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APPENDIX A

A Technique for Summarizing the Current Behavior of Groups of Indicators

The user of statistical indicators must, as a final step in his analysis, sum up what he believes they indicate. From one set of data he may make many different types of summary, depending upon what significance he attaches to each series and how he interprets its movements. Several types of summary are presented in this paper. Chart 3, based upon a large group of series selected for the consistency with which they conform to business cycles, illustrates two forms of summary: the distribution in time of peaks and troughs in the series and the percentage of series expanding. Series that have not conformed well to business cycles are ignored, all other series are given equal weight, and the magnitude of the cyclical expansions and contractions in the individual series is not taken into account (except in identifying their cycles). Despite their simplicity these forms of summary appear to have some merit in identifying business cycles.

In Charts 4 and 5 similar information is organized differently. Series that not only conform well to business cycles but exhibit consistently similar timing at revivals and recessions are classified in three groups, and summaries struck for each group separately. This threefold summary utilizes more information about the cyclical characteristics of the series, information that also should prove useful in identifying business cycles.

In all three charts the basic data are the dates of cyclical peaks and troughs in the individual series. Often there is some uncertainty about these dates when one seeks to determine them historically, and identifying them currently is much more difficult. Can curves analogous to the percentage expanding curves of Charts 3 and 5 be constructed without recognizing cyclical turning points explicitly?

One way would be simply to take the direction of change in each series from month to month as an observation on its cyclical phase and count how many series rise each month. Obviously, if series rose smoothly to their cyclical peaks and declined smoothly to their troughs this would give the same result as the method of Charts 3 and 5. But most series do not behave in this way, and during a cyclical expansion some go down almost as often as they go up, on a month to month basis. Moreover, differences among series in this respect are substantial, and the directions of change would provide a less reliable indication of cyclical phase in some series than in others. A simple count of directions of change would not, therefore, be satisfactory.

A modification of the plan can avoid this difficulty; namely, use different intervals for series that behave differently. That is, one might record month to month directions of change for very smooth series, and directions of change over longer intervals, say between the first and fifth months, for choppy series. This is equivalent to smoothing the series with moving averages of different periods and observing the month to month changes in the moving averages, or to smoothing the first differences of the series with moving averages of different periods and recording the signs of these moving averages.

By means of moving averages, then, it should be possible to reduce series to something like equivalent degrees of smoothness. But there are limitations. Very long-period moving averages must be avoided, for two reasons: when centered they will be much out of date; and they may seriously distort the timing of series at cyclical turns. It is common practice to use in effect a 12-month moving average by comparing, say, December of this year with December of last year. Though this obviates the need for seasonal adjustments the change in a moving average centered on a date 6 months ago not only is a crude device for recording cyclical developments then but also is obviously out of date with respect to cyclical developments *now*.

To offset the imperfect smoothness of relatively short-period moving averages we may adopt another device, and record both the direction of change in the given month and the number of months the series has been moving in that direction. That is, a rise of 1 month in the moving average (preceded by a decline) is counted as a run of +1, a continued rise the second month, +2, and so on. Declines are registered as –1, –2, etc. The reason for observing runs is that the longer the run the more likely is it to correspond in direction with the cyclical phase of the series.

To summarize the behavior of a group of series month by month frequency distributions of runs by direction and duration

Table A1

Measures of Timing and Smoothness of Fifteen Statistical Indicators

	Series	Av. lead (—) or lag (+) at ref. turns 1919-38	Av. duration of run: Original data[a]	Av. duration of run: Smoothed data 1919-38	Period of moving average[b]
		M O	N	T H	S
1	Inner tube production	—5.7[c]	1.8	5.0[c]	6
2	Resid. bldg. contracts, fl. space	—5.4	1.9	6.1	5
3	Railroad operating income	—4.8[e]	1.8	4.3	6
4	Indus. common stock price index	—4.1	2.9	5.7	3
5	Bus. failures, liab., indus. & comm., inverted	—3.4[e]	1.6	3.2	7
6	Av. hours worked per week, mfg.	—3.2[d]	2.3	5.0[d]	4
7	Indus. bldg. contracts, fl. space	—2.2	1.5	3.6	7
	Average, 7 leading series	—4.1	2.0	4.7	5.4
8	Railroad freight ton-miles	—1.2	2.4	4.3	4
9	Wholesale price index, BLS	—1.2[e]	3.4	3.9	2
10	Factory employ. index, total	—1.0	5.1	5.2	1
11	Steel ingot production	—0.8	2.7	4.2	4
12	Indus. production index, FRB	—0.8	3.3	5.5	2
13	Indus. production index, S.S. Co.	—0.6	4.4	4.1	1
14	Bank clearings outside NYC	—0.1[e]	1.7	5.8	6
15	Bus. activity index, AT&T	+0.9	3.4	5.0	2
	Average, 8 roughly coincident series	—0.6	3.3	4.8	2.8
	Average, 15 series	—2.2	2.7	4.7	4.0

[a] *Bulletin 69,* Table 2, col. 14. Based, for most series, on data for 1919-33; hence not strictly comparable with entries for smoothed data.

[b] Selected according to scale given in text.

[c] Data begin in 1921.

[d] Data begin in 1920.

[e] War cycle observations (1919-20) are omitted.

may be drawn up, an average for each month's distribution struck, and so on. In computing the average duration of the runs recorded for a group of series in a given month, weights might be applied to runs of different length, based perhaps on probability considerations. We have not, however, devised such a system of weights. In averaging we have found it expedient to group together all runs of 6 months or more, counting them as runs of 6. In effect, the observed direction of change in the moving average of a series in a given month is weighted by the number of months (from 1 to 6) that the moving average has been proceeding in the same direction. Of course, since we record only directions of change there is no need actually to compute the moving average; for a 5-month average the direction of change is obtained simply by comparing the 1st month with the 6th, the 2nd with the 7th, etc.

To test and illustrate this method we have applied it to 15 economic time series selected from the list of statistical indicators in *Bulletin 69* (Table A1).[1] The first step was to determine the appropriate periods of the moving averages. After some experimentation the accompanying scale was adopted, whereby the period of moving average is selected according to the average duration of run in the original data. This scale appears to yield an average duration of run in the smoothed data of about 5 months.[1a]

AV. DURATION OF RUN, ORIGINAL DATA	PERIOD OF MOVING AVERAGE	AV. DURATION OF RUN, SMOOTHED DATA, 15 SERIES
	MONTHS	
1.5–1.6	7	3.2; 3.6
1.7–1.8	6	4.3; 5.0; 5.8
1.9–2.2	5	6.1
2.3–2.7	4	4.2; 4.3; 5.0
2.8–3.2	3	5.7
3.3–3.9	2	3.9; 5.0; 5.5
4.0 or more	1	4.1; 5.2

The durations of run of the centered moving averages were recorded month by month for each of the 15 sample series, and frequency distributions drawn up. The striking shifts in these distributions in the 1948-49 recession are illustrated in Table A2. In June 1948 most of the series were rising, though the upward runs were relatively brief. By December all except one of the moving averages were declining and half had been declining 5 months or more. In the June 1949 distribution some series have still longer declines, others, brief rises. The September 1949 distribution is just about equally divided between rises and declines, and the whole distribution is widely dispersed.

To interpret these distributions (ignoring for the moment the identity and timing characteristics of the individual series), they must be viewed in an historical perspective. For this purpose averages are useful, and in Chart 7 the average durations of run

[1] Subsequently the method was applied to the new list of 21 indicators in Table 12 and Chart 6. See *Advanced Management,* August 1950.

[1a] The average duration of run in the original data for some of the series approaches the expected value for a random series, 1.5. Nevertheless, the average durations obtained in the smoothed data, using 7-month moving averages, considerably exceed the expected value, 2.0, for a moving average (of any period) of a random series. This is, of course, a manifestation of the fact that smoothing tends to expose the cyclical elements these series clearly contain.

TABLE A2

Distribution of Fifteen Indicators by Duration of Run in Moving Averages

DURATION OF RUN, MONTHS	June 1948	Dec. 1948	June 1949	Sept. 1949
	NUMBER OF SERIES			
More than +6	1			1
+5 or +6	1	1		1
+3 or +4	5		1	2
+1 or +2	4		3	3
—1 or —2	4	3	3	5
—3 or —4		3	2	1
—5 or —6		7	1	1
More than —6		1	5	1
Total	15	15	15	15
	AV. DURATION OF RUN, MONTHS[1]			
	+2.1	—3.5	—2.5	+0.1

[1] Runs of more than 6 months are counted as runs of 6 months.

for the 15 series 1919-49 are recorded and compared with the percentage expanding curve of Chart 3, which is based in 1919-39 on the specific cycle movements of about 350 series. The larger movements in the two curves are quite similar, but the average duration is more erratic than the percentage expanding. Probably it would be smoother if more series were used; but the difference is partly inherent in the methods of constructing the curves, since the moving averages used in the one method do not smooth out all the irregularities that are ignored in identifying the specific cycles upon which the other method is based.

In view of the irregularities in the average duration of run it is helpful to express it in cumulative form, and in Chart 8 both curves of Chart 7 are plotted in this fashion. The cumulated percentage expanding is derived by first taking the deviations of the percentage expanding in each month from 50 percent, then cumulating the deviations. The excess of the percentage expanding above 50 is a measure of the scope of the expansion in the economy; when this excess declines to zero the expansion can be said to have ceased—contraction balances expansion; and as the expansion percentage declines below 50 the scope of the contraction increases. A positive excess in a given month indicates that economic activity, in general, has attained a higher level than the month before, and the cumulative curve rises; a negative excess indicates that economic activity has receded to a lower level, and the cumulative curve falls. The cumulated average duration may be interpreted similarly, since in computing the average duration the falling series offset the rising series for a given duration of run (and all runs of 6 months or more are counted alike).

The peaks and troughs in the cumulative curves very nearly match the reference peaks and troughs, a result of the fact that the curves of Chart 7 cross their respective base lines on or near the reference dates; this in turn reflects the approximate centering of the alternate clusters of peaks and troughs in the series on the reference dates.[2] Moreover, the cyclical swings in the cumulative curves resemble the swings in various economic aggregates; for example, the FRB index of industrial production. As remarked in Section 6, the amplitude of a cyclical movement in the economy is associated with the extent to which it is diffused throughout the economy. In Chart 8 the FRB index records amplitude, while the slopes of the cumulative curves, into which no measure of the magnitude of a cyclical rise or fall enters, record diffusion. Obviously, the larger the percentage of series that expand during a given cyclical expansion the greater will be the rise in the cumulative curves.

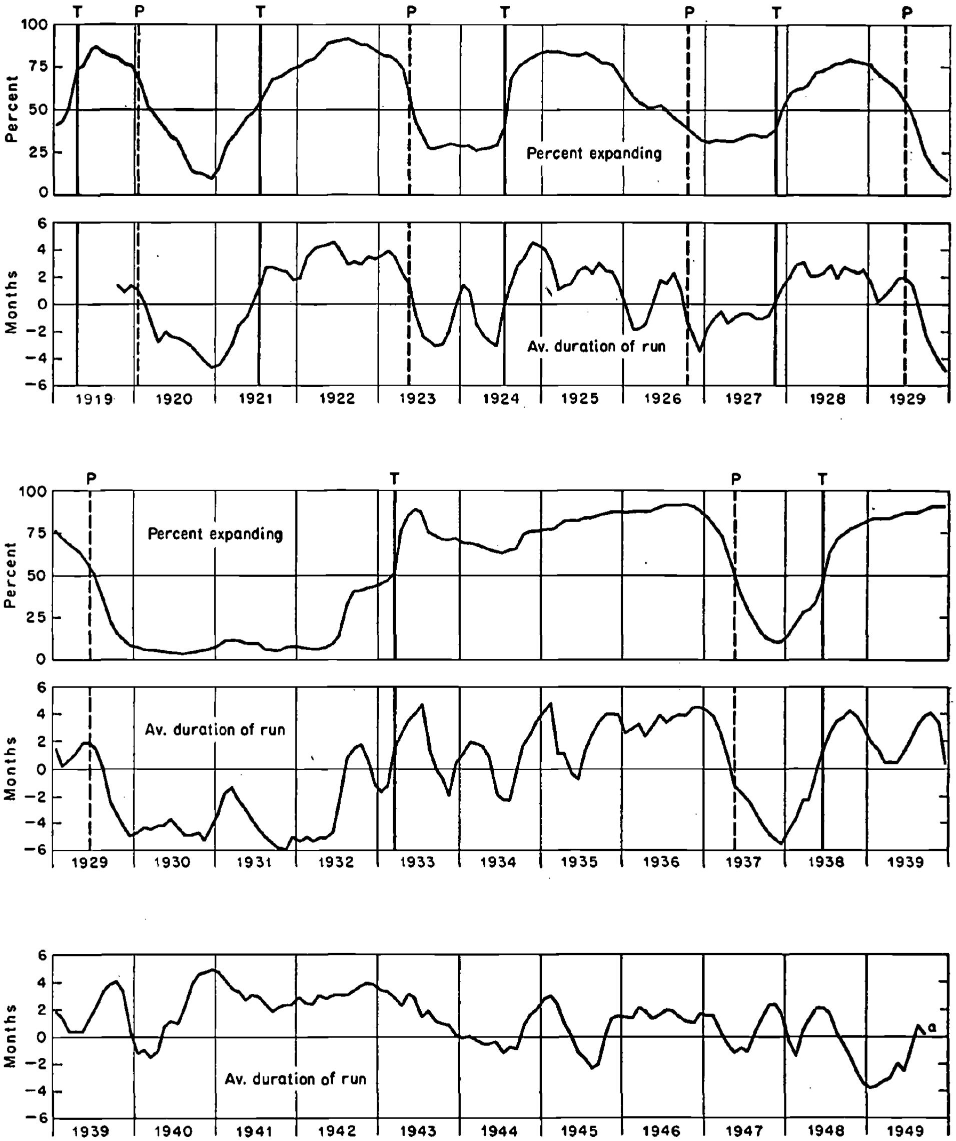
In the noncumulative curves of Chart 7 diffusion is measured by the height reached by the curves during a cyclical expansion and their depth during a cyclical contraction. A rather critical average duration of run for the group of 15 series seems to be about 3 months. In all of the business contractions (the intervals between P and T on the chart) the curve reached the level –3 or lower, as it did at the end of 1948. Moreover, it reached the –3 level fairly early in each contraction. Similar statements might be made about the level +3 and business expansions. The implication is that from a curve of this type one should be able to tell, at a rather early stage, something about the strength or weakness of current cyclical movements in the economy, though the critical level would of course vary with the sample of series.

This potentiality will be enhanced if the processes covered by the sample are classified by their typical timing characteristics. We have divided the 15 series into two groups according to their average timing at business cycle peaks and troughs in 1919-38 (Table A1). One group consists of 7 series whose average timing

[2] The number of series expanding is itself a cumulation of the number of troughs minus the number of peaks (see Sec. 3). Hence the serial distribution of turning points (peaks counted negatively) is the second difference of the cumulated number expanding.

Chart 7
Percentage Expanding, All Series with 'Acceptable' Conformity
Average Duration of Run, 15 Series

(solid vertical lines indicate reference troughs; broken vertical lines, reference peaks)

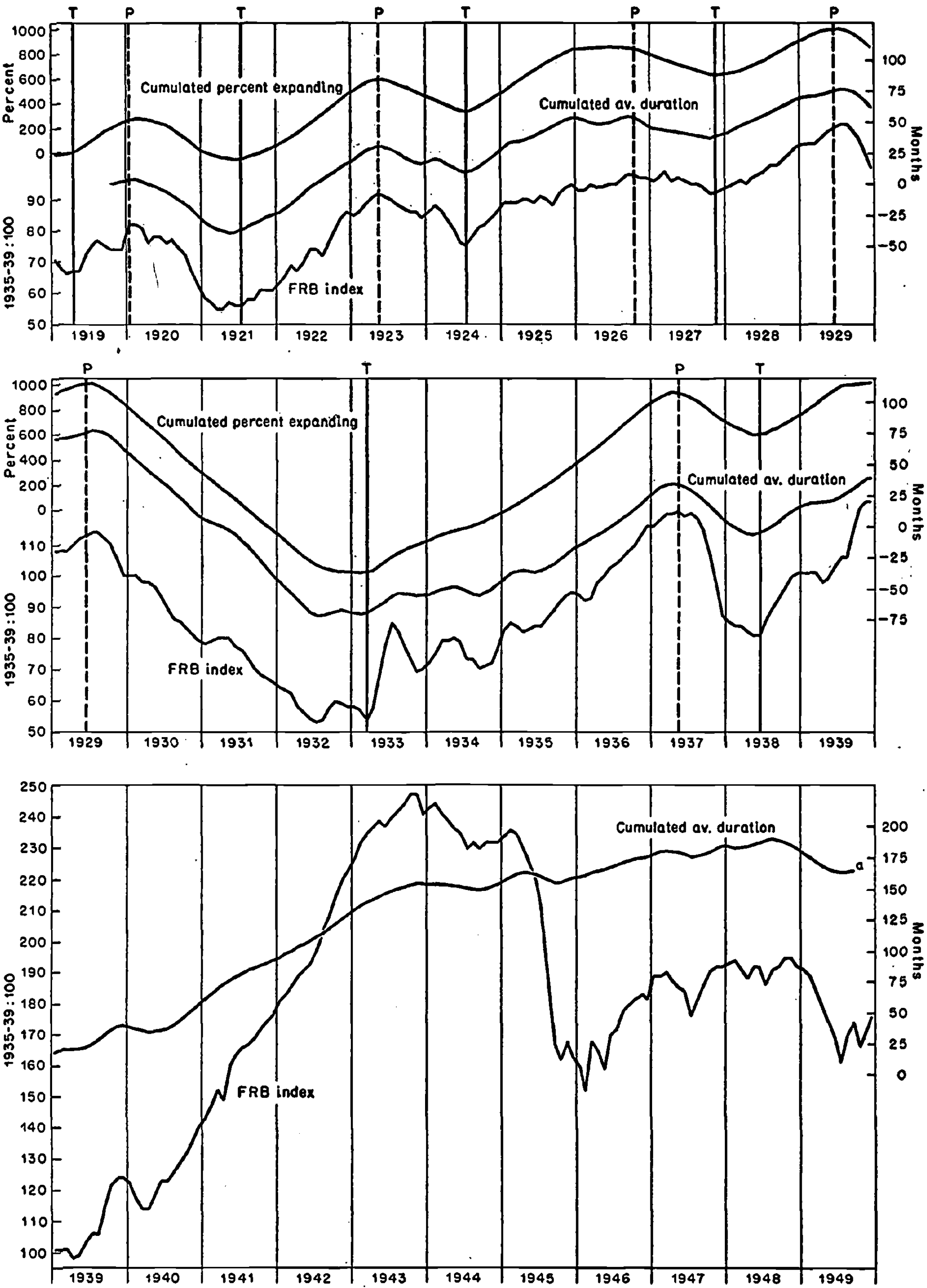


a July-September 1949 partly extrapolated. See text.

Chart 8

Cumulated Percentage Expanding, All Series with 'Acceptable' Conformity
Cumulated Average Duration of Run, 15 Series; FRB Index of Industrial Production

(solid vertical lines indicate reference troughs; broken vertical lines, reference peaks)



a July-September 1949 partly extrapolated. See text.

Table A3

Duration of Run in Moving Averages, Seven Leading and Eight Roughly Coincident Indicators

DURATION OF RUN, MONTHS	JUNE 1948 Leading	JUNE 1948 Roughly coincident	DECEMBER 1948 Leading	DECEMBER 1948 Roughly coincident	JUNE 1949 Leading	JUNE 1949 Roughly coincident	SEPTEMBER 1949 Leading	SEPTEMBER 1949 Roughly coincident
More than +6	Rr. income						Resid. con.[1]	
+5 or +6		Clearings		Steel prod.			Av. hours[1]	
+3 or +4	Tube prod. Stock prices Av. hours	Ton-miles Wh. prices			Resid. con.		Stock prices Bus. fail.[2]	
+1 or +2	Resid. con.	Employment Steel prod. SS index			Rr. income Bus. fail. Av. hours		Rr. income[3]	Employment SS index
—1 or —2	Bus. fail. Indus. con.	FRB index AT&T index		FRB index SS index AT&T index	Tube prod.	SS index Clearings	Indus. con.[2]	Wh. prices FRB index Clearings[2] AT&T index
—3 or —4				Ton-miles Wh. prices Clearings	Stock prices	Ton-miles	Tube prod.[3]	
—5 or —6			Tube prod. Resid. con. Rr. income Stock prices Av. hours Indus. con.	Employment		Steel prod.		Ton-miles
More than —6			Bus. fail.		Indus. con.	Wh. prices Employment FRB index AT&T index		Steel prod.[1]
Average[4]	+2.3	+2.0	—5.3	—2.0	—0.3	—4.4	+2.0	—1.5

See Table A1 for full titles of series.
[1, 2, 3] Moving average extrapolated by extending last month of original data 1, 2, or 3 months, as indicated.
[4] Runs longer than 6 months are counted as runs of 6 months.

ranges from a lead of 6 months to a lead of 2 months, averaging 4 months. The other group consists of 8 series whose average timing ranges from a lead of 1 month to a lag of 1 month, averaging about a half month lead. Thus there is a difference of about three and a half months in the average timing of the two groups.

When frequency distributions of runs are drawn up separately for leading and roughly coincident series (Table A3), some rather striking differences appear. In December 1948 all 7 series in the leading group had been declining 5 months or more, whereas most of the declines in the roughly coincident series were shorter. By June 1949 the position of the two groups was reversed: most of the roughly coincident series showed long declines, whereas some of the leading series exhibited brief rises. In September 1949 the rises in the leading group were further extended, and the long declines in most roughly coincident series had ceased. These shifts reflect differences in the timing of the movements of the two groups, as inspection of the average durations in Chart 9 and the cumulated average durations in Chart 10 makes clear.

During 1920-38 the cumulated average durations have almost precisely the average timing expected of them on the basis of the average (specific cycle) timing of the component series (compare Tables A1 and A4). Indeed, the peaks and troughs in the cumulated durations match rather closely the peaks and troughs in the cumulated percentage expanding, as derived from

TABLE A4

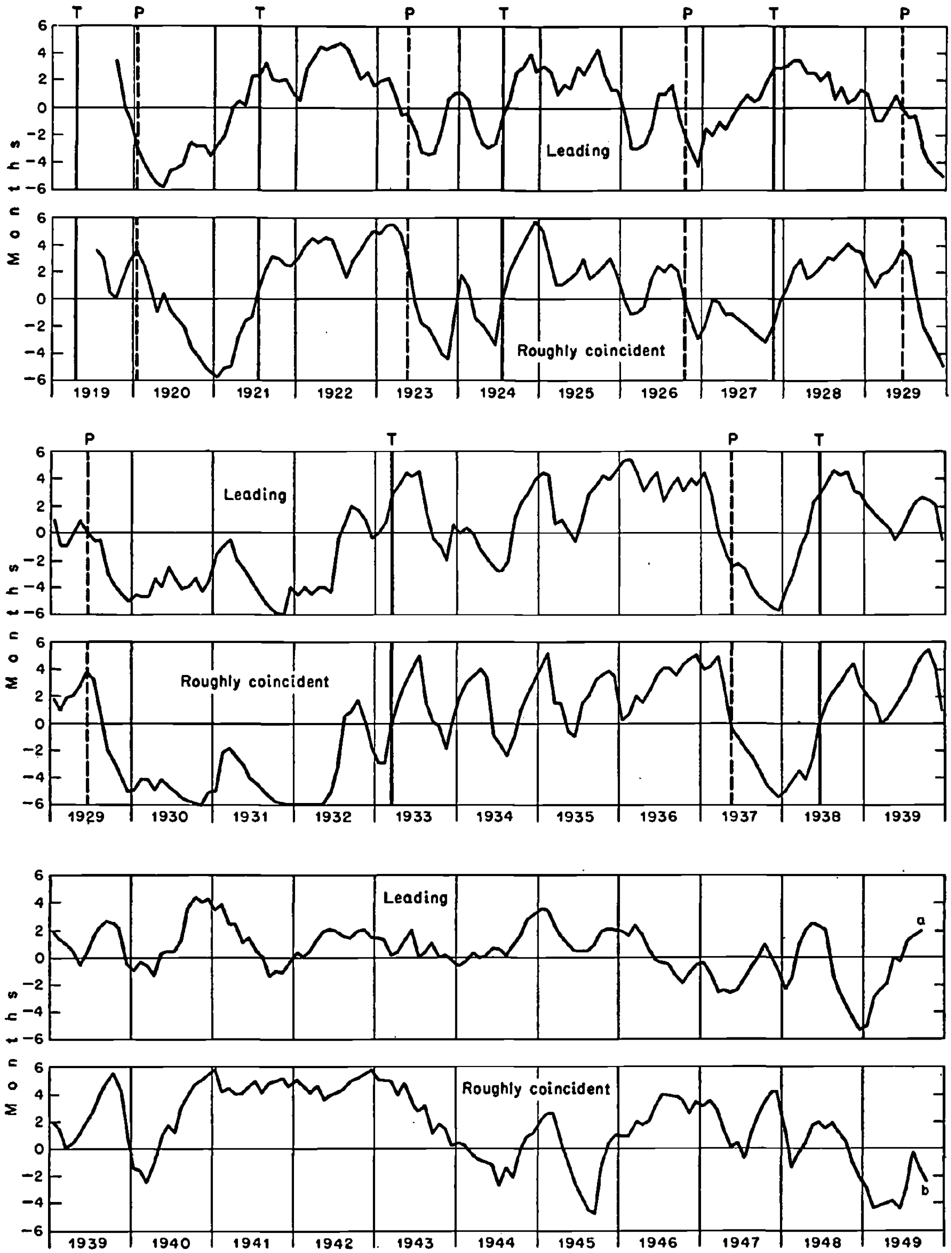
Timing of Cumulated Percentage Expanding and Cumulated Average Duration of Run, Two Groups of Indicators, 1920-1938

REFERENCE TURN	LEAD (—) OR LAG (+) AT REFERENCE TURNS: 7 LEADING SERIES, Cum. % expanding	7 LEADING SERIES, Cum. av. duration	8 ROUGHLY COIN. SERIES, Cum. % expanding	8 ROUGHLY COIN. SERIES, Cum. av. duration
	MONTHS			
Peak, Jan. 1920	—5	—2	+2	+2
Trough, July 1921	—5	—4	0	—1
Peak, May 1923	—1	—2	0	0
Trough, July 1924	—9	0	0	0
Peak, Oct. 1926	—7	—10	—1	—1
Trough, Nov. 1927	—1	—6	0	+1
Peak, June 1929	—4	—5	+2	+2
Trough, Mar. 1933	—8	—8	—1	—1
Peak, May 1937	—3	—2	0	—1
Trough, June 1938	—2	—2	—1	—1
Average	—4.5	—4.1	+0.1	0.0

Chart 9

Average Duration of Run, 7 Leading and 8 Roughly Coincident Series

(solid vertical lines indicate reference troughs; broken vertical lines, reference peaks)

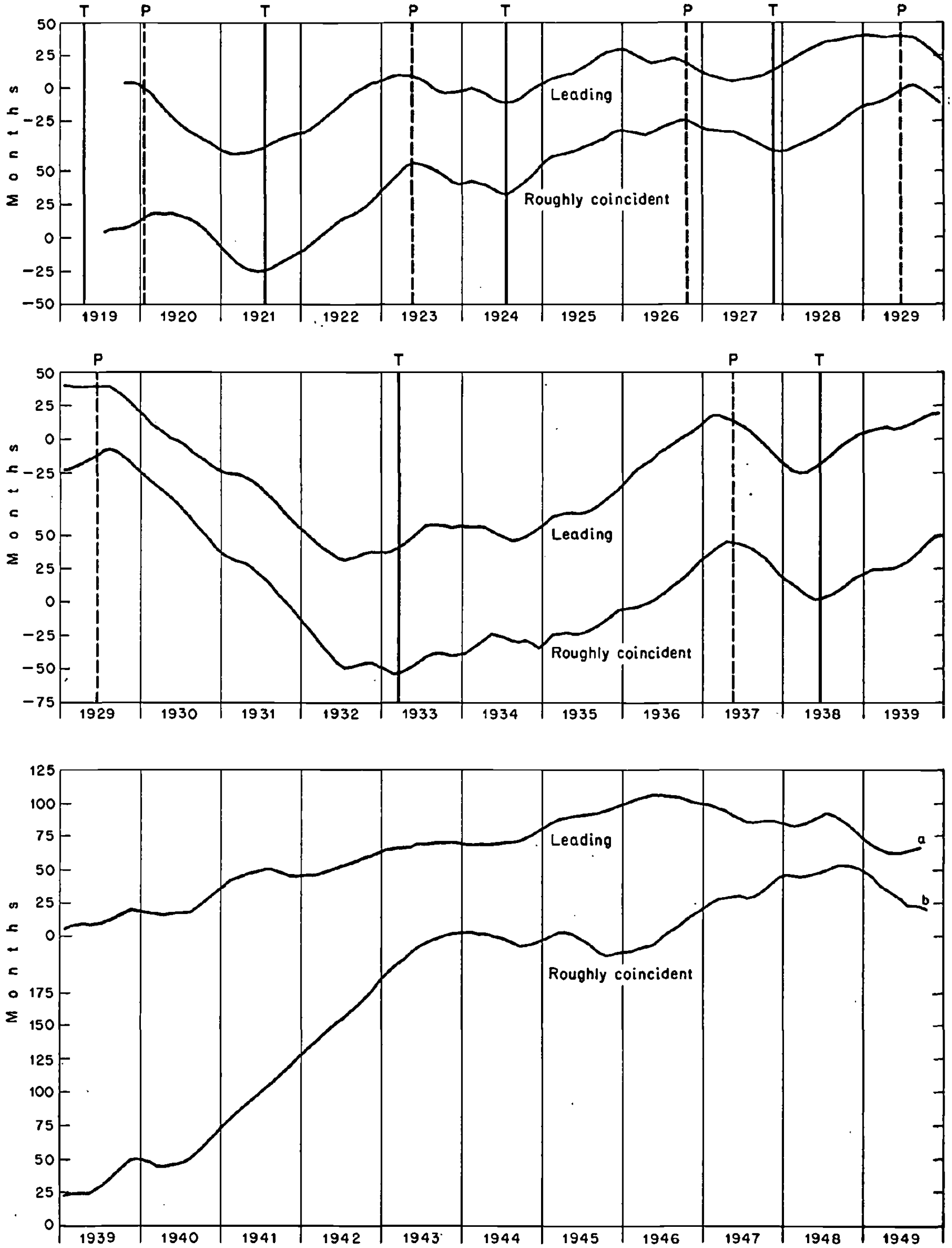


a July-September 1949 partly extrapolated. See text.
b August-October 1949 partly extrapolated. See text.

Chart 10

Cumulated Average Duration of Run, 7 Leading and 8 Roughly Coincident Series

(solid vertical lines indicate reference troughs; broken vertical lines, reference peaks)



a July-September 1949 partly extrapolated. See text.

b August-October 1949 partly extrapolated. See text.

the specific cycle turns in the same groups of series. Clearly the moving averages reflect rather closely, at least for groups of series, the cyclical turns in the series.

The so-called critical level for the average durations of the smaller but more homogeneous samples of series in Chart 9 should be somewhat higher than when the samples are combined, as in Chart 7. In Chart 9 an average duration of 3½ or 4 months, instead of 3 months, might be taken as a fairly critical level. In each contraction the leading group approached this level, –3.5, a few months after the reference peak, and the roughly coincident group usually approached it a month or two later.

The notion of critical levels is an aid in interpreting the average duration curves of Chart 9. Another point to bear in mind is that one curve may serve to confirm or qualify the indications of the other. In this way the chances of being misled by false indications in one curve or the other can be reduced. A case in point is 1947. The average duration for the leading group sagged through 1946, passing the zero level in June and reaching its lowest level, –2.7, the following May. Taken by itself this indicated that a recession was in the offing, though the figures still were not at a critical level. The roughly coincident curve, however, while it showed a sympathetic fluctuation in mid-1947, went below the zero line in only one month, July 1947, and then only slightly below. The price one pays for this sort of check is, of course, delay in the prognosis. But frequently the delay is not long, particularly in comparison with the usual lag in recognizing revivals or recessions after they have begun. In December 1948, for example, both curves seem to indicate rather clearly that a recession of some consequence was in the making, and even before that the curves indicate a weakening of the situation (cf. Sec. 7, note 40).

The use of runs in moving averages is subject to a special difficulty with respect to getting an up-to-date picture, however, since the centered moving averages will not cover the most recent months for which data are available. In the case of a 7-month moving average (the longest period used) the original data cover three months beyond the last moving average value. Nevertheless, since the only information required for measuring runs is the direction of change in the moving average, it should not be difficult to devise a reasonably accurate method of extrapolation. Perhaps a simple autoregressive scheme would be effective. An even simpler method is to extrapolate the last available month of original data (cf. Table A3). This is equivalent to reducing the period of the moving average and centering this average closer to the end of the data than it should be. The general effect, therefore, is to shorten the runs, so the distribution of runs in a group of series may be shifted toward the central values (short runs up or down). Some allowance for this, based on experience with the method under various conditions, can no doubt be made. Further experimentation on this and other features of the method of summarizing the behavior of statistical indicators suggested in this note may lead to improvements.