Random Walks in Stock Market Prices

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For many years economists, statisticians, and teachers of finance have been interested in developing and testing models of stock price behavior. One important model that has evolved from this research is the theory of random walks. This theory casts serious doubt on many other methods for describing and predicting stock price behavior—methods that have considerable popularity outside the academic world. For example, we shall see later that if the random walk theory is an accurate description of reality, then the various “technical” or “chartist” procedures for predicting stock prices are completely without value.

In general the theory of random walks raises challenging questions for anyone who has more than a passing interest in understanding the behavior of stock prices. Unfortunately, however, most discussions of the theory have appeared in technical academic journals and in a form which the non-mathematician would usually find incomprehensible. This article describes, briefly and simply, the theory of random walks and some of the important issues it raises concerning the work of market analysts. To preserve brevity some aspects of the theory and its implications are omitted. More complete (and also more technical) discussions of the theory of random walks are available elsewhere; hopefully the introduction provided here will encourage the reader to examine one of the more rigorous and lengthy works listed at the end of this article.

COMMON TECHNIQUES FOR PREDICTING STOCK MARKET PRICES

In order to put the theory of random walks into perspective we first discuss, in brief and general terms, the two approaches to predicting stock prices that are commonly espoused by market professionals. These are (1) “chartist” or “technical” theories and (2) the theory of fundamental or intrinsic value analysis.

The basic assumption of all the chartist or technical theories is that history tends to repeat itself, i.e., past patterns of price behavior in individual securities will tend to recur in the future. Thus the way to predict stock prices (and, of course, increase one’s potential gains) is to develop a familiarity with past patterns of price behavior in order to recognize situations of likely recurrence.

Essentially, then, chartist techniques attempt to use knowledge of the past behavior of a price series to predict the probable future behavior of the series. A statistician would characterize such techniques as assuming that successive price changes in individual securities are dependent. That is, the various chartist theories assume that the sequence of price changes prior to any given day is important in predicting the price change for that day.

The techniques of the chartist have always been surrounded by a certain degree of mysticism, however, and as a result most market professionals have found them suspect. Thus it is probably safe to say that the pure chartist is relatively rare among stock market analysts. Rather the typical analyst adheres to a technique known as fundamental analysis or the intrinsic value method. The assumption of the fundamental analysis approach is that at any point in time an individual security has an intrinsic value (or in the terms of the economist, an equilibrium price) which depends on the earning potential of the security. The earning potential of the security depends in turn on such fundamental factors as quality of management, outlook for the industry and the economy, etc.

Through a careful study of these fundamental factors the analyst should, in principle, be able to determine whether the actual price of a security is above or below its intrinsic value. If actual prices tend to move toward intrinsic values, then attempting to determine the intrinsic value of a security is equivalent to making a prediction of its future price; and this is the essence of the predictive procedure implicit in fundamental analysis.

THE THEORY OF RANDOM WALKS

Chartist theories and the theory of fundamental analysis are really the province of the market

professional and to a large extent teachers of finance. Historically, however, there has been a large body of academic people, primarily economists and statisticians, who adhere to a radically different approach to market analysis—the theory of random walks in stock market prices. The remainder of this article will be devoted to a discussion of this theory and its major implications.

Random walk theorists usually stray from the premise that the major security exchanges are good examples of "efficient" markets. An "efficient" market is defined as a market where there are large numbers of rational, profit-maximizers actively competing, with each trying to predict future market values of individual securities, and where important current information is almost freely available to all participants.

In an efficient market, competition among the many intelligent participants leads to a situation where, at any point in time, actual prices of individual securities already reflect the effects of information based both on events that have already occurred and on events which, as of now, the market expects to take place in the future. In other words, in an efficient market at any point in time the actual price of a security will be a good estimate of its intrinsic value.

Now in an uncertain world the intrinsic value of a security can never be determined exactly. Thus there is always room for disagreement among market participants concerning just what the intrinsic value of an individual security is, and such disagreement will give rise to discrepancies between actual prices and intrinsic values. In an efficient market, however, the actions of the many competing participants should cause the actual price of a security to wander randomly about its intrinsic value. If the discrepancies between actual prices and intrinsic values are systematic rather than random in nature, then knowledge of this should help intelligent market participants to better predict the path by which actual prices will move towards intrinsic values. When the many intelligent traders attempt to take advantage of this knowledge, however, they will tend to neutralize such systematic behavior in price series. Although uncertainty concerning intrinsic values will remain, actual prices of securities will wander randomly about their intrinsic values.

Of course intrinsic values can themselves change across time as a result of new information. The new information may involve such things as the success of a current research and development project, a change in management, a tariff imposed on the industry's product by a foreign country, an increase in industrial production or any other actual or anticipated change in a factor which is likely to affect the company's prospects.

In an efficient market, on the average, competition will cause the full effects of new information on intrinsic values to be reflected "instantaneously" in actual prices. In fact, however, because there is vagueness or uncertainty surrounding new information, "instantaneous adjustment" really has two implications. First, actual prices will initially overadjust to changes in intrinsic values as often as they will underadjust. Second, the lag in the complete adjustment of actual prices to successive new intrinsic values will itself be an independent, random variable with the adjustment of actual prices sometimes preceding the occurrence of the event which is the basis of the change in intrinsic values (i.e., when the event is anticipated by the market before it actually occurs) and sometimes following.

This means that the "instantaneous adjustment" property of an efficient market implies that successive price changes in individual securities will be independent. A market where successive price changes in individual securities are independent is, by definition, a random walk market. Most simply the theory of random walks implies that a series of stock price changes has no memory—the past history of the series cannot be used to predict the future in any meaningful way. The future path of the price level of a security is no more predictable than the path of a series of cumulated random numbers.

It is unlikely that the random walk hypothesis provides an exact description of the behavior of stock market prices. For practical purposes, however, the model may be acceptable even though it does not fit the facts exactly. Thus although successive price changes may not be strictly independent, the actual amount of dependence may be so small as to be unimportant.

What should be classified as unimportant depends, of course, on the question at hand. For the stock market trader or investor the criterion is obvious: The independence assumption of the random walk model is valid as long as knowledge of the past behavior of the series of price changes cannot be used to increase expected gains. More specifically, if successive price changes for a given security are independent, there is no problem in timing purchases and sales of that security. A simple policy of buying and holding the security will be as good as any more complicated mechani-
Empirical Evidence on Independence

Over the years a number of empirical tests of the random walk theory have been performed; indeed, so many that it is not possible to discuss them adequately here. Therefore in describing the empirical evidence we limit ourselves to a brief discussion of the different approaches employed and the general conclusions that have evolved.

The main concern of empirical research on the random walk model has been to test the hypothesis that successive price changes are independent. Two different approaches have been followed. First there is the approach that relies primarily on common statistical tools such as serial correlation coefficients and analyses of runs of consecutive price changes of the same sign. If the statistical tests tend to support the assumption of independence, one then infers that there are probably no mechanical trading rules or chartist techniques, based solely on patterns in the past history of price changes, which would make the expected profits of the investor greater than they would be with a simple buy-and-hold policy. The second approach to testing independence proceeds by testing directly different mechanical trading rules to see whether or not they provide profits greater than buy-and-hold.

Research to date has tended to concentrate on the first or statistical approach to testing independence; the results have been consistent and impressive. I know of no study in which standard statistical tools have produced evidence of important dependence in series of successive price changes. In general, these studies (and there are many of them) have tended to uphold the theory of random walks. This is true, for example, of the serial correlation tests of Cootner, Fama, Kendall, and Moore. In all of these studies, the sample serial correlation coefficients computed for successive price changes were extremely close to zero, which is evidence against important dependence in the changes. Similarly, Fama's analysis of runs of successive price changes of the same sign, and the spectral analysis techniques of Granger and Morgenstern, and Godfrey, Granger, and Morgenstern also support the independence assumption of the random walk model.

We should emphasize, however, that although the statistical techniques mentioned above have been the common tools used in testing independence, the chartist or technical theorist probably would not consider them adequate. For example, he would not consider either serial correlations or runs analyses as adequate tests of whether the past history of series of price changes can be used to increase the investor's expected profits. The simple linear relationships that underlie the serial correlation model are much too unsophisticated to pick up the complicated "patterns" that the chartist sees in stock prices. Similarly, the runs tests are much too rigid in their manner of determining the duration of upward and downward movements in prices. In particular: in runs-testing, a run is considered as terminated whenever there is a change in sign in the sequence of successive price changes, regardless of the size of the price change that causes the change in sign. The chartist would like to have a more sophisticated method for identifying movements—a method which does not always predict the termination of the movement simply because the price level has temporarily changed direction.

These criticisms of common statistical tools have not gone unheeded, however. For example, Alexander's filter technique is an attempt to apply more sophisticated criteria to the identification of moves. Although the filter technique does not correspond exactly to any well-known chartist theory, it is closely related to such things as the Dow Theory. Thus, the profitability of the filter technique can be used to make inferences concerning the potential profitability of other mechanical trading rules.

A filter of, say, 5 percent is defined as follows: if the daily closing price of a particular security moves up at least 5 percent, buy and hold the security until its price moves down at least 5 percent from a subsequent high, at which time simultaneously sell and go short. The short position is maintained until the daily closing price rises at least 5 percent above a subsequent low, at which time one should simultaneously cover and buy. Moves less than 5 percent in either direction are ignored.

It is, of course, unnecessary to limit the size of the filter to 5 percent. In fact, Professor Alexander has reported tests of the filter technique for filters...
mitting their performance to a rigorous comparison with a random selection procedure.

**CONCLUSION**

In sum the theory of random walks in stock market prices presents important challenges to both the chartist and the proponent of fundamental analysis. For the chartist, the challenge is straightforward. If the random walk model is a valid description of reality, the work of the chartist, like that of the astrologer, is of no real value in stock market analysis. The empirical evidence to date provides strong support for the random walk model. In this light the only way the chartist can vindicate his position is to show that he can consistently use his techniques to make better than chance predictions of stock prices. It is not enough for him to talk mystically about patterns that he sees in the data. He must show that he can consistently use these patterns to make meaningful predictions of future prices.

The challenge of the theory of random walks to the proponent of fundamental analysis, however, is more involved. If the random walk theory is valid and if security exchanges are "efficient" markets, then stock prices at any point in time will represent good estimates of intrinsic or fundamental values. Thus, additional fundamental analysis is of value only when the analyst has new information which was not fully considered in forming current market prices, or has new insights concerning the effects of generally available information which are not already implicit in current prices. If the analyst has neither better insights nor new information, he may as well forget about fundamental analysis and choose securities by some random selection procedure.

In essence, the challenge of the random walk theory to the proponent of fundamental analysis is to show that his more complicated procedures are actually more profitable than a simple random selection policy. As in the case of the chartist, the challenge is an empirical one. The analyst cannot merely protest that he thinks the securities he selects do better than randomly selected securities; he must demonstrate that this is in fact the case.

**FOOTNOTES**

1. Probably the best known example of the chartist approach to predicting stock prices is the Dow Theory.
6. Fama, "The Behavior of Stock Market Prices."
10. Alexander, "Price Movements in Speculative Markets: Trends or Random Walks, Number 2."
12. Fama, "The Behavior of Stock Market Prices."