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CHAPTER 9

Diffusion Indexes, Rates of Change, and Forecasting

Geoffrey H. Moore

In a recent issue of *The American Statistician* (June 1955) Arthur Broida analyzed some of the characteristics of diffusion indexes, especially their relation to rates of change in economic aggregates, and raised some questions concerning their potential value for business forecasting. Coincidentally an analysis of the latter problem by Milton Lipton appeared in *The Business Record* (June 1955) of the National Industrial Conference Board. These contributions prompt me to make some observations.

Diffusion Indexes and Rates of Change

I believe it has been clearly established by the tests we have made at the National Bureau, by the work in Germany at the IFO-Institute, by Lipton's examination of production, price, and sales aggregates,[1] and by Broida's analysis of the Federal Reserve production index that certain types of diffusion indexes, namely those computed by taking directions of change over identical intervals in the components of economic aggregates, are closely correlated with the rates of change in the corresponding aggregates.[2] Under these circumstances it is possible to get a fairly good estimate of the current level of a diffusion index from the corresponding rate of change, or a fairly good estimate of the current rate of change from the corresponding diffusion index, and there are occasions when such estimates are of interest. Millard Hastay, for example, has made use of the latter route in his analysis of the Dun and Bradstreet surveys, where data on anticipations are given only in terms of diffusion indexes.[3] The Munich Institute has done the same thing with their surveys in order to get prompt and relatively inexpensive estimates of aggregates.[4]

Note: Reprinted from *The American Statistician* ("Diffusion Indexes: A Comment"), October 1955.

[1] *The Business Record*, June 1954. See also *Cyclical Diffusion: A New Tool for Business Analysis*, Technical Paper 5, New York, National Industrial Conference Board, 1956.

[2] For further evidence, see Chapters 11 and 18; Bert Hickman, "An Experiment with Weighted Indexes of Cyclical Diffusion," *Journal of the American Statistical Association*, March 1958; and Sidney S. Alexander, "Rate of Change Approaches to Forecasting—Diffusion Indexes and First Differences," *Economic Journal*, June 1958.

[3] Millard Hastay, "The Dun and Bradstreet Surveys of Businessmen's Expectations," *Proceedings of the Business and Economic Statistics Section, American Statistical Association*, September 10–13, 1954.

[4] Oskar Anderson, Jr., "The Business Test of the IFO-Institute for Economic Research, Munich, and Its Theoretical Model," *Review of the International Statistical Institute*, 1952, Vol. 20, No. 1, pp. 1–17.

Nevertheless, one must not forget that a high correlation is not the same as an identity; there may be systematic and significant differences between highly correlated variables. Broida's paper raises the question, at least implicitly, what these differences, if any, are, and hence whether there is any point in compiling diffusion indexes when economic aggregates and their rates of change are readily available. I think there are good reasons for doing so.

One of the fundamental features of our economic system is that economic movements spread from one firm to another, from one industry to another, from one region to another, and from one economic process to another. Moreover, these spreading movements cumulate over time. This being so, it is desirable to have measures showing how this spreading and cumulation goes on. A diffusion index is just such a measure. The rate of change in the usual sort of aggregate is not, even though it may be closely correlated with a diffusion index. This follows from the fact that the rate of change in an aggregate is independent of the economic units or components into which the aggregate may conceivably be divided and among which the spreading and cumulation of economic change goes on; the rate of change can be computed without specifying the unit, the diffusion index cannot. In other words, one cannot construct a diffusion index without deciding whether the unit should be the firm, the industry, the region, or the economic process. It therefore focuses attention on the economic entities whose activities are added up to form an aggregate.

More than that, a diffusion index focuses attention on the interrelations among these activities, for it provides a simple measure of intercorrelation. For example, we have found that diffusion indexes for output and employment in durable goods industries have larger amplitudes than indexes for nondurable goods industries. That is, at any given time during expansions in business activity, relatively more durable goods industries are expanding and during contractions more are contracting than in the case of nondurable goods industries. This is a direct observation to the effect that the durable goods industries tend to keep in step with one another more closely than the nondurables. This behavior clearly has an effect on the movement of aggregate indexes of output or employment in durable goods and in nondurable goods; it contributes to the more rapid rates of change typically shown by durable goods indexes. But from the rates of change in the aggregate indexes themselves it would be a most uncertain inference that the movements in the durable goods industries are more closely intercorrelated than those in the nondurable goods industries, for it is also true that most individual durables show wider relative changes than nondurables, and *this* might be responsible for the behavior of the aggregates. On the other hand, the less rapid rates of change in the nondurable industries could not be responsible for the

behavior of the diffusion indexes, since they are constructed without reference to the size of the change in the component industries.[5]

As this example illustrates, diffusion indexes have enabled us to discover and establish certain facts about the behavior of the economy that we had not found by rather extensive studies of rates of change in economic aggregates. Another example: our studies of diffusion indexes support the broad statement that the scope of a business cycle expansion or contraction invariably diminishes toward the end of the expansion or contraction. In our experience the factual evidence would not warrant a similar statement regarding rates of change in most economic aggregates; the evidence, particularly for expansions, is far more equivocal and conflicting.[6] Again, we have found from study of diffusion indexes that the scope of a contraction in its early stages is roughly correlated with the magnitude of the contraction. Perhaps something similar is true for the rates of change in the various available aggregates—after all, they are correlated with diffusion indexes. But I believe that some analytical significance attaches to the finding apart from whether the phenomenon is reflected in rates of change. For instance, it underlines the importance of policies that promptly have a *general* effect on the economy, as well as the importance of knowing how general the effects of various types of policy are.

It is possible, too, that consideration of the kind of information utilized in diffusion indexes will contribute to the further development of certain business cycle theories, such as the acceleration principle, which has

[5] A somewhat different use of diffusion indexes is in testing whether the behavior of a weighted average is due to shifts in the weights. For example, average hourly earnings in manufacturing, if derived by dividing total earnings by total man-hours, may decline during a cyclical contraction because man-hours in the durable goods industries, where rates per hour are typically higher, decline relative to nondurable goods industries. The unweighted diffusion index will indicate whether earnings generally went up or went down.

[6] One reason for the difficulty is that rates of change in aggregates are often so irregular that some means of smoothing the aggregate must be used. But if this is accomplished by means of a moving average, the "rounding bias" that such averages produce around a peak or trough tends to reduce the rate of change in the neighborhood of the turn and cause it to "lead." The diffusion index, on the other hand, is free of this bias, even if the components from which it is computed are smoothed by moving averages. The reason is that the bias applies to the magnitude of change, not its direction, and diffusion indexes take account only of direction. For an example of this effect, see Chapter 19, Chart 19.1 and accompanying text.

Some observations on the difficulties of reaching a conclusion with respect to the cyclical patterns in rates of change may be found in Burns and Mitchell, *Measuring Business Cycles*, pp. 157–160, 251–252, 343–349. Factual evidence on the matter is provided in Thor Hultgren, *American Transportation in Prosperity and Depression*, New York, NBER, 1948, pp. 157–163; Moses Abramovitz, *Inventories and Business Cycles*, New York, NBER, 1950, Chapter 15; Wesley C. Mitchell, *What Happens during Business Cycles*, New York, NBER, 1951, pp. 296–305; Geoffrey H. Moore, "Business Cycles and the Labor Market," reprinted here, Chapter 16; and Ruth P. Mack, *Consumption and Business Fluctuations*, New York, NBER, 1956.

ordinarily been formulated and tested in terms of the rate of change in aggregate output. For it seems likely that, insofar as business firms vary their investment with the rate of change in output, it is the rate of change in their own output, not that in aggregate output, to which they react. And since the reaction to a decrease in output cannot, in general, be equal and opposite to the reaction to an increase in output, it is important to know something about the distribution of increases and decreases among firms.[7] A diffusion index may not provide all the required information, but it does supplement significantly the information provided by the rate of change in aggregate output.

The relationships between diffusion indexes and rates of change are far from simple, and one cannot always make a choice, as Broida appears to do, in favor of the rate of change simply because it includes information that is not utilized in the diffusion index. The additional information may obscure rather than clarify (see note 6), or it may be more useful when considered separately from the information provided by a diffusion index. Indeed, as I have already noted, it is equally true that a diffusion index contains additional information, information that cannot be inferred from the rate of change. Clearly, however, we need to know more about these relationships. In the course of our researches a number of puzzling phenomena have appeared. Some are illustrated in Chart 9.1.

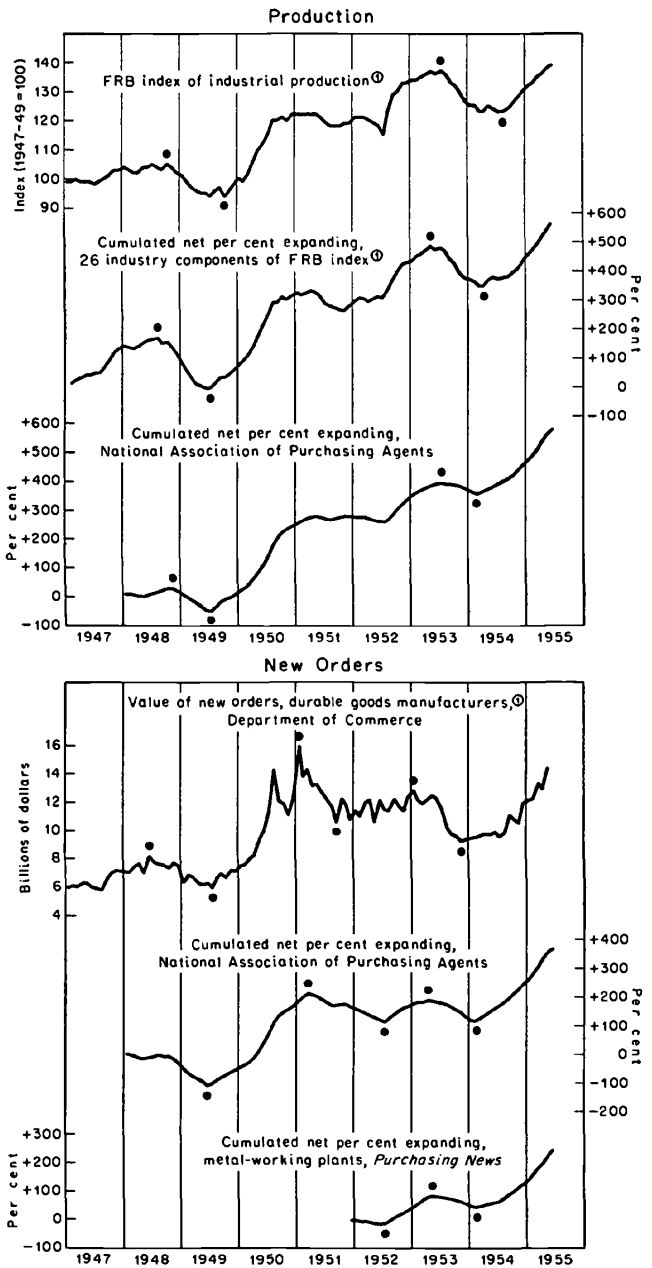
Here the diffusion indexes are plotted in cumulative form, for readier comparison with the related aggregates (alternatively, the first differences might be compared—i.e. the diffusion index proper with the rate of change in the aggregate). For production two types of diffusion index are presented, one with the firm and the other with the industry as the unit; for new orders, the firm is the unit. The production diffusion index based on the twenty-six industry components of the FRB index is perhaps a trifle smoother than the corresponding aggregate, and its cyclical turns are more sharply defined. The earlier turns in the cumulated diffusion index than the aggregate index are probably accidental; we have observed no such tendency in the interwar period.

The production diffusion index computed from individual firm reports (obtained by the National Association of Purchasing Agents) is notably smoother than the industry diffusion index or the production index, though it faithfully reproduces the cyclical swings. A similar freedom from erratic movements is exhibited by the diffusion indexes for new orders, especially in comparison with the Department of Commerce aggregate. It is curious, too, that the purchasing agents' surveys show no regular

[7] See Arthur F. Burns' review of Hicks' theory of the trade cycle, reprinted in *The Frontiers of Economic Knowledge*, Princeton for NBER, 1954, pp. 248–250. Also, Bert G. Hickman, "Diffusion, Acceleration, and Business Cycles," *American Economic Review*, September 1959.

CHART 9.1

Diffusion Indexes and Economic Aggregates, Production and Orders



① Adjusted for seasonal variation.

● Specific cycle peaks and troughs.

The cumulated net per cent expanding is obtained by cumulating from month to month the excess (+ or −) of the per cent increasing over the per cent decreasing.

seasonal variations.[7a] Whence these differences between aggregates and diffusion indexes? Various hypotheses might be offered and investigated, but until this is done I should not regard the differences as trivial, even from the standpoint of business forecasting, which was Broida's main concern.

Diffusion Indexes and Business Forecasting

Broida and Lipton both reach somewhat negative conclusions as to the value of diffusion indexes for business forecasting. Broida bases his case largely on the ground that "historical" diffusion indexes—which seem to have useful properties for forecasting—cannot be reproduced currently, while "current" diffusion indexes do not have any more forecasting value than the rate of change in aggregates, which isn't much. Lipton examines the behavior of a "current" diffusion index during 1921–39, and finds that its erratic fluctuations "tended to obscure whatever lead it evidenced at business cycle turning points," although it did "successfully mark each of the nine turning points." He concludes that "the diffusion index, while admittedly an imperfect mechanism for forecasting cyclical fluctuations, is a useful analytical tool for identifying current and near-term business trends."

The National Bureau's investigations of diffusion indexes have as their basic objective the discovery and verification of significant generalizations about business cycle phenomena. If such generalizations are discovered, they ought to be useful in forecasting. But there is often a long and tortuous road between scientific generalization and successful practical application, and even the ultimate application may not come to much.

I have already indicated some of the generalizations about the behavior of diffusion indexes that are suggested by the evidence so far assembled. The two most important, in my judgment, are: (1) cyclical expansions or contractions in aggregate activity diminish in scope before they come to an end; (2) contractions that ultimately become severe are widespread in their early stages. Much of the evidence for these generalizations is presented in my paper, "The Diffusion of Business Cycles" (Chapter 8). In the end they may or may not prove of much help to the practical forecaster and they may, of course, be modified or extended in the course of further investigation.

Apart from this, there are a few points that the practical forecaster should bear in mind as he studies Broida's and Lipton's evaluations. Broida draws a distinction between "historical" and "current" diffusion indexes. Various devices have enabled us to approximate, on a "current" basis, the so-called "historical" indexes based on the identification of

[7a] Since this report was prepared a perceptible seasonal pattern in the new orders survey has been found. See Volume II, diffusion index D 4.3.

TABLE 9.1

Timing of Production Diffusion Indexes at Business Cycle Peaks and Troughs, 1920–38, 1948–54

Type of Turning Point	Date of Business Cycle Turn[a]	*Date of Specific Turn in Production Diffusion Indexes*		*Lead of Production Diffusion Indexes at Business Cycle Turns (months)*	
		"Historical"	"Current"	"Historical"	"Current"
Peak	Jan. 1920	July 1919	July 1919	−6	−6
Trough	July 1921	Dec. 1920	Sep. 1920	−7	−10
Peak	May 1923	Nov. 1922	June 1922	−6	−11
Trough	July 1924	June 1924	June 1924	−1	−1
Peak	Oct. 1926	Dec. 1924	Dec. 1924	−22	−22
Trough	Nov. 1927	Sep. 1927	Sep. 1927	−2	−2
Peak	June 1929	Nov. 1928	Aug. 1928	−7	−10
Trough	Mar. 1933	Feb. 1932	Aug. 1930	−13	−31
Peak	May 1937	June 1936	Oct. 1936	−11	−7
Trough	June 1938	Oct. 1937	Dec. 1937	−8	−6
Peak	Nov. 1948		Nov. 1947		−12
Trough	Oct. 1949		Feb. 1949		−8
Peak	July 1953		Sep. 1952		−10
Trough	Aug. 1954		Sep. 1953		−11

SOURCE: "The Diffusion of Business Cycles" (Chapter 8), Table 8.2. Entry for 1954 has been added.

[a] NBER chronology; the peak of February 1945 and the trough of October 1945 are omitted.

specific cycle turns in individual component series. None of these devices is fully successful in reproducing exactly any given "historical" index. But this does not preclude the possibility that diffusion indexes can be constructed that will enable one to make judgments as to what the comparative scope of the current cyclical movement is and whether it is increasing or receding—judgments that will correspond at least broadly to those that historical materials will subsequently provide. If these questions can be answered affirmatively, there is some hope that the generalizations mentioned above may be applied in practice.

I do not presume to know the final answer to these questions, but I do see grounds for optimism. For example, Table 8.2 in "The Diffusion of Business Cycles" (Chapter 8) shows the timing at successive business cycle turns over a twenty-five-year period of a group of "historical" diffusion indexes and a group of "current" indexes. I believe the entries for the two groups are broadly similar from cycle to cycle, and both show a tendency to lead the turn in aggregate activity by six months to a year, as is suggested by Table 9.1 which gives the results for the production diffusion indexes. The "current" index is based on month-to-month

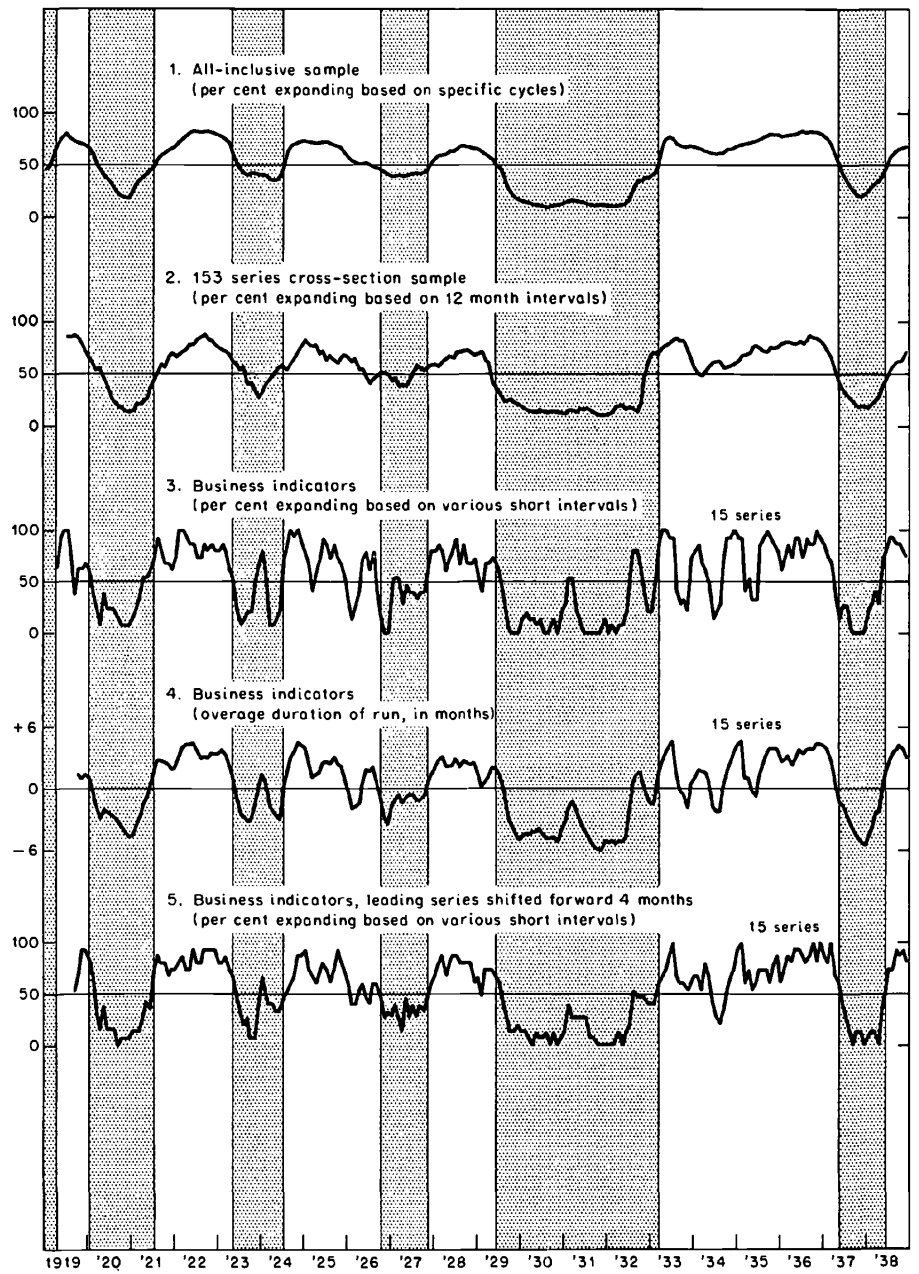
directions of change in the seasonally adjusted industry components of the FRB index; hence it can be computed as currently as the index itself. Possibly these timing entries overstate the similarity between the two types of indexes; there are also very considerable differences between them. But there is at least this basic resemblance, which a practical forecaster may seek to improve upon.

Some devices that may assist him in this process, which demonstrate further the affinity between "historical" and "current" indexes, are illustrated in Chart 9.2. At the top is the historical index *par excellence*, an index based on specific cycles identified in 705 time series covering a wide variety of types of economic activity. The next line is constructed from 153 series covering a similar variety of activities. Here a series is said to be "expanding" in a given month if its level six months later is higher than its level six months earlier. That is, the entries are based on the familiar comparison with the same month of the previous year, and are centered in the middle of the interval. This too is an "historical" index—at least, it is always six months out of date because of the centering. But note also that it need never be more than six months out of date, aside from lags in publication of data. Moreover, although "six months ago" may seem like history to a forecaster, he may find it worth-while to give up some degree of currency in his information in exchange for other valuable considerations, many of which are evident in the chart.

The third line illustrates the use of shorter intervals than twelve months for determining whether a series is expanding or contracting, and the use of different intervals for different series. The shorter interval permits more up-to-date results, but at the price of greater erratic fluctuations in the index (the smaller number of series than in the top two indexes is also a factor). The varying interval (shorter intervals for smoother series) helps to prevent widespread erratic fluctuations, such as might be caused by a strike, from influencing the index, and hence contributes to its smoothness.

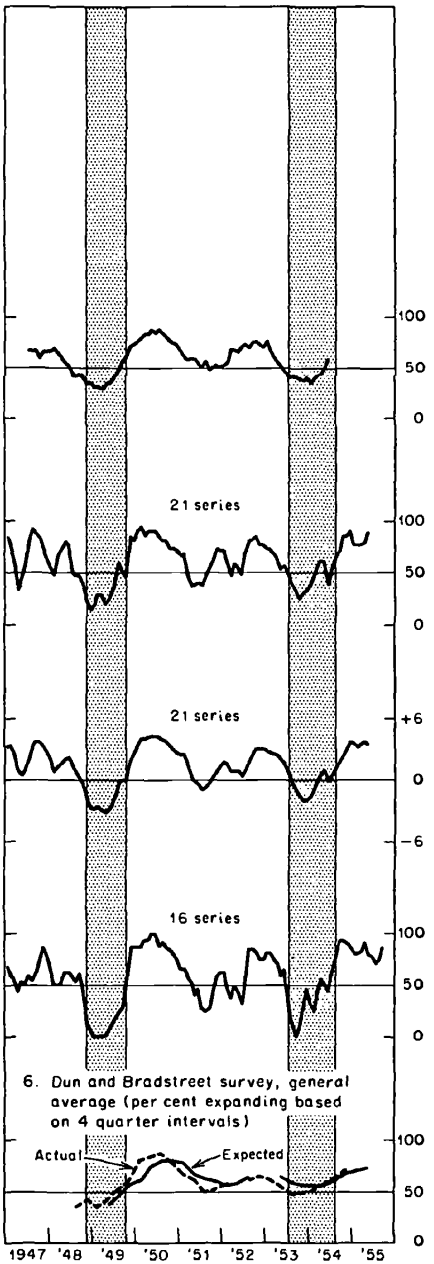
The fourth line illustrates the average duration of run device, which was used by Lipton in his evaluation. This type of index is ordinarily somewhat smoother than the simple percentage expanding based on the same data, but is more complicated to compute and to explain, and it often lags by a month or two behind the latter. The reason for the lag is implicit in the theory underlying the duration of run statistic. In the simple percentage expanding each successive change in a given series from month to month (or longer interval if that is used) is accorded equal weight; in effect, a rise is counted $+1$, a decline -1, and the sum of the rises divided by the number of series is the proportion expanding. In the duration of run, the changes that occur later in a run of changes in the same direction are given greater weight, since longer runs are presumed

CHART 9.2
"Historical" and "Current" Diffusion Indexes



Shaded areas represent contractions of business cycles; unshaded areas, expansions.

CHART 9.2 (concluded)



to be more indicative of cyclical movements in the series. That is, the first rise is called a run of +1, the second +2, etc., while successive declines are designated −1, −2, etc. The average of these entries for a given month for the group of series is the average duration of run. The greater weight given to later movements produces the lag.[8]

Another scheme, suggested by Milton Friedman, is shown in line 5. Here a group of series that tend to lead in business cycle movements are shifted forward by the amount of their average lead (four months), and combined with a group that typically move together with aggregate activity. One of its merits is that the shifting spreads the impact of short-run fluctuations that affect many series at the same time, so that the diffusion index is smoother than it would be otherwise. Insofar as the leading series are faithful precursors of the other series, such an index can be extrapolated forward a few months on the basis of the former alone.

The bottom pair of lines on the chart demonstrate still another device for constructing current diffusion indexes: the anticipation survey. Dun and Bradstreet make a survey every quarter of a sample of manufacturing concerns, wholesalers, and retailers. They ask whether sales, orders, employment, prices, profits, and inventories are up or down in the current quarter as compared with the same quarter a year ago. The general average of these results (omitting inventories), in terms of the percentage reporting increases, is the line labeled actual. Each point is plotted in the middle of the four-quarter interval over which the comparison is made, just as in the 153 series index. The survey also asks about expected results in terms of a comparison of the second quarter ahead with the same quarter a year earlier. This result too we have centered in the middle of the year. Consequently the actual and expected points plotted at a given date refer to comparisons of the same quarters, although the expected figure was available six months earlier than the actual. Now the actuals trace a course that is very similar to that followed by the 153 series index. The expecteds do so also, although they display a tendency to lag behind the actuals by about one quarter, so that the effective gain is cut in half. Some experimental work now going forward may make it possible to increase this gain.

Taken together, the various "current" indexes shown in the chart

[8] It is partly in an effort to reduce this lag that we have counted durations of run of more than six months as runs of six months in computing the average for the selected group of indicators. Without such a restriction, a long-continued rise in a single series might prevent the average from becoming negative despite widespread and sustained declines in the other series. Indeed, since the runs are used because they are taken to be an index of cyclical movements, there is no point in extending the numerical value of the run indefinitely once the cyclical movement is established. We have arbitrarily taken that point to be established at a run of six months in data smoothed by moving averages according to the scheme used for the business indicators; for data not smoothed in this fashion the six-month point would presumably be less appropriate (or at least have a different significance).

illustrate an important principle. Individual index numbers are fallible, but they are also, to a degree, consilient. Diffusion indexes are no exception. Consequently it is well to be guided by a number of them rather than any single one. Armed with a workable set of diffusion indexes covering different economic sectors and utilizing various techniques,[9] the analyst may eventually be able to make judgments on the scope of current movements that will not only stand the test of history but actually assist him in his appraisal of future prospects.

This assistance, I may add, may not come in the form of specific quantitative forecasts of the levels that will be reached by specific economic aggregates on specific future dates. It may merely serve to confirm or to modify some judgments or assumptions that he had already formulated on the basis of other information. Or it may be helpful only when there is an extended period of uncertainty as to the direction of business trends. There is room for many contributions of these varied kinds to the problem of business forecasting and my guess is that students of diffusion indexes will make their share of them as we learn more about how to construct and interpret them. Although they may not enable us to take the whole measure of the business cycle, it is challenging, at least, to have another dimension to work with.

[9] See Chapter 3.