THE ABILITY OF *THE VALUE LINE INVESTMENT SURVEY* TO FORECAST "PROBABLE TWELVE MONTHS MARKET PERFORMANCE RANK"

by

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ABSTRACT

In the thesis the author attempts to discover whether or not The Value Line Investment Survey shows evidence of an ability to forecast "Probable Twelve Months Market Performance Rank," a ranking of stocks according to their probable relative price performance within the succeeding twelve months. To test the ability to forecast, the author determines the significance of the correlation between the ranking of stocks according to the forecast and the ranking of stocks according to the observed relative price performance within the year. The conclusion drawn is that The Value Line Investment Survey does not show evidence of a consistent ability to forecast "Probable Twelve Months Market Performance Rank."

The author also presents a model of the process which may underly the generation of stock market price changes. The author tests the assumption of the independence of price changes, a part of the model, on the data of the thesis and finds that the test results do not refute the assumption. The model, the "Random Walk Hypothesis," is related to the ability of The Value Line Investment Survey to forecast "Probable Twelve Months Market Performance Rank." It is concluded that The Value Line Investment Survey has failed to show that its forecasts are superior to forecasts based solely on past prices where the market is assumed to follow a random walk.

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CHAPTER I

INTRODUCTION

It is the purpose of this paper to present the method and findings of a research project [1] undertaken to test the ability of The Value Line Investment Survey [2] to forecast "Probable Twelve Months Market Performance Rank"[3] (hereafter called "predictions"). The findings are interpreted, and then related to the "Random Walk Hypothesis," a model which may describe the generation of market price changes.

Chapter II describes the method used by The Value Line Investment Survey to make "predictions" which are primarily based on a calculated "intrinsic value." This method is then compared with some generally received procedures for appraising the values of stocks.

In Chapter III the method and findings of the author's research project are presented. The project adopts rank correlation methods to compare different rankings of a set of stocks.

In Chapter IV the findings of the study are interpreted to determine the ability of The Value Line Investment Survey to forecast.

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[1] The research project was conducted by the author in 1965 on data for the period 1961 to 1964.

[2] The Value Line Investment Survey, New York, Arnold Bernhard & Co., Inc. (a weekly publication).

[3] A ranking of stocks according to their probable relative market price performance within the succeeding twelve months.

In Chapter V the "Random Walk Hypothesis" is discussed. Some earlier findings concerning the adequacy of the hypothesis to describe actual stock price changes are presented. A test of the independence assumption for stock price changes, which is part of the "Random Walk Hypothesis," is carried out on the findings of the research project. The "Random Walk Hypothesis" is then related to the study of The Value Line Investment Survey's ability to "predict."

The conclusion follows; it includes some inferences made in the earlier chapters and discusses further some subjects already considered.

The present study should be of interest to those persons wishing to adopt the forecasts of short-run price changes as presented in The Value Line Investment Survey. It should also serve students interested in a description of the random walk hypothesis of stock market price changes.

CHAPTER II

METHOD USED BY THE VALUE LINE INVESTMENT SURVEY TO FORECAST "PROBABLE TWELVE MONTH MARKET PERFORMANCE RANK"

The method used in *The Value Line Investment Survey*since November 1957 to forecast "Probable Twelve Months Market Performance Rank" is to assign ranks to stocks according to the ratio of the most recent 52-week average price of the stock to its "Value Line Rating of Intrinsic Value" projected 12 months ahead. ("Intrinsic value" is described as "the average price for a 12 month period that is statistically determined to be the normal price in relation to the subject stock's dividend-paying ability in that year.") [1]

The "intrinsic value" is obtained by performing a multiple correlation analysis [2] on a group of similar "quality" [3] stocks and applying the results to the particular stock. The correlation is performed on time series data for approximately 20 years. In the analysis, price is considered to depend upon earnings, dividends, past price, and a market sentiment factor.

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[1] Arnold Bernhard, *The Evaluation of Common Stocks*, (New York, Simon and Schuster, 1959), p. 120.

[2] Although described as a multiple correlation analysis by Bernhard, the analysis should more fittingly be described as a regression analysis as "intrinsic value" is assumed to depend upon the values of the other variables involved.

[3] "Quality" refers to a composite index of past performance in growth and stability of earnings and dividends. For a derivation of the "quality" index see Arnold Bernhard, *The Evaluation of Common Stocks*, pp. 41-57.

The relationship formulated is that the independent variable, the logarithm of the annual average price for the group, is dependent upon the regressor variables, the logarithms of:

A. A fraction of average annual earnings, which is combined with average annual dividends, where the fraction is determined by the ratio of the standard deviation in the dividends to the standard deviation in the earnings for the period considered.[4]

B. The annual average lagged price (the annual average of prices in the preceding year).

C. The annual mean yields of 45 "representative" stocks[5] over the period considered.

Once the net regressor coefficients for the group have been determined they are applied as weighting factors to the similar variables for the particular stock in arriving at the stock's "intrinsic value."

The logarithm of the "Value Line Rating of Intrinsic Value" for a particular stock is calculated by weighting, with the appropriate net regressor coefficients (obtained from the group multiple correlation analysis), the variables of:

1. a combination of earnings and dividends projected 12 months ahead, where earnings are multiplied by a ratio (the ratio of the standard deviation in earnings of the particular stock for

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[4]The fraction, Bernhard states, (Arnold Bernhard, The Evaluation of Common Stocks, p. 99) tends to "equalize the variations in the earnings and dividend series."

[5]The yields are included as a market sentiment factor.

a 10 year period) before being combined with dividends, and

2. the present average annual price,

and combining them together with a constant which is for the particular stock equal to a 10-year average of its log price, minus the appropriate net regressor coefficient [6] times the 10-year average of log lagged price, minus the appropriate net regressor coefficient times the 10-year average of log combined earnings and dividends. [7]

The market sentiment factor (the average yield of 45 representative stocks) is not included in arriving at the "Value Line Rating of Intrinsic Value" for a particular stock "since market sentiment is held constant." [8]

Once the "Rating of Intrinsic Value" for all the stocks considered is determined, the stocks are ranked according to the ratio of the 52-week average price of the stock to its "Rating of Intrinsic Value," to arrive at the forecast of "Probable Twelve Months Market Performance Rank."

It should be noted that the ranks are not based solely on past information. To arrive at "intrinsic value," both earnings and dividends must be projected for a year into the future and the results of the projection used in the formula.

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[6]The appropriate net regressor coefficient is the net regressor coefficient of the similar variable determined for the group analysis.

[7]Earnings are multiplied by the ratio of the standard deviation of dividends to the standard deviation of earnings for the particular stock for a 10 year period before being added to dividends.

[8]Arnold Bernhard, The Evaluation of Common Stocks, p. 106.

The method for arriving at "intrinsic value" differs in form rather than substance from another generally accepted method for appraising stock values. Graham, Dodd and Cottle [9] assume that the basic components in common-stock valuation are:

1. The expected future earnings.
2. The expected future dividend.
3. The capitalization rate - or multiplier - of dividends and earnings.
4. The asset value.

They present a model for the valuation of common stocks which is:

$$V = M(D + \frac{1}{3} E) + A$$ [10]

where:

V is the value of the stock.

M is the earnings multiplier assumed appropriate for the type of stock.

D is the expected dividend.

E is the Expected earnings.

A is an adjustment for asset value if necessary.

In both methods, once the values of the parameters (based on "quality" factors) have been determined, it still remains to project both earnings and dividends for the coming year.

The choice of projecting earnings rather than or together with

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[9] B. Graham, D. Dodd and S. Cottle, Security Analysis, 4th ed. (New York, McGraw-Hill Book Company, Inc., 1962).

[10] Ibid., p. 518.

dividends for a period as indicated by Sauvain [11] serves only as a short-cut to the valuation of stocks based on a consideration of all future dividends. A method which does treat of all future dividends and which is generally considered more theoretically sound than the methods already considered is the J.B. Williams [12] model. Williams assumes that the intrinsic value of a stock is equal to the present value of all future dividends. [13] The model may be adjusted to take into account the risk of divergence from expected values in the stream of dividends. The model, although theoretically sound, is difficult, if not impossible, to apply, as it is impossible to project the expected dividends for all future years.

A procedure more generally applied than any of the preceding is simply to multiply a price earnings ratio (often the average price earnings ratio of the stock for that year) by a projection of earnings for the following year.

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[11]H. Sauvain, Investment Management 2nd ed. (New Jersey, Prentice-Hall, Inc. 1960), p. 310.

[12]J.B. Williams, The Theory of Investment Value (Amsterdam, North-Holland Publishing Company, 1956).

[13]The discount rates used to arrive at present values are determined by the interest rates sought by the investor.

CHAPTER III

NATURE, METHOD AND FINDINGS OF THE RESEARCH PROJECT

NATURE OF THE PROJECT

The purpose of the research project is to determine the significance of the correlations between given series of stock price changes as viewed in The Value Line Investment Survey, during the period 1961-1964.

First, the correlation, or the degree of correspondence, of the ranking of stocks according to their "Probable Twelve Month Market Performance Rank" ("predictions") with the "observed" [1] ranking for the twelve months following the date of the "predictions" is investigated. A significant correlation may indicate that a system successful in forecasting price changes has been devised.

Secondly, the correlation of the "predictions" with the "actual performance" (the ranking of stocks according to their percentage price appreciations) for the six months preceding the date of the "predictions" is determined. A significant correlation may indicate that "predictions" are primarily based upon past price performance.

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[1]The "observed" ranking of stocks, according to their twelve months market performance, is a ranking of the stocks according to the maximum percentage price increase in the stocks achieved during the twelve months considered. The maximum prices are taken from the charts of stock prices as presented in The Value Line Investment Survey.

Thirdly, the correlation between the "actual performance" for the six month period preceding and the "observed" performance for the twelve month period following the date of the "predictions" is determined. A significant correlation may indicate that stock market price changes are not independent of past price changes, although they are assumed to be independent in the "Random Walk Hypothesis." [2]

The correlation between the "predicted" and "observed" rankings is considered at four phases in the market cycle: the bottom, the top, the middle of a falling market, and the middle of a rising market. The dates of the phases have been discovered by viewing weekly figures of Standard and Poor's Index of Total Common Stock Prices. The number of dates for which correlation studies have been possible has been limited by the number of surveys available for study. The actual computations to obtain correlation coefficients have been performed on the I.B.M. 7040 computer at the University of British Columbia.

To determine the significance of the correlation between two rankings, it is first necessary to compute a correlation coefficient between the rankings. The formula used is presented in the following section together with a note regarding a test of the significance of the coefficients.

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[2] For a description of the "Random Walk Hypothesis" see Chapter V.

METHOD OF THE PROJECT

The following is a description of the method and formula used to determine the degree of correspondence between the different rankings in the study.

The correlation between two rankings is obtained from Spearman's formula:

$$P = \frac{1/6\,(n^3-n) - \sum_{i=1}^{n} d_i^{\,2} - T'}{\sqrt{\left(1/6\,(n^3-n) - 2T'\right)\left(1/6\,(n^3-n)\right)}}$$ [3]

where:

P = Spearman's coefficient of rank correlation

n = number of ranks used

d_i = difference in ranks

$T' = 1/12 \sum_m (t^3 - t)$, where t is a tied set of t members and m typifies a set of ties in the ranking. [4]

The formula takes tied ranks into account in spite of the fact that ties should not occur in an objective ordering of ranks. [5] In the survey the ranks of 1 to 5 are allocated to stocks according to their prospect for relative price performance.

The method used to rank tied sets is to allocate to each member the average of the rank which the members would have possessed had they

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[3]M.G. Kendall, <u>Rank Correlation Methods</u>, (London, Charles Griffin & Co. Ltd., 1948) p. 28.

[4]<u>Ibid</u>., p. 29.

[5]<u>Ibid</u>., p. 28.

been distinguishable.[6] For example, if a total of six stocks had the "predicted" rank of 1, the rank allocated to stocks with the highest prospect for relative price performance, then each would be allocated the rank 3.5, the average of the numbers 1 to 6.

The resulting coefficients of rank correlation, P, are tested for significance. As each sample size n (the number of stocks considered in each test) is greater than 50, the distribution of P is assumed to be normal. (For a sample size n greater than twenty, the assumption of normality is likely justified.)[7] If there were no correlation between two rankings the maximum likelihood value of P would be zero; however, for a normally distributed variable, the maximum likelihood value and the mean coincide, so that the mean of the distribution of P would be zero.

The variance of the distribution of P under the assumption of normality and no correlation is given approximately by $\text{var } P = \frac{1}{n-1}$.[8] Hence the standard normal form of the variable (assuming zero population correlation) is given by $Z = P\sqrt{n-1}$.

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[6]Kendall, Rank Correlation Methods, p. 25.

[7]*Ibid.*, p. 47.

[8]*Ibid.*, p. 48.

FINDINGS OF THE PROJECT

Presented below are the findings of the study, that is, the significance of the correlations between the rankings studied.

First, it is found that in only three cases out of thirteen are there significant [9] correlations between "predicted" and "observed" market performance. Also, in no given stage of the market cycle do the number of significant relations seem large enough to distinguish that stage from any other. At the "Bottom of a Market Break," in only two out of six cases tested are the correlations significant. At the "Top of a Market Break" only one out of the three cases studied is significant. At the "Middle of a Falling Market" and "Middle of a Rising Market," in which only two cases each are tested, none of the correlations are statistically significant.

Second, the correlation between "actual performance" for the six months preceding publication of the survey and the "predicted" performance is found to be significant in three out of the four tests made.

Third, in only one test out of three is the correlation between "actual performance" for the six months preceding publication of the survey and the "observed" market performance found to be significant.

The findings are summarized and presented in the following pages. The Spearman rank correlation coefficients P, and the P's in standard form ($Z = P\sqrt{n-1}$) are summarized together with the level of significance α which would make the absolute value of $\pm Z$, hence the absolute value of $\pm P$ significant. An asterisk beside an α indicates that the P is significant at a critical level of .050.

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[9] Significance is considered to exist at the critical level of .050.

Correlation between "predicted" and "observed" market performance:

1. Bottom of a Market Break:

Date	P	Z	α
July 2, 1962	0.1375	1.05	.294
Oct. 29, 1962	-0.0984	-0.78	.435
Mar. 4, 1963	0.0837	0.65	.516
July 29, 1963	0.2512	2.10	.036 *
Oct. 4, 1963	-0.1405	-1.27	.204
Nov. 22, 1963	0.3640	3.30	.000 *

2. Top of a Market Break:

Date	P	Z	α
May 22, 1961	0.2416	1.96	.050 *
Aug. 20, 1962	0.1427	1.20	.230
Feb. 11, 1963	-0.0161	-0.14	.889

3. Middle of a Falling Market:

Date	P	Z	α
May 7, 1962	0.1746	1.45	.147
Oct. 8, 1962	0.0924	0.76	.447

4. Middle of a Rising Market:

Date	P	Z	α
Dec. 24, 1962	0.1623	1.42	.156
Apr. 8, 1963	0.0251	0.23	.818

Correlation between "actual performance" for the six months preceding publication of the survey and the "predicted" performance:

Date	P	Z	α
May 22, 1961	0.1587	0.14	.889
Oct. 29, 1962	0.2761	2.36	.018 *
Mar. 4, 1963	0.2649	2.40	.016 *
Dec. 20, 1963	0.2490	2.32	.020 *

Correlation between "actual performance" for the six months preceding publication of the survey and the "observed" market performance:

Date	P	Z	α
May 22, 1961	-0.0146	-0.12	.904
Oct. 29, 1962	-0.3516	-2.78	.005 *
Mar. 4, 1963	0.1981	1.68	.093

In Chapters IV and V the findings of the tests are related to the ability of the Value Line Investment Survey to predict "Probable Twelve Months Market Performance Rank."

CHAPTER IV

THE ABILITY OF FORECASTERS TO FORECAST

This chapter is concerned with the ability of forecasters of the stock market to predict price changes. Presented first is a summary of some research attempted to test the forecasting ability of different concerns. Following this summary is the interpretation of the author's research findings, which should indicate whether or not *The Value Line Investment Survey* shows any ability to predict "Probable Twelve Months Market Performance Rank."

Alfred Cowles III, in his study of the forecasting ability of forty-five professional agencies for the years 1928-1932, found that these agencies failed to demonstrate any skill in forecasting stock price changes. [1] Of sixteen financial services, only six showed better returns than the market average, and even the best record did not indicate a performance better than that to be expected by chance.

In Cowles' study of twenty-five fire insurance companies, each of which carried more than twenty percent of their total investments in common stocks, only six showed evidence of forecasting ability. Again it was found that the records could not be attributed to skill.

He found that, of ninety forecasts of the stock market as a whole over the period 1904-1929 made by William P. Hamilton using the Dow

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[1]Alfred Cowles, "Can Stock Market Forecasters Forecast?" (*Econometrica*, vol. 1, July 1933, pp. 309-324).

Theory, only half were successful.

He also investigated twenty-four forecasting publications for the period 1928-1932. His analysis failed to indicate better than random successes for these publications.

In his "Stock Market Forecasting," [2] Cowles extends the records of eleven of the twenty-four financial services he had previously studied. This study covers the period from 1928-1943. He found that the records of these services, during varying periods ranging from ten to fifteen years after 1927, failed to disclose any ability to predict the stock market.

In another study, "A Study of Mutual Funds," [3] by Brown, Herman and Vickers, it was found that the average performance of the funds was about the same as to be expected from an unmanaged fund consisting of similar securities. "Both for balanced funds and common stock funds separately, the distribution of funds classified by the number of years in which they demonstrated above-average performance seem completely random or conforming to chance." [4]

Wu, [5] in following the transactions on the New York Stock Exchange

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[2] A. Cowles, "Stock Market Forecasting," (Econometrica, Nos. 3-4, July-October, 1944, pp. 206-214).

[3] I. Friend, F.E. Brown, E. Herman and D. Vickers, "A Study of Mutual Funds: Investment Policy and Investment Company Performance," (in H. Wu and A.J. Zakon, ed. Elements of Investments, New York, Holt, Rinehart and Winston, Inc., 1965).

[4] *Ibid.*, p. 383.

[5] H. Wu, "Corporate Insider Trading Profits and the Ability to Forecast Stock Prices," (in H. Wu and A.J. Zakon, ed. Elements of Investments, New York, Holt, Rinehart and Winston, Inc., 1965).

of fifty common stocks from October to December 1959, finds that "there is very little evidence that a definite relationship exists between insider[6] transactions and subsequent price movements in relation to the general market trend."[7] His tests indicate that the insiders in the fifty companies did not outperform the market.

As indicated, there is evidence that stock market traders exhibit little, if any, skill in forecasting the future prices on the stock market. However, it is still possible that a system has been devised which may accurately predict future stock price changes. It is the purpose of this section to interpret the author's research findings regarding the forecasting ability of the Investment Line Survey in presenting the "Probable Twelve Months Market Performance Rank" of stocks.

To test the forecasting ability, the "predicted" ranking is compared with the actual "observed" ranking (a ranking of the maximum percentage price appreciations achieved by the stocks during the year) of the stocks. A test of the correlation between the two rankings shows that in only three out of thirteen tests performed on data taken from different periods are there statistically significant correlations. The results fail to indicate any consistent ability of the survey to forecast the relative performance of stocks over the period of 12 months.

In the book describing his survey[8] Bernhard states, "It is of

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[6]Every person who is the beneficial owner of ten percent of the stock or is a director or officer or issuer of the security is a corporate insider.

[7]Wu, "Corporate Insider Trading Profits and the Ability to Forecast Stock Prices," p. 448.

[8]Arnold Bernhard, The Evaluation of Common Stocks.

little practical value, under a method based upon yearly evaluation of earnings and dividends to determine that a stock is overvalued or undervalued in a particular year, if prices do not perform in accordance with the recommendation within that year."[9] It would seem then, by Bernhard's own admission, that the survey's predictions of the "Probable Twelve Months Market Performance Rank" are of little practical value, as they fail to indicate any consistent ability of the survey to forecast.

In commencing the research project the author thought that the "predictions" might be more accurate at one stage in the market cycle than another. However, the results of the study failed to support this assumption; at no stage of the cycle was a consistent ability to forecast discovered.

The forecasting ability of stock market forecasters is further considered in the following chapter.

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[9]Bernhard, The Evaluation of Common Stocks, p. 86.

CHAPTER V

THE "RANDOM WALK HYPOTHESIS" AND ITS RELATION TO THE PRESENT STUDY

THE HYPOTHESIS

In this chapter a model is presented of a process which may generate stock prices. The model, the "Random Walk Hypothesis," once discussed, is related to The Value Line Investment Survey's "predictions."

The random walk hypothesis for price changes is actually composed of two separate hypotheses:

1. That successive price changes are independent of preceding price changes, that is, that

   $$P\ (\underline{X}_t = X_t / X_{t-1}, X_{t-2}, \ldots) = P\ (\underline{X}_t = X_t)$$

   where $P\ (\underline{X}_t = X_t)$ is the unconditional probability that the variable $\underline{X}_t$, the price change during the period t, will assume the value X_t and where $P\ (\underline{X}_t = X_t / X_{t-1}, X_{t-2}, \ldots)$ is the conditional probability that $\underline{X}_t$ will assume the value X_t.
2. That the individual price changes conform to probability distributions each with mean zero. [1]

The random walk process itself is given by: $\underline{X}_t = \underline{Z}_t - \underline{Z}_{t-1}$ where $\underline{Z}_t$ is a variable generated at time t by the process in such a way that $\underline{X}_t$ forms, for successive periods t, a sequence of random,

[1] The price changes for successive periods need not necessarily conform to identical probability distributions.

independent numbers, each conforming to probability distributions with mean zero.

For the random walk process as hypothesized to hold for stock price changes, successive price changes should exhibit the same characteristics as a sequence of random independent numbers, each conforming to probability distributions with mean zero.

It was Louis Bachelier [2] who first hypothesized that the process underlying speculative price changes was the random walk. However, his pioneering work remained in obscurity until later (about 1934) when H. Working [3] hypothesized that the revealed speculative price changes were generated by a random walk process.

Bachelier tested the hypothesis on the French Bond Market, assuming a "fair game," that is, a zero expectation of gain. A close correspondence was found to exist between the distribution of price changes to be expected from his theory and that of the observed price changes.

For his study, Bachelier chose to consider only one type of security at a time. Had Bachelier been working with various types of securities as Osborne [4] did later for common stocks, he might have been led to the percentage form of price changes. In this form, if a single probability distribution for a given period were hypothesized to generate

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[2] L. Bachelier, "Théorie de la Spéculation" (Annales de l'Ecole Normale Supérieure, Ser. 3, XVII (1900), pp. 21-86.

[3] H. Working, "A Random-Difference Series for Use in the Analysis of Time Series," (Journal of the American Statistical Association, XXIX (1934), pp. 11-24).

[4] M.F.M. Osborne, "Brownian Motion in the Stock Market," (Operations Research, Vol. 7 (March-April, 1959), pp. 145-173.

equal probabilities for given percentage price changes for all securities, then a "fair game" would result from the model. That is, it would be equally likely that a \$100 security would rise or fall \$10, or that a \$10 security would rise or fall \$1. Empirical findings of approximate normality in the distribution of percentage price changes lend support to the hypothesis that there is equal probability for given percentage price changes. [5] However, the apparent long run trend in stock market prices as a whole does not lend support to the assumption of a "fair game" which is part of Bachelier's model.

Osborne, in his study of the random character of the market was led to consider the logarithm of price as the variable of concern in the "Random Walk Hypothesis." However, if the distribution of changes in the logarithms of prices for a given period is hypothesized to generate equal probabilities for given changes in the logarithm of price, then the model is no longer a "fair game." [6]

Empirical findings concerning the changes in the logs of prices for a number of differing stocks from one period to the next, tend to support the hypothesis that there is equal probability for given changes in the logs of prices. [7] Such evidence would indicate that the model is other

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[5] S. Alexander, "Price Movements in Speculative Markets: Trends or Random Walks," (<u>Industrial Management Review, 2</u> No. 2 (May 1961), pp. 7-26) p. 467.

[6] If there is an equal probability of a change of one in the $\log_{10}$, on one hundred dollars the expected amount of gain is:

$$\tfrac{1}{2}(\$10 + \$1000) - \$100 = \$405.$$

[7] A.B. Moore, "Some Characteristics of Changes in Common Stock Prices" (in P.H. Cootner, ed. <u>The Random Character of Stock Market Prices</u>, Cambridge, Mass., M.I.T. Press, 1964).

than a "fair game." In fact, using log prices as the variable of concern in the "Random Walk Hypothesis" allows for expectation of gain in the model.

It is apparent that a long-run trend in stock market prices as a whole does exist. [8] The market is not a "fair game," but rather is weighted in favour of the investor (at the moment the long-run trend is for the market to rise). The choice of logarithm of price as the variable of concern in the "Random Walk Hypothesis" does allow for a rising trend in prices. However, it seems unlikely that the "Random Walk Hypothesis" as formulated, using logs of prices, is the "best" choice to describe the random nature of the market where a rising trend in prices is apparent.

A revised form of the "Random Walk Hypothesis" which takes trend into account is the "Random Walk Hypothesis" incorporating drift, that is: $\underline{Z}_t - \underline{Z}_{t-1} = \underline{X}_t$ Where the symbols refer to the variables previously indicated, save that $\underline{X}_t$ is now assumed to conform to distributions with means other than zero, chosen so that the expected value of $\underline{X}_t$ accounts for the trend in the market.

So regarded, a test of the random nature of stock market prices may be made by comparing actual performance in stock prices under a systematic trading rule with price performance possible through a "buy-and-hold" plan. If results indicate that significantly greater "profits" are available to a systematic trading plan, which takes into account only

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[8] M.G. Kendall might differ, (M.G. Kendall, "The Analysis of Economic Time-Series, Part I: Prices," (Journal of the Royal Statistical Society, Vol. 96, Part I (1953), pp. 11-25) p. 11), for he found that "In a series of prices which are observed at fairly close intervals the random changes from one term to the next are so large as to swamp any systematic effect which may be present."

past prices, than to a "buy-and-hold" system on the same stocks, then a dependency between past and future prices may be established, and grounds may be made on which to refute the "Random Walk Hypothesis."

Alexander [9] has suggested such a scheme, a filter scheme, [10] and has tested it [11] on some commonly used price indices. His original results have indicated that, generally, all sizes of filters yield greater profits than a simple "buy-and-hold" policy.

However, as Mandelbrot [12] points out, Alexander's trading system has incorporated certain computational biases. [13] In his second paper, [14] Alexander has tested the "Random Walk Hypothesis" after attempting to remove all biases from his filter scheme. These later results indicate that the apparent profitability of the filter technique is drastically reduced but still indicate that the technique should be more profitable than a "buy-and-hold" policy for filter sizes up to about 10% and over about 40%.

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[9] S. Alexander, "Price Movements in Speculative Markets" (in Wu) and "Price Movements in Speculative Markets: Trends or Random Walks, No. 2," (in P.H. Cootner, ed. Random Character of Stock Market Prices, Cambridge, Mass., M.I.T. Press, 1964).

[10] Alexander's scheme is to select a stock and watch it. If its price goes up X percent, buy it. Hold onto it until its price falls X percent from a subsequent high price then sell the stock and go short. Buy the stock when its price rises X percent from a subsequent low price.

[11] A non-statistical test is used.

[12] B. Mandelbrot, "The Variation of Certain Speculative Prices," (Journal of Business, Vol. 36, No. 4 (October, 1963), pp. 394-419).

[13] Ibid., p. 417.

[14] S. Alexander, "Price Movements in Speculative Markets: Trends or Random Walks, No. 2."

However, as Fama and Blume [15] point out, Alexander has not adjusted the price indices for dividends which are lost through active trading of the stocks.[16] The results of tests carried out by Fama and Blume indicate that only for very small filters, 1.5% and less, is the filter technique more profitable than a "buy-and-hold" policy before commissions. They suggest that there is a positive dependence in very small price changes; and evidence of a negative dependence in intermediate sized changes (1.5% to 12% filters). However, when commissions and the time funds will be idle are taken into account, the apparent dependencies are not likely to increase the profitability of the filter scheme to more than that of the simple "buy-and-hold" policy.

In another paper, "A new Look at Clustering of Stock Prices," [17] dependencies are found to exist in terms of the exact prices at which stocks are sold. It is found that stocks trade at even eighths more often than at odd eighths, and most often at whole number prices like 10, 25, 50, 75 and 100, all even eighths. The same phenomenon has been demonstrated earlier by Osborne in his work, A Physicist Looks at Stock Prices.[18]

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[15] E. Fama and M. Blume, "Filter Rules and Stock-Market Trading," (The Journal of Business, Vol. XXXIX (January, 1966), pp. 226-241).

[16] Fama and Blume point out (E. Fama and M. Blume, "Filter Rules and Stock-Market Trading," p. 235) that "In a short sale the borrower of the securities typically reimburses the lender for any dividends that are paid while the short position is outstanding. Thus adjusting for dividends will reduce the profitability of short sales and thereby reduce the profitability of the filter technique relative to buy-and-hold."

[17] V. Niederhoffer, "A New Look at Clustering of Stock Prices," (Journal of Business, Vol. 39, No. 2 (April, 1966), pp. 309-313).

[18] Osborne, A Physicist Looks at Stock Prices (cited in A.B. Moore, "Some Characteristics of Changes in Common Stock Prices," p. 153).

A recent paper by Mandelbrot [19] introduces the thought that stock prices may follow a "Martingale" rather than a random walk. The "Martingale" property "implies only that the expected values of future prices will be independent of the values of past prices; the distributions of future prices, however, may very well depend on the values of past prices." [20] The random walk is a "Martingale," but the "Martingale" is not necessarily a random walk. However, as Fama and Blume point out, the degree of dependence shown by the "Martingale" is likely so small that for practical purposes the random walk hypothesis is not greatly violated for stock price changes.

Some statistical tests do not reject the assumption of independence in the "Random Walk Hypothesis" for stock price changes. Kendall found for British stock price averages that "stock-exchange movements revealed little serial correlation within series and little lag correlation between series." [21] Moore [22] found that, although there was slight positive serial correlation in the differences of the logs of prices for successive periods, non-parametric tests of the runs in the signs of Standard and Poor's 500 Stock index tended to support the hypothesis of independence in runs.

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[19] B. Mandelbrot, "Forecasts of Future Prices, Unbiased Markets, and 'Martingale' Models," Journal of Business, vol. XXXIX (January, 1966), pp. 242-255.

[20] E. Fama and M. Blume, "Filter Rules and Stock-Market Trading," p. 226.

[21] M.G. Kendall, "The Analysis of Economic Time-Series, Part I; Prices," p. 11.

[22] A.B. Moore, "Some Characteristics of Changes in Common Stock Prices," p. 145.

As only slight, if any, dependence in stock price changes has been observed, for all practical purposes the assumption that successive price changes are independent of preceding price changes may be an adequate description of reality where it seems that the slight dependencies cannot be used to produce greater profits than a "buy-and-hold" policy.

The nature of the probability distribution likely to underly stock price changes for any given period has been explored by some researchers. Kendall, [23] in analyzing changes in both stock price averages and commodity prices on the London market, found approximate normality in the changes. Osborne, [24] in his study of the New York Stock Exchange, found approximate normality in changes in the logarithms of stock prices. Mandelbrot [25] questions the findings of normality in stock price changes. He finds that more observations lie near the mean and more lie in the extreme tails in the frequency distribution of price changes than would be expected if the underlying distribution were normal. He suggests that, not the mormal distribution which is a member of the Pareto family of distributions, but rather, some other member of the family would better "fit" the empirical data. However, those candidates of the Pareto family which might better "fit" the empirical findings, although they have the additive properties associated with the normal distribution,[26] do not have finite variances. Tests of significance have not been developed for the

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[23]M.G. Kendall, "The Analysis of Economic Time-Series, Part I: Prices," p. 17.

[24]M.F.M. Osborne, "Brownian Motion in the Stock Market."

[25]B. Mandelbrot, "The Variation of Certain Speculative Prices."

[26]A linear combination of normal independent variables is itself normal.

Pareto family as a whole. As such is the case, if a Pareto distribution with infinite variance is assumed to underly price changes, then parametric significance tests of the independence of stock price changes cannot be applied. However, Fama [27] indicates that the mean deviation, rather than the variance, may be the basis for future significance tests for the Pareto distribution.

FINDINGS WHICH MAY SUPPORT THE HYPOTHESIS

Now, in the present study, many differing stocks are considered at once so that percentage price changes or the difference in the logarithms of successive prices would be the acceptable variables for testing the independence assumption of the "Random Walk Hypothesis" where it is assumed that single probability distributions underly the changes in common stock prices for given periods. [28] The method chosen to test the independence assumption is non-parametric and hence does not involve the parameters of the underlying distributions. The question as to whether or not the underlying distributions are normal, Paretian, or even symmetric, or whether or not the means of the underlying distributions are zero or some other value to account for drift in the prices is circumvented by performing the rank correlation study described in the paper. The choice of percentage price changes or differences in logarithms of prices would yield the same results in the test. In fact, the non-parametric rank correlation method chosen to

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[27] Eugene F. Fama, "The Behaviour of Stock Market Prices."

[28] S. Alexander, "Price Movements in Speculative Markets: Trends or Random Walks," p. 15.

test the forecasting ability of the survey would yield the same results whether relative price changes, relative prices, the log of relative prices, or the difference in the logs of prices were chosen to conduct the tests, as there is a one to one ordered correspondence between each of the variables listed.[29]

If the "Random Walk Hypothesis" is assumed and if a single distribution does underly price changes for a given period, or if single distributions underly price changes for every fraction of a period, then, for any period chosen, a random ordering of stocks should result according to percentage price changes.[30] If single distributions underly all price changes for different periods throughout a year, then a random ordering of stocks according to the greatest percentage price appreciations achieved during the year should result from cumulations of the random percentage changes.

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[29]Log of relative prices equals the difference in the logs of prices, i.e.

$$\log \frac{P_{t+1}}{P_t} = \log P_{t+1} - \log P_t$$

Log of relative prices has a one to one ordered correspondence to relative prices (relative prices in all cases are or can be made positive).

Relative prices have a one to one ordered correspondence to relative price changes, that is, $\frac{P_{t+1}}{P_t}$ has a one to one correspondence to $\frac{P_{t+1} - P_t}{P_t}$

Proof: $\frac{P_{t+1} - P_t}{P_t}$ is the same as $\frac{P_{t+1}}{P_t} - 1$

Hence $\frac{P_{t+1} - P_t}{P_t}$ and $\frac{P_{t+1}}{P_t}$ have a one to one ordered correspondence, as they differ only by a constant -1.

[30]If the single distributions are themselves each Paretian (including normal) then the percentage price changes over a number of periods will appear to have been generated by a single Paretian distribution.

Assuming that a single distribution does underly stock price changes for different stocks in a market characterized by a random walk, and hence that a random ordering of stocks according to percentage price changes is the result, the comparison of the orderings for successive periods should not reveal any significant correlation; that is, they should indicate independence in price changes. Such comparisons were undertaken in the research project, and, as indicated in the findings of Chapter III, the correlation between the "observed" (future) and actual past market performance was found to be significant at the 5% level of significance in only one test out of three. These results are not adequate to refute the hypothesis that price changes are independent. However, it might be fruitful to make more tests of the independence hypothesis between prices in a period during which most prices are falling and a succeeding period in which most prices are rising, as was the case for the one test which was significant. Such a test may indicate that there is a correlation between price changes in the two periods and thus may be grounds for refuting the assumption of independence. Then again, if the prices are found to be dependent using the present test, but independent using other tests, the assumption that single distributions underly all stock price changes, rather than the assumption of independence, may be false. Benjamin King finds, through factor analysis, "that the movement of a group of security price changes can be broken down into market and industry components;[31] his results seem to indicate that the assumption of a single underlying distribution may not be correct.

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[31]B.F. King, "Market and Industry Factors in Stock Price Behavior," (Journal of Business, Vol. XXXIX (January, 1966), pp. 139-190), p. 163.

RELATION TO THE PRESENT STUDY

Assuming that the "Random Walk Hypothesis" is applicable to stock market price changes, it should be clear that any forecast of future price changes based wholly on past price changes is not likely to yield accurate results. In the author's study, the correlation coefficient between "actual past performance" and "predictions" of future price performance is determined. It is found that, in three out of four tests, the correlation between the two performances is significant. Such consistent significant correlations might lead one to suppose that the Value Line "predictions" are heavily based on past performance in price changes. If such is the case, one might expect that there should be little significance to the correlation between "forecasted" and "observed" (future) price appreciations. The author finds that in only three out of thirteen tests performed were correlation coefficients between the "predicted" and the "observed" price appreciations found significant at the five percent level of significance. The results do not differ greatly from the results one might expect had predictions been based on past prices alone, where the market is assumed to follow a random walk. It would seem from the present tests, that the Value Line Investment Survey has failed to prove that its "predictions" of future "Twelve Months Market Performance Rank" are superior to "predictions" based solely on past prices. However, The Value Line Survey's "predictions" do not take into account solely the price appreciations over a six months preceding period (the Value Line method is described in Chapter II). This fact is borne out by the tests made on The Value Line Survey "predictions" for Oct. 29,

1962. Although the "predictions" are significantly correlated with "actual performance" for the six months preceding publication of the survey, and, although the "actual performance" for the six months preceding publication of the survey is significantly correlated with the "observed" (future) market performance, the "predictions" are not significantly correlated with the "observed" (future) market performance. Also, in the one case out of four in which "actual past six month's performance" is not found to be significantly correlated with "predicted" performance, "predicted" performance is found to be significantly correlated with "observed" (future) market performance.

Although the method for "forecasting" "Twelve Months Market Performance Rank" does not take into account only changes in past prices (which, for all practical purposes seem to be independent of future prices), the results of its application have not shown any consistent accuracy. The author is led to conclude that the accuracy of predictions by this method is no greater than to be expected by basing "predictions" of a "Twelve Months Market Performance Rank" on a random ranking of stocks.

CHAPTER VI

CONCLUSION

The results of the author's study do not refute the "Random Walk Hypothesis" for stock prices. However, though adopted in the present study, the assumption that a single distribution underlies all stock price changes for a given period may not be valid generally. King finds "that the movement of a group of security price changes can be broken down into market and industry components." [1] In the present study, the "actual past performance" is not significantly correlated with "observed" performance, even though both rankings involve stocks from different industries. It is possible that, at least for the present project, the assumption of a single distribution underlying percentage price changes for all stocks is an adequate assumption.

"Predictions" in a market following a random walk may be accurate where the "predictions" are based upon an appraisal of new information which affects prices. Dependencies in the information should not lead to dependencies in price changes, as sophisticated traders will take such dependencies into account, and their actions should tend to eliminate the dependencies in price changes. Those analysts who can

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[1] B.F. King, "Market and Industry Factors in Stock Price Behavior," p. 163.

consistently predict the appearance of new information and determine its effects on stock prices should show evidence of an ability in making "predictions."

The Value Line Investment Survey fails to evince a consistent ability to forecast "Probable Twelve Months Market Performance Rank," the ranking of stocks according to their probable relative market price performance for the year. It seems that results comparable to those based on the "predictions" could be gained by randomly ranking the same stocks.

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