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STOCK-MARKET "PATTERNS" AND FINANCIAL ANALYSIS: METHODOLOGICAL SUGGESTIONS

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INTRODUCTION

OF ALL ECONOMIC time series, the history of security prices, both individual and aggregate, has probably been most widely and intensively studied. While financial analysts agree that underlying economic facts and relationships are important, many also believe that the history of the market itself contains "patterns" that give clues to the future, if only these patterns can be properly understood. The Dow theory and its many offspring are evidence of this conviction. In extreme form such theories maintain that *only* the patterns of the past need be studied, since the effect of everything else is reflected "on the tape."

A common and convenient name for analysis of stock-market patterns is "technical analysis." Perhaps no one in the financial world completely ignores technical analysis—indeed, its terminology is ingrained in market reporting—and some rely intensively on it. Technical analysis includes many different approaches, most requiring a good deal of subjective judgment in application. In part these approaches are purely empirical; in part they are based on analogy with physical processes, such as tides and waves.

In light of this intense interest in patterns and of the publicity given to statistics in recent years, it seems curious that there has not been widespread recognition among financial analysts that the patterns of technical analysis may be little, if anything, more than a statistical artifact. At least, it is safe to say that the close resemblance between market behavior over relatively long time periods and that of simple chance devices has escaped general attention,

* I am indebted to Lawrence West and Arnold Moore for help in the preparation of this paper.

though the role of chance variation in very short time periods has often been recognized. One possible explanation is that the usual method of graphing stock prices gives a picture of successive *levels* rather than of *changes,* and levels can give an artificial appearance of "pattern" or "trend." A second is that chance behavior itself produces "patterns" that invite spurious interpretations.

More evidence for this assertion about stock-market behavior is still needed, but almost all the fragmentary evidence known to me is consistent with it. The major published evidence from recent years is a paper about British stock indexes (and American commodity prices) by the British statistician, M. G. Kendall, which appeared in 1953.[1] I have done similar, though less comprehensive, work with recent American data, for both indexes and individual companies, which has been entirely consistent with Kendall's findings. If, for example, weekly *changes* of the Dow Jones Index are examined statistically, it is apparent that these changes behave very much as if they had been generated by an extremely simple chance model. The history of market *levels* behaves very much as if levels had been generated by a *cumulation* of results given by the chance model.

These general conclusions have been reached, probably repeatedly, long before Kendall's study. Thus Holbrook Working, writing in 1934, said:

> It has several times been noted that time series commonly possess in many respects the characteristics of series of cumulated random numbers. The separate items in such time series are by no means random in character, but the changes between successive items tend to be largely random. This characteristic has been noted conspicuously in sensitive commodity prices. . . . King has concluded that stock prices resemble cumulations of purely random changes even more strongly than do commodity prices.[2]

Indeed, the main reason for this paper is to call to the attention of financial analysts empirical results that seem to have been ignored in the past, for whatever reason, and to point out some methodological implications of these results for the study of securities.

From the point of view of the scholar, much more research is needed to establish more precisely the limits to which these generalizations can be carried. For example, do they apply to changes for periods other than weekly? (In my own explorations they have

1. Maurice G. Kendall, "The Analysis of Economic Time Series. I," *Journal of the Royal Statistical Society* (Ser. A), CXVI (1953), 11–25.

2. Holbrook Working, "A Random-Difference Series for Use in the Analysis of Time Series," *Journal of the American Statistical Association,* XXIX (1934), 11.

worked fairly well for both longer and shorter periods.) How well do they apply to individual securities? (Most work has been done on indexes.) What slight departures from the chance model are detectable? Perhaps the traditional academic suspicion about the stock market as an object of scholarly research will be overcome, and this work will be done.[3] This paper, however, is concerned with the methodological problems of the financial analyst who cannot afford to ignore evidence that is easily obtainable from the most casual empirical analysis. From his point of view there should be great interest in the possibility that, to a first approximation, stock-market behavior may be statistically the simplest, by far, of all economic time series.

This paper will describe the chance model more precisely, discuss briefly the common-sense interpretation of the model, and outline a number of methodological suggestions for financial analysts.

The Chance Model

Kendall found that changes in security prices behaved nearly as if they had been generated by a suitably designed roulette wheel for which each outcome was statistically independent of past history and for which relative frequencies were reasonably stable through time. This means that, once a person accumulates enough evidence to make good estimates of the relative frequencies (probabilities) of different outcomes of the wheel, he would base his predictions only on these relative frequencies and pay no attention to the pattern of recent spins. Recent spins are relevant to prediction only insofar as they contribute to more precise estimates of relative frequencies. In a gambling expression, this roulette wheel "has no memory."

The chance model just described insists on independence but makes no commitment about the relative frequencies, or probabilities, of different outcomes except that these must be stable over time. A frequency distribution of past changes is a good basis for estimating these probabilities, so long as the independence assumption holds. For concreteness in demonstration, we shall assume that weekly changes of a particular index behave as if they were independent observations on a normal distribution, with mean +0.5 and standard deviation 5.0. The details of constructing such a roulette wheel need not concern us here. We shall, in fact, employ for our purpose a published table of random numbers that can be modified easily to

3. Holbrook Working has worked for many years on the behavior of commodities markets, and full publication of his findings is still forthcoming.

conform to the specifications stated above.[4] Assuming that the series starts at 450, we obtain a hypothetical year's experience graphed in Figures 1 and 2.

To even a casual observer of the stock market, Figure 2 is hauntingly realistic, even to the "head-and-shoulders" top. Probably all the classical patterns of technical analysis can be generated artificially by a suitable roulette wheel or random-number table. Figure 1 gives much less evidence of patterns, although intensive and imaginative scrutiny would undoubtedly suggest some. The only *persistent*

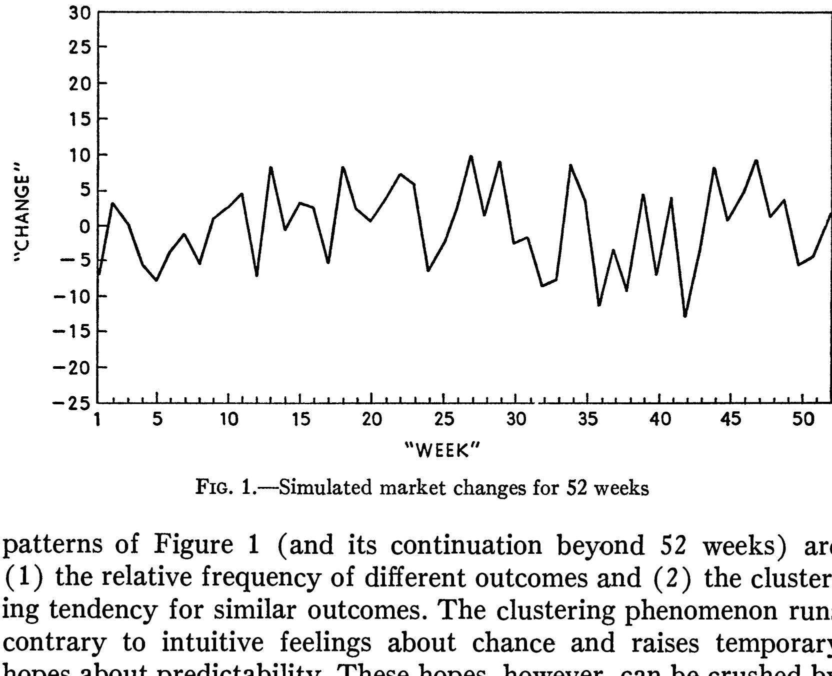

FIG. 1.—Simulated market changes for 52 weeks

patterns of Figure 1 (and its continuation beyond 52 weeks) are (1) the relative frequency of different outcomes and (2) the clustering tendency for similar outcomes. The clustering phenomenon runs contrary to intuitive feelings about chance and raises temporary hopes about predictability. These hopes, however, can be crushed by theoretical analysis that shows clustering to give no information beyond that contained in the relative frequencies.

Figures 3 and 4 give the corresponding diagrams for the Dow Jones Industrial Index for 1956. The general resemblance between Figures 3–4 and Figures 1–2 is unmistakable, although no pains were taken to devise a "roulette" wheel that would simulate closely the actual history of 1956. The major difference in detail between Figures 1 and 3 is that Figure 3 shows greater dispersion. We prob-

4. The RAND Corporation, *A Million Random Digits with 100,000 Normal Deviates* (Glencoe, Ill.: Free Press, 1955).

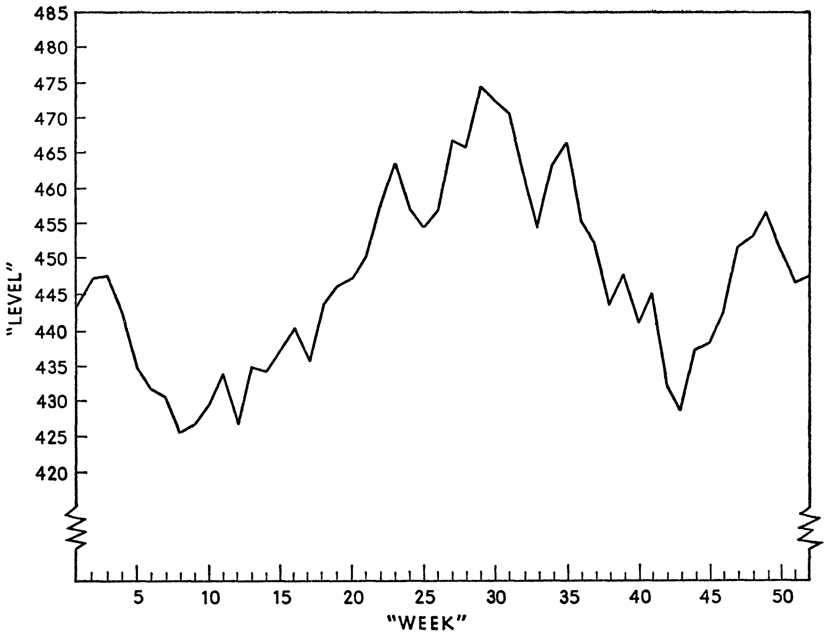

FIG. 2.—Simulated market levels for 52 weeks

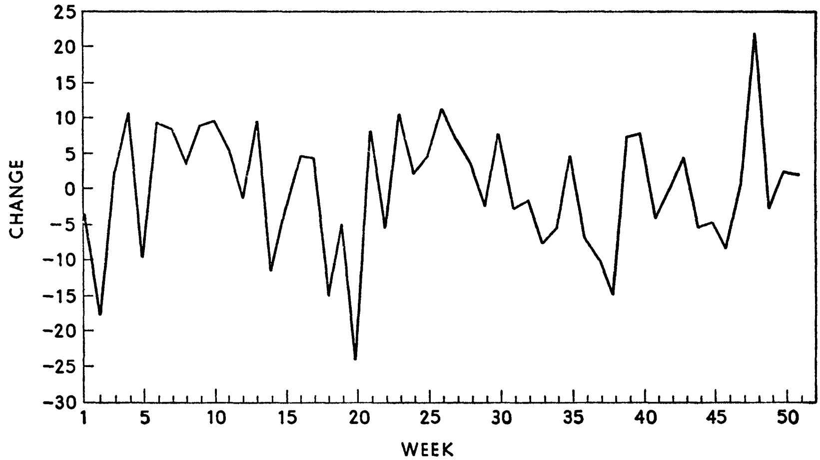

FIG. 3.—Changes from Friday to Friday (closing) January 6, 1956—December 28, 1956. Dow Jones Industrial Index.

ably could have imitated Figure 3 more closely by using a somewhat larger standard deviation than 5 in constructing the artificial series. It is well, however, to avoid giving the wrong impression by showing *too* striking a parallel in all details. Two artificial series constructed by precisely the same method typically differ from each other just as would two brothers or two years of market history. To put it differently, the chance model cannot duplicate history in any sense other than that in which one evening in a gambling casino duplicates an-

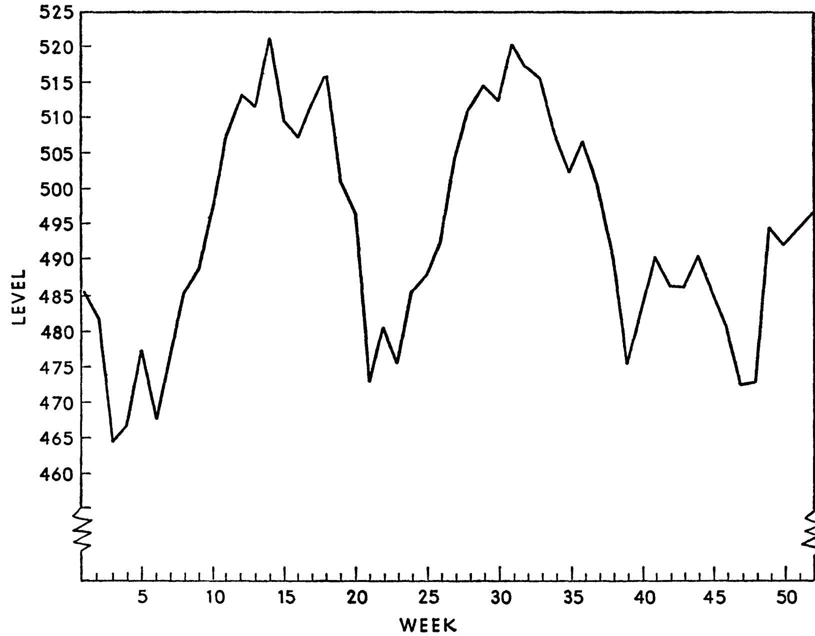

FIG. 4.—Friday closing levels, December 30, 1955—December 28, 1956. Dow Jones Industrial Index.

other. For relatively short periods of history like 52 weeks, there can be substantial differences. In fact, however, the dispersion of Figure 3 is almost surely greater than that of Figure 1 by more than we would expect from the same chance mechanism. We subsequently obtained a better simulation by using a standard deviation of 7 rather than 5.

MEANING OF THE CHANCE MODEL

There are two common reactions to this chance model: (1) while "chance" may be important in extremely short-run stock-market movements, it is inconceivable that the longer-term movement should be a cumulation of short-term "chance" development; (2) once one reflects on the situation, it is obvious that a simple chance model must hold. We shall discuss each reaction briefly.

The first reaction stems partly from a misunderstanding of the term "chance." The chance model of the previous section was meant to illustrate the possibility of constructing a simple mechanical device that would duplicate many of the characteristic features of stock-market movements. Even if the statistical behavior of the market and the mechanical device were completely indistinguishable, it might still be possible to attain a degree of predictability better than that given by knowledge of past relative frequencies alone. To attain such predictability, however, more would be needed than the past history of market prices: e.g., economic theory and knowledge of economic facts might suggest relationships of market prices with other economic variables that might be of predictive value. It seems more likely that economic analysis could give predictive insight into stock-market behavior than that physical analysis could help with a real roulette wheel. Even completely deterministic phenomena, such as the decimal expansions of irrational numbers (e.g., e and π), appear to be "chance" phenomena to an observer who does not understand the underlying mechanism. Phenomena that can be described only as "chance" today, such as the emission of alpha particles in radioactive decay, may ultimately be understood in a deeper sense.

In another sense the reaction against "chance" is sound. Much more empirical work is needed, and it seems likely that departures from simple chance models will be found—if not for stock-market averages, then for individual stocks; if not for weekly periods, then for some other period; if not from the independence assumption, then from the assumption of a stable underlying distribution; etc. Indeed, the analytical proposals of this paper are based on the assumption that such departures will occasionally be found. Holbrook Working has discovered such departures in his commodity market research.[5]

As to the second reaction, that the chance model is obvious, there is a plausible rationale. "If the stock market behaved like a mechanically imperfect roulette wheel, people would notice the imperfections and by acting on them, remove them." This rationale is appealing, if for no other reason than its value as counterweight to the popular view of stock market "irrationality," but it is obviously incomplete.

5. Holbrook Working, "New Ideas and Methods for Price Research," *Journal of Farm Economics,* XXXVIII (1956), 1427–36.

For example, why should not observation of market imperfection lead to greater imperfection rather than less? All we can do is to suggest the importance of the study of such questions.

Suggestions for Financial Analysis

This section is devoted to statistical suggestions to financial analysts and others who make their living by the study of the market. The fundamental suggestion, of course, is to analyze price *changes* as well as price *levels*. Initially, the weekly change seems worth using, but other time periods may also be useful. This suggestion seems trivial, but it is not. If the simple chance hypothesis is correct, then the statistical behavior of changes, which are independent, is much simpler than that of levels, which are not. There already exists, for example, a body of statistical techniques for analysis of independent data: in fact, modern statistical theory has been largely built up on the assumption of independence. Much of it also assumes, as we did for convenience in the artificial example, that the underlying distribution is a normal distribution in the technical sense of that term. The assumption of normality usually seems far less crucial to the applicability of statistical methods than does that of independence, and some statistical techniques, called "non-parametric," do not make the normality assumption.

If one graphs weekly changes without any formal statistical analysis, he will have taken the most important single step. So long as the stock or stock index behaves like a reasonably good roulette wheel, the visual impression will be similar to that of Figures 1 and 3. If there is a really fundamental shift in the underlying situation, it can be detected visually more readily by an analysis of changes than of levels. Conversely, if there has been no fundamental shift, a graph of changes will be much less likely to give the impression that there has been a shift.

There are formal statistical techniques to supplement visual analysis (though never to replace it entirely, since graphical study is always partial insurance against misapplication of statistical analysis). The most popular field of applied statistics—industrial quality control—draws on these techniques extensively. Though there would undoubtedly be many differences in detail, a financial analyst should find much of interest and relevance in methods of quality control.[6]

6. W. Allen Wallis and Harry V. Roberts, *Statistics: A New Approach* (Glencoe, Ill.: Free Press, 1956), chaps. 16, 18; A. Hald, *Statistical Theory with Engineering Applications* (New York: John Wiley & Sons, Inc., 1952), chap. 13; Eugene L. Grant, *Statistical Quality Control* (rev. ed.; New York: McGraw-Hill Book Co., Inc., 1952).

We shall illustrate briefly how these ideas might be applied in financial analysis. For concreteness, we begin with the data given graphically in Figure 3.

1. The first question is that of independence: Can we regard these weekly changes as independent? Purely to illustrate one test of independence, we shall apply a test based on runs above and below zero. If we denote a positive change by "+" and a negative change by "—", Figure 3 yields the following sequence of +'s and —'s.

− − + + − + + + + + + − + − − + + − − − + − + + + + + +
− + − − − − + − − − + + − − + − − − + + − + +

A "run" is a consecutive sequence of the same symbol: e.g., — —, + +, —, and + + + + + + are the first four runs. We count 24 runs, which does not differ significantly from the expected number of 26.41.[7]

There are many tests for independence, and experience will show the most useful ones for this kind of application. I would guess that the mean-square successive difference[8] would prove useful. This has the virtue of providing a descriptive measure of the degree of independence or dependence, as well as a test that gives simply an all-or-none verdict or a significance level. A slight degree of dependence may not invalidate subsequent analysis of the kind proposed here, while substantial dependence may open the way for forecasts that exploit the observed pattern, just as one might do by careful study of a defective roulette wheel.

The idea of "rational subgroups" commonly used in industrial practice may be useful,[9] particularly in relating changes for different intervals of time, such as days and weeks.

2. If substantial dependence is found, it may be directly useful for forecasting, using the well-known methods of autoregression. Dependence may also suggest useful avenues for investigation. A sharp jump in the level of price changes for a particular stock, for example, might be found to coincide with a change in management. The company's history since that change would then be the object of an analysis like that described in the preceding paragraph.

3. If a close approximation to independence is found for any moderately large number of weeks (say at least 52, as a rule of thumb), set up "control limits" to aid visual analysis in the future.

7. For mechanical details see Wallis and Roberts, *op. cit.*

8. *Ibid.*

9. Grant, *op. cit.*

These limits can be calculated in many ways.[10] If a point falls outside the control limits, this gives a signal for the analyst to search for an explanation beyond the series itself: e.g., company developments, economic changes, governmental actions. So long as points stay within the limits, there is no need for special attention, although there may also be supplemental warning signals based on gradual shifts that cause trends but do not immediately throw points outside control limits. There will be risks of failing to search when a search is warranted and of searching when nothing is to be found. These risks can be evaluated and the control limits determined accordingly. The aim of the procedure is to economize the time of the financial analyst, who cannot possibly be simultaneously in close contact with the many individual companies that he must be familiar with. It should tend to avoid the numerous false signals that are so strongly suggested by examination of levels rather than changes.

This outline of statistical procedure is meant only to be suggestive. The general nature of the statistical attack is obvious, but the details will be supplied with practical experience guided by sound statistical theory. It may be found, for example, that it is wiser to analyze changes of logarithms or square roots of levels than absolute changes, especially when long periods of time are examined. But much is to be gained simply by viewing a familiar problem from a new vantage point, and minor statistical refinements or blemishes may not be crucial.

These statistical suggestions are only a preliminary to the real work of the financial analyst, which extends far beyond the tape itself and draws on knowledge and skills, including statistical knowledge and skills, that are not discussed here. There is every reason to believe, however, that this method of looking at the tape will facilitate all that takes place afterward. Further statistical analysis, such as multiple regression, will be sounder if based on independent changes rather than dependent levels. Judgment and intuition will proceed more soundly if not hindered by an unnecessary grappling with market "patterns."

10. Wallis and Roberts, *op. cit.*; Hald, *op. cit.*; and Grant, *op. cit.*