made as to avoid the systematic differences from the quarterly. See p. 151. But monthly data are basic in our scheme; we therefore used that method of analysis which seems best suited to them, and adapted the quarterly analysis to it.

[38] The text presupposes positive analysis. If the specific cycles are treated on an inverted basis, the relations between the quarterly and monthly patterns are similar; but stages II, IV, VI and VIII of positive cycles become VI, VIII, II and IV, respectively, in inverted cycles.

[39] The very feature of our method that tends to produce a lower standing of monthly than quarterly data in stage II tends to make the interval from stage I to II shorter in monthly than in quarterly data; the one change tends to offset the other so far as the rate of change between stage I and II is concerned. Similar statements apply to the rates of change between other stages: thus the increment from stage II to III tends to be larger in monthly than quarterly data, but the interval between stage II and III also tends to be longer in monthly data, and so on.

ing in the middle of the phase must be determined by interpolation. These poor substitutes for actual observations account for 75 out of 174, or over two-fifths of the mid-phase standings in our six series.

Close observation of the form of specific cycles is a matter of great importance. A sine curve in the strict sense has been a common device of mathematical economists in their work on business cycles. In a looser sense, the sine curve assumption is a favorite of 'literary economists' as well. Numerous hypotheses about cyclical fluctuations, particularly those that make much of the 'acceleration principle', proceed on the tacit assumption that the cyclical movements of time series behave like sine curves, in the sense that the rate of rise reaches a maximum around mid-expansion and the rate of fall attains a maximum around mid-contraction. Sometimes the specific cycles of economic activities conform to this model, probably more often they do not; the crucial point is that monthly, or at least quarterly, data are necessary to grapple with the acceleration principle or any other hypothesis that calls for fairly detailed knowledge of cyclical patterns.[40] For example, monthly data on iron production show that the rise is fastest typically in the early or late stages of expansion, while the decline is sharpest toward the close of contraction; the annual patterns cover up these variations in the progress of the cyclical movements. Again, the annual pattern of call money rates suggests that the rise is faster in the second than in the first half of expansions, and that the decline is faster in the first than in the second half of contractions. In fact the large movements of call money rates are characteristic of brief intervals in the vicinity of cyclical peaks, not of the full period from mid-expansion to mid-contraction.[41]

Chart 28 completes the preceding analysis. The chart shows cyclical patterns of monthly and annual data adjusted for variation in the average duration and amplitude of their separate phases.[42] If annual and monthly data conveyed the same information concerning relative variations in the rate of cyclical movements, their adjusted patterns would be the same. If neither conveyed any information on the subject—which would happen if both represented the standing of a series merely at the initial trough, peak, and terminal trough—the adjusted patterns would be the same regardless of the series or the time unit, as are the triangles formed by connecting peaks and troughs in Chart 28. Actually, the annual patterns, as a rule, hug closely the triangular guidelines, while the monthly patterns move freely; in other words, annual data tell little about the form of specific cycles, and what little they tell is not always trustworthy. The real culprit, of course, is the small number of observations from which the annual patterns are made. When a cyclical phase lasts only

[40] Cf. pp. 340-7.

[41] See Charts 26-27 and Table 76.

[42] See pp. 157-9 concerning this adjustment.

TABLE 76
Position of Fastest and Slowest Rates of Change in Specific-cycle Patterns
Six Monthly American Series

| Series | No. of specific cycles | Distribution of rates of change between stages | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | I-II | II-III | III-IV | IV-V | V-VI | VI-VII | VII-VIII | VIII-IX |
| | | No. of expansions in which rise is fastest | | | | No. of contractions in which fall is fastest | | | |
| Deflated clearings | 15 | 5 | 1 | 2 | 7 | 6.5 | 4.5 | 3 | 1 |
| Pig iron production | 15 | 7 | 1 | 2 | 5 | 1 | 2 | 4 | 8 |
| Railroad stock prices | 18 | 2 | 4 | 4 | 8 | 5 | 2 | 4 | 7 |
| Shares traded | 15 | 4 | 4 | 1 | 6 | 9 | 1 | 1 | 4 |
| Call money rates | 23 | 2 | 1 | 3 | 17 | 16 | 2 | 3 | 2 |
| Railroad bond yields | 20 | 6.5 | 4 | 1 | 8.5 | 10.5 | 3 | 2.5 | 4 |
| | | No. of expansions in which rise is slowest | | | | No. of contractions in which fall is slowest | | | |
| Deflated clearings | 15 | 6 | 4 | 3 | 2 | ... | 7 | 5.5 | 2.5 |
| Pig iron production | 15 | 3 | 1 | 11 | ... | 5.5 | 4.5 | 2 | 3 |
| Railroad stock prices | 18 | 6 | 2 | 6 | 4 | 5 | 4 | 8 | 1 |
| Shares traded | 15 | 2 | 2 | 9 | 2 | 2 | 4 | 8 | 1 |
| Call money rates | 23 | 3 | 7 | 12 | 1 | 1 | 8 | 4 | 10 |
| Railroad bond yields | 20 | 2 | 7.5 | 7.5 | 3 | 2.5 | 8 | 3.5 | 6 |

To minimize the number of ties the rates of change were computed to extra decimals. But some ties remained; hence the fractions. See Table 55 for the periods covered.

one year, as happens frequently, we know nothing about variations in the rate of movement within it. When a phase lasts two or three years we have some knowledge; but since we cannot even be sure that annual figures tell correctly the direction of the cyclical movements, we must accept with serious reservations what they tell about rates of change in cyclical movements.[43]

## XI Different Forms of Annual Data

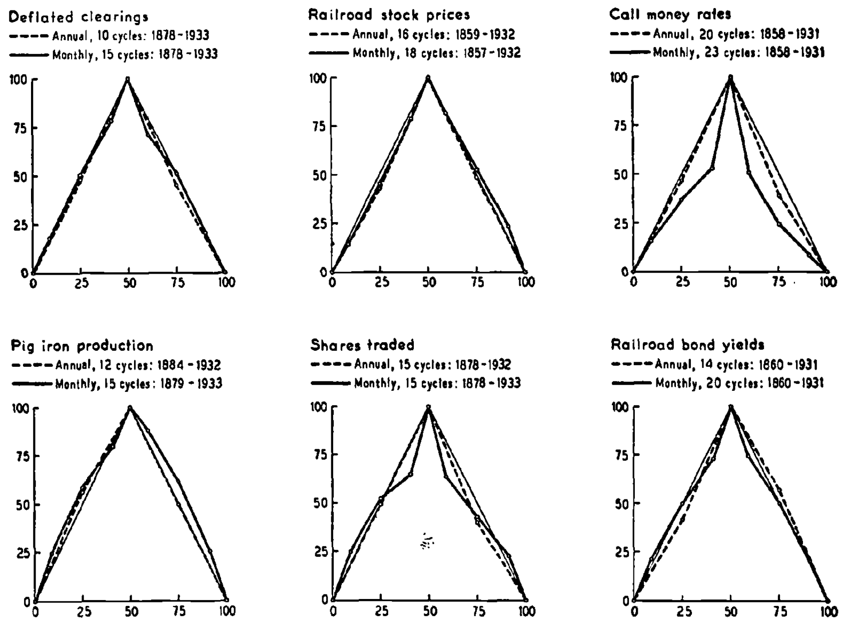
The problem of the time unit consists of three distinct parts, only one of which we have considered thus far. Cyclical measures depend, first, upon the number of entries per year, second, upon the boundaries of the time unit to which the entries refer, third, upon the presence or absence of a gap between the entries. If the number of observations per year is large the three factors merge; as the number dwindles the second and third factors become increasingly important. Specific cycles determined from monthly data are practically independent of the limits of the monthly figures; that is, they would not be changed appreciably if calendar-month figures were replaced by figures running from the fifteenth of one month

[43] To observe how the monthly and annual patterns compare when both show equivalent detail, it is necessary merely to connect the standings at the initial trough, mid-expansion, peak, mid-contraction, and terminal trough in the monthly curves on Chart 28. Some enormous differences appear, particularly in iron production, call money rates, and bond yields. Clearly, annual data provide less reliable as well as scantier information about cyclical patterns than do monthly data. See the comparison between the directions of annual and monthly data in Sec. III.

CHART 28

Variation of Average Rates of Change from Stage to Stage of Expansions and Contractions of Specific Cycles in Monthly and Annual Data

Six American Series




To facilitate study, the peaks and troughs are joined by straight lines representing uniform rates of expansion and contraction. For further explanations, see Ch. 5, Sec. VI.

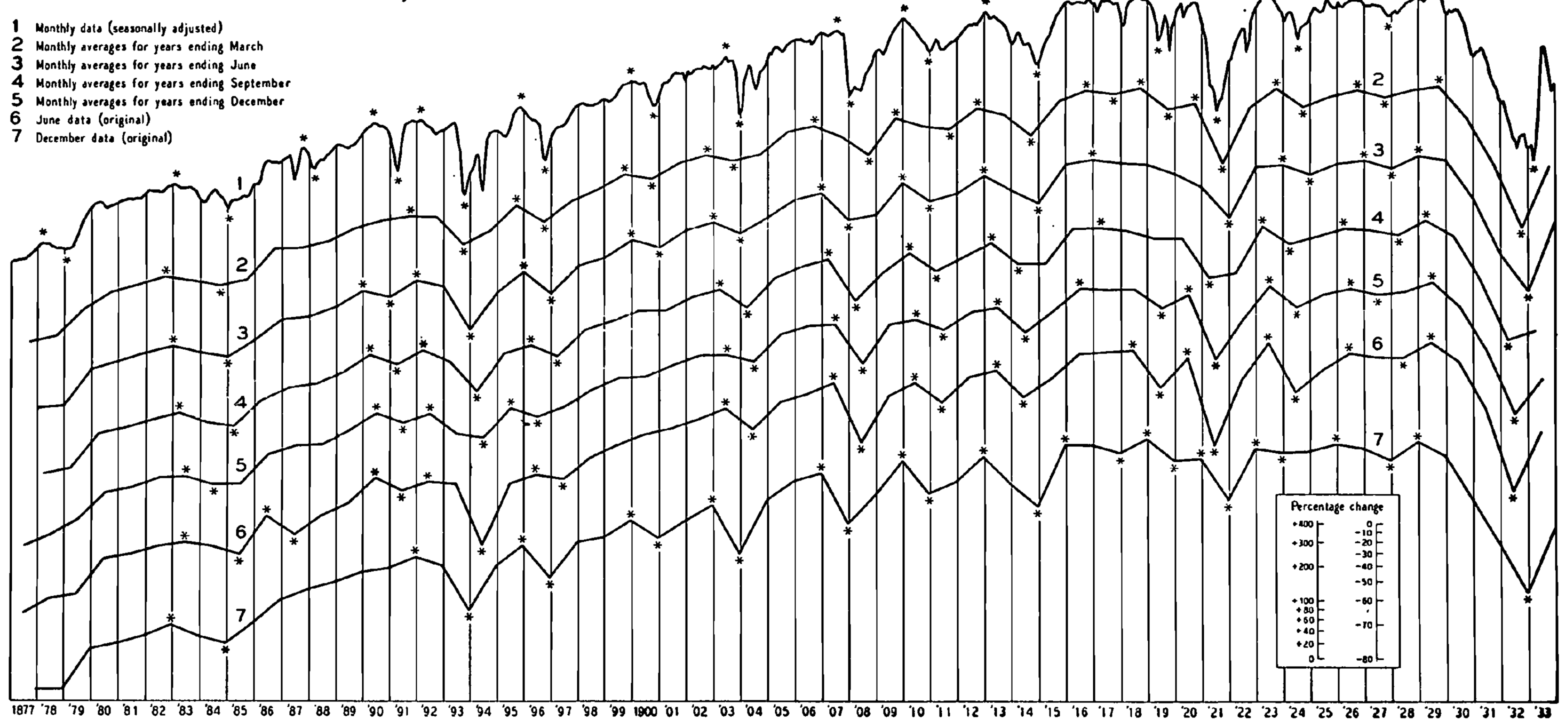
to the fifteenth of the next, or from the tenth to the tenth. Nor would they be changed materially, except in highly erratic series, if full-month averages or aggregates were replaced by daily figures reported once a month. Annual data lack this stability. What annual data do to the specific cycles depends in considerable measure on the boundaries of the figures and on the size of the gap, if any, between the successive figures.

Imagine a twelve-month moving total (or average) passed through a time series, properly centered, and plotted on a chart. Next suppose that the moving totals plotted at the end of June in successive years are singled out and all others ignored. The figures chosen are the calendar-year summations analyzed in preceding sections,[44] but they are merely one out

[44] This interpretation of annual figures is helpful in analyzing various problems raised by the time unit. For example, we know that a twelve-month moving average lops off cyclical peaks and fills in cyclical troughs. But the cyclical amplitude is cut further by selecting every twelfth item of the series of moving averages, for these selected values rarely coincide with the peaks and troughs of the moving averages. It follows that the annual amplitudes must be lower than the monthly at least by the amount of dampening produced by a twelve-month moving average, and are likely to be lower by a larger amount. (See, however, note 27.)

CHART 29

Pig Iron Production, United States, 1877–1933
Monthly and Six Forms of Annual Data

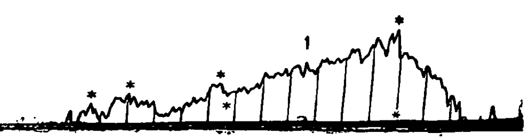



Asterisks identify peaks and troughs of specific cycles, determined on our standard plan. The annual series are derived from monthly figures unadjusted for seasonal variations. See the note at the end of Sec. II.



CHART 30

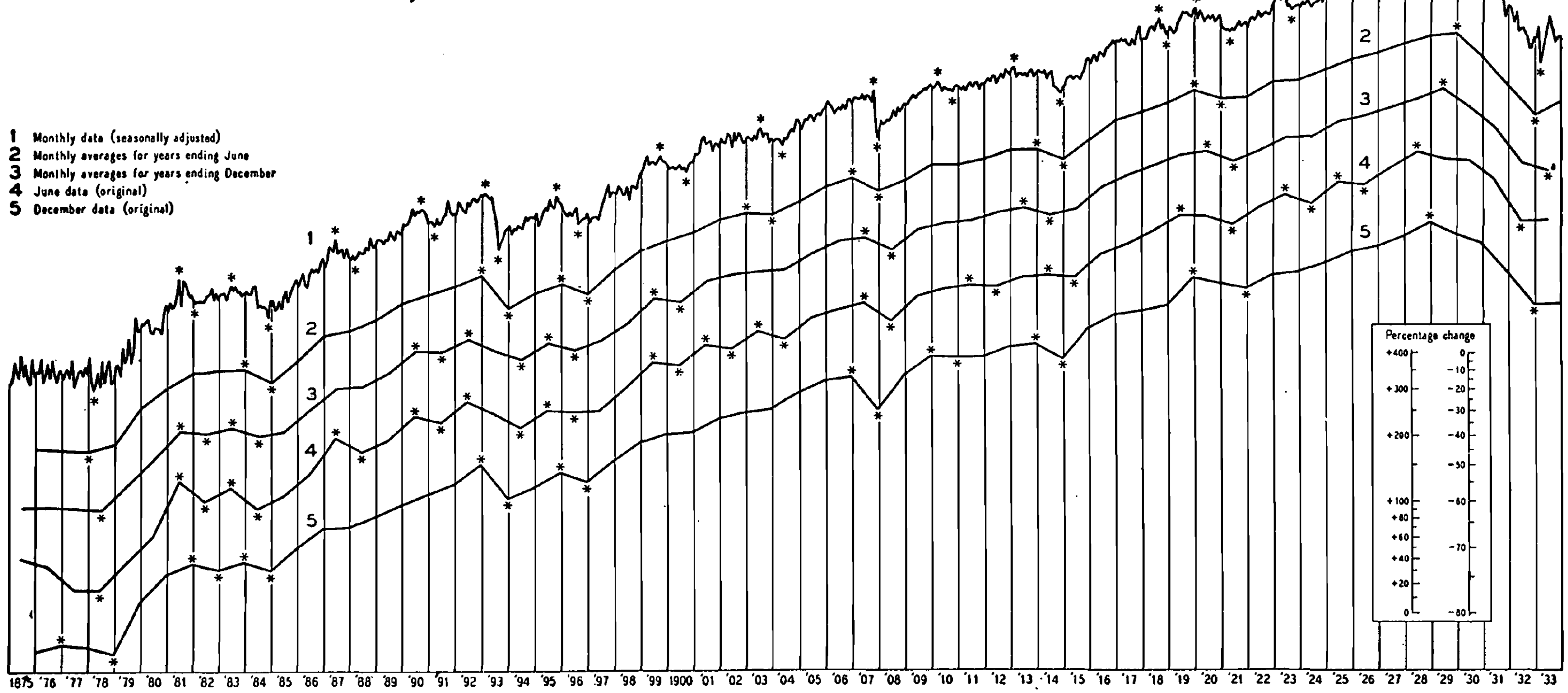
Bank Clearings outside New York City, Deflated, 1875–1933
Monthly and Four Forms of Annual Data



Asterisks identify peaks and troughs of specific cycles, determined on our standard plan. The annual series are derived from monthly figures unadjusted for seasonal variations. See the note at the end of Sec. II.

CHART 30

## Bank Clearings outside New York City, Deflated, 1875–1933
### Monthly and Four Forms of Annual Data




The vertical scale in this chart is double that in Charts 29 and 31.

See note to Chart 29. From Jan. 1919 on, bank debits in 140 cities outside New York are used in place of bank clearings; the level of the former is adjusted to that of the latter in Jan. 1919.

a Data rise after 1933.

TABLE 77

Duration and Amplitude of Successive Specific-cycle Contractions in Monthly and Twelve Forms of Annual Data
Pig Iron Production, United States, 1883–1933

| Contraction in monthly data | | Duration and amplitude of corresponding contraction in annual summations from | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Peak – trough dates | Duration and amplitude | Aug. to July | Sep. to Aug. | Oct. to Sep. | Nov. to Oct. | Dec. to Nov. | Jan. to Dec. | Feb. to Jan. | Mar. to Feb. | Apr. to Mar. | May to Apr. | June to May | July to June |
| Feb. 1883 – Jan. 1885 | 23,21 | 24,14 | 24,14 | 24,15 | 24,14 | 24,13 | 12,10 | 24, 9 | 24,10 | 24,10 | 24,11 | 24,11 | 24,12 |
| Oct. 1887 – Mar. 1888 | 5,19 | S | S | S | S | S | S | S | S | S | 12,0.3 | S | S |
| May 1890 – Apr. 1891 | 11,38 | 12, 8 | 12,10 | 12,11 | 12,11 | 12,11 | 12,10 | 12, 7 | 12, 2 | S | S | 12, 3 | 12, 7 |
| Feb. 1892 – Oct. 1893 | 20,56 | 24,46 | 24,43 | 24,39 | 24,34 | 24,29 | 24,25 | 12,24 | 12,27 | 24,29 | 24,34 | 24,40 | 24,45 |
| Nov. 1895 – Oct. 1896 | 11,44 | 12,22 | 12,19 | 12,12 | 12, 3 | 12, 5 | 12,10 | 12,14 | 12,16 | 12,18 | 12,20 | 12,22 | 12,23 |
| Dec. 1899 – Oct. 1900 | 10,24 | 12, 6 | 12, 3 | S | S | S | S | 12, 2 | 12, 4 | 12, 6 | 12, 7 | 12, 8 | 12, 8 |
| June 1903 – Dec. 1903 | 6,42 | 12,15 | 12,18 | 12,20 | 12,19 | 12,15 | 12, 7 | 12, 3 | 12, 5 | 12, 7 | 12, 8 | 12, 9 | 12,13 |
| July 1907 – Jan. 1908 | 6,50 | 12,32 | 12,36 | 12,39 | 12,42 | 12,43 | 12,38 | 24,35 | 24,32 | 24,30 | 24,28 | 24,26 | 12,27 |
| Jan. 1910 – Dec. 1910 | 11,30 | 12,21 | 12,21 | 12,20 | 12,19 | 12,17 | 12,13 | 24,10 | 24,11 | 24,13 | 24,14 | 12,17 | 12,20 |
| Jan. 1913 – Dec. 1914 | 23,44 | 24,27 | 24,25 | 12,22 | 12,24 | 12,25 | 12,25 | 24,24 | 24,26 | 24,28 | 24,29 | 24,30 | 24,29 |
| July 1917 – Jan. 1918[a] | 6,21 | S | S | S | S | S | 12, 2 | 12, 4 | 12, 4 | 12, 4 | 12, 4 | 12, 4 | S |
| Sep. 1918 – May 1919 | 8,35 | S | S | 24,12 | 36,16 | 36,19 | 12,20 | 12,23 | 12,24 | 12,23 | 12,21 | S | S |
| Sep. 1920 – July 1921 | 10,70 | 60,47 | 60,44 | 12,38 | 12,46 | 12,51 | 12,54 | 12,56 | 12,55 | 12,52 | 12,46 | 36,53 | 60,50 |
| May 1923 – July 1924 | 14,40 | 24, 9 | 12,14 | 12,19 | 12,22 | 12,23 | 12,22 | 12,21 | 12,20 | 12,20 | 12,19 | 12,16 | 12,10 |
| July 1926 – Nov. 1927 | 16,17 | 12, 8 | 24, 7 | 24, 7 | 24, 7 | 12, 7 | 12. 7 | 12, 7 | 12, 8 | 12, 9 | 12, 9 | 12, 9 | 12, 9 |
| July 1929 – Mar. 1933 | 44,86 | 48,78 | 48,75 | 36,76 | 36.78 | 36,79 | 36,79 | 36,80 | 36,81 | 36,82 | 36,82 | 48,82 | 48,81 |

S means that the contraction is skipped; see Chart 29. The figure to the left of the comma shows the duration of the contraction (in months), the figure to the right shows its amplitude. To economize effort, the annual amplitudes are expressed as percentages of the peak value from which the contraction starts. The monthly declines are shown on a similar plan, but they are computed from three-month averages centered on the peaks and troughs.

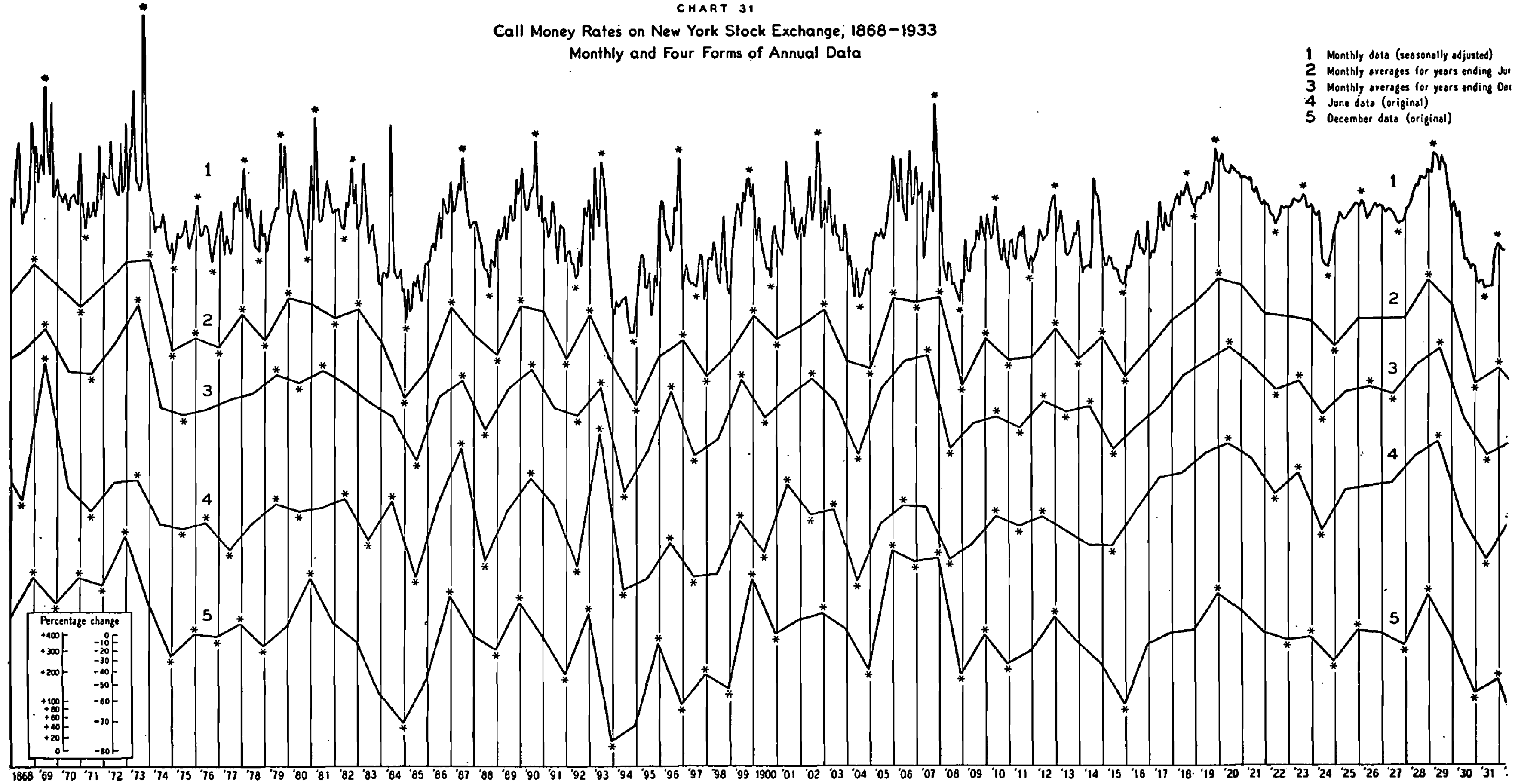
[a] See text below.

of twelve annual summaries that might have been selected.[45] This point is important; and to give it emphasis, we have carried through an experiment with twelve sets of annual totals for pig iron output. The first two columns of Table 77 list the specific-cycle contractions, their duration and their amplitude. The contraction from July 1917 to January 1918, which we consider a random movement, is also listed because several annual summations reflect it. The succeeding columns give the durations and amplitudes of corresponding declines in each of the twelve annual summations, every decline—however slight—being listed. There is, of course, considerable similarity among the twelve arrangements, but the thing to notice is how whimsically the cyclical movements change now and then with shifts in the annual boundaries (see Chart 29). The contraction of 1892–93 appears in every form of the annual data; but in one summation its duration is one year and its amplitude 24 per cent, in another the duration is two years and the amplitude 46 per cent. The contraction of

[45] On the whole there is an increasing tendency to present annual figures on a calendar-year basis, but this practice is far from universal. For example, the receipts and expenditures of the United States government are reported for the fiscal year ending June 30, similar data for Great Britain and Germany cover years ending March 31, agricultural data are frequently reported by crop years, and so on.

CHART 31

Call Money Rates on New York Stock Exchange, 1868–1933
Monthly and Four Forms of Annual Data




See note to Chart 29. For monthly data, 1857–67, see Chart 53.

TABLE 78

Characteristics of Cyclical Phases Skipped by Calendar- and Fiscal-year Data
Three American Series

| Series and phase | Phase (marked S) skipped by | | Characteristics of skipped phase[c] | | |
|---|---|---|---|---|---|
| | Calendar-year data | Fiscal-year data[a] | Nature[b] | Duration in months | Amplitude in specific-cycle relatives |
| DEFLATED CLEARINGS | | | | | |
| June 1881 – Jan. 1882 | . . | S | C | 7 | 10.2 |
| June 1887 – Mar. 1888 | S | S | C | 9 | 6.5 |
| Sep. 1890 – Mar. 1891 | . . | S | C | 6 | 8.0 |
| Sep. 1899 – Sep. 1900 | . . | S | C | 12 | 6.2 |
| July 1903 – May 1904 | S | . . | C | 10 | 5.9 |
| Mar. 1910 – Oct. 1910 | S | S | C | 7 | 3.3 |
| Aug. 1918 – Dec. 1918 | S | S | C | 4 | 4.9 |
| May 1923 – Sep. 1923 | S | S | C | 4 | 5.7 |
| PIG IRON PRODUCTION | | | | | |
| Oct. 1887 – Mar. 1888 | S | S | C | 5 | 25.5 |
| Dec. 1899 – Oct. 1900 | S | . . | C | 10 | 30.5 |
| May 1919 – Sep. 1920 | . . | S | E | 16 | 40.7 |
| CALL MONEY RATES | | | | | |
| Jan. 1876 – Sep. 1876 | S | . . | C | 8 | 51.9 |
| Jan. 1878 – Sep. 1878 | S | . . | C | 8 | 66.5 |
| Oct. 1880 – Feb. 1881 | . . | S | E | 4 | 98.0 |
| May 1882 – Sep. 1882 | S | . . | E | 4 | 60.1 |
| Aug. 1918 – Dec. 1918 | S | S | C | 4 | 31.0 |
| June 1922 – Aug. 1923 | . . | S | E | 14 | 33.0 |
| Feb. 1926 – Sep. 1927 | . . | S | C | 19 | 27.0 |

See Table 55 for the periods covered.
[a] Years ending June 30.
[b] C stands for specific-cycle contraction, E for expansion.
[c] See also Table 53 and Charts 29-31.

1907–08 lasted six months according to the monthly data, but one or two years according to the annual data; its amplitude was 50 per cent according to the monthly data, 26 to 43 per cent according to the annual. The contraction of 1910 is reflected in every form of the annual data, while the contraction of 1890–91, which was just as long and more pronounced, is skipped in two instances. The contraction of 1929–33, by far the longest and deepest in the record, is reflected fairly accurately in the annual series, its duration varying from three to four years and its amplitude from 75 to 82 per cent. But even here some annual series are deceptive: in the summations ending June, July, and August, there is a four-year contraction from 1929 to 1933 but a five-year contraction from 1917 to 1922.[46]

These results for iron production are not unusual. Charts 30 and 31 show the monthly, calendar-year, and fiscal-year figures (that is, for years ending June 30) of two additional series, clearings and call money rates.

[46] Compare the present analysis, where we take the monthly turning dates of the cycles as they come and observe shifts in the annual cycles produced by changing the annual boundaries, with the analysis of Sec. II where we treat the years as fixed but shift hypothetical monthly series along the time scale. The principle is the same: the shapes of annual cycles depend upon the months of cyclical turn in relation to the annual boundaries.

TABLE 79

Average Measures of Specific Cycles in Monthly and Four Forms of Annual Data

Three American Series

| Series and form of data | Period covered[a] | No. of specific cycles | Av. lead (−) or lag (+) in months at reference[b] | | Av. duration in months | | | Av. amplitude in specific-cycle relatives | | | Av. per cent change from cycle to cycle | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Peaks | Troughs | Expansion | Contraction | Full cycle | Rise | Fall | Rise & fall | Total | Per month (wtd.) |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) |
| DEFLATED CLEARINGS | | | | | | | | | | | | |
| Monthly | 1878–1933 | 15 | +3.2 | −5.8 | 32.6 | 11.4 | 44.0 | 26.9 | 13.4 | 40.2 | +15.2 | +0.37 |
| Calendar-year | 1878–1933 | 10 | +1.8 | −3.8 | 49.2 | 16.8 | 66.0 | 29.7 | 9.8 | 39.5 | +22.6 | +0.36 |
| Fiscal-year | 1878–1933 | 8 | +4.8 | −5.9 | 67.5 | 15.0 | 82.5 | 36.8 | 13.6 | 50.4 | +28.4 | +0.36 |
| June | 1878–1932 | 16 | +0.5 | −2.8 | 24.8 | 15.8 | 40.5 | 22.0 | 8.5 | 30.5 | +14.7 | +0.38 |
| December | 1878–1932 | 9 | −0.8 | −4.3 | 54.7 | 17.3 | 72.0 | 35.6 | 14.6 | 50.2 | +25.4 | +0.36 |
| PIG IRON PRODUCTION | | | | | | | | | | | | |
| Monthly | 1879–1933 | 15 | +1.9 | −3.4 | 28.8 | 14.5 | 43.3 | 62.1 | 54.8 | 116.8 | +14.5[c] | +0.35[d] |
| Calendar-year | 1884–1932 | 12 | +0.3 | −3.7 | 31.0 | 17.0 | 48.0 | 41.1 | 32.4 | 73.5 | +14.5 | +0.32 |
| Fiscal-year | 1885–1933 | 12 | −1.5 | −2.9 | 27.0 | 21.0 | 48.0 | 41.8 | 33.6 | 75.4 | +13.8 | +0.30 |
| June | 1885–1932 | 13 | +1.7 | −2.0 | 27.7 | 15.7 | 43.4 | 51.9 | 44.6 | 96.5 | +15.3 | +0.35 |
| December | 1884–1932 | 13 | −0.6 | −3.3 | 25.8 | 18.5 | 44.3 | 48.8 | 45.0 | 93.8 | +10.2 | +0.25 |
| CALL MONEY RATES | | | | | | | | | | | | |
| Monthly | 1858–1931 | 23 | −0.1 | +1.5 | 19.9 | 18.0 | 37.9 | 115.9 | 116.1 | 232.0 | −0.1 | 0.00 |
| Calendar-year | 1858–1931 | 20 | −0.4 | −1.8 | 25.2 | 18.6 | 43.8 | 62.7 | 64.4 | 127.1 | −0.5 | −0.01 |
| Fiscal-year | 1859–1931 | 21 | +0.4 | +2.9 | 20.6 | 20.6 | 41.1 | 56.2 | 58.0 | 114.2 | −0.4 | −0.01 |
| June | 1858–1931 | 23 | −2.1 | +0.7 | 21.4 | 16.7 | 38.1 | 68.6 | 70.9 | 139.5 | +0.1 | 0.00 |
| December | 1858–1930 | 24 | −4.2 | +1.0 | 17.0 | 19.0 | 36.0 | 63.7 | 63.7 | 127.4 | −0.3 | −0.01 |

[a] Applies to col. (6)-(13). Col. (4)-(5) include all timing measures within the period covered by the monthly data.

[b] The timing of each series is measured from the monthly reference dates. The number of turns included in the averages depends on the number of comparisons made with the reference dates. Usually this number is not the same as the number of full specific cycles (see Charts 29-31).

[c] If the monthly average is restricted to the period of the annual, +12.9.

[d] If the monthly average is restricted to the period of the annual, +0.32.

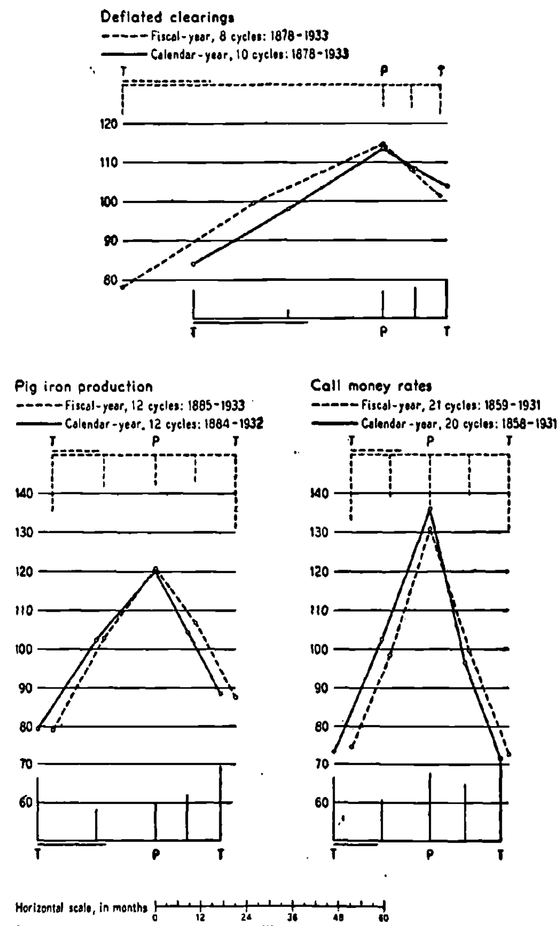
Tables 78-79 and Chart 32 compare the cyclical measures derived from the calendar- and fiscal-year figures of all three series. The discrepancies between the two annual forms are considerable. In clearings the calendar-year figures skip five specific-cycle contractions, the fiscal-year figures skip seven. In call money rates both annual forms skip four cyclical phases, but they skip only one phase in common.[47] Notable discrepancies appear in the timing averages and in the average rates of change within expansions and contractions. The measures of cyclical duration and amplitude differ conspicuously, though they tell a reasonably consistent story. The one measure not affected appreciably by the character of the

[47] Table 78 records merely the skipped cycles. But as stated on p. 217 the calendar-year figures of call money rates show an 'extra' specific-cycle expansion from 1913 to 1914. The fiscal-year figures reflect this movement, and besides seem to show another 'extra' cycle. The decline from Sept. 1906 to April 1907, which we have treated as a random movement in analyzing monthly data, is fairly prominent in the fiscal-year data; we have treated it, after some hesitation, as cyclical.

Only two changes in the direction of the fiscal-year figures were disregarded in marking off specific cycles: a decline of 0.1 per cent in deflated clearings from 1910 to 1911 and in call money rates from 1926 to 1927. The decline from 1906 to 1907 in call money, which we have not disregarded, is 6 per cent of the value in 1906.

CHART 32

Average Specific-cycle Patterns of Calendar- and Fiscal-year Data Three American Series




For explanation of chart, see Ch. 5, Sec. VI and XI.

annual summation is the average secular change per month over the period covered by all cycles.

Charts 29-31 and Table 79 give us a glimpse also of what happens when an annual series fails to represent full years, but refers instead—as do many financial series—to a single date within the year. For the present purpose we have merely taken the original (that is, unadjusted for seasonal) June and December figures in every year covered by three series, and analyzed each set of June and each set of December figures by the technique we apply to full-year data. Our sample is small and the evidence not clear-cut, but the following conclusions seem justified. (1) Specific cycles tend to be more numerous in single-date than in full annual series.

The reason is that in single-date series erratic values may be joined together into movements that look like specific cycles. (2) The specific cycles that can be distinguished in the June figures are not very good approximations to the specific cycles in the calendar-year data, nor are the December figures very good approximations to the fiscal-year data. (3) The June and December entries are independent observations. But the calendar-year figure for any given year has six months in common with the fiscal-year figure. Hence the full-year forms of a series are more nearly similar in their movements than are the single-date forms. (4) Estimates of average timing and the average monthly rate of secular change tend to be slightly better when made from full-year than from one-date-per-year series. (5) On the average, specific cycles tend to be shorter but of larger amplitude in single-date than in full-year series. Consequently, it may be expected that these average measures will approximate more closely the averages of the underlying monthly data in single-date than in full annual series. This expectation is stronger for durations than for amplitudes.[48] (6) But it is always necessary to make qualitative amendments of average durations and amplitudes derived from annual data; that is to say, some judgment must be made of the biases to which the averages are subject. However difficult this may be in the case of full-year data, it is still more difficult in single-date series, for a change in the boundaries of the data is apt to make a larger difference in single-date than in full-year figures. In comparing annual series of different processes, an investigator is therefore even more likely to err when the series represent only one date a year than when they represent whole years.

## XII Reference-cycle Measures

As explained in Section IV of Chapter 4, our procedure in dating business cycles is to set monthly reference dates, and then make the quarterly and annual reference dates match the monthly as well as may be. Once a monthly reference cycle has been recognized, we recognize also a quar-

[48] In the absence of erratic movements, the peak of (say) calendar-year data (conceived of as every twelfth term of a twelve-month moving average of average daily figures, centered at the end of June) is likely to be lower than the peak of actual (last day of) June figures, while the trough of the former is likely to be higher than the trough of the latter. Erratic movements do not affect the expectation. Regardless of erratic movements, so far as the specific cycles in a single-date annual series and in a full-year series correspond, the amplitudes of the single-date series are likely to be larger on the average. However, this tendency is offset by the tendency of single-date series to show more cycles than do full-year series.

The average amplitudes of specific cycles that correspond in the calendar-year and June series are as follows:

| | No. of cycles | Calendar-year data | | | June data | | |
|---|---|---|---|---|---|---|---|
| | | Rise | Fall | Rise & fall | Rise | Fall | Rise & fall |
| Deflated clearings | 6 | 22.9 | 5.8 | 28.7 | 27.4 | 9.0 | 36.4 |
| Pig iron production | 11 | 37.5 | 34.0 | 71.4 | 51.5 | 48.8 | 100.3 |
| Call money rates | 11 | 78.3 | 73.3 | 151.6 | 84.4 | 76.3 | 160.7 |

terly and annual cycle in approximately the same period. It is reasonably certain that if we attempted to date quarterly reference cycles independently of the monthly, we would get practically the same results as are yielded by our method. Independent dating of annual reference cycles, on the other hand, would probably yield fewer reference cycles. Such a chronology would be less significant than the one we obtain by forcing the annual reference cycles into correspondence with the monthly. For the new annual cycles would not be homogeneous, some corresponding to single cycles in the monthly chronology and others combining two or even three cycles. We might get one set of reference cycles on a calendar-year basis and a different set on a fiscal-year basis. There is no assurance that the new list, even if restricted to calendar years, would consistently include the largest and exclude the mildest cycles in the monthly list; for as the experiments of this chapter demonstrate, annual data sort out mild and substantial cyclical movements imperfectly. We can even imagine a case in which every annual series reflected a cyclical movement disclosed by monthly data but which we could not recognize as a reference cycle unless we took account of the monthly data: that would happen if some annual series declined one year, others equally important declined the following year, and a dependable composite of all series merely registered a retarded rise over the two years. By forcing quarterly and annual reference cycles into correspondence with monthly cycles, we avoid these difficulties and ensure that the analysis is always focused on the same units of business experience, though its exactness varies with the form of the data.

The small number of annual observations on individual cycles re-

TABLE 80
Number of One-year Phases in Annual Reference Cycles
Four Countries

| Country and period covered | Total no. of reference phases | Number of one-year phases | | |
|---|---|---|---|---|
| | | Expansion | Contraction | Both |
| United States | | | | |
| 1834–1938 | 52 | 6 | 17 | 23 |
| 1878–1938 | 32 | 3 | 13 | 16 |
| Great Britain | | | | |
| 1793–1938 | 58 | 3 | 18 | 21 |
| 1879–1938 | 24 | 3 | 7 | 10 |
| Germany | | | | |
| 1866–1932 | 24 | 1 | 6 | 7 |
| 1878–1932 | 20 | 1 | 5 | 6 |
| France | | | | |
| 1840–1938 | 42 | 5 | 12 | 17 |
| 1879–1938 | 26 | 3 | 8 | 11 |
| Four countries[a] | 176 | 15 | 53 | 68 |

Derived from the calendar-year reference dates in Table 16.

[a]The summary is based on the maximum period shown above for each country.

stricts the detail in which reference-cycle patterns can be measured, just as it restricts the detail in which specific-cycle patterns can be measured. If we attempted to make nine-point reference-cycle patterns of annual data without interpolating, we would succeed in only 4 of the 88 reference cycles covered by our annual chronology in four countries. Table 80 shows how numerous one-year phases have been in these countries, particularly contractions in the United States after 1878. Since interpolations are necessary to obtain mid-phase standings for phases lasting one year, even our five-point patterns elaborate excessively upon the raw data of many annual reference cycles, just as they elaborate excessively upon the raw data of many specific cycles.

That the loss of detail is a serious disadvantage is apparent from Table 81 and Chart 33. The annual patterns are like the monthly in that both show that bank clearings, iron production, share trading, stock prices, and call money rates on the average tend to rise and fall with the general tides in business activity, while bond yields bear a quasi-inverted relation to business cycles. But the annual patterns sacrifice precious information:

TABLE 81

Average Reference-cycle Patterns of Monthly, Quarterly and Annual Data
Six American Series

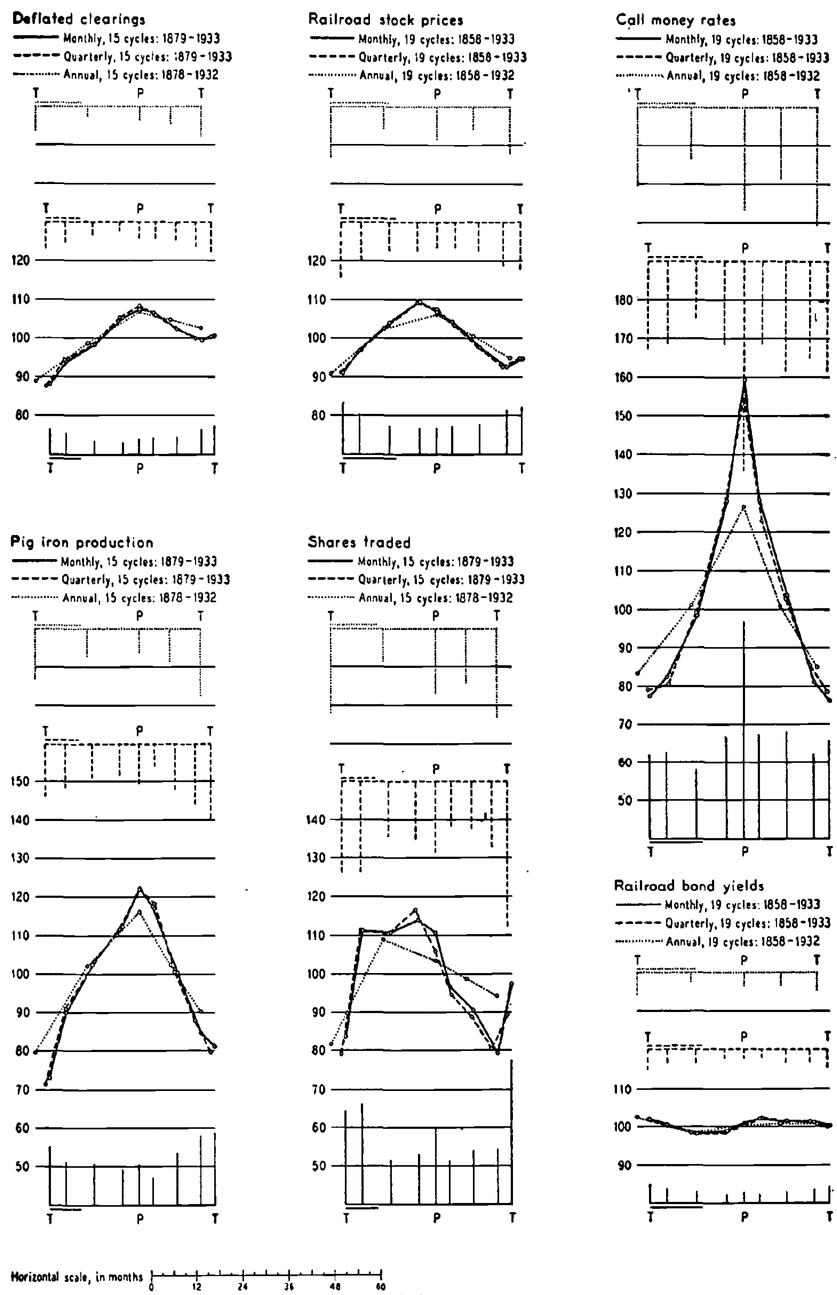
| Series and form of data | No. of reference cycles | Average in reference-cycle relatives at stage | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | I | II | III | IV | V | VI | VII | VIII | IX |
| | | | Expansion | | | | Contraction | | | |
| | | Initial trough | First third | Middle third | Last third | Peak | First third | Middle third | Last third | Terminal trough |
| DEFLATED CLEARINGS | | | | | | | | | | |
| Monthly | 15 | 88.1 | 94.0 | 98.4 | 105.2 | 107.5 | 106.7 | 102.3 | 99.5 | 100.6 |
| Quarterly | 15 | 87.6 | 94.3 | 98.2 | 105.3 | 108.2 | 106.0 | 102.7 | 100.0 | 100.3 |
| Annual | 15 | 88.8 | ... | 98.6 | ... | 106.9 | ... | 104.9 | ... | 102.6 |
| PIG IRON PRODUCTION | | | | | | | | | | |
| Monthly | 15 | 73.3 | 90.0 | 103.5 | 112.5 | 122.2 | 117.6 | 100.4 | 84.8 | 81.1 |
| Quarterly | 15 | 71.6 | 91.0 | 102.5 | 111.8 | 122.0 | 118.3 | 100.6 | 87.9 | 79.8 |
| Annual | 15 | 79.7 | ... | 102.1 | ... | 116.2 | ... | 102.5 | ... | 90.2 |
| RAILROAD STOCK PRICES | | | | | | | | | | |
| Monthly | 19 | 91.0 | 96.9 | 104.0 | 109.4 | 106.9 | 104.3 | 97.7 | 92.5 | 94.7 |
| Quarterly | 19 | 91.1 | 97.0 | 103.6 | 109.2 | 107.5 | 103.2 | 97.8 | 92.5 | 94.7 |
| Annual | 19 | 90.8 | ... | 102.5 | ... | 106.1 | ... | 100.5 | ... | 94.9 |
| SHARES TRADED | | | | | | | | | | |
| Monthly | 15 | 83.8 | 111.2 | 110.9 | 114.0 | 110.6 | 96.8 | 90.5 | 79.5 | 97.5 |
| Quarterly | 15 | 79.3 | 111.2 | 110.3 | 116.7 | 105.9 | 94.7 | 89.0 | 80.4 | 89.5 |
| Annual | 15 | 81.7 | ... | 109.0 | ... | 103.4 | ... | 98.7 | ... | 94.2 |
| CALL MONEY RATES | | | | | | | | | | |
| Monthly | 19 | 77.5 | 82.4 | 98.4 | 128.2 | 159.5 | 128.5 | 103.9 | 81.1 | 76.2 |
| Quarterly | 19 | 79.1 | 80.4 | 99.3 | 125.9 | 155.1 | 123.0 | 102.9 | 85.6 | 78.6 |
| Annual | 19 | 83.5 | ... | 101.2 | ... | 126.7 | ... | 100.9 | ... | 85.1 |
| RAILROAD BOND YIELDS | | | | | | | | | | |
| Monthly | 19 | 102.0 | 100.5 | 98.3 | 98.9 | 101.0 | 102.0 | 101.5 | 101.1 | 100.2 |
| Quarterly | 19 | 102.0 | 100.3 | 98.3 | 98.7 | 100.4 | 102.1 | 101.5 | 101.4 | 100.0 |
| Annual | 19 | 102.6 | ... | 98.8 | ... | 100.6 | ... | 100.9 | ... | 100.8 |

See Chart 33 for the periods covered.

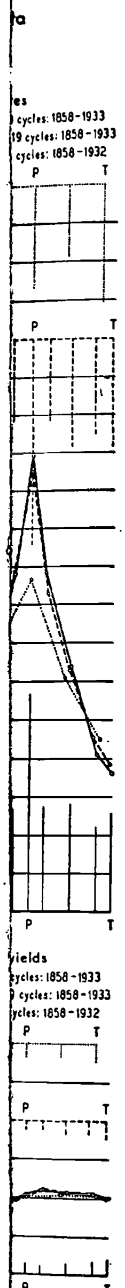
CHART 33

**Average Reference-cycle Patterns of Monthly, Quarterly and Annual Data**

**Six American Series**




In each figure the three horizontal lines representing the average duration of reference cycles are zero base lines from which the average deviations of the three patterns are to be read. For other explanations, see Ch. 5, Sec. VII and XI. See also Table 81.



they give no hint of the tendency of clearings, stock prices, and share trading to turn up early in business-cycle revivals; they indicate that share trading tends to turn down early in recessions but fail to disclose a similar tendency in stock prices; they conceal the retardation of the rise in pig iron production in mid-expansion and its accelerated decline in mid-contraction. Quarterly data, on the other hand, trace out the reference-cycle movements with practically the same fidelity as the monthly data.[49]

Also measures of conformity to business cycles are rougher approximations in annual than in monthly or quarterly data. If a reference peak or trough is misdated by one year, it is apt to leave a mark on conformity indexes of annual data, but minor shifts of monthly or quarterly reference dates usually have slight influence. Similarly, if there is a substantial error in a series one month or quarter, the effect on conformity measures is likely to be slight, while even a small error that affects the direction of an annual figure may easily prove serious. If a series conforms badly to business cycles, conformity indexes on an annual basis may be higher or lower than indexes on a monthly or quarterly basis. But if a series conforms well, the chances are that annual indexes will understate conformity. For annual data tend to skip conforming contractions when the secular trend is rising and conforming expansions when the secular trend is declining; they therefore understate the conformity to reference contractions in series of the first type and the conformity to reference expansions in series of the second type. These effects are likely to be reinforced by the greater flexibility of monthly or quarterly data when one is dividing reference cycles into stages of expansion and contraction.

The differences between the conformity indexes of the monthly and quarterly data of our six series are generally slight and seem erratic (Table 82). The annual indexes, on the other hand, betray their coarse origins. The contraction index of annual data is conspicuously lower than the monthly in five series and slightly higher in one; it is lower than the quarterly in all six series. Again, the full-cycle index of annual data is lower than the monthly in four series and the same in two; it is likewise lower than the quarterly in four series and the same in two. The downward bias of annual expansion indexes is slight, but that merely reflects the dominance of series with rising secular trends in our sample. We must, however, chalk up two credits for the annual measures. First, while the indexes of conformity to full business cycles tend to run lower in the annual than in the monthly or quarterly data, the reduction does not seem large in view of the inherent instability of conformity indexes.[50] Second,

[49] Compare the analysis in Sec. X of monthly versus quarterly specific-cycle patterns. In making reference-cycle patterns of American series by quarters, interpolations are needed in the expansion of 1919–20 and the contractions of 1887–88, 1890–91, and 1918–19; in monthly data the need to interpolate never arises.

[50] See pp. 183-5, 195.

TABLE 82

Conformity to Business Cycles of Monthly, Quarterly and Annual Data
Six American Series

| Series and form of data | No. of reference cycles[a] | Stages matched with reference expansion | Average change per month in reference-cycle relatives during stages matched with reference | | Index of conformity to reference | | |
|---|---|---|---|---|---|---|---|
| | | | Expansions | Contractions | Expansions | Contractions | Cycles |
| DEFLATED CLEARINGS | | | | | | | |
| Monthly | 15 | VIII-V | +0.78 | −0.50 | +100 | +73 | +86 |
| Quarterly | 15 | VIII-V | +0.74 | −0.63 | +100 | +73 | +93 |
| Annual | 15 | I-V | +0.65 | −0.17 | +100 | +7 | +86 |
| PIG IRON PRODUCTION | | | | | | | |
| Monthly | 15 | I-V | +2.26 | −2.27 | +100 | +100 | +100 |
| Quarterly | 15 | I-V | +2.29 | −2.47 | +100 | +87 | +100 |
| Annual | 15 | I-V | +1.46 | −1.65 | +100 | +73 | +100 |
| RAILROAD STOCK PRICES | | | | | | | |
| Monthly | 19* | VIII-IV | +0.77 | −0.61 | +79 | +60 | +74 |
| Quarterly | 19* | VIII-IV | +0.74 | −0.62 | +68 | +70 | +68 |
| Annual | 19* | I-V | +0.50 | −0.32 | +68 | +40 | +63 |
| SHARES TRADED | | | | | | | |
| Monthly | 15 | VIII-IV | +1.96 | −1.66 | +87 | +73 | +93 |
| Quarterly | 15 | VIII-IV | +2.06 | −1.89 | +100 | +73 | +86 |
| Annual | 15 | I-III | +1.73 | −0.59 | +87 | +47 | +86 |
| CALL MONEY RATES | | | | | | | |
| Monthly | 19* | I-V | +3.62 | −3.57 | +68 | +100 | +100 |
| Quarterly | 19* | I-V | +3.27 | −3.67 | +89 | +90 | +100 |
| Annual | 19 | I-V | +1.60 | −2.12 | +79 | +68 | +84 |
| RAILROAD BOND YIELDS | | | | | | | |
| Monthly | 19* | III-VI | +0.24 | −0.17 | +47 | +30 | +68 |
| Quarterly | 19* | III-VI | +0.24 | −0.17 | +37 | +40 | +74 |
| Annual | 19* | III-VII | +0.11 | −0.16 | +26 | +35 | +63 |

[a] See Chart 33 for the periods covered; but note that where an asterisk appears, the contraction and full-cycle indexes cover an additional reference contraction at the beginning of the series.

the average rates of change during reference expansions and contractions have invariably the same sign in the annual as in the monthly and quarterly data. Of course, the fact that the annual averages are smaller than the others merely reflects the smaller amplitudes of annual data.[51]

[51] Our device of recognizing the timing of a series in units of cycle-stages when measuring conformity breaks down partly in annual series, since only one or two observations are commonly available for a reference phase. Hence we often follow another plan when the cyclical turns of a series tend to lead or lag behind the annual reference dates—whether for calendar or fiscal years—by some uniform interval. See the explanation in Table 48.

Three of our six annual series show some tendency to lead or lag by a uniform interval, and yield the following conformity indexes on this basis:

| | No. of months lead (−) or lag (+) assumed | Index of conformity to reference: Expansions | Contractions | Cycles |
|---|---|---|---|---|
| R. R. stock prices | −6 | +53 | +41 | +70 |
| Shares traded | −6 | +60 | +87 | +79 |
| R. R. bond yields | +12 | +37 | +45 | +55 |

On the whole, these measures do not differ greatly from those obtained by our standard method; but the higher contraction indexes are worth noting.

TABLE 83
Conformity to Business Cycles of Monthly and Four Forms of Annual Data
Three American Series

| Series and form of data | No. of reference cycles | Stages matched with reference expansion | Average change per month in reference-cycle relatives during stages matched with reference: Expansions | Contractions | Index of conformity to reference: Expansions | Contractions | Cycles |
|---|---|---|---|---|---|---|---|
| DEFLATED CLEARINGS | | | | | | | |
| Monthly | 15 | VIII-V | +0.78 | −0.50 | +100 | +73 | +86 |
| Calendar-year | 15 | I-V | +0.65 | −0.17 | +100 | +7 | +86 |
| Fiscal-year | 15 | I-V | +0.66 | −0.14 | +100 | +20 | +86 |
| June | 15 | I-V | +0.68 | −0.21 | +87 | +33 | +79 |
| December | 15 | I-V | +0.76 | −0.25 | +100 | +7 | +86 |
| PIG IRON PRODUCTION | | | | | | | |
| Monthly | 15 | I-V | +2.26 | −2.27 | +100 | +100 | +100 |
| Calendar-year | 15 | I-V | +1.46 | −1.65 | +100 | +73 | +100 |
| Fiscal-year | 15 | I-V | +1.38 | −1.31 | +87 | +73 | +86 |
| June | 15 | I-V | +1.90 | −2.13 | +100 | +60 | +86 |
| December | 15 | I-V | +1.57 | −1.84 | +87 | +60 | +66 |
| CALL MONEY RATES[a] | | | | | | | |
| Monthly | 17 | I-V | +3.92 | −3.94 | +76 | +100 | +100 |
| Calendar-year | 17 | I-V | +1.68 | −2.34 | +76 | +65 | +82 |
| Fiscal-year | 17 | III-V | +3.42 | −1.18 | +76 | +76 | +88 |
| June | 17 | I-V | +1.73 | −3.19 | +65 | +65 | +64 |
| December | 17 | III-V | +4.82 | −1.72 | +76 | +65 | +82 |

See Chart 34 for the periods covered. The calendar-year periods apply also to June data, and the fiscal-year periods to December data. The calendar-year and June figures are analyzed on the basis of the calendar-year reference dates, the fiscal-year and December figures on the basis of the fiscal-year reference dates.

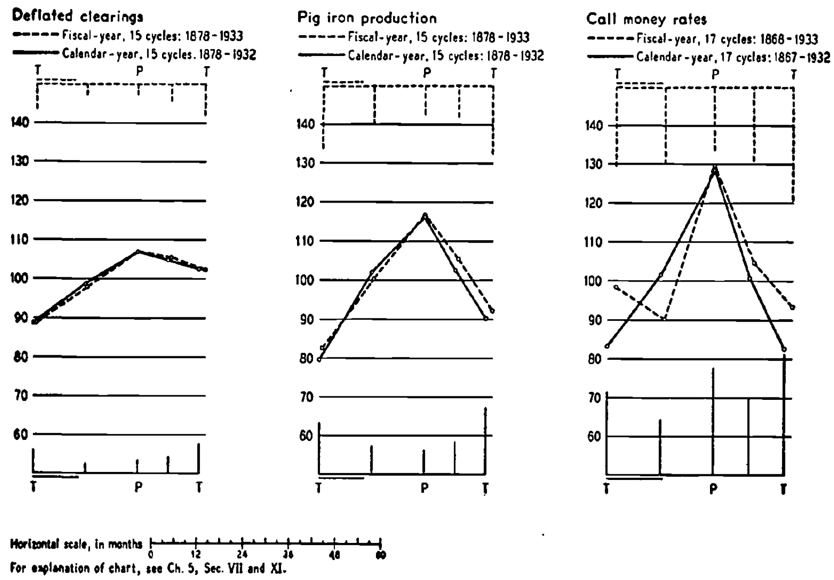
[a] Since our fiscal-year reference dates start in 1868, the analysis of the fiscal-year and December data cannot start earlier. To ensure comparability, the analysis of other forms of the data covers approximately the same period. Cf. Table 82.

To illustrate the influence of the form of annual data on reference-cycle patterns and conformity measures, we present Chart 34 and Table 83. The patterns of calendar- and fiscal-year data differ conspicuously in call money rates. They seem similar in iron production and clearings, although in the former the variations in the slopes of the patterns within reference expansions and contractions are sufficiently different to discredit their value. On the other hand, the conformity measures of the calendar- and fiscal-year data agree fairly well, as do also the measures of single-date and full-year data.[52] But the rate of change during reference phases is somewhat greater on the average in single-date figures, while the indexes of conformity tend to run higher in full-year figures. Discrepancies of this character are to be expected whenever the conformity of the underlying monthly data is high.[53]

[52] But in call money rates the division of reference cycles is not the same in the fiscal-year and December data as in the other forms. If stages I-V are taken to represent expansions, the indexes of conformity of the fiscal-year data are: expansion +53, contraction +53, full cycles +70. The corresponding indexes of the December data are +71, +53, +76.

[53] For an adaptation of our method of measuring conformity, especially designed to handle single-date annual series, see a forthcoming monograph on inventory cycles by Moses Abramovitz.

CHART 34
Average Reference-cycle Patterns of Calendar- and Fiscal-year Data
Three American Series




## XIII Conclusions

At the risk of elaborating the obvious we have attempted in this long chapter, first, to explain why we eschew the easy path of working with annual data, second, to provide an experimental basis for judging cyclical measures made from annual data. Yearly observations are excessively crude materials for studying business cycles, not because they suffer from any inherent flaw, but simply because a year is such a substantial fraction of the usual length of specific and reference cycles. In studies of 'long waves', such as are found in building construction and certain other activities, the annual time unit is not likely to prove a disadvantage, while in studies of broad secular changes data by decades may suffice. On the other hand, in analyzing the financial adjustments that take place during a brief and violent crisis, such as occurred in 1907 in the United States, even monthly data are excessively coarse, and weekly or perhaps daily figures need to be used.[54]

There is no single optimum time unit for economic investigations. A time unit that serves well the needs of one investigation, or some part of one investigation, may serve poorly the needs of another. Nor can an in-

[54] See Wesley C. Mitchell, *Business Cycles* (1913), Ch. XII; or the new edition of Part III of that volume, published under the title *Business Cycles and Their Causes* (University of California Press, 1941), Ch. 3.

vestigator usually do more than approximate the time unit that serves his purposes best. For example, the tests of this chapter demonstrate conclusively that annual data falsify essential features of cyclical fluctuations, but they speak haltingly on the merits of quarterly versus monthly data for the type of analysis we are now making. If a series is characterized by mild erratic fluctuations, subtle responses to cyclical movements of general business may be spotted better in monthly than in quarterly data; monthly data make it possible to trace more faithfully the sequence of changes in revivals and recessions, and to show more accurately the form of the cyclical movements, particularly in short phases. But if erratic movements are pronounced these advantages of monthly data are likely to be lost, and the scale may tip in favor of the quarterly. It is possible that we have carried our preference for monthly data too far; it may be better to handle monthly series with substantial erratic movements on a quarterly basis, which is less expensive than monthly analysis.

The use of annual data, on the other hand, is a poor economy if an investigator seeks earnestly to understand the business cycles of actual life. True, by making careful qualitative allowances, some useful knowledge may be wrung from annual data; but the knowledge thus gained is extremely rough, and may be utterly misleading, as in the case of cyclical patterns. Some shortcomings of annual data may be mitigated by removing secular trends before subjecting time series to analysis, but the elimination of trends raises difficult questions which call for a separate chapter.